A27 Arundel Bypass
Report on Further Consultation

Appendix A:
Further consultation materials

Introduction

We operate, maintain and improve England's motorways and major A-roads, the strategic road network. We care about your journey and we want to make sure all our major roads are more dependable, durable, and most importantly, safe. That's why we're delivering £15 billion of investment on our network – the largest investment in a generation.

Our proposed improvements to the A27 around Arundel would improve journeys by replacing the existing single carriageway road with a new dual carriageway, linking the two existing dual carriageway sections either side of the town.

We'll be seeking views on our proposals to develop the A27 Arundel Bypass and we want to ensure you know how we'll do this. That's why we've produced this document which outlines our approach to the consultation, including the different ways we'll collect feedback. It also provides details about how you can take part and how feedback will be used to influence our proposals.

To make sure we approach our consultation in the very best way, we've developed this document in conjunction with relevant local authorities and the South Downs National Park Authority.

About the previous non-statutory consultation

The initial non-statutory public consultation for the project was completed between August and October 2017, to seek views on three options to improve the A27 at Arundel.

During the consultation period:

- 2,062 people attended exhibitions and stakeholder meetings.
- 2,821 people completed questionnaires.
- 7,135 responses were received via letter or email.

Of the written responses, 132 were from key stakeholders while there were also two petition email response campaigns, co-ordinated by Friends of the Earth and the Woodland Trust. These received 737 and 5,748 signatories, respectively.

The consultation showed that Option 5A was the favoured option amongst local authorities, businesses groups, political representatives and consultation respondents who completed the questionnaire.

However, many of those that wrote objection emails attributed to Friends of the Earth and The Woodland Trust, and all of those (2,508) that signed the petition on behalf of Arundel Bypass Neighbourhood Committee (ABNC), rejected Option 5A.

About the further consultation

In May 2018, we announced a preferred route for the proposed A27 Arundel Bypass, known as Option 5Av3, following public consultation in autumn 2017. We then began further developing the design as part of our works towards submitting a formal planning application, the process of which is outlined on page 10. This included looking at options for minimising impacts on protected ancient woodland and biodiversity at the western end of the route. We also considered enhancements to alternate options.

We discovered new information during this work. Given the significant environmental sensitivities in the area around Arundel, even relatively minor design changes can have an important impact on overall route assessments. We therefore want to understand your views on the options for the scheme based on the latest available information, which we're presenting through this further consultation.

Following this further consultation, we will consider the responses alongside all other relevant evidence, before deciding on, and announcing, a new preferred route for the scheme.

The scheme

Background

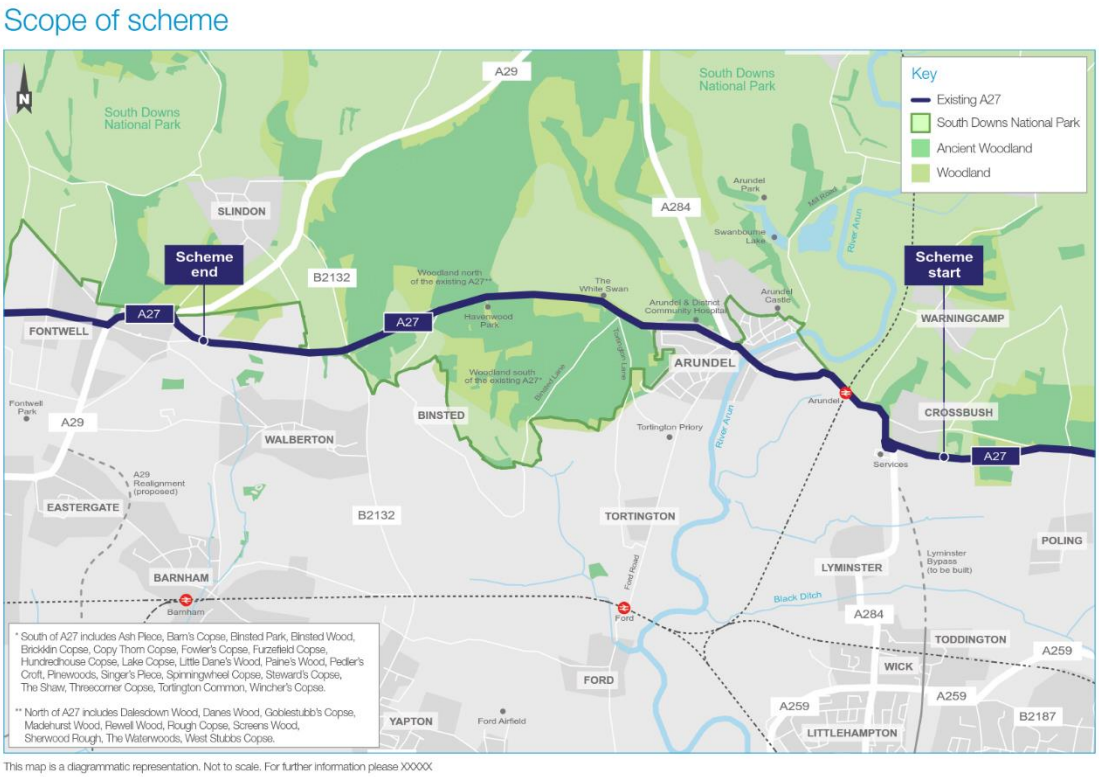
In December 2014, the Department for Transport (DfT) published the first Road Investment Strategy 2015-2020 (RIS1), which lists the schemes to be delivered by Highways England during this period.

In response to the Road Investment Strategy announcement, we developed our Delivery Plan (Highways England Delivery Plan 2015-2020) which detailed how the key strategic outcomes sought for the Road Investment Strategy would be delivered.

The A27 Arundel Bypass is one of more than 100 major schemes being progressed nationally as part of the Highways England Delivery Plan 2015-2020.

This project explores solutions for replacing the existing A27 single carriageway road, which lies between the A284 Crossbush junction (east of Arundel), and extends to the west of Arundel, with a new dual carriageway. Figure 1 below shows the scheme location.

Figure 1 - Scheme location



Need for the scheme

- The A27 is the only major east-west trunk road south of the M25. It links many of the towns and cities along the south coast, including Portsmouth, Chichester, Arundel, Brighton and Hove, Lewes and Eastbourne, serving a combined population of more than 1 million[1] people, as well as a large number of businesses.
- The smooth running of this road plays a key part in the region's success. West Sussex attracts, on average, 17 million visitor days per year, worth approximately £508 million to the local economy[2].
- On either side of Arundel, the A27 is a dual-carriageway with capacity to carry existing traffic flows and more able to cope with future traffic growth. The single carriageway section of the A27 around Arundel creates a bottleneck that holds up traffic, costing commuters, businesses, communities and visitors valuable time and money.
- Congestion around Arundel results in some drivers seeking alternative routes which are less suited to higher traffic flows. These alternatives include the B2139 through the South Downs National Park, disrupting the otherwise tranquil nature of the Park. Residents in local towns and villages are affected by increases in through traffic, while air quality is also a concern, most notably in Storrington which was identified by the World Health Organisation as one of the poorest places for air quality in the UK[3].
- The A27 currently has a poor safety record, with a higher than average accident rate for rural A-roads[4].
- Relatively poor transport connectivity in the area has contributed to pockets of deprivation by restricting access to employment opportunities. For example, Littlehampton has some of the highest levels of deprivation in the country, partly because local people have reduced access to employment (especially higher paid, higher value jobs) elsewhere in the region[5]. Improving connectivity could help tackle this inequality.

[1] Based on census 2011 population data for these districts; Portsmouth, Havant, Chichester, Arundel, Worthing, Adur, Brighton and Hove, Lewes, and Eastbourne.

[2] The GB Day Visitor Statistics 2015, VisitBritain

[3] WHO report available here http://www.who.int/airpollution/data/aap_air_quality_database_2018_v12.xlsx?ua=1 with further information about air quality from WHO accessible here https://www.who.int/airpollution/en/

[4] In the latest 5-year period (1 January 2013 to 31 December 2017) there have been 81 personal injury collisions, resulting in 121 casualties, recorded between Yapton Lane to the east and Crossbush junction to the west.

[5] For more detail see the Combined Modelling and Appraisal Report (ComMA).

Objectives

The high-level objectives for the scheme were developed while working with the relevant local authorities, the South Downs National Park Authority, other environmental bodies and the emergency services over a two-year period prior to the first non-statutory public consultation. They are to:

- Improve the safety of all travellers along the A27 and consequently the wider local road network.
- Ensure that customers and communities are fully considered throughout the design and delivery stages.
- Improve capacity of the A27 whilst supporting local planning authorities to manage the impact of planned economic growth.
- Reduce congestion, reduce travel time and improve journey time reliability along the A27.
- Improve accessibility for all users to local services and facilities.
- Deliver a scheme that minimises environmental impact and seeks to protect and enhance the quality of the surrounding environment through its high-quality design.
- Respect the South Downs National Park and its special qualities in our decision-making.

Approach to Public Consultation

The purpose of the Approach to Public Consultation is to explain what you can expect from us and to outline the details of the consultation process The Approach to Public Consultation will be included on the scheme webpage and copies will be available locally at libraries and Arundel Town Hall (as listed on page 7) once the consultation is launched.

Public consultation is an important part of the delivery of this scheme and provides people with a real opportunity to influence our proposals. It also allows us the opportunity to help people fully understand the scheme and resolve concerns. It's not the only time we'll be consulting about this scheme. We will consult again once the final option for the scheme has been selected to help further inform the design ahead of an application for a Development Consent Order (DCO) to proceed with the scheme. Find out more about the DCO process on page 10.

Why and when will we consult?

Your comments will help us better understand the local area and any potential impacts our scheme may have on road users and the local community. We will listen to everyone's views and we'll consider your opinions before we select a preferred option for the scheme.

Options for the scheme will be consulted on between 30 August 2019 – 24 October 2019.

A number of exhibitions will be held so you have the opportunity to meet our team and ask questions about the proposals.

Table 1 shows our exhibition dates and locations.

Table 1: Public exhibitions

Date	Location	Address	Time
Friday 30 August	Cathedral Centre, Arundel	London Road, Arundel, BN18 9AY	17.30-20.00
Tuesday 10 September	The White Swan	16 Chichester Road, Arundel, BN18 0AD	15.30-20.00
Wednesday 11 September	Whiteways Car Park (South Downs National Park – consultation van)	Bury Hill, Houghton, BN18 9FD	11.00-13.00

Wednesday 11 September	Impulse Leisure Centre, Storrington (consultation van)	Spierbridge Road, Storrington, Pulborough, RH20 4PG	15.00-18.00
Saturday 14 September	Fontwell Park Racecourse – Premier Grandstand	Fontwell Avenue, Fontwell, Arundel, BN18 0SX	10.30-14.30
Thursday 19 September	Coronation Hall, Slindon	Reynold's Lane, Slindon BN18 0QT	14.00-20.00
Saturday 28 September	Walberton Village Hall	The Street, Walberton, Arundel, BN18 0PJ	10.00-17.00
Tuesday 1 October	Littlehampton Town Council – Manor House	Church Street, Littlehampton, BN17 5EW	14.00-20.00
Tuesday 8 October	Arundel Town Centre – Mill Road Car Park (consultation van)	Mill Road, Arundel, BN18 9PA	11.00-14.00
Friday 12 October	Arundel Town Hall	Maltravers Street, Arundel, BN18 9AP	10.30-16.00

Additional information about the scheme, including the options we are consulting on and associated benefits, will be included in our public consultation brochure.

There will also be a series of unstaffed exhibitions, where members of the public will be able to view some of the exhibition materials, and printed copies of the brochure and Consultation Response Form. Please see Table 2 for our unstaffed exhibition locations.

Table 2: Unstaffed exhibition locations

Monday 16 & Tuesday 17 September	Bognor Regis Town Hall	Clarence Road, Bognor Regis, PO21 1LD	During usual opening hours
Wednesday 25 September	Storrington Library	Ryecroft Lane, Storrington, Pulborough, RH20 4PA	9.30pm-5.30pm

Wednesday 9 October	Yapton Village Hall	Main Road, Yapton, BN18 0ET	10am-5:30pm
Monday 14 – Friday 18 October	Arun Civic Centre, Littlehampton	Maltravers Road, Littlehampton, BN17 5LF	During usual opening hours

Copies of the brochure will be available locally at deposit points when the consultation is launched and on the scheme website: https://highwaysengland.citizenspace.com/he/a27-arundel-bypass-further-consultation. Please see Table 3 for our deposit point locations.

Table 3: Deposit point locations

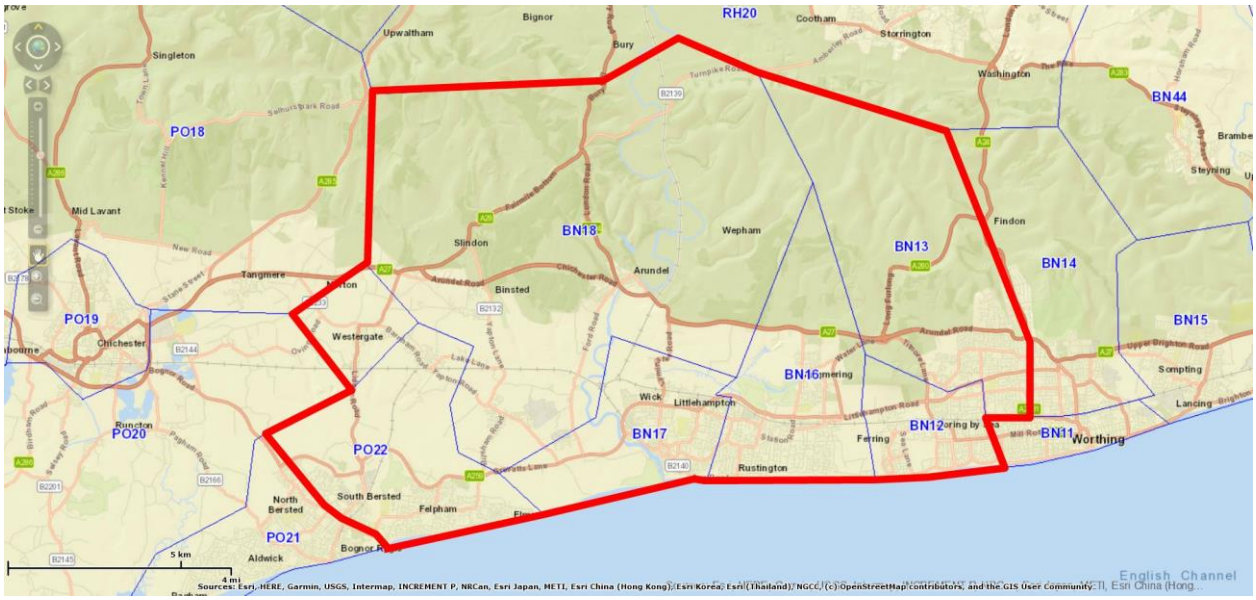
Arundel Town Hall	Maltravers Street, Arundel, BN18 9AP
Arundel Library	2 Surrey Street, Arundel, BN18 9DT
Littlehampton Library	Maltravers Road, Littlehampton, BN17 5NA
Angmering Library	Arundel Road, Angmering, Littlehampton, BN16 4JS
Rustington Library	Claigmar Road, Rustington, Littlehampton, BN16 2NL
East Preston Library	The Street, East Preston, Littlehampton, BN16 1JJ
Bognor Regis Library	69 London Road, Bognor Regis, PO21 1DE

Who will we consult?

Working with the local highway and planning authorities (West Sussex County Council, Arun District Council and South Downs National Park Authority), we have developed a consultation target area for the distribution of our consultation materials. This is based on who we jointly think will be interested in or affected by our proposals. We'll let people living/working in this area know about our consultation by posting information in advance.

We will also work with the local authorities to identify groups who are traditionally hard to reach to ensure that reach all those who could be affected by our proposals (e.g. the West Sussex Youth Cabinet).

Figure 2 – Consultation Area: Letter Distribution



Who can take part?

Anyone who is interested in this scheme is welcome to take part. We welcome all views and will take them into account to help shape and improve our scheme design.

How will we consult?

We will use the following methods to promote our public consultation.

Table 4: Channels for consultation

Method	Detail
Public consultation exhibition	Exhibition at local venues where members of the team will be available to answer questions about the proposals. Visitors to the exhibitions will be able to submit their consultation responses if they choose to.
Scheme webpage	A full summary of the scheme, the public consultation brochure and the online response form, available at: https://highwaysengland.citizenspace.com/he/a27-arundel-bypass-further-consultation
Consultation letter	At the start of the consultation period, a letter will be delivered to all homes and businesses in the locality of the proposed scheme, containing information on public exhibitions, details of how to

	respond to the consultation and where to find more information.
Public consultation brochure	A public consultation brochure containing details of the exhibitions will be available locally at the public exhibitions, deposit points, upon request and in other formats.
Council and community / area forum briefings	We'll speak to local councils and community / area forums affected or interested in our scheme.
Elected Representatives Forum	This forum enables Highways England to update elected community representatives on scheme progress and maintain an ongoing dialogue.
Consultation response	Comments can be submitted online by completing the online response form at https://highwaysengland.citizenspace.com/he/a27-arundel-bypass-further-consultation or in writing to the following freepost address: FREEPOST A27 ARUNDEL, or by visiting a consultation exhibition. All responses must be received by midnight 24 October 2019.
Media	Adverts will be placed in local newspapers to promote the launch of the consultation. Press releases detailing the public consultation period and how the community and road users can get involved will be issued.
Social media	The public consultation will be advertised on Highways England's official Twitter channel. Other channels are being considered, including Facebook.

What will happen to the consultation responses?

All responses received during the public consultation will be recorded and analysed. The content of each response will be categorised and broken down by sentiment, themes and respondent profile – helping us understand your comments and why you have made them. Where it is possible to do so, we will use your feedback to help influence the scheme design or to help identify ways to address concerns about the impacts of the scheme.

We'll summarise our findings in a public consultation report which will explain our analysis and how it influenced our proposals.

Environmental information

An Environmental Assessment Report is being prepared to assess the potential environmental effects of the scheme options, and will be ready to view at the start of the consultation period. Environmental input to the scheme development has been ongoing. Environmental constraints analyses and design changes have been considered throughout the design process to avoid or reduce the potential for adverse environmental impacts associated with the scheme.

The Environmental Assessment Report will outline the environmental impact mitigation measures that would be implemented during construction and operation to reduce the potential adverse environmental impacts arising from the scheme. Potential impact mitigation measures will also be outlined within the consultation brochure.

The complete report will be available to view and download via the consultation website, with copies also available at our public consultation exhibitions and at several accessible locations around the area, including local libraries and Arundel Town Hall.

Once a preferred route has been confirmed, a detailed impact mitigation strategy will be developed in parallel with the ongoing design process.

Application process and scheme development

The A27 Arundel Bypass scheme has been classified by the Secretary of State as a Nationally Significant Infrastructure Project (NSIP) due to the size of the project. To build an NSIP scheme we must obtain a Development Consent Order (DCO). A DCO is a comprehensive instrument that combines planning permissions with powers necessary to develop complex infrastructure schemes, such as powers to buy land.

We will undertake a statutory public consultation, where we will then prepare and lodge the DCO application with the Planning Inspectorate, who will check and decide whether to accept the application.

A pre-examination stage follows this, where the public will be able to register with the Planning Inspectorate and provide a written summary of their views on the application. The Planning Inspectorate then has six months to carry out the formal examination. During this stage, people who have registered will be invited to provide more detail of their views in writing.

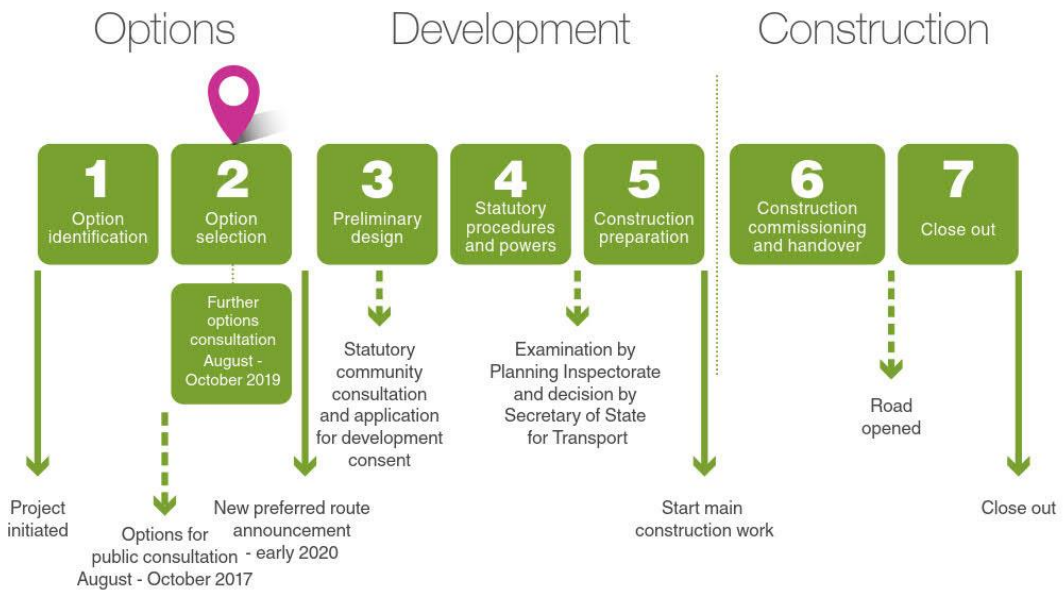
At the end of the examination stage, the Planning Inspectorate prepares a report on the application to the Secretary of State for Transport, including a recommendation on whether to grant development consent. The Secretary of State of Transport then makes the decision on whether to grant or refuse development consent.

If we do not obtain consent from the Secretary of State for Transport, then the scheme cannot be delivered.

More information is available from the Planning Inspectorate website: infrastructure.planninginspectorate.gov.uk/.

The process for this is outlined in the graphic on the following page.

Figure 3 – Scheme timeline and milestones



For more information visit our scheme webpage where you can also sign up for email alerts whenever the webpage is updated. If you have any queries about this scheme, please contact the project team directly by calling: 0300 123 5000 (24 hours) or emailing: A27ArundelBypass@highwaysengland.co.uk

Our ref: A27 ABR

Sophie Hartfield
Project Manager
A27 Arundel Bypass
Highways England
Bridge House
Walnut Tree Close
Guildford GU1 4LZ

19 August 2019

Dear Sir/Madam

A27 Arundel Bypass further consultation: Have your say

I am writing to invite you to take part in a further public consultation to let us know your views on proposals to improve the A27 around Arundel.

As you may recall, we announced a preferred route known as Option 5Av3 last year, following public consultation in autumn 2017. We then began further developing the design as part of our work towards submitting a formal planning application. We discovered new information during the course of this work and, given the significant environmental sensitivities in the area, even relatively minor changes can have an important impact on overall route assessments. We therefore want to understand your views on the revised options for the scheme based on the latest available information, which we are presenting through this further consultation.

The further consultation is planned from **Friday 30 August to 11.59pm on Thursday 24 October 2019** and there will be several ways to have your say:

Public consultation events
Our consultation events will give you an opportunity to learn more about the proposed options and discuss any queries that you have with members of our project team. The following events are planned:

Date	Location	Address	Time
Friday 30 August	Cathedral Centre	Cathedral Centre, London Road, Arundel, BN18 9BA	5.30pm-8pm
Tuesday 10 September	The White Swan	The White Swan, Chichester Road, Arundel, BN18 0AD	3.30pm -8pm
Wednesday 11 September	Whiteways car park, South Downs National Park (our consultation van will be on-site)	Bury Hill, Houghton, BN18 9FD	11am-1pm
Wednesday 11 September	Impulse Leisure Centre car park, Storrington (our consultation van will be on-site)	Spierbridge Road, Storrington, Pulborough, RH20 4PG	3pm-6pm
Saturday 14 September	Fontwell Park Racecourse	Fontwell Park Racecourse, Arundel Road, Fontwell, Arundel, BN18 0SY	10:30am-2.30pm
Thursday 19 September	Coronation Hall, Slindon	Coronation Hall, Reynold's Lane, Slindon, Near Arundel, West Sussex, BN18 0QT	2pm-8pm
Saturday 28 September	Walberton Village Hall	The Street, Walberton, Arundel, BN18 0PJ	10am-5pm
Tuesday 1 October	Littlehampton Town Council – Manor House, Littlehampton	Littlehampton Town Council, Manor House, Church Street, Littlehampton, BN17 5EW	2pm-8pm
Tuesday 8 October	Mill Road car park, Arundel (our consultation van will be on-site)	Mill Road, Arundel, BN18 9PA	11am-2pm
Saturday 12 October	Arundel Town Hall	Maltravers Street, Arundel, BN18 9AP	10:30am-4pm

In addition, we will be running four unstaffed exhibitions where you will be able to view some of the exhibition materials, and printed copies of the brochure and questionnaire:

Date	Location	Address	Time
Monday 16 & Tuesday 17 September	Bognor Regis Town Hall	Clarence Road, Bognor Regis, PO21 1LD	During usual opening hours
Wednesday 25 September	Storrington Library	Ryecroft Lane, Storrington, Pulborough, RH20 4PA	9.30pm-5.30pm
Wednesday 9 October	Yapton Village Hall	Main Road, Yapton, BN18 0ET	10am-5:30pm
Monday 14 – Friday 18 October	Arun Civic Centre, Littlehampton	Maltravers Road, Littlehampton, BN17 5LF	During usual opening hours

Locations to collect consultation material
You will be able to find copies of the brochure and the questionnaire at the following locations throughout the consultation period (30 August to 24 October 2019):

Location	Address
Angmering Library	Arundel Road, Angmering, Littlehampton, BN16 4JS
Arundel Town Hall	Maltravers Street, Arundel, BN18 9AP
Arundel Library	Surrey Street, Arundel, BN18 9DT
Bognor Regis Library	69 London Road, Bognor Regis, PO21 1DE
East Preston Library	The Street, East Preston, Littlehampton, BN16 1JJ
Littlehampton Library	Maltravers Road, Littlehampton, BN17 5NA
Rustington Library	Claigmar Road, Rustington, Littlehampton, BN16 2NL

Online
From 30 August, key information about the proposals, including the consultation brochure, questionnaire and supporting information, will be available from our project website: **www.highwaysengland.co.uk/a27arundel**

How to respond
You can complete the questionnaire and:

- Submit it online at **www.highwaysengland.co.uk/a27arundel**
- Post it to **Freepost A27 ARUNDEL** free of charge
- Return it to us at one of the consultation events

If you are responding on behalf of a business, charity or community organisation, please complete our organisation-specific questions within the questionnaire.

All responses to the public consultation will be considered by our project team as part of the option selection process. A report on the public consultation will then be produced and considered alongside all other evidence as part of our work to identify a new preferred route.

If you have any general queries regarding this project, please don't hesitate to contact us on 0300 123 5000 (local call rate), or email **A27ArundelBypass@highwaysengland.co.uk**

We look forward to hearing from you via the questionnaire and meeting you in person at one of the public consultation events.

Yours faithfully

S. Hartfield

Sophie Hartfield
Project Manager, A27 Arundel Bypass

Our ref: A27 ABR2

Sophie Hartfield
Project Manager
A27 Arundel Bypass
Highways England
Bridge House
Walnut Tree Close
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13th September 2019

Dear Sir/Madam

A27 Arundel Bypass further consultation: updated consultation materials

I wrote to you on 19 August about our further consultation on improving the A27 near Arundel and to encourage you to share your views.

I am writing to you again today to let you know that we have made a small number of corrections to the consultation brochure.

The corrected brochure is available online at www.highwaysengland.co.uk/a27arundel, at all our consultation events and at convenient locations across the Arundel area from 13 September. These corrections are summarised in the below table.

The corrections relate to data entry issues when the consultation brochure was produced from the underlying project documents. The corrections do not affect or change the assessments undertaken and reported in the consultation documents, but simply relate to the drafting of the consultation brochure.

Because Highways England is committed to full and open consultation, and because we want people responding to the consultation to have all the facts available, I thought it important to share these changes with you straight away.

See table overleaf for details.

Brochure page/ section reference	Original text	Updated text	Reason for correction
Page 8, footnote 4	In the latest 5-year period (1 January 2013 to 31 December 2017) there have been 81 personal injury collisions, resulting in 121 casualties, recorded between Yapton Lane to the east and Crossbush junction to the west.	In the latest 5-year period (1 January 2013 to 31 December 2017) there have been 81 personal injury collisions, resulting in 121 casualties, recorded between **Crossbush junction** to the east and **Yapton Lane** to the west.	Data entry issue.
Page 9, footnote 5	For more detail see the Combined Modelling and Appraisal Report (ComMA)	For more detail, see the **Interim Scheme Assessment Report (Interim SAR)** (bold text inserted. 'Combined Modelling and Appraisal Report (ComMA)' removed)	Wrong report referenced.
Page 24, Cultural Heritage row, Crimson (Option 3V1) column	Operation: Large adverse significance of effect for all heritage assets.	Operation: Large adverse **effects on setting of Tortington Priory Scheduled Monument and one Grade II* listed building. Neutral effects on setting for all remaining heritage assets.** (bold text inserted. 'significance of effect for all heritage assets' removed)	Data entry issue.
Page 25, Cultural Heritage row, Magenta (Option 4/5AV1) column	Construction: Moderate adverse significance of effect on setting for Tortington Priory Scheduled Monument and one Grade II* listed building. Slight adverse significance of effect on setting for the remainder of the heritage assets. Neutral effects on setting for Lyminster Conservation Area. Slight adverse significance of effect on below ground archaeology for remaining Grade II listed buildings and other heritage assets.	Construction: Moderate adverse significance of effect on setting for Tortington Priory Scheduled Monument and one Grade II* listed building. Slight adverse significance of effect on setting for the remainder of the heritage assets. **Moderate adverse significance of effect on the curtilages of 6 Grade II Listed Buildings. Slight adverse effects on below ground archaeology for all heritage assets.** (Bold text inserted. 'Neutral effects on setting for Lyminster Conservation Area. Slight adverse significance of effect on below ground archaeology for remaining Grade II listed buildings and other heritage assets' removed)	Data entry issue
Page 25, Biodiversity row, Magenta (Option 4/5AV1) column	Operation: Very large adverse effects for bats. Moderate adverse effects on barn owls. Large adverse effect on Binstead Wood Complex LWS. Slight beneficial effects on Arundel Park SSSI and Fairmile Bottom SSSI.	Operation: **Large** adverse effects for bats. Moderate adverse effects on barn owls. Slight beneficial effects on Arundel Park SSSI and Fairmile Bottom SSSI. (Bold text inserted. 'Very Large adverse effect for bats' amended to 'Large adverse effect for bats'. 'Large adverse effect on Binstead Wood Complex LWS' removed.) '	Results for 4/5AV1 and 4/5AV2 switched (transposition issue).
Page 25, Biodiversity row, Amber (Option 4/5AV2) column	Operation: Large adverse effects for bats. Moderate adverse effects on barn owls. Slight beneficial effects on Arundel Park SSSI and Fairmile Bottom SSSI.	Operation: **Very** Large adverse effects for bats **and a Large adverse effect on Binsted Wood Complex LWS**. Moderate adverse effects on barn owls. Slight beneficial effects on Arundel Park SSSI and Fairmile Bottom SSSI. (bold text inserted).	Results for 4/5Av1 and 4/5Av2 switched (transposition issue).

There were also a small number of misspellings corrected in the brochure.

The revised version of the brochure is available at www.highwaysengland.co.uk/a27arundel from 13 September. You can also collect a copy from one of our consultation events and at various locations around the area from this date, as detailed in the enclosed sheet.

We have also identified a small number of corrections in the technical documents underpinning the consultation brochure: The Environmental Assessment Report (EAR), the Scheme Assessment Report (SAR) and the Combined Modelling and Appraisal Report (ComMA). As with the consultation brochure, these corrections relate to data entry issues when the documents were drafted from the information on which the assessments were based. The corrections in the underlying technical documents do not affect or change the assessments undertaken and reported in the consultation documents. We will publish errata for the EAR and SAR on 16 September. We published an updated ComMA on 6 September. These will be available on our website www.highwaysengland.co.uk/a27arundel and at convenient local locations (see details enclosed) from 16 September.

Have your say

If you have already responded to the consultation and would like to make any alterations to your submission as a result, then we will be happy to help you do so. Please either call 0300 123 5000 (local call rate) and ask for the Arundel Bypass project team, or email **A27ArundelBypass@highwaysengland.co.uk**. If you submitted your response online, we would need to have your unique response ID and the date you submitted it.

If you are yet to respond to the consultation, I would also like to take this opportunity to encourage you to have your say. The consultation continues until **11.59pm on Thursday 24 October 2019** and there are several ways to find out more about the Arundel Bypass scheme, as set out on the enclosed sheet.

As a reminder, you can respond to the consultation via www.highwaysengland.co.uk/a27arundel Alternatively, you can complete a hard copy of the response form and either post it to **Freepost A27 ARUNDEL** free of charge or return it to us at one of the consultation events.

I sincerely apologise for any inconvenience this update may cause and hope to meet you at one of our upcoming events.

Yours faithfully

S. Hartfield

Sophie Hartfield
Project Manager, A27 Arundel Bypass

Encl.

A27 Arundel Bypass further consultation: find out more

There are a number of ways in which you can find out more about the proposed options for improving the A27 around Arundel:

Online
All key information about the proposals, including the updated consultation brochure, Environmental Assessment Report, Scheme Assessment Report and Combined Modelling and Appraisal report are available from **www.highwaysengland.co.uk/a27arundel**

Public consultation events
Our team will be available at the following upcoming events to discuss any queries that you may have about the proposed options:

Date	Location	Address	Time
Thursday 19 September	Coronation Hall, Slindon	Coronation Hall, Reynold's Lane, Slindon, Near Arundel, West Sussex, BN18 0QT	2pm-8pm
Saturday 28 September	Walberton Village Hall	The Street, Walberton, Arundel, BN18 0PJ	10am-5pm
Tuesday 1 October	Littlehampton Town Council – Manor House, Littlehampton	Littlehampton Town Council, Manor House, Church Street, Littlehampton, BN17 5EW	2pm-8pm
Tuesday 8 October	Mill Road car park, Arundel (our consultation van will be on-site)	Mill Road, Arundel, BN18 9PA	11am-2pm
Saturday 12 October	Arundel Town Hall	Maltravers Street, Arundel, BN18 9AP	10:30am-4pm

We are also holding unstaffed exhibitions where you can view the consultation materials (including the updated reports) and collect printed copies of the brochure and questionnaire:

Date	Location	Address	Time
Wednesday 25 September	Storrington Library	Ryecroft Lane, Storrington, Pulborough, RH20 4PA	9.30pm-5.30pm
Wednesday 9 October	Yapton Village Hall	Main Road, Yapton, BN18 0ET	10am-5:30pm
Monday 14 – Friday 18 October	Arun Civic Centre, Littlehampton	Maltravers Road, Littlehampton, BN17 5LF	During usual opening hours

Locations to collect consultation materials
Copies of the consultation brochure and response form are available from the following locations throughout the consultation period:

Location	Address
Angmering Library	Arundel Road, Angmering, Littlehampton, BN16 4JS
Arundel Town Hall	Maltravers Street, Arundel, BN18 9AP
Arundel Library	Surrey Street, Arundel, BN18 9DT
Bognor Regis Library	69 London Road, Bognor Regis, PO21 1DE
East Preston Library	The Street, East Preston, Littlehampton, BN16 1JJ
Littlehampton Library	Maltravers Road, Littlehampton, BN17 5NA
Rustington Library	Claigmar Road, Rustington, Littlehampton, BN16 2NL

A27 **Arundel Bypass** Further public consultation

We are consulting on proposals to improve the A27 around Arundel.

We have published details of six proposed options that would help reduce congestion and delays around Arundel, and want to hear your views.

Find out more about the proposals by coming to a public exhibition, where our team will be on hand to answer any questions you may have about the proposals. You can also pick up a brochure and questionnaire, which are also available at local libraries.

For more information and to respond to the consultation visit:
www.highwaysengland.co.uk/a27arundel

If you have any queries, please email us at:
A27ArundelBypass@highwaysengland.co.uk

Call us on:
0300 123 5000* (24 hours)

*Calls to 03 numbers cost no more than a national rate call to an 01 or 02 number and must count towards any inclusive minutes in the same way as 01 and 02 calls.

Staffed public exhibition details

- **The White Swan, Chichester Road, Arundel, BN18 0AD**
  Tuesday 10 September 2019, 3.30pm-8pm
- **Whiteways car park, Bury Hill, Houghton, BN18 9FD** (our consultation van will be on-site)
  Wednesday 11 September 2019, 11am-1pm
- **Impulse Leisure Centre car park, Spierbridge Road, Storrington, Pulborough, RH20 4PG** (our consultation van will be on-site)
  Wednesday 11 September 2019, 3pm-6pm
- **Fontwell Park Racecourse, Arundel Road, Fontwell, Arundel, BN18 0SY**
  Saturday 14 September 2019, 10.30am-2.30pm
- **Coronation Hall, Reynold's Lane, Slindon, West Sussex, BN18 0QT**
  Thursday 19 September 2019, 2pm-8pm
- **Walberton Village Hall, The Street, Walberton, Arundel, BN18 0PJ**
  Saturday 28 September 2019, 10am-5pm
- **Littlehampton Town Council, Manor House, Church Street, Littlehampton, BN17 5EW**
  Tuesday 1 October 2019, 2pm-8pm
- **Mill Road car park, Mill Road, Arundel, BN18 9PA** (our consultation van will be on-site)
  Tuesday 8 October 2019, 11am-2pm
- **Arundel Town Hall, Maltravers Street, Arundel, BN18 9AP**
  Saturday 12 October 2019, 10.30am-4pm

Unstaffed exhibitions

- **Bognor Regis Town Hall, Clarence Road, Bognor Regis, PO21 1LD**
  Monday 16 - Tuesday 17 September 2019, during usual opening hours
- **Storrington Library, Ryecroft Lane, Storrington, Pulborough, RH20 4PA**
  Wednesday 25 September, 9.30am-5.30pm
- **Yapton Village Hall, Main Road, Yapton, BN18 0ET**
  Wednesday 9 October 2019, 10am-5.30pm
- **Arun Civic Centre, Maltravers Road, Littlehampton, BN17 5LF**
  Monday 14 - Friday 18 October 2019, during usual opening hours

The consultation runs from Friday 30 August to 11.59pm on Thursday 24 October 2019

GFD19_0095

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A27 Arundel Bypass Further Consultation
Have your say

We're holding a public consultation on our proposals from
30 August to 24 October 2019.
We want to hear your views.

* North of A27 includes Dalesdown Wood, Danes Wood, Goblestubb's Copse, Madehurst Wood, Rewell Wood, Rough Copse, Screens Wood, Sherwood Rough, The Rough, The Waterwoods, West Stubbs Copse.

** South of A27 includes Ash Piece, Barn's Copse, Binsted Park, Binsted Wood, Brickklin Copse, Brickklin Piece, Fowler's Copse, Furzefield Copse, Hundredhouse Copse, Lake Copse, Little Dane's Wood, Paine's Wood, Pedler's Croft, Pinewoods, Singer's Piece, Spinningwheel Copse, Steward's Copse, The Shaw, Tortington Common, Wincher's Copse, Threecorner Wood.

Source: Ordnance Survey base map/DEFRA Magic Map application

This map is a diagrammatic representation. Not to scale.

Please respond using one of the following methods by 11:59pm (before midnight) on 24 October 2019.
Responses received after this time may not be considered.

If you have any questions, or would like the information in a different format, please contact us by:

- Online: complete the consultation response form online at **www.highwaysengland.co.uk/a27arundel**
- Freepost: complete the consultation response form and return it to **Freepost A27 ARUNDEL**
- Email: your response to **A27ArundelBypass@highwaysengland.co.uk**
- Telephone: **0300 123 5000 (24 hours)**

www.highwaysengland.co.uk/a27arundel

GFD19_0095

A27 Arundel Bypass Further Consultation
Have your say

We're holding a public consultation on our proposals from 30 August to 24 October 2019.
We want to hear your views.

You can find out more about the options at our staffed public consultation exhibitions, where the project team will be on hand to answer your questions.

Date	Location	Time	Address
Friday 30 August	**Cathedral Centre**	5.30pm-8pm	London Road, Arundel, BN18 9BA
Tuesday 10 September	**The White Swan**	3.30pm-8pm	Chichester Road, Arundel, BN18 0AD
Wednesday 11 September	**Whiteways car park, South Downs National Park (our consultation van will be on-site)**	11am-1pm	Bury Hill, Houghton, BN18 9FD
Wednesday 11 September	**Impulse Leisure Centre car park, Storrington (our consultation van will be on-site)**	3pm-6pm	Spierbridge Road, Storrington, Pulborough, RH20 4PG
Saturday 14 September	**Fontwell Park Racecourse**	10:30am-2.30pm	Arundel Road, Fontwell, Arundel, BN18 0SY
Thursday 19 September	**Coronation Hall, Slindon**	2pm-8pm	Reynold's Lane, Slindon, West Sussex, BN18 0QT
Saturday 28 September	**Walberton Village Hall**	10am-5pm	The Street, Walberton, Arundel, BN18 0PJ
Tuesday 1 October	**Littlehampton Town Council – Manor House, Littlehampton**	2pm-8pm	Manor House, Church Street, Littlehampton, BN17 5EW
Tuesday 8 October	**Mill Road car park (near Arundel Castle), Arundel (our consultation van will be on-site)**	11am-2pm	Mill Road, Arundel, BN18 9PA
Saturday 12 October	**Arundel Town Hall**	10:30am-4pm	Maltravers Street, Arundel, BN18 9AP

Please respond using one of the following methods by 11:59pm (before midnight) on 24 October 2019. Responses received after this time may not be considered.

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A27 Arundel Bypass

Further public consultation

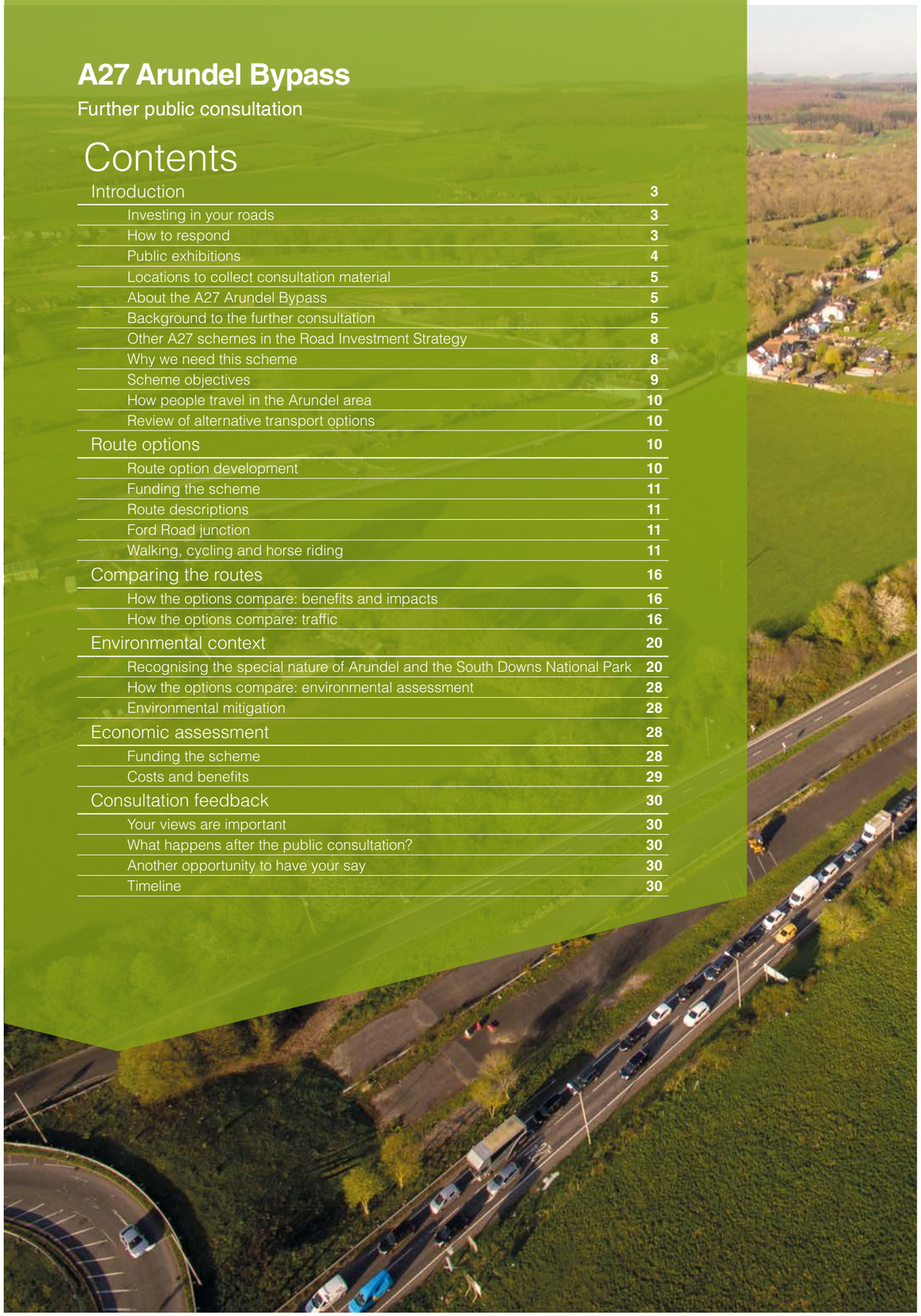
Have your say

30 August to 24 October 2019

A27 Arundel Bypass

Further public consultation

Contents



Introduction

Investing in your roads

At Highways England, we believe in a connected country and our network makes these connections happen. We strive to improve our major roads and motorways – engineering the future to keep people moving today and moving better tomorrow. We want to make sure all our major roads are more dependable, durable and most importantly safe. That's why we're delivering £15 billion of investment on our network – the largest investment in a generation.

The A27 Arundel Bypass is part of this investment: by reducing congestion in the area, the scheme will improve journeys along the corridor between Brighton and Portsmouth, which would provide benefits for the local and regional economy.

In this brochure, we explain our six proposed options for the A27 Arundel Bypass scheme, based on the latest available information, and set out how you can give us your feedback during our public consultation.

All consultation materials, including supporting technical documents are available from **www.highwaysengland.co.uk/a27arundel**

This is a revised version of the consultation brochure published on 13 September 2019

How to respond

We're holding a public consultation on our proposals. We'd like to hear what you think, so please share any views, ideas or local knowledge that you may have. The consultation is open for eight weeks, between 30 August and 24 October 2019, and there are lots of ways to have your say. Why not fill in the consultation response form online or come along to one of our public consultation exhibitions? Full details of how you can respond are below.

Your comments will help us better understand the local area and any potential impacts our proposals may have on the community. We will listen to everyone's feedback and consider all comments before we select a preferred option.

Please respond using one of the following methods by **11:59pm on 24 October 2019.** Responses received after this time may not be considered.

- Online: complete the consultation response form online via **www.highwaysengland.co.uk/a27arundel**
- Freepost: complete the consultation response form and return it to **Freepost A27 ARUNDEL**
- In person: complete the consultation response form and hand it to a member of staff at a public exhibition

If you have any questions, or would like the information in a different format, please contact us by:

- Email: **A27ArundelBypass@highwaysengland.co.uk**
- Telephone: **0300 123 5000 (24 hours)**

Public exhibitions

You can find out more about the options at our staffed public consultation exhibitions, where the project team will be on hand to answer your questions.

Date	Location	Time	Address
Friday 30 August	Cathedral Centre	5.30pm-8pm	London Road, Arundel, BN18 9BA
Tuesday 10 September	The White Swan	3.30pm-8pm	Chichester Road, Arundel, BN18 0AD
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Tuesday 8 October	Mill Road car park (near Arundel Castle), Arundel (our consultation van will be on-site)	11am-2pm	Mill Road, Arundel, BN18 9PA
Saturday 12 October	Arundel Town Hall	10:30am-4pm	Maltravers Street, Arundel, BN18 9AP

We will also hold unstaffed exhibitions, where visitors can view some consultation materials and collect printed copies of the consultation response form. These exhibitions will be held at the locations below, during the venues' normal opening hours. All consultation materials are available from www.highwaysengland.co.uk/a27arundel

Date	Location	Address
Monday 16 - Tuesday 17 September	Bognor Regis Town Hall	Clarence Road, Bognor Regis, PO21 1LD
Wednesday 25 September	Storrington Library	Ryecroft Lane, Storrington, Pulborough, RH20 4PA
Wednesday 9 October	Yapton Village Hall	Main Road, Yapton, BN18 0ET
Monday 14 - Friday 18 October	Arun Civic Centre	Maltravers Road, Littlehampton, BN17 5LF

Locations to collect consultation material

You can find copies of the brochure and consultation response form at the following deposit points throughout the consultation period (30 August to 24 October 2019), during the locations' normal opening hours. Reference copies of supporting technical documents will also be available.

Location	Address
Angmering Library	Arundel Road, Angmering, Littlehampton, BN16 4JS
Arundel Library	Surrey Street, Arundel, BN18 9DT
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East Preston Library	The Street, East Preston, Littlehampton, BN16 1JJ
Littlehampton Library	Maltravers Road, Littlehampton, BN17 5NA
Rustington Library	Claigmar Road, Rustington, BN16 2NL

About the A27 Arundel Bypass

The A27 Arundel Bypass scheme is identified within the Government's 2015-2020 Road Investment Strategy (RIS1), which states that England's strategic road network requires upgrading and improving to ensure it can deliver the performance needed to support the nation in the 21st century.

A budget of between £100-£250 million has been allocated to the scheme. The scope of the A27 Arundel Bypass scheme described in the Road Investment Strategy is: *"the replacement of the existing single carriageway road with a dual carriageway bypass, linking together the two existing dual carriageway sections of the road".*

The 'existing single carriageway road' proposed to be replaced lies within to the six-kilometre section of the A27 from the A284 Crossbush junction (east of Arundel) to the west of Yapton Lane (west of Arundel). The A27 currently goes through the South Downs National Park and Arundel crossing the River Arun and the railway line.

Background to the further consultation

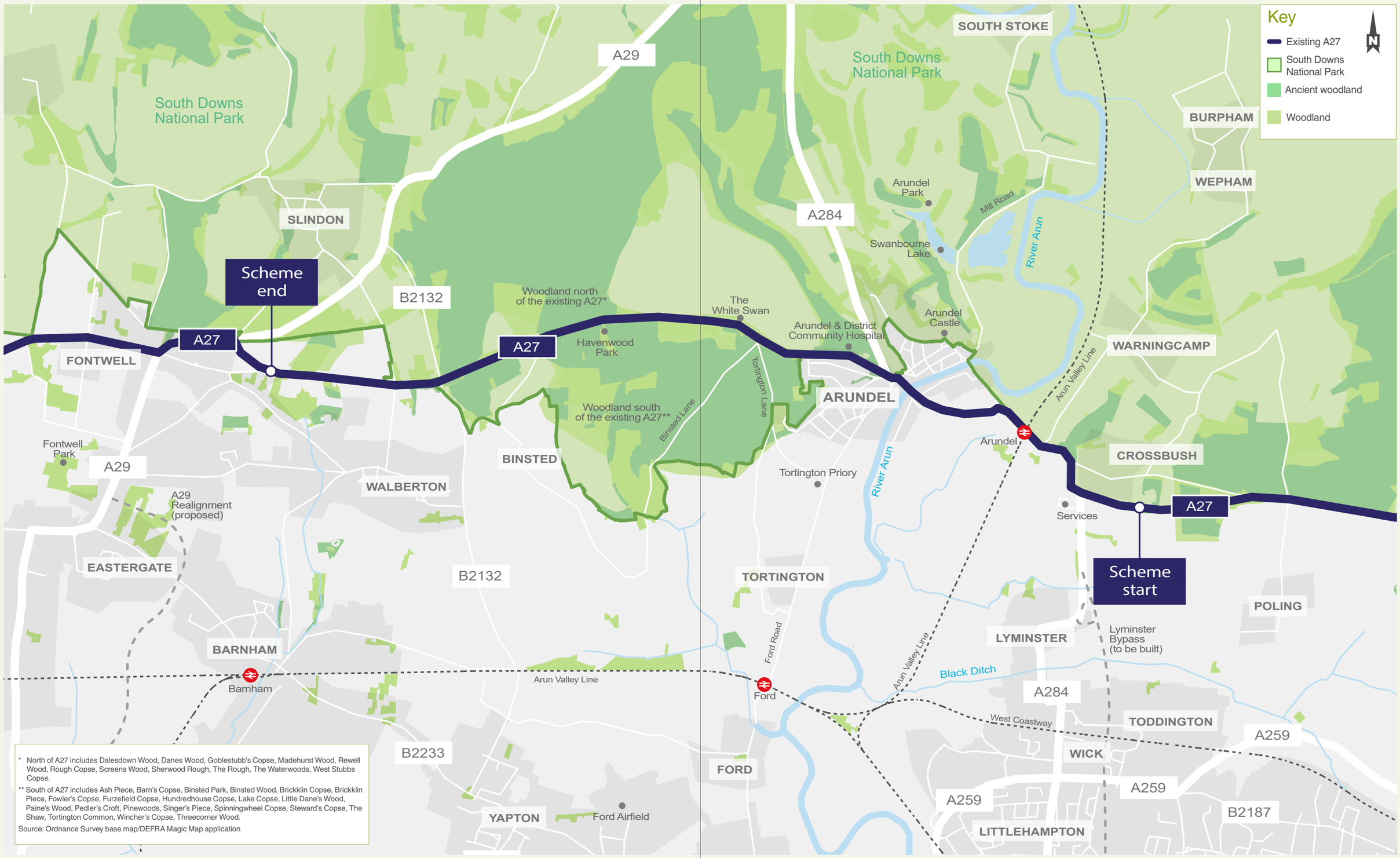
In May 2018, we announced a preferred route for the proposed A27 Arundel Bypass, known as Option 5AV3, following public consultation in autumn 2017. We then began developing the design as part of our work towards submitting an application for consent from the Secretary of State. This included looking at alternatives for minimising impacts on protected ancient woodland and biodiversity at the western end of the route.

We discovered new information during the course of this work. We therefore want to understand your views on the revised options for the scheme based on the latest available information, which we are presenting through this further consultation.

Views received during this consultation will be important in helping us to ensure that we find the best long-term solution for the area.

Inside this brochure, you will find details of the six proposed improvement options for the A27 around Arundel. You'll also find information explaining how we have developed the options, along with a summary of key benefits and impacts.

Figure 1: Scope of scheme



* North of A27 includes Dalesdown Wood, Danes Wood, Goblestubb's Copse, Madehurst Wood, Rewell Wood, Rough Copse, Screens Wood, Sherwood Rough, The Rough, The Waterwoods, West Stubbs Copse.

** South of A27 includes Ash Piece, Barn's Copse, Binsted Park, Binsted Wood, Brickklin Copse, Brickklin Piece, Fowler's Copse, Furzefield Copse, Hundredhouse Copse, Lake Copse, Little Dane's Wood, Paine's Wood, Pedler's Croft, Pinewoods, Singer's Piece, Spinningwheel Copse, Steward's Copse, The Shaw, Tortington Common, Wincher's Copse, Threecorner Wood.

Source: Ordnance Survey base map/DEFRA Magic Map application

This map is a diagrammatic representation. Not to scale.

Please note that this consultation brochure contains only summary information regarding the proposals. For more detail, please refer to the supporting technical documents:

Environmental Assessment Report (EAR), Interim Scheme Assessment Report (Interim SAR) and the Combined Modelling and Appraisal Report (ComMA), which are available from www.highwaysengland.co.uk/a27arundel

You will see the icon throughout this brochure indicating where more detailed technical information is available.

Other A27 schemes in the Road Investment Strategy

Although the A27 Arundel Bypass scheme is part of a wider programme of investment, it is a standalone scheme and would bring about significant benefits to the area. Other improvements along the A27 were also identified within the Road Investment Strategy (RIS1). The current position of these other A27 schemes is:

- **A27 East of Lewes**: In summer 2017, a preferred route was announced and since then the preliminary design for this scheme has been developing. Public information exhibitions for both junctions and shared use paths were held in March and July 2019, respectively. Works are planned to start from spring 2020. More information can be found at: www.highwaysengland.co.uk/a27-east-of-lewes

- **A27 Worthing and Lancing improvements:** The current scheme is paused and remains part of the RIS1 package of works. As set out in our Delivery Plan Update 2019-20, the scheme is under review in order to best meet the needs of the local stakeholders. More information can be found at: www.highwaysengland.co.uk/a27-worthing-and-lancing-improvement

- **A27 Chichester Bypass:** The scheme is no longer part of the RIS1 package of works. As set out in our Delivery Plan Update 2019-20, it has been stopped as agreed with the Department for Transport. More information can be found at www.highwaysengland.co.uk/projects/a27-chichester/

Why we need this scheme

- The A27 is the only major east-west trunk road south of the M25. It links many of the towns and cities along the south coast, including Portsmouth, Chichester, Arundel, Brighton and Hove, Lewes and Eastbourne, serving a combined population of more than one million[1] people, as well as a large number of businesses.

- The smooth running of this road plays a key part in the region's success. West Sussex attracts, on average, 17 million visitor days per year, worth approximately £508 million to the local economy[2].

- On either side of Arundel, the A27 is a dual-carriageway with capacity to carry existing traffic flows and more able to cope with future traffic growth. The single carriageway section of the A27 through Arundel creates a bottleneck that holds up traffic, costing commuters, businesses, communities and visitors valuable time and money.

- Congestion around Arundel results in some drivers seeking alternative routes which are less suited to higher traffic flows. Residents in local towns and villages are affected by increases in through traffic, while air quality is also a concern, most notably in Storrington which was identified by the World Health Organisation as one of the poorest places for air quality in the UK[3].

- The A27 currently has a poor safety record, with a higher than average accident rate for rural A-roads[4].

- Relatively poor transport connectivity in the area has contributed to pockets of deprivation by restricting access to employment opportunities. For example, Littlehampton has some of the highest levels of deprivation in the country, partly because local people have reduced access to employment (especially higher paid, higher value jobs) than elsewhere in the region[5]. Improving connectivity could help tackle this inequality.

Scheme objectives

Our scheme objectives have been developed while working with the local authorities, the South Downs National Park Authority, other environmental bodies, the emergency services and the Department for Transport (DfT).

The scheme objectives are to:

- Improve the safety of travellers along the A27 and consequently the wider local road network.

- Ensure that customers and communities are fully considered throughout the design and delivery stages.

- Improve capacity of the A27 whilst supporting local planning authorities to manage the impact of planned economic growth.

- Reduce congestion, reduce travel time and improve journey time reliability along the A27.

- Improve accessibility for all users to local services and facilities.

- Deliver a scheme that minimises environmental impact and seeks to protect and enhance the quality of the surrounding environment through its high-quality design.

- Respect the South Downs National Park and its special qualities in our decision-making.

One scheme objective is to reduce congestion and reduce journey time along the A27

[1] Based on census 2011 population data for these districts; Portsmouth, Havant, Chichester, Arundel, Worthing, Adur, Brighton and Hove, Lewes, and Eastbourne.
[2] The GB Day Visitor Statistics 2015, VisitBritain.
[3] WHO report available here **http://www.who.int/airpollution/data/aap_air_quality_database_2018_v12.xlsx?ua=1** with further information about air quality from WHO accessible here **https://www.who.int/airpollution/en/**
[4] In the latest 5-year period (1 January 2013 to 31 December 2017) there have been 81 personal injury collisions, resulting in 121 casualties, recorded between Crossbush junction to the east and Yapton Lane to the west.

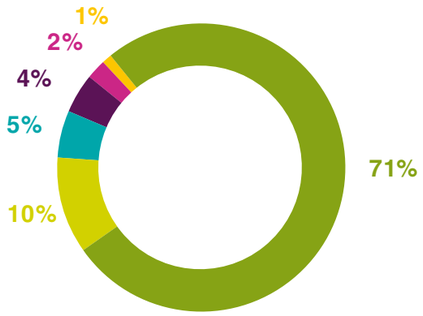
[5] For more detail see the Interim Scheme Assessment Report (SAR).

How people travel in the Arundel area

There is relatively low use of public transport, walking and cycling in the area. This means that even a significant increase in these modes of transport would be unlikely to solve the problems of queuing and congestion on the A27 through Arundel. Furthermore, planned population increases during the coming years, would likely make these issues worse.

The car is an important means of transport in the area. Arun District residents travel to work using the following transport modes[6].

Mode of travel



Review of alternative transport options

Bus

There are no significant plans for bus improvements in the area. With the relatively low proportion of bus use in the area, there is no current evidence to suggest that bus services could accommodate the overall future demand for travel.

Rail

There have been two studies about rail infrastructure investments for the south coast corridor. One study looked at infrastructure investment priorities for railways from London to the south coast, and the other explored opportunities to improve the Coastway rail service. Neither study recommended improvements in the area as a priority, nor found that the improvements would offer good value for money. We understand that Network Rail is currently assessing options for West Coastway and Arun Valley line enhancements, although we have no current evidence to suggest that there would be any significant switch from road use to rail use (along the A27 corridor between Chichester and Brighton) that would meet the overall future demand for travel.

Route options

Route option development

After announcing in October 2018 our intention to carry out further consultation, we took a fresh look at the full range of possible route alignments. These were grouped by corridor (or similar route alignments) and then sifted according to compliance with the scheme objectives and legal and national planning policy tests, including consideration of environmental impacts.

Our technical work concluded that six options should be put forward for consideration as part of this further consultation. These are shown in Figure 2. For ease of reference, we have assigned a colour to each option.

All options would support the local housing and employment growth strategies of the local authorities and cater for traffic growth until at least 2041[7]. However, there are significant environmental constraints and national planning policy risks that affect all six options as outlined in the following pages.

[6] Method of travel to work 2011 Census Nomis (Nomis is a service provided by the Office for National Statistics, providing free access to detailed, up-to-date UK labour market statistics from official sources). 6% 'work from home' and 1% were categorised as 'other'.

[7] 2041 would be 15 years from the scheme opening date which is currently planned for 2026. The 15-year timeframe is Highways England standard for scheme design performance assessments.

For further details on the process we followed to identify these six options, please see the *Interim Scheme Assessment Report (Interim SAR).* For more information on the longer history of the scheme dating back to the 1980s, please see *Interim Scheme Assessment Report (Interim SAR)* which is available on our website.

Funding the scheme

As outlined on page 5, a £100-£250 million budget remains allocated to the scheme. However, the estimated costs have increased since the consultation in 2017 due to a number of factors. For example, new environmental surveys carried out in mid/late 2018 indicated that further environmental mitigation would be needed than had previously been anticipated, while costs associated with constructing an embankment across the floodplain have risen.

There has also been an associated increase in construction duration, while changes to the overall scheme timeline have also added to costs and inflation[8]. The cost ranges published within this consultation are early estimates based on work done to date and as such do not represent our final costs for the project. We will continue to develop our design in such a way that seeks to deliver the best possible value for money in line with the needs of the scheme.

For more info on costs, including benefit to cost ratios, please see page 28 and 29.

Route descriptions

Key features of all options would include:

- A new viaduct spanning over the River Arun and a bridge over the Arun Valley Railway.
- A junction at Crossbush with access to and from the A27 in both directions.
- A speed limit of 70 mph (in its current design, the Beige option - 1V9 - would need a 50 mph speed limit in some sections).
- An embankment across the River Arun floodplain, although all routes could alternatively be built with a viaduct. A decision on this will be taken once a preferred route is confirmed and more detailed design work is undertaken.

Please refer to the *Interim Scheme Assessment Report (Interim SAR)* for more information.

Ford Road junction

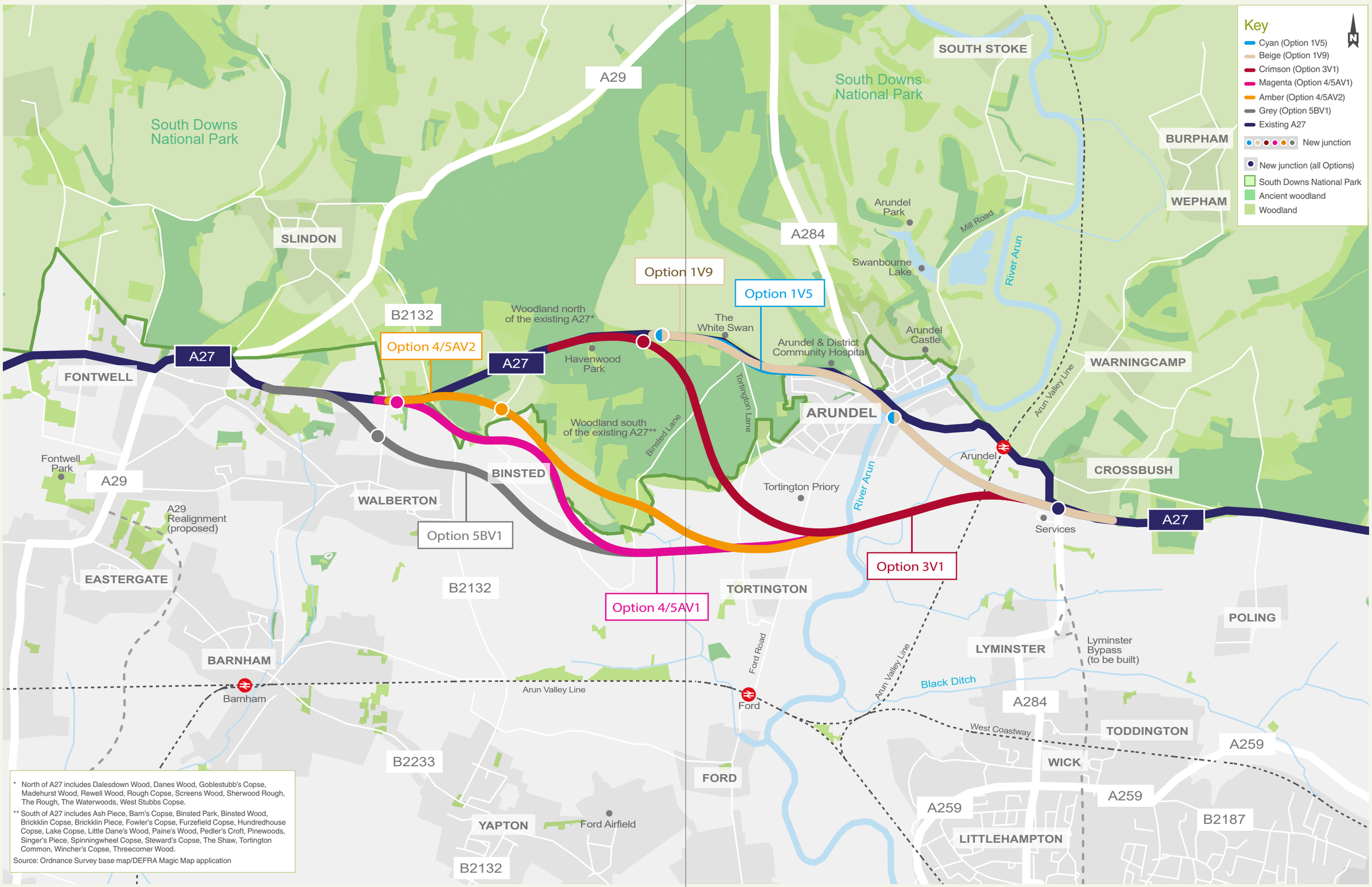
We received feedback from the 2017 consultation expressing interest in having a new junction with Ford Road. The options put forward in this further consultation do not feature such a junction, but we have not discounted this idea. The scheme design is flexible enough that each of the offline options could include a junction at Ford Road. As a result, this will be considered further during the next design stage, once we have identified a new preferred route. Please refer to our *Interim Scheme Assessment Report (Interim SAR)* for more information.

Walking, cycling and horse riding

Access would be maintained for pedestrians, cyclists and horse riders across all six options, although some existing routes would need to be diverted. More detail can be found in the *Interim Scheme Assessment Report (Interim SAR).*

[8] Ideas of areas where costs could be reduced are set out in the Interim Scheme Assessment Report (Interim SAR).

Figure 2: Scheme options



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Source: Ordnance Survey base map/DEFRA Magic Map application

This map is a diagrammatic representation. Not to scale.

Cyan (Option 1V5)

Cyan (Option 1V5) would feature 4.5km (approx.) of new dual two-lane carriageway between Crossbush and the existing transition between single and dual carriageway to the west of Arundel. The viaduct extends over the Ford Road junction with no direct access to the local road network. Key features would include:

- 2.5km (approx.) of dual two-lane carriageway to the south of the existing A27 east of the River Arun
- 2.0km (approx.) of dual two-lane carriageway west of the River Arun
- New access to Arundel and District Community Hospital off the A284
- 1.92km (approx.) of the existing single carriageway within the South Down National Park replaced with dual carriageway and resulting in the loss of 1.95 hectares (approx.) of ancient woodland
- Fitzalan Road would be realigned to pass under the A27 and connect to the existing A27 at a new junction
- The existing A27 junction with Jarvis Road would be closed. Alternative access would be from the existing local road network
- Properties fronting the existing A27 would have their current access closed and alternative access provided by new local roads joining a new junction near Long Lane, with the side road passing over the A27. The new junction would have access to/from the A27 in both directions
- 2.2km (approx.) of the existing A27 between Ford Road roundabout and Crossbush junction returned to the local road network, subject to agreement with West Sussex County Council

Beige (Option 1V9)

Beige (Option 1V9) would feature 4.5km (approx.) of new dual two-lane carriageway between Crossbush and the existing transition between single and dual carriageway to the west of Arundel. The junction at Ford Road would be a traffic signal controlled 'through about'. Key features would include:

- 2.4km (approx.) of dual two-lane carriageway to the south of the existing A27 east of the River Arun
- 2.1km (approx.) of dual two-lane carriageway west of the River Arun with reduced cross section width
- A left-in, left-out junction to Arundel and District Community Hospital using the eastbound carriageway
- Fitzalan Road would be realigned to pass under the A27 and connected to the existing A27 at a new junction
- The existing A27 junction with Jarvis Road would be closed. Alternative access would be from the existing local road network
- A left in, left out junction at Tortington Lane using the westbound carriageway
- 1.93km (approx.) of the existing single carriageway within the South Downs National Park replaced with dual carriageway and resulting in the loss of 1.09 hectares (approx.) of ancient woodland
- Properties fronting the existing A27 would have their current access closed and alternative access provided by new local roads joining a new junction near Long Lane, with the side road passing over the A27. The new junction would have access to/from the A27 in both directions
- 1.9km (approx.) of the existing A27 between Ford Road roundabout and Crossbush junction, returned to the local road network, subject to agreement with West Sussex County Council

Crimson (Option 3V1)

Crimson (Option 3V1) would feature 6km (approx.) of new dual two-lane carriageway bypass located to the south of the existing A27. Starting in the east at Crossbush and ending just west of Havenwood Park. Key features would include:

- 2.28km (approx.) would be located within the South Downs National Park and resulting in the loss of 9.20 hectares (approx.) of ancient woodland
- A new junction to the east of Havenwood Park with the side road passing over the A27 with westbound access to the A27 and eastbound access from the A27
- The existing access to Havenwood Park would be closed and alternative access provided by a new local connector road to Binsted Lane
- 4.0km (approx.) of the existing A27 between the proposed junction (east of Havenwood Park) and the Crossbush junction, returned to the local road network, subject to agreement with West Sussex County Council

Magenta (Option 4/5AV1)

Magenta (Option 4/5AV1) would feature 7.2km (approx.) of new dual two-lane carriageway bypass located to the south of the existing A27. Starting in the east at Crossbush and ending just west of the existing B2132 Yapton Lane and Shellbridge Road junction. Key features would include:

- New bridge over Binsted Rife
- 0.74km (approx.) of the route would be located within the South Downs National Park and resulting in the loss of 0.40 hectares (approx.) of ancient woodland
- A full movement junction with the existing A27 and B2132 Yapton Lane and Shellbridge Road, with the side road passing over the A27
- Closure of the existing junctions with the A27 at Mill Road and Tye Lane
- Closure of Hedgers Hill Road as a through route other than for pedestrians, cyclists and horse riders
- 6.1km (approx.) of the existing A27 between the B2132 junction at Yapton Lane and Shellbridge Road and Crossbush junction, returned to the local road network, subject to agreement with West Sussex County Council

Amber (Option 4/5AV2)

Amber (Option 4/5AV2) would feature 6.9km (approx.) of new dual two-lane carriageway located to the south of the existing A27. The proposed route would start in the east at Crossbush and would end just west of existing B2132 at Yapton Lane and Shellbridge Road junction. Key features would include:

- New bridge over Binsted Rife
- 1.97km (approx.) would be located within the South Downs National Park and resulting in the loss of 1.83 hectares (approx.) of ancient woodland
- New junction with the existing A27 at Binsted Lane east of Walberton, with the A27 passing under Binsted Lane. This allows for westbound access to the A27 from Binsted Lane and eastbound access from the eastbound carriageway of the A27 to Binsted Lane
- Closure of Hedgers Hill Road as a through route other than for pedestrians, cyclists and horse riders
- Closure of the existing junctions with the A27 at Mill Road and Tye Lane
- A left-in, left-out junction at Shellbridge Road using the eastbound carriageway
- A left-in, left-out junction at Yapton Lane using the westbound carriageway
- 6.2km (approx.) of the existing A27 between the B2132 junction at Yapton Lane and Shellbridge Road and Crossbush junction, returned to the local road network, subject to agreement with West Sussex County Council

Grey (Option 5BV1)

Grey (Option 5BV1) would feature 8km (approx.) of new dual two-lane carriageway located to the south of the existing A27. The proposed route would start in the east at Crossbush and end east of the A27/ A29 Fontwell (east) roundabout. Key features would include:

- New bridge over Binsted Rife
- New junction with the existing A27 at Tye Lane to the north of Walberton (with the A27 continuing via an underpass) enabling westbound access onto the A27 and an eastbound access from the A27. Closure of Tye Lane south of the proposed route
- 6.6km (approx.) of the existing A27 between the junctions with Tye Lane and Mill Road and Crossbush junction, returned to the local road network, subject to agreement with West Sussex County Council

Comparing the routes

How the options compare: benefits and impacts

A high-level summary[9] of the benefits and impacts of the six options is presented below.

For more details on any of the following content, please refer to the *Interim Scheme Assessment Report (Interim SAR), Combined Modelling and Appraisal Report (ComMA) and Environmental Assessment Report (EAR).*

If you have different views or local information we should be aware of, please tell us in your response to the consultation.

How the options compare: traffic

All our options have been tested in the same way, based on the latest available information, so that their performance can be compared[10]. We compared how well they cope with the expected traffic levels in 2041 taking account of all known developments in the area and anticipated economic growth[11].

Figure 3 on page 18 shows how each of the options would affect the number of vehicles using the local road network in 2041[12] relative to a 'do minimum'[13] scenario. It shows that a high proportion of traffic would use a new bypass in preference to the existing road and other routes to the north and south of Arundel. The traffic flows are measured as Annual Average Daily Traffic (AADT) flow – the daily total flow of vehicles (in both directions) averaged across the year, but we also test how peak time traffic would be affected.

We also tested a 'do minimum' scenario. This showed that if the existing A27 is not improved, motorists who currently use local roads to avoid delays would continue to do so. For more information about the traffic modelling work, please see the *Combined Modelling and Appraisal Report (ComMA).*

More information is also contained within the 'traffic heat maps' available on our website: www.highwaysengland.co.uk/a27arundel

Benefits and impacts

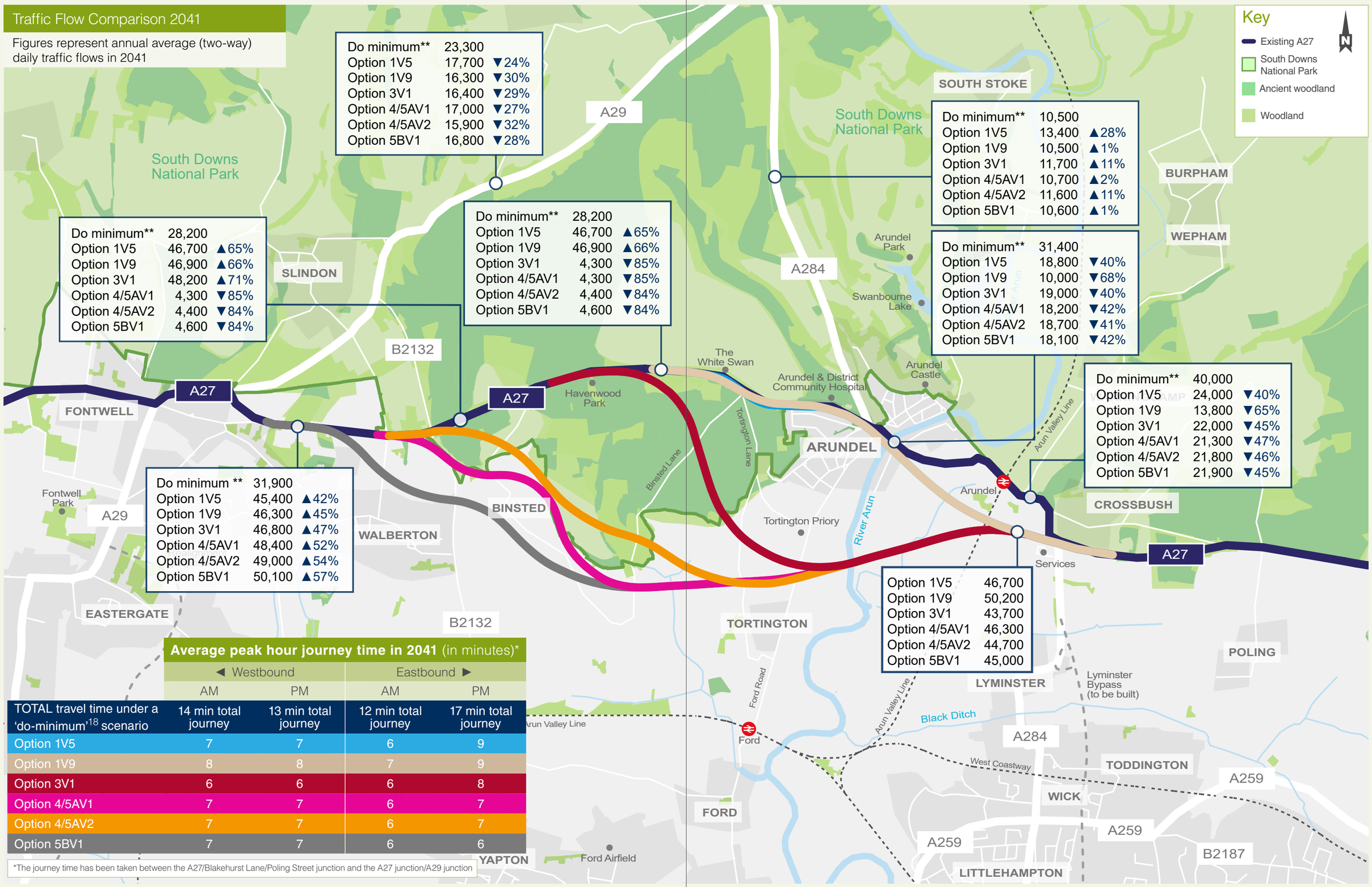
Objective	Cyan (Option 1V5)	Beige (Option 1V9)	Crimson (Option 3V1)	Magenta (Option 4/5AV1)	Amber (Option 4/5AV2)	Grey (Option 5BV1)
Improve the safety of travellers along the A27 and consequently the wider local road network	For the Cyan and Beige options, traffic which currently uses local roads to avoid congestion would use the improved A27 instead, leading to fewer accidents. However, the benefit would be lower than the Magenta, Amber and Grey options. For the Crimson option, safety improves to a similar degree as the Cyan and Beige options. The impact is less than the Magenta and Amber options due to the shorter bypass section. For the Magenta, Amber and Grey options, there are significant safety benefits, with the Amber option providing the greatest improvements, as traffic is diverted from the local roads onto the new A27. Accidents avoided are calculated over a 60-year period (from opening in 2026 to 2085) compared to a 'do minimum'[14] scenario where 55,484 accidents would occur.					
	411 ACCIDENTS AVOIDED	397 ACCIDENTS AVOIDED	379 ACCIDENTS AVOIDED	527 ACCIDENTS AVOIDED	727 ACCIDENTS AVOIDED	676 ACCIDENTS AVOIDED
Throughout the design and delivery stages, the scheme should ensure that customers are fully considered	Visual, noise and severance impacts on communities will be mitigated, where possible, but all options would have significant impacts on different communities. For further details, please refer to 'How the options compare: environmental assessment' on page 24. All options would have an impact on agricultural land with the Cyan and Beige options taking the least amount of agricultural land. The Grey option would take the most agricultural land, followed by the Magenta, Amber and Crimson options. We will work closely with affected landowners to mitigate the impacts and provide accommodation works through agreement. The Magenta and Grey options would also affect the golf course at Avisford Park. The approximate number of residential properties located within 50m of the scheme footprint are illustrated below.					
	120 RESIDENTIAL PROPERTIES	142 RESIDENTIAL PROPERTIES	3 RESIDENTIAL PROPERTIES	29 RESIDENTIAL PROPERTIES	21 RESIDENTIAL PROPERTIES	41 RESIDENTIAL PROPERTIES
	36-month construction timeframe	34-month construction timeframe	36-month construction timeframe	32-month construction timeframe	32-month construction timeframe	36-month construction timeframe

[9] This information is indicative not exhaustive. For details on how the preferred route will be selected, please see the Interim Scheme Assessment Report (Interim SAR).
[10] Our analysis is based on the latest available information and results are subject to change, as the scheme continues to progress through our Project Control Framework.
[11] In line with Highways England guidance, the traffic modelling presented in the brochure assumes that planned developments (such as the Lyminster Bypass and Worthing and Lancing scheme) proceed. However, given the uncertainty around the future of these schemes, a number of people have asked us how the traffic and economic assessments would change if this scheme did not progress. The results of this analysis are set out in the Combined Modelling and Appraisal Report (ComMA) available on our website.
[12] 2041 would be 15 years from the scheme opening date, which is currently planned for 2026. The 15-year timeframe is Highways England standard for scheme design performance assessments.
[13] 'Do minimum' refers to a scenario where the A27 Arundel Bypass scheme would not go ahead, but this scenario does take into consideration other non-A27 Arundel Bypass improvements that have been considered as part of the traffic forecasts (e.g. Worthing and Lancing scheme and Lyminster Bypass).
[14] See footnote 13 above.

Objective	Cyan (Option 1V5)	Beige (Option 1V9)	Crimson (Option 3V1)	Magenta (Option 4/5AV1)	Amber (Option 4/5AV2)	Grey (Option 5BV1)
Improve capacity of the A27 whilst supporting local planning authorities to manage the impact of planned economic growth	The Cyan option journey time savings would reduce business costs, save time and provide business and employment opportunities throughout the wider area.	The Beige option would be close to capacity by 2041, making congestion and delays more likely from that point. All other impacts/ benefits similar to the Cyan option.	Remaining options are, as per the benefits for the Cyan option, although these options would provide additional journey time savings that aid business efficiency particularly in the longer term.			
	Route would operate at around 45-60% capacity in 2041	Route would operate at around 85-90% capacity in 2041	Route would operate at around 45-60% capacity in 2041	Route would operate at around 45-60% capacity in 2041	Route would operate at around 45-60% capacity in 2041	Route would operate at around 45-60% capacity in 2041
Reduce congestion, reduce travel time[15] and improve journey time reliability along the A27	68 minutes saved	48 minutes saved	69 minutes saved	610 minutes saved	610 minutes saved	611 minutes saved
Improve accessibility for all users to local services and facilities	All options would attract traffic onto the A27 and off the local road network, which would improve accessibility to local services and reduce congestion in Arundel. The Beige option would provide more direct access from Arundel onto the A27 than the other options, although the Ford Road roundabout would become congested after 2041. For the Cyan option, a new access to the hospital would be built. For the Beige option, access to the hospital would be away from the new A27 dual carriageway, making it slightly less accessible than the Cyan option. For the Crimson, Magenta, Amber and Grey options access to the hospital remains unchanged.					
Deliver a scheme that minimises environmental impact and seeks to protect and enhance the quality of the surrounding environment through its high-quality design	All six options would have significant potential environmental impacts with the potential to adversely impact biodiversity, heritage features, landscape, soils, noise and hydrology. These impacts could be both direct (such as loss of habitat area) or indirect (such as edge effects and fragmentation of woodland areas). However, some impacts can be mitigated and compensated through design and construction phase environmental management. The design development process takes into account environmental considerations through numerous iterations – from initial concept through to detailed design. Further detail can be found in the Environmental Assessment Report (EAR). Each option would impact[16] woodland to a varying degree, as shown below:					
	Impacting 8.37 hectares of woodland	Impacting 7.44 hectares of woodland	Impacting 20.57 hectares of woodland	Impacting 3.51 hectares of woodland	Impacting 5.33 hectares of woodland	Impacting 1.49 hectares of woodland
Respect the South Downs National Park (SDNP) and its special qualities in our decision-making[17]	Reducing congestion on the A27 is likely to reduce traffic on other less suitable routes through the South Downs National Park. However, the scheme could have impacts on landscape, biodiversity, tranquillity, farming and enterprise, recreation and learning, heritage and communities. The South Downs National Park Authority has been engaged from an early stage of the design for the scheme and would continue to be involved in the process. The design of the preferred option would incorporate best practice mitigation measures to minimise any potential effects on the National Park.					
	The additional lanes and additional traffic would generally result in an increase in existing effects on the special qualities of the National Park.		The new route corridor would require land take from the National Park. The new transport corridor and introduction of traffic in these otherwise tranquil areas would introduce a range of new effects on the special qualities of the National Park and its setting.			There would be less direct impact on the National Park as the route is outside the National Park boundary, but its setting and views from within the National Park may be affected.
	1.92km within the SDNP	1.93km within the SDNP	2.28km within the SDNP	0.74km within the SDNP	1.97km within the SDNP	0km within the SDNP

[15] For information on start and end points for these journeys see map on page 18.
[16] Impacted woodland includes all woodland areas identified by the National Forest Inventory. Loss of woodlands is assumed within the scheme footprint. Woodlands at risk is woodlands within 15 meters of the scheme footprint. See Arboriculture Report (an appendix to the EAR) for further details.
[17] The special qualities include; diverse, inspirational landscapes and breath-taking views; a rich variety of wildlife and habitats including rare and internationally important species; tranquil and unspoilt places; an environment shaped by centuries of farming and embracing new enterprise, great opportunities for recreational activities and learning experiences, well-conserved historical features and a rich cultural heritage; and distinctive towns and villages and communities with real pride in their area. Further information can be found in the South Downs National Park Special Qualities Assessment which is available as an appendix in the EAR.

Figure 3: Annual average daily traffic (AADT)



Average peak hour journey time in 2041 (in minutes)*

	◄ Westbound		Eastbound ►	
	AM	PM	AM	PM
TOTAL travel time under a 'do-minimum'[18] scenario	14 min total journey	13 min total journey	12 min total journey	17 min total journey
Option 1V5	7	7	6	9
Option 1V9	8	8	7	9
Option 3V1	6	6	6	8
Option 4/5AV1	7	7	6	7
Option 4/5AV2	7	7	6	7
Option 5BV1	7	7	6	6

*The journey time has been taken between the A27/Blakehurst Lane/Poling Street junction and the A27 junction/A29 junction

[18] 'Do minimum' refers to a scenario where the A27 Arundel Bypass would not go ahead, but the scenario does take into consideration other non-A27 Arundel improvements that have been considered as part of the traffic forecasts (e.g. Worthing and Lancing and Lyminster Bypass)

Environmental context

Recognising the special nature of Arundel and the South Downs National Park

We are committed to minimising the environmental impact of our road network and protecting and enhancing the quality of the surrounding environment.

We recognise that the area around Arundel is very special in environmental terms and delivering any scheme here would present particular challenges.

When considering what improvements might be possible to the A27 in the area, we have carefully considered a range of significant environmental values and features, as set out in the *Environmental Assessment Report (EAR)*[19]. Some examples of the environmental values and features of the area include:

South Downs National Park

The South Downs was designated a National Park in 2009 in recognition of its significant ecological, biological, cultural and scenic value.

We have a legal duty to have regard to the twin purposes of the National Park:

- To conserve and enhance the natural beauty, wildlife and cultural heritage of the National Park.
- To promote opportunities for the understanding and enjoyment of its special qualities.

Work has been done to assess the impact of the scheme on South Downs National Park special qualities. Please refer to the appendix in the *Environmental Assessment Report (EAR).*

Ancient woodland and veteran trees

Ancient woodland and veteran trees are protected by national planning policy. There is ancient woodland to both the north and south of the existing A27. The soils in these areas have been relatively undisturbed for centuries.

We recognise that ancient woodland is irreplaceable and plants and animals in these areas depend on the stable and rare conditions that an ancient woodland provides.

In the meantime, high-level provision has been made for environmental mitigation and compensation measures within our scheme cost estimates. The scale of any new woodland creation and potential suitable locations will progress further once a preferred option has been confirmed.

Protected and notable species and habitats

The area around Arundel provides an array of wildlife habitats that support rich and varied biodiversity features. Many rare and protected species and notable plant species are found in the area, including:

- Amphibians and reptile species
- Badgers
- Bats
- Birds (including breeding and wintering bird species)
- Hazel dormice
- Plant species
- Terrestrial invertebrate species
- Water voles
- Fish and aquatic invertebrates

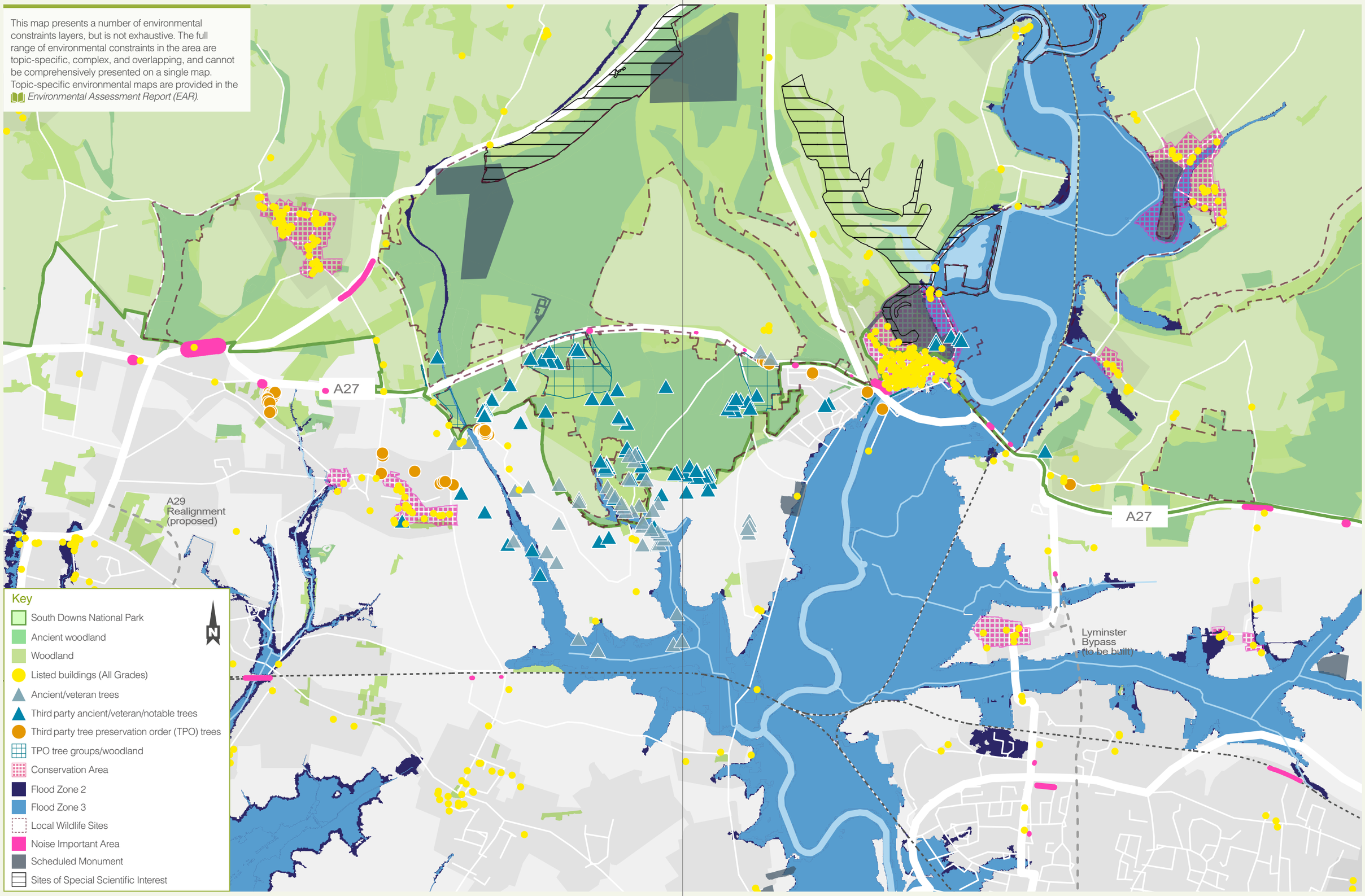
[19] Our analysis is based on the latest available information and results are subject to change.

Key label	Definition
South Downs National Park	National Parks are areas of relatively undeveloped and scenic landscape that are designated under the National Parks and Access to the Countryside Act 1949. The South Downs National Park was designated in 2009 covering 1600km^2 from Winchester (in the west) to Eastbourne (in the east).
Ancient woodland	Woodland that has existed since at least 1600 AD. It is given national level of protection under planning regulations.
Woodland	A habitat where trees are the dominant plant form.
Listed buildings (All Grades)	Listing marks a building's special architectural and historic interest and brings it under the consideration of the planning system, so it can be protected for future generations. There are three gradings in order of the level of interest: Grade I, Grade II* and Grade II.
Ancient/veteran trees	Trees that have been surveyed using a standard, industry-recognised approach (BS 5837). Ancient: A tree that has passed beyond maturity and is old, or aged, in comparison with trees of the same species. Characterised by biological, cultural or aesthetic features of interest. Veteran: A tree that has the biological or aesthetic characteristics of an ancient tree but is not ancient in years compared with others of the same species. A veteran tree may not necessarily be particularly old but, due to the rigours of life, may exhibit signs of ancientness.
Third party ancient/veteran/ notable trees	Tree data that has been sourced through other means such as a desk study or provided by another organisation. Ancient: as per description above. Veteran: as per description above. Notable: Trees generally recorded as such based upon their maturity, size (height and/or girth) and importance within the local environment. Notable trees do not necessarily have to be particularly old and nor do they have to exhibit any veteran characteristics.
Third party tree preservation order (TPO) trees	Arboricultural features that were present at the time the Order was made and identified on a plan are protected by a Tree Preservation Order (TPO)[20]. A TPO is afforded by a local planning authority under the Town and County Planning Act 1990. TPO data was provided by Arun District Council. Trees: Individual trees that merit protection in their own right.
TPO tree groups/ woodland	TPO definition as above. Tree Groups: A group of trees that display similar arboricultural features either aerodynamically, visually or for containing similar biodiversity value. A group category is used where the individual category is not appropriate and the overall impact or quality of the group merits protection. Woodland: A woodland may contain some trees that lack individual merit, all trees within a woodland are protected and made subject to the same provisions and exemptions. In addition, trees and saplings which grow naturally or are planted within the woodland area after the Order is made are also protected by the Order.
Conservation Area	Area designated by Local Planning Authority that is of special architectural or historic interest, the character and appearance of which it is desirable to preserve or enhance.
Flood Zones	Flood Zone 2: land having between a 1 in 100 and 1 in 1000 annual probability of river flooding; or between a 1 in 200 and 1 in 1000 annual probability of sea flooding. Flood Zone 3: land having a 1 in 100 or greater annual probability of river flooding; or a 1 in 200 or greater annual probability of sea flooding.
Local Wildlife Sites	Area of land that has been identified and selected locally, using robust, scientifically-determined criteria and detailed ecological surveys for its nature conservation importance.
Noise Important Area	Noise Action Planning Important Areas for roads and railways provide a framework for the local management of the important areas.
Scheduled Monument	An historic building or site that is included in the Schedule of Monuments kept by the Secretary of State for Culture, Media and Sport.
Site of Special Scientific Interest	Providing statutory protection for the best examples of the UK's flora, fauna, or geological or physiographical features. These sites are also used to underpin other national and international nature conservation designations.

[20] More information about tree preservation orders and trees in conservation areas can be found here **https://www.gov.uk/guidance/tree-preservation-orders-and-trees-in-conservation-areas**

Figure 4: Environmental constraints

This map presents a number of environmental constraints layers, but is not exhaustive. The full range of environmental constraints in the area are topic-specific, complex, and overlapping, and cannot be comprehensively presented on a single map. Topic-specific environmental maps are provided in the *Environmental Assessment Report (EAR).*



This map is a diagrammatic representation. Not to scale.

	Cyan (Option 1V5)	Beige (Option 1V9)	Crimson (Option 3V1)	Magenta (Option 4/5AV1)	Amber (Option 4/5AV2)	Grey (Option 5BV1)
Air quality	**Construction:** There is potential for temporary adverse impacts from dust emissions within 200 metres of the works. Best practice mitigation would be included in construction environmental management plans to address these impacts. There would be no significant adverse effect. **Operation:** There would be low risk of non-compliance with EU ambient air quality limit values. Reductions in nitrogen dioxide concentrations would occur within the Storrington Air Quality Management Area. There would be no significant adverse effect.					
Cultural heritage[21]	**Construction:** Moderate adverse significance of effect for all heritage assets with exception of Lyminster Conservation Area which is neutral. Slight adverse significance of effect on below-ground archaeology. **Operation:** Slight adverse significance of effect for all heritage assets.		**Construction:** Large adverse effects on setting of Tortington Priory Scheduled Monument and one Grade II* listed building. Neutral effects in setting for the remainder of heritage assets. Slight adverse effects on all heritage assets for below-ground archaeology including the course of the Roman road (MWS14385). **Operation:** Large adverse effects on setting of Tortington Priory Scheduled Monument and one Grade II* listed building. Neutral effects on setting for all remaining heritage assets.	**Construction:** Moderate adverse significance of effect on setting for Tortington Priory Scheduled Monument and one Grade II* listed building. Slight adverse significance of effect on setting for the remainder of the heritage assets. Moderate adverse significance of effect on the curtilages of six Grade II Listed Buildings. Slight adverse effects on below ground archaeology for all heritage assets. **Operation:** Moderate adverse significance of effect for Tortington Priory Scheduled Monument and one Grade II* listed building. Slight adverse significance of effect for the remainder of the Grade II listed buildings.	**Construction:** Moderate adverse significance of effect on setting for Tortington Priory Scheduled Monument and one Grade II* and two Grade II listed buildings. Neutral effects for the remainder of the heritage assets. Slight adverse effects on below-ground archaeology for all heritage assets. **Operation:** Moderate adverse significance of effect for the Tortington Priory Scheduled Monument and one Grade II* and two Grade II listed buildings. Neutral for the remainder of the Grade II listed buildings.	**Construction:** Moderate adverse significance of effect on setting for Tortington Priory Scheduled Monument and one Grade II* and eight Grade II listed buildings. Neutral effect on the remaining Grade II listed buildings. Slight adverse significance of effect on the setting for Walberton Village and Walberton Green Conservation Areas. Moderate adverse significance of effect on below-ground archaeology for all heritage assets. **Operation:** Moderate adverse significance of effect for the Tortington Priory Scheduled Monument and one Grade II* and eight Grade II listed buildings. Neutral effect on the remaining Grade II listed buildings. Slight adverse significance of effect for Walberton Village and Walberton Green Conservation Areas.
Landscape The following assessment refers to effects on Landscape Character Areas as defined by Natural England[22]. Operation refers to summer 2041, when the new road is expected to have been in place for 15 years.	**Construction:** Slight adverse effect on the following landscape character areas: Western Downs, Downland Arun Valley, Central Downs, Angmering Park and Angmering Upper Coastal Plain. Neutral effect on Littlehampton to Worthing fringes local landscape area. **Operation:** Slight adverse effect on; Central Downs and Downland Arun Valley landscape character areas. Neutral adverse effect on the following landscape character areas; Chichester to Yapton Coastal Plain, Western Downs, Angmering Park, Angmering Upper Coastal Plain and Littlehampton to Worthing fringes.					
	Construction: Very large adverse effect on Arundel landscape character area. Large adverse effect on Lower Arun Valley landscape character area. Slight adverse effect on Fontwell Upper Coastal Plain landscape character area. Neutral on Chichester to Yapton Coastal Plain landscape character area. **Operation:** Large adverse effect on Arundel landscape character area. Moderate adverse effect on Lower Arun Valley landscape character area. Neutral adverse effect on Fontwell Upper Coastal Plain landscape character area.		**Construction:** Very large adverse effect on Lower Arun Valley landscape character area. Large adverse effect on Arundel and Fontwell Upper Coastal Plain landscape character area. Slight adverse effect on Chichester to Yapton Coastal Plain landscape character area. **Operation:** Large adverse effect on Lower Arun Valley landscape character area. Moderate adverse effect on Arundel landscape character area. Moderate adverse effect on Fontwell Upper Coastal Plain landscape character area.	**Construction:** Very large adverse effect on Lower Arun Valley landscape character areas. Large adverse effect on Arundel landscape character area and Fontwell Upper Coastal Plain. Slight adverse effect on Chichester to Yapton Coastal Plain landscape character area. **Operation:** Large adverse effect on Lower Arun Valley landscape character area. Moderate adverse effect on Arundel landscape character area. Large adverse effect on Fontwell Upper Coastal Plain landscape character area.		**Construction:** Very large adverse effect on Lower Arun Valley landscape character area. Large adverse effect on Arundel and Fontwell Upper Coastal Plain landscape character area. Slight adverse effect on Chichester to Yapton Coastal Plain landscape character area. **Operation:** Large adverse effect on Lower Arun Valley landscape character area. Moderate adverse effect on Arundel landscape character area. Moderate adverse effect on Fontwell Upper Coastal Plain landscape character area.
Biodiversity LWS: Local Wildlife Sites HPI: Habitat of Principal Importance. SSSI: Site of Special Scientific Interest	**Construction:** Large adverse effect for Binsted Wood Complex LWS, Rewell Wood Complex LWS, ancient woodland, deciduous woodland HPI. Moderate adverse effect for wood pasture and parkland HPI, coastal and floodplain grazing marsh HPI, bats, hazel dormice, terrestrial invertebrates, barn owl, protected and notable plants. Very large adverse effect for ancient and veteran trees. **Operation:** Moderate adverse effects for bats. Slight beneficial effects for Arundel Park SSSI and Fairmile Bottom SSSI. All other construction and operation phase effects on biodiversity features would be slight adverse or neutral.		**Construction:** Very large adverse effect for Binsted Wood Complex LWS, ancient woodland, deciduous woodland HPI, bats, terrestrial invertebrates. Large adverse effect for Rewell Wood Complex LWS, coastal and floodplain grazing marsh HPI, birds/breeding (woodland), hazel dormice, protected and notable plants. Moderate adverse effect on barn owl and water vole. **Operation:** Very large adverse effects for bats. Slight beneficial effects for Arundel Park SSSI and Fairmile Bottom SSSI. Large adverse effect on Binsted Wood Complex LWS. All other construction and operation phase effects on biodiversity features would be slight adverse or neutral.	**Construction:** Very large adverse effect on ancient and veteran trees. Large adverse effect for Binsted Wood Complex LWS, coastal and floodplain grazing marsh HPI, bats, protected and notable plants. Moderate adverse effect on ancient woodland, traditional orchard HPI, aquatic ecology, hazel dormice, barn owl and water vole. **Operation:** Large adverse effects for bats. Moderate adverse effects on barn owls. Slight beneficial effects on Arundel Park SSSI and Fairmile Bottom SSSI. All other construction and operation phase effects on biodiversity features would be slight adverse or neutral.	**Construction:** Very large adverse effect for Binsted Wood Complex LWS, ancient woodland, ancient and veteran trees, deciduous woodland HPI, wood pasture and parkland HPI, bats, terrestrial invertebrates. Large adverse effects on coastal and floodplain grazing marsh HPI, hazel dormice, protected and notable plants. Moderate adverse effect on aquatic ecology, water vole, barn owl and birds/breeding (woodland). **Operation:** Very large adverse effects for bats and a large adverse effect on Binsted Wood Complex LWS. Moderate adverse effects on barn owls. Slight beneficial effects on Arundel Park SSSI and Fairmile Bottom SSSI. All other construction and operation phase effects on biodiversity features would be slight adverse or neutral.	**Construction:** Very large adverse effect on ancient and veteran trees.Large adverse effects on coastal and floodplain grazing marsh HPI, and protected/ notable plants. Moderate adverse effect on aquatic ecology, bats, hazel dormice, barn owl and water vole. **Operation:** Moderate adverse effect on bats, barn owls. Slight beneficial effects for Arundel Park SSSI and Fairmile Bottom SSSI. All other construction and operation phase effects on biodiversity features would be slight adverse or neutral.

[21] A list of the relevant remaining heritage assets can be found in the Environmental Assessment Report (EAR). A full list of all relevant listed buildings can be found in the EAR.
[22] Natural England's LCA definition **https://www.gov.uk/guidance/landscape-and-seascape-character-assessments**

	Cyan (Option 1V5)	Beige (Option 1V9)	Crimson (Option 3V1)	Magenta (Option 4/5AV1)	Amber (Option 4/5AV2)	Grey (Option 5BV1)
Geology and soils	**Construction:** Slight adverse effect of direct land take (best and most versatile agricultural land). Moderate to large adverse effect on soil resources affecting social, economic or environmental services.			**Construction:** Moderate adverse effect of direct land take (best and most versatile agricultural land). Moderate adverse effect on soil resources affecting social, economic or environmental services.		
	Construction: Slight adverse effects for changes in ground level resulting in geological or geomorphological change – this can include embankment creation or cuttings. Slight adverse effects for construction workers potentially exposed to contaminated land. Potential effects associated with the exposure of contaminated land to adjacent site users is neutral. **Operation:** Potential effects associated with the exposure of contaminated land to end-users and maintenance workers is neutral.					
Noise and vibration	**Construction:** Approximately 427 properties within 100m with potential for significant effects.	**Construction:** Approximately 429 properties within 100m with potential for significant effects.	**Construction:** Approximately 24 properties within 100m with potential for significant effects.	**Construction:** Approximately 70 properties within 100m with potential for significant effects.	**Construction:** Approximately 76 properties within 100m with potential for significant effects.	**Construction:** Approximately 98 properties within 100m with potential for significant effects.
	Operation: Significant adverse effects on existing dwellings: ■ East and south of Crossbush ■ North of Ford Road roundabout ■ On Fitzalan Road ■ On Ford Road	**Operation:** Significant adverse effects on existing dwellings: ■ East and south of Crossbush ■ North of Ford Road roundabout ■ On Fitzalan Road ■ On Ford Road ■ South of A27 (west of Ford Road roundabout)	**Operation:** Significant adverse effects on existing dwellings: ■ East and south of Crossbush ■ On Fitzalan Road ■ On Ford Road ■ In Tortington ■ South of A27 (west of Ford Road roundabout)	**Operation:** Significant adverse effects on existing dwellings: ■ East and south of Crossbush ■ In Tortington and Binsted ■ South of A27 (west of Ford Road roundabout)	**Operation:** Significant adverse effects on existing dwellings: ■ East and south of Crossbush ■ On Fitzalan Road ■ In Tortington and Binsted ■ South of A27 (west of Ford Road roundabout) ■ Slindon	**Operation:** Significant adverse effects on existing dwellings: ■ East and south of Crossbush ■ On Fitzalan Road ■ South of A27 (west of Ford Road roundabout) ■ Tortington, Binsted and Walberton
Population and health	**Construction:** Moderate adverse effects due to permanent requirement for demolitions or land from private assets for construction purposes. Moderate adverse effects for temporary changes to walking, cycling and horse riding journeys due to construction works. Adverse effects for temporary alteration of views in the landscape due to construction works (altering the views from the road for vehicle travellers). Neutral effects for temporary requirement of development land. Neutral effects for temporary impacts on health outcomes from construction dust. Negative effects on health outcomes from construction noise and access to active travel opportunities.					
	Construction: Slight adverse permanent effect due to requirement of community land or facilities (or access to) for construction purposes. Large adverse permanent effect due to requirement of agricultural land or access.	**Construction:** Moderate adverse permanent effect due to requirement of community land or facilities (or access to) for construction purposes. Large adverse permanent effect due to requirement of agricultural land or access.	**Construction:** Moderate adverse permanent effect due to requirement of community land or facilities (or access to) for construction purposes. Large adverse permanent effect due to requirement of agricultural land or access.	**Construction:** Neutral effect on community land or facilities (or access to) for construction purposes. Moderate adverse permanent effect due to requirement of agricultural land or access.	**Construction:** Slight adverse permanent effect due to requirement of community land or facilities (or access to) for construction purposes. Moderate adverse permanent effect due to requirement of agricultural land or access.	**Construction:** Neutral effect on community land or facilities (or access to) for construction purposes. Moderate adverse permanent effect due to requirement of agricultural land or access.
	Operation: Moderate adverse effects on permanent road and public right of way diversions or closures which result in changes in journey length or severance. Moderate adverse effects on permanent changes in amenity. Positive effects on health outcomes resulting from air quality improvements and access to active travel opportunities. Negative impacts on health outcomes resulting from changes in noise levels.					
	Operation: Beneficial effects to permanent alteration of views in the landscape due to the new bypass (altering the views from the road for vehicle travellers).		Neutral effects to permanent alteration of views in the landscape due to the new bypass (altering the views from the road for vehicle travellers).	**Operation:** Adverse and beneficial effects to permanent alteration of views in the landscape due to the new bypass (altering the views from the road for vehicle travellers).		
Water environment	**Construction:** Slight adverse temporary risk of pollution effect due to works within proximity to the River Arun and neutral effect to ordinary watercourses. Slight adverse temporary effect related to pond dewatering of Secondary A Aquifers[23]. Neutral effect to the physical character and content of water bodies (hydro morphological) and ecological quality of ordinary watercourses and flooding with appropriate measures adopted during construction.		**Construction:** Slight adverse temporary risk of pollution effect due to works in close proximity to the River Arun and main rivers. Neutral effect to ordinary watercourses. Slight adverse temporary effect related to pond dewatering of Secondary A Aquifers. Neutral effect to the physical character and content of water bodies (hydro morphological) and ecological quality of ordinary watercourses and flooding with appropriate measures adopted during construction.			
	Operation: Neutral permanent effects for flooding, pollution, impacts to physical character and content of water bodies (hydro morphological) on the assumption that flood management measures can be successfully implemented. These flood management measures would be developed in consultation with the relevant statutory environmental bodies. Slight adverse permanent effect related to pond dewatering of Secondary A Aquifers.					

[23] Secondary A Aquifers is a designation given by the Environment Agency.

How the options compare: environmental assessment

The table on pages 24 to 27 summarises results from the *Environmental Assessment Report (EAR)* and reflects the latest available information at this stage of the scheme. For full details, including the extent of impacts outlined below, please refer to the *EAR and Interim Scheme Assessment Report (Interim SAR).*

The environmental assessments conducted to date assume that the route would be built on an embankment across the River Arun floodplain. The routes could alternatively be built with a viaduct. A decision on this will be taken once a preferred route is confirmed and more detailed design work is undertaken. These assessments also assume the A27 Worthing Lancing improvements progresses[24].

Environmental mitigation

We continuously strive to manage the potential environmental impacts of all of our schemes via an environmental management hierarchy: avoid, minimise, mitigate, offset and compensate. Opportunities for environmental enhancement will also form an important part of the management regime.

We intend to manage the potential adverse environmental impacts of this scheme through our design process (to avoid and minimise impacts) and by introducing specific impact mitigation measures during construction and operation. We recognise that some elements, such as ancient woodland, are irreplaceable and cannot be offset. We are also committed to monitoring and reviewing the effectiveness of all environmental management measures.

Specific mitigation and compensation measures which could be implemented include[25]:

- Green bridges and oversized structures (like culverts) to facilitate safer animal crossings of the A27
- Habitat creation to provide compensation for habitats affected by the scheme
- Planting of suitable vegetation to mitigate landscape impacts
- Flood management measures to avoid changes to flood characteristics
- Screening to mitigate impacts on cultural heritage setting

Provision has been made for environmental mitigation and compensation measures within our scheme cost estimates.

We will continue to engage with statutory environmental bodies and other key stakeholders to develop the full environmental mitigation strategy, once a preferred route is identified.

Economic assessment

All our road schemes must demonstrate how the costs of the scheme compare to the benefits. This is known as the Benefit to Cost Ratio (BCR). As set out by the Department for Transport (DfT), benefits include journey time savings and safety improvements, while costs include the funding needed to develop the scheme, maintenance and construction fees and the purchase of any land required.

The final Value for Money assessment includes more than just the BCR and also takes account of all expected effects, risks and uncertainty. Taking into account all impacts, risk and uncertainty, no option significantly outperforms the other options in terms of value for money.

Funding the scheme

Two of the six options are broadly deliverable within the current budget that has been allocated for the scheme through the Road Investment Strategy. We are still keen to receive feedback on all six options during the consultation since the cost ranges published within this consultation are early estimates based on work done to date and as such do not represent our final costs for the project. We will continue to develop our design in such a way that seeks to deliver the best possible value for money in line with the needs of the scheme.

[24] In line with Highways England process, the environmental assessments presented in this brochure assume that planned developments (such as the Lyminster Bypass and the Worthing and Lancing scheme) proceed. However, given the uncertainty around the future of the Worthing and Lancing scheme, we have received queries about how the assessment would change should the scheme not progress. The results of the environmental assessments excluding Worthing and Lancing are set out in the Environmental Sensitivity Testing Technical Note. This will be published by 13th September.

[25] For more information refer to Environmental Assessment Report (EAR).

Costs and benefits

	Cyan (Option 1V5)	Beige (Option 1V9)	Crimson (Option 3V1)	Magenta (Option 4/5AV1)	Amber (Option 4/5AV2)	Grey (Option 5BV1)
Cost range (million)	£200 - £295m	£195 - £290m	£255 - £380m	£280 - £405m	£290 - £420m	£320 - £455m
BCR[26]	1.7 - 2.5	1.6 - 2.3	1.7 - 2.4	1.5 - 2.2	1.6 - 2.3	1.5 - 2.1
Value for Money	Medium	Medium	Medium	Medium	Medium	Medium

Compliance with National Networks National Policy Statement (NN NPS)

The A27 Arundel Bypass meets the criteria of being a Nationally Significant Infrastructure Project (NSIP) under the Planning Act 2008 and therefore must be authorised by the Secretary of State by way of a Development Consent Order (DCO). A DCO is a statutory instrument which will contain the necessary powers for us to construct, operate and maintain the scheme and replaces the need to obtain planning permission and a number of other consents. A DCO can also include a number of associated powers, including in relation to compulsory acquisition. More information is available in our planning policy summary on our website or from the Planning Inspectorate website:

https://infrastructure.planninginspectorate.gov.uk

Because the project is a NSIP, the primary policy document against which the Secretary of State must assess the scheme is the National Networks National Policy Statement (NN NPS). While the scheme aligns with many of the NN NPS policies, there are also policies which it may conflict with, including:

- **5.133: Heritage –** 'Where the proposed development will lead to substantial harm to or total loss of significance of a designated heritage asset, the Secretary of State should refuse consent unless it can be demonstrated that the substantial harm or loss of significance is necessary in order to deliver substantial public benefits that outweigh that loss or harm.'
- **5.151: National Park –** 'The Secretary of State should refuse development consent in these areas except in exceptional circumstances and where it can be demonstrated that it is in the public interest.'
- **5.154: National Park** – 'The duty to have regard to the purposes of nationally designated areas also applies when considering applications for projects outside the boundaries of these areas which may have impacts within them. The aim should be to avoid compromising the purposes of designation…'
- **5.169: Minerals Safeguarding Area –** 'Applicants should safeguard any mineral resources on the proposed site as far as possible.'
- **5.32: Ancient woodland –** Requires the Secretary of State to not grant development consent for any developments that would result in the loss or deterioration of irreplaceable habitats including Ancient woodland, unless the need for and benefits of development in that location clearly outweigh the loss.

Any scheme which conflicts with NN NPS policy carries a greater risk of being refused consent and therefore not being delivered. We will consider the NN NPS when selecting the preferred option, undertaking further detailed design and proceeding to prepare an application for consent.

[26] Combined Modelling and Appraisal Report (ComMA).

Consultation feedback

Your views are important

We would like to hear your views about the options presented. The consultation runs for eight weeks from **30 August to 11.59pm on 24 October 2019.** Responses received after this time may not be considered.

Details of how to submit your response to the consultation can be found on page 3 of this brochure.

What happens after the public consultation?

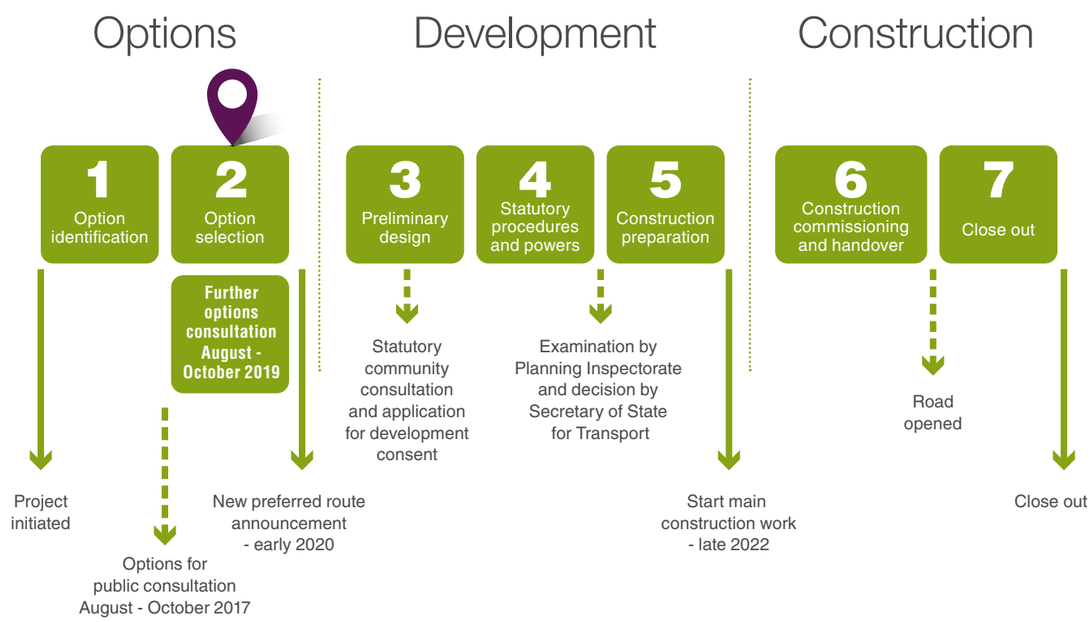
All responses and comments received during the public consultation will be considered and summarised in our Public Consultation Report, which will be published on our website. We will carefully consider the responses alongside several factors to determine our preferred route for the scheme.

Another opportunity to have your say

Following a preferred route announcement, we will develop detailed proposals. This will include further surveys and investigations to allow us to design the scheme in more detail.

There will be a further opportunity to have your say on the design of this preferred route during further public consultation prior to any application for consent.

Timeline



If you need help accessing this or any other Highways England information, please call **0300 123 5000** and we will help you.

This document is also available on our website at **www.highwaysengland.co.uk**

For an accessible version of this publication please call **0300 123 5000** and we will help you.

If you have any enquiries about this publication email **info@highwaysengland.co.uk** or call **0300 123 5000***. Please quote the Highways England publications code **PR74/19.**

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A27 Arundel Bypass
Consultation response form

Share your views

We want to understand your views about the proposed options for improvements to the A27 around Arundel. Please review the consultation materials and share your views with us by completing this response form here or online via **www.highwaysengland.co.uk/a27arundel**

If you're returning this form to us by post, please send it to: **Freepost A27 ARUNDEL** – no stamp is required.

The consultation period ends at **11.59pm on 24 October 2019** so please ensure your response arrives with us in time, to help us take your comments into account when we are considering the options. Responses received after this time, may not be considered.

A1. The first part (sections A-C) of this questionnaire is for you to provide your personal views. If you are responding on behalf of a local business, charity or community organisation, represent a statutory body or are a local elected representative, please ensure you also complete section D of the response form (pages 8-11 shaded in green). This will help us better understand the possible impact of the options on the local economy and communities.

Please let us know whether you are responding as: *(Please tick one only)*

- ☐ An individual (please complete **sections A-C** only)
- ☐ On behalf of a business/charity/community organisation/statutory body/elected representative – and you have the authority to represent the views of the organisation/elected representative. (please complete **sections A-D**)

A2. Please indicate your age group:

☐ 18 or under	☐ 19-29	☐ 30-39
☐ 40-49	☐ 50-59	☐ 60-69
☐ 70-79	☐ 80 or above	☐ Prefer not to say

A3. Please provide your home postcode. This will only be used to inform our analysis of responses.

About the scheme

B1. If all options are brought into an affordable range*, which option would you prefer?
(Please tick one option)

- ☐ Cyan (Option 1V5)
- ☐ Beige (Option 1V9)
- ☐ Crimson (Option 3V1)
- ☐ Magenta (Option 4/5AV1)
- ☐ Amber (Option 4/5AV2)
- ☐ Grey (Option 5BV1)
- ☐ Do nothing
- ☐ Don't know

B2. The scheme budget is currently £100-250m. Affordability is an ongoing concern and if only Cyan and Beige (Options 1V5 and 1V9) remain affordable, which option(s) would you support?
(Please tick all that apply)

- ☐ Cyan (Option 1V5)
- ☐ Beige (Option 1V9)
- ☐ Do nothing

B3. To what extent do you agree or disagree that there is a need to improve the A27 around Arundel?

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Don't know
☐	☐	☐	☐	☐	☐

B4. How concerned are you about the following issues in relation to the existing A27 around Arundel?
(Please select one option in each row)

Issue	Very concerned	Slightly concerned	Not concerned	Don't know	Not applicable
Road safety	☐	☐	☐	☐	☐
Congestion and delays	☐	☐	☐	☐	☐
Accommodating extra traffic from future housing and economic development without further congestion on the A27	☐	☐	☐	☐	☐
The effects of A27 traffic on the environment, including the South Downs National Park and air quality	☐	☐	☐	☐	☐
The separation of local communities	☐	☐	☐	☐	☐
Access between the A27 and local roads	☐	☐	☐	☐	☐

Table continues on next page...

*Through securing additional funding, value engineering and contractual efficiencies.

Issue	Very concerned	Slightly concerned	Not concerned	Don't know	Not applicable
The provision of walking, cycling and horse riding facilities around the area	☐	☐	☐	☐	☐
Difficulty crossing the A27 on foot, cycle or horseback	☐	☐	☐	☐	☐
Traffic using local roads to avoid the A27 ('rat-running')	☐	☐	☐	☐	☐
Connections along the coast to other parts of the country	☐	☐	☐	☐	☐

B5. Please add any other comments that you may have regarding existing issues:

B6. Please indicate the extent to which you agree or disagree with the following statements when considering your preferred option(s) for improving the A27 around Arundel: *(Please select one option in each row)*

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Don't know
Any new route should be located as closely as possible to the current road through Arundel	☐	☐	☐	☐	☐	☐
Any new route should avoid the South Downs National Park	☐	☐	☐	☐	☐	☐
Any new route should not cut through local communities	☐	☐	☐	☐	☐	☐
'Rat-run' traffic should be removed from unsuitable local roads	☐	☐	☐	☐	☐	☐
Any improvements should prioritise through traffic	☐	☐	☐	☐	☐	☐
Maintaining local access to/ from the A27 is essential	☐	☐	☐	☐	☐	☐

B7. Please indicate which option would… *(Please select one option in each row)*

	Cyan (Option 1V5)	Beige (Option 1V9)	Crimson (Option 3V1)	Magenta (Option 4/5AV1)	Amber (Option 4/5AV2)	Grey (Option 5BV1)	Don't know	None	Not applicable
Make you feel **most safe** as a pedestrian, cyclist or horse rider?	☐	☐	☐	☐	☐	☐	☐	☐	☐
Make you feel **least safe** as a pedestrian, cyclist or horse rider?	☐	☐	☐	☐	☐	☐	☐	☐	☐
Make you feel **most safe** as a driver?	☐	☐	☐	☐	☐	☐	☐	☐	☐
Make you feel **least safe** as a driver?	☐	☐	☐	☐	☐	☐	☐	☐	☐
Be **best** for reducing congestion and delays in Arundel	☐	☐	☐	☐	☐	☐	☐	☐	☐
Be **worst** for reducing congestion and delays in Arundel	☐	☐	☐	☐	☐	☐	☐	☐	☐
Be **best** for maintaining/ creating a sense of community?	☐	☐	☐	☐	☐	☐	☐	☐	☐
Be **worst** for maintaining/ creating a sense of community?	☐	☐	☐	☐	☐	☐	☐	☐	☐
Be **best** for your enjoyment of the local environment	☐	☐	☐	☐	☐	☐	☐	☐	☐
Be **worst** for your enjoyment of the local environment	☐	☐	☐	☐	☐	☐	☐	☐	☐
Be **best** for improving access to local services and employment opportunities	☐	☐	☐	☐	☐	☐	☐	☐	☐

Table continues on next page...

	Cyan (Option 1V5)	Beige (Option 1V9)	Crimson (Option 3V1)	Magenta (Option 4/5AV1)	Amber (Option 4/5AV2)	Grey (Option 5BV1)	Don't know	None	Not applicable
Be **worst** for improving your access to local services and employment opportunities	☐	☐	☐	☐	☐	☐	☐	☐	☐
Be **best** for your quality of life	☐	☐	☐	☐	☐	☐	☐	☐	☐
Be **worst** for your quality of life	☐	☐	☐	☐	☐	☐	☐	☐	☐

B8. Taking into consideration what you know about the proposed options, which option would you prefer if all options were brought into an affordable range*?

Please select your preferred options, ranked by **first**, **second** and **third** preference: *(If you have only one or two preferred options, please select accordingly)*

		First preference	Second preference	Third preference
	Cyan (Option 1V5)	☐	☐	☐
	Beige (Option 1V9)	☐	☐	☐
	Crimson (Option 3V1)	☐	☐	☐
	Magenta (Option 4/5AV1)	☐	☐	☐
	Amber (Option 4/5AV2)	☐	☐	☐
	Grey (Option 5BV1)	☐	☐	☐
	Do nothing	☐	☐	☐
	Don't know	☐	☐	☐

B9. Taking into consideration what you know about the proposed options, please select your **least preferred** (or last choice) option if all options were brought into an affordable range:

		Least preferred/last choice
	Cyan (Option 1V5)	☐
	Beige (Option 1V9)	☐
	Crimson (Option 3V1)	☐
	Magenta (Option 4/5AV1)	☐
	Amber (Option 4/5AV2)	☐
	Grey (Option 5BV1)	☐
	Do nothing	☐
	Don't know	☐

*Through securing additional funding, value engineering and contractual efficiencies.

B10. Please add any other comments about the proposed options:

About the consultation

C1. How did you find out about the consultation? *(Please tick all that apply)*

- ☐ Letter through the door
- ☐ Local newspaper advert
- ☐ West Sussex County Council website or email
- ☐ Arun District Council website or email
- ☐ Highways England website or email
- ☐ Online news
- ☐ Other website (please provide details below)
- ☐ Local radio
- ☐ Local television
- ☐ Local newspaper
- ☐ Poster
- ☐ Local community group
- ☐ Public notice
- ☐ Social media
- ☐ Word of mouth
- ☐ Other (please provide details) .....

C2. Have you found the consultation materials useful in answering your questions about the A27 around Arundel?

- ☐ Yes
- ☐ To a certain extent
- ☐ No

C3. Have you visited one of our public consultation events, or do you intend to?

☐ Yes, have visited ☐ Intend to visit ☐ No

Details of upcoming events can be found at www.highwaysengland.co.uk/a27arundel

C4. If you have visited an exhibition, how useful did you find it in terms of addressing your questions about the options for improving the A27 around Arundel? *(Please tick one option)*

Very useful	Useful	No feeling either way	Not useful	Not at all useful	Don't know	Not applicable
☐	☐	☐	☐	☐	☐	☐

C5. Do you have any other comments about the consultation process or materials?

Keep up-to-date with the project

If you would like to receive updates on the A27 Arundel Bypass, please subscribe via our project webpage: www.highwaysengland.co.uk/a27arundel

Thank you for completing this consultation response form.

Some specific questions for organisations continue over the page.

Your data, your rights

On 25 May 2018, the General Data Protection Regulations (GDPR) became law. The law requires Highways England to explain to you – consultees, stakeholders and customers – how your personal data will be used and stored.

Highways England adheres to the government's consultation principles, the Planning Act 2008 and the Highways Act 1980 as required, and may collect personal data to help shape development of highways schemes.

Personal data collected by the project team will be processed and retained by Highways England and its appointed contractors until the scheme is complete.

Under the GDPR regulations you have the following rights:

- Right of access to the data (Subject Access Request)
- Right for the rectification of errors
- Right to erasure of personal data – this is not an absolute right under the legislation
- Right to restrict processing or to object to processing
- Right to data portability

If, at any point, Highways England plans to process the personal data we hold for a purpose other than that for which it was originally collected, we will tell you what that other purpose is. We will do this prior to any further processing taking place and we will include any relevant additional information, including your right to object to that further processing.

You have the right to lodge a complaint with the supervisory authority, the Information Commissioners Office.

If you'd like more information about how we manage data, or a copy of our privacy notice, please contact:
DataProtectionAdvice@highwaysengland.co.uk

Organisation-specific questions

We are keen to gather the views of businesses/charities/community groups/statutory bodies/elected representatives to ensure that they are fairly represented in the assessment of the consultation.

In addition to the main questionnaire, we are asking representatives of these organisations to help us by answering the following questions:

D1. Please state the name of the organisation you are responding on behalf of, along with your organisation's website address:

Organisation name:
Organisation postcode:
Organisation website address:

D2. Please confirm you have the authority to respond on behalf of your organisation:

- ☐ Yes
- ☐ No

D3. In which capacity are you responding on behalf of the organisation?

- ☐ Owner/partner
- ☐ Director
- ☐ Manager
- ☐ Other (please specify below)

D4. How many people do you/does your organisation employ or represent in the Arundel/A27 area?

- ☐ 1-10
- ☐ 11-49
- ☐ 50-99
- ☐ 100-249
- ☐ 250 or more
- ☐ Not applicable

D5. In which sector does your organisation operate?

- ☐ Agriculture
- ☐ Charity/voluntary sector
- ☐ Construction
- ☐ Education
- ☐ Energy/utilities
- ☐ Finance
- ☐ Healthcare
- ☐ Hospitality
- ☐ Leisure/tourism
- ☐ Manufacturing
- ☐ Retail
- ☐ Transport or logistics
- ☐ Other (please specify below)

D6. What are the key challenges faced by your organisation in relation to the A27 around Arundel?
(Please tick all that apply)

- ☐ Congestion
- ☐ Journey times
- ☐ Journey time reliability
- ☐ Quality of road/infrastructure
- ☐ Access to/from A27
- ☐ Loading/unloading
- ☐ Parking
- ☐ Impact on local roads/'rat-running'
- ☐ Lack of up to date information (variable message signing - VMS)
- ☐ Safety
- ☐ Air quality
- ☐ Economic impacts
- ☐ Impact of incidents
- ☐ None
- ☐ Other – please provide details below

D7. Please provide more details of how current issues with the A27 around Arundel affect your organisation:

D8. How important is the A27 around Arundel to your organisation's operations?

Very important	Important	Neither important nor unimportant	Unimportant	Very unimportant	Don't know
☐	☐	☐	☐	☐	☐

D9. Which option (if any) would have the most significant impact on your organisation during construction? *(Please select one only)*

☐	Cyan (Option 1V5)
☐	Beige (Option 1V9)
☐	Crimson (Option 3V1)
☐	Magenta (Option 4/5AV1)
☐	Amber (Option 4/5AV2)
☐	Grey (Option 5BV1)
☐	No difference
☐	Don't know

D10. Please explain the reasons for your selection:

D11. Which option (if any) would most benefit your organisation once built? *(Please select one only)*

☐	Cyan (Option 1V5)
☐	Beige (Option 1V9)
☐	Crimson (Option 3V1)
☐	Magenta (Option 4/5AV1)
☐	Amber (Option 4/5AV2)
☐	Grey (Option 5BV1)
☐	No difference
☐	Don't know

D12. Please explain the reasons for your selection:

D13. Which option (if any) would least benefit your organisation once built?
(Please select one only)

☐	Cyan (Option 1V5)
☐	Beige (Option 1V9)
☐	Crimson (Option 3V1)
☐	Magenta (Option 4/5AV1)
☐	Amber (Option 4/5AV2)
☐	Grey (Option 5BV1)
☐	No difference
☐	Don't know

D14. Please explain the reasons for your selection:

Thank you for completing this consultation response form.

highways england

A27 Arundel Bypass

Welcome

Improving the A27 Arundel Bypass will make journeys safer, quicker and more reliable.

We would like to know what you think about the proposals in this consultation.

www.highwaysengland.co.uk/a27arundel

About Highways England

At Highways England, we believe in a connected country and our network makes these connections happen. We strive to improve our major roads and motorways – engineering the future to keep people moving today and moving better tomorrow. We want to make sure all our major roads are more dependable, durable and most importantly safe. That's why we're delivering £15 billion of investment on our network – the largest investment in a generation.

The A27 Arundel Bypass is part of this investment: by reducing congestion in the area, the scheme will improve journeys along the corridor between Brighton and Portsmouth, which is great news for the local and regional economy.

At this exhibition, you can find out more about our proposed options for improving the A27 around Arundel. For more information, visit **www.highwaysengland.co.uk/a27arundel**

Have your say

How to respond

We would like to hear what you think, so please share any views, ideas or local knowledge that you may have. The consultation is open for eight weeks, between 30 August and 24 October 2019.

Please provide your responses by **11:59pm on 24 October 2019.**

There are lots of ways in which you can have your say:

- Online: complete the consultation response form via: **www.highwaysengland.co.uk/a27arundel**
- Freepost: complete the consultation response form and return it to **Freepost A27 ARUNDEL**
- In person: complete the consultation response form and hand it to a member of staff at a public exhibition

Or if you have any questions, or would like the information in a different format, please contact us by:

- Email: **A27ArundelBypass@highwaysengland.co.uk**
- Telephone: **0300 123 5000 (24 hours)**

Your comments will help us better understand the local area and any potential impacts our proposals may have on the community. We will listen to everyone's feedback and consider all comments before we select a preferred option.

All consultation materials, including supplementary technical information are available from

www.highwaysengland.co.uk/a27arundel

Scheme objectives

Our scheme objectives have been developed while working with the local authorities, the South Downs National Park Authority, other environmental bodies, the emergency services and the Department for Transport. The scheme objectives are to:

- Improve the safety of travellers along the A27 and consequently the wider local road network.
- Ensure that customers and communities are fully considered throughout the design and delivery stages.
- Improve capacity of the A27 whilst supporting local planning authorities to manage the impact of planned economic growth.
- Reduce congestion, reduce travel time and improve journey time reliability along the A27.
- Improve accessibility for all users to local services and facilities.
- Deliver a scheme that minimises environmental impact and seeks to protect and enhance the quality of the surrounding environment through its high-quality design.
- Respect the South Downs National Park and its special qualities in our decision-making.

Why we need this scheme

- The A27 is the only east-west trunk road south of the M25, serving more than one million[1] people, as well as a large number of businesses.
- West Sussex attracts 17 million visitor-days per year, worth around £508 million to the local economy[2].
- The single carriageway section of the A27 through Arundel creates a bottleneck that holds up traffic, costing commuters, businesses, communities and visitors valuable time and money.
- Congestion around Arundel results in some drivers seeking alternative routes which are less suited to higher traffic flows.
- Air quality is a concern near these alternative routes, most notably in Storrington which has been identified by the World Health Organisation as one of the poorest places for air quality in the UK[3].
- Safety is a concern as the A27 currently has a higher than average accident rate for rural A-roads[4].
- Relatively poor transport connectivity has created pockets of deprivation by restricting access to employment opportunities.

[1] Based on census 2011 population data for these districts; Portsmouth, Havant, Chichester, Arundel, Worthing, Adur, Brighton and Hove, Lewes, and Eastbourne.

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[4] In the latest 5-year period (1 January 2013 to 31 December 2017) there have been 81 personal injury collisions, resulting in 121 casualties, recorded between Crossbush junction to the east and Yapton Lane to the west.

Route option development

1. In October 2018 we announced our intention to undertake further consultation on options for Arundel.

2. We revisited the full range of possible route alignments. These were grouped by corridor (or similar route alignments).

3. We then sifted down further according to their compliance with the scheme objectives and legal and national planning policy tests, including consideration of environmental impacts.

4. Our technical work concluded that six options should be put forward for consideration as part of this further consultation.

All options would support the local housing and employment growth strategies of the local authorities and cater for traffic growth until at least 2041[1].

However, there are significant environmental constraints and national planning policy risks that affect all six options.

More details on the process we followed to identify these six options can be viewed in the Interim Scheme Assessment Report.

For more information on the longer history of the scheme dating back to the 1980's, please see the Interim Scheme Assessment Report or please ask a member of staff.

[1]2041 would be 15 years from the scheme opening date which is currently planned for 2026. The 15-year timeframe is Highways England standard for scheme design performance assessments.

Environmental context

We are committed to minimising the environmental impact of our road network and to protecting and enhancing the quality of the surrounding environment. When considering what improvements might be possible on the A27 area, we have carefully considered a range of significant environmental values and features, including:

South Downs National Park

The South Downs was designated a National Park in 2009 in recognition of its significant ecological, biological, cultural and scenic value. We have a legal duty to have regard to the twin purposes of the National Park:

- To conserve and enhance the natural beauty, wildlife and cultural heritage of the National Park.
- To promote opportunities for the understanding and enjoyment of its special qualities.

Work has been done to assess the impact of the scheme on South Downs National Park special qualities. Please refer to the appendix in the Environmental Assessment Report (EAR).

Ancient woodland and veteran trees

Ancient woodland and veteran trees are protected by national planning policy. There is ancient woodland to both the north and south of the existing A27. The soils in these areas have been relatively undisturbed for centuries. We recognise that ancient woodland is irreplaceable and plants and animals in these areas depend on the stable and rare conditions that an ancient woodland provides.

Protected and notable species and habitats

The area around Arundel provides an array of wildlife habitats that support rich and varied biodiversity features. Many rare and protected species and notable plant species are found in the area.

Artist impressions 1 of 2

Indicative impressions of possible structural elements of the scheme.

Floodplain embankment alignment

There are two alignments proposed across the Arundel Floodplain. In a flat open landscape both will be visible from elevated viewpoints. This particular viewpoint is from Arundel Castle.

Cyan (Option 1V5), Beige (Option 1V9)

Crimson (Option 3V1), Magenta (Option 4/5AV1), Amber (Option 4/5AV2), Grey (Option 5BV1)

Arundel town bridge

Applicable for options Cyan (Option 1V5) and Beige (Option 1V9). The viewpoint is from the existing footpath (which runs adjacent to the River Arun) looking towards the existing A27 Arundel Road Bridge.

Flyover Cyan (Option 1V5) – Spans over the existing roundabout. The higher profile allows more natural light through and is a less intimidating space for users. The height of the bridge will be similar to the upper levels of nearby buildings.

Flyover Cyan (Option 1V5) – The higher alignment helps maintain river views but will impact sight lines of the town backdrop. The difference in alignments of the new and existing bridge will produce more visual interference.

Throughabout Beige (Option 1V9) – Divides the existing roundabout in two. The lower bridge deck will produce a very restricted ground condition and may also create an intimidating space for users.

Throughabout Beige (Option 1V9) – The lower vertical profile of the bridge is less intrusive to the elevated features of the town. Low level sightlines will be affected, though the alignment broadly follows that of the existing town bridge.

These artist impressions are based upon design data available at the time of their production. They are architectural impressions of the design at its current stage and exclude specific environmental mitigations such as noise barriers and drainage features, however the environmental assessments do include these mitigations. The designs are illustrative and subject to change.

Artist impressions 2 of 2

Indicative impressions of possible structural elements of the scheme.

Viaduct overview

Innovation is a core principle of Highways England's approach to delivery. Potential benefits, of integrating viaducts within keys section of embankment, have been identified across the scheme, providing a more permeable alignment. Further work is being undertaken to explore their viability and understand what support exists for them. The current scheme is based on an embankment, however an alternative viaduct option across the floodplain is also being considered which has the potential to reduce the environmental impact. The viaduct option will be reviewed further following confirmation of the Preferred Route Announcement.

1. Short floodplain viaduct option. This viewpoint is looking north towards Arundel from the River Arun floodplain.

Two options for the structure of the new bypass when crossing the River Arun are shown. The first solution is to build an embankment along the floodplain, with smaller viaducts spanning discrete sections of the floodplain including the railway, the River Arun and Ford Road.

Understated and elegant appearance of the three-span bridge over the River Arun.

2. Full floodplain viaduct option (incorporating the River Arun crossing). This viewpoint is looking north towards Arundel from the River Arun floodplain.

The second solution is a continuous viaduct from the railway to Ford Road. As it has not been determined yet what is the most appropriate of the two variants, photomontages of the two alternatives, from the same viewpoint in most of the cases, are presented.

Understated, elegant balanced and transparent appearance of the viaduct over the River Arun floodplain.

These artist impressions are based upon design data available at the time of their production. They are architectural impressions of the design at its current stage and exclude specific environmental mitigations such as noise barriers and drainage features, however the environmental assessments do include these mitigations. The designs are illustrative and subject to change.

Planning policy

Compliance with National Networks National Policy Statement (NN NPS)

The A27 Arundel Bypass meets the criteria of being a Nationally Significant Infrastructure Project (NSIP) under the Planning Act 2008 and therefore must be authorised by the Secretary of State by way of a Development Consent Order (DCO). A DCO is a statutory instrument which will contain the necessary powers for us to construct, operate and maintain the scheme and replaces the need to obtain planning permission and a number of other consents. A DCO can also include a number of associated powers, including in relation to compulsory acquisition. More information is available in our planning policy summary on our website or from the Planning Inspectorate website:

https://infrastructure.planninginspectorate.gov.uk

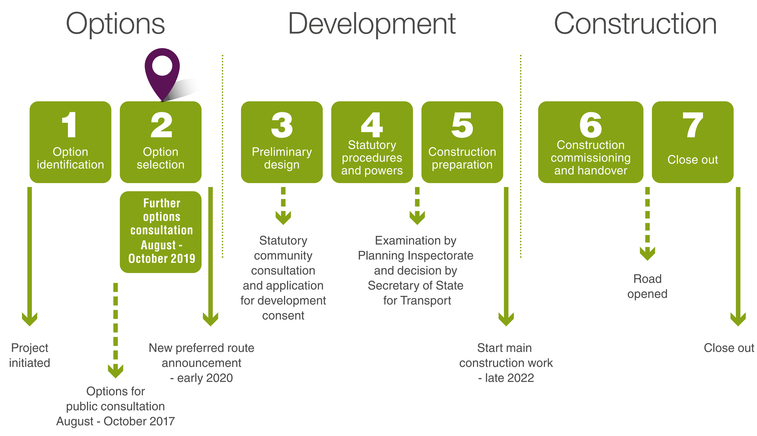
Because the project is a NSIP, the primary policy document against which the Secretary of State must assess the scheme is the NN NPS. While the scheme aligns with many of the NN NPS policies, there are also policies which it may conflict with, including:

- **5.133: Heritage –** 'Where the proposed development will lead to substantial harm to or total loss of significance of a designated heritage asset, the Secretary of State should refuse consent unless it can be demonstrated that the substantial harm or loss of significance is necessary in order to deliver substantial public benefits that outweigh that loss or harm'.
- **5.151: National Park –** 'The Secretary of State should refuse development consent in these areas except in exceptional circumstances and where it can be demonstrated that it is in the public interest.'
- **5.154: National Park –** 'The duty to have regard to the purposes of nationally designated areas also applies when considering applications for projects outside the boundaries of these areas which may have impacts within them. The aim should be to avoid compromising the purposes of designation…'
- **5.169: Minerals Safeguarding Area –** 'Applicants should safeguard any mineral resources on the proposed site as far as possible.'
- **5.32: Ancient woodland –** Requires the Secretary of State to not grant development consent for any developments that would result in the loss or deterioration of irreplaceable habitats including Ancient woodland, unless the need for and benefits of development in that location clearly outweigh the loss.

Any scheme which conflicts with NN NPS policy carries a greater risk of being refused consent and therefore not being delivered. We will consider the NN NPS when selecting the preferred option, undertaking further detailed design and proceeding to prepare an application for consent.

What happens next?

Timeline



A27 Arundel Bypass
Have Your Say

At Highways England, we believe in a connected country and our network makes these connections happen. We strive to improve our major roads and motorways – engineering the future to keep people moving today and moving better tomorrow. We want to make sure all our major roads are more dependable, durable and most importantly safe. That's why we're delivering £15 billion of investment on our network – the largest investment in a generation.

The A27 Arundel Bypass is part of this investment: by reducing congestion in the area, the scheme will improve journeys along the corridor between Brighton and Portsmouth, which is great news for the local and regional economy.

At this exhibition, you can find out more about our proposed options for improving the A27 around Arundel. For more information, visit **www.highwaysengland.co.uk/a27arundel**

Have your say

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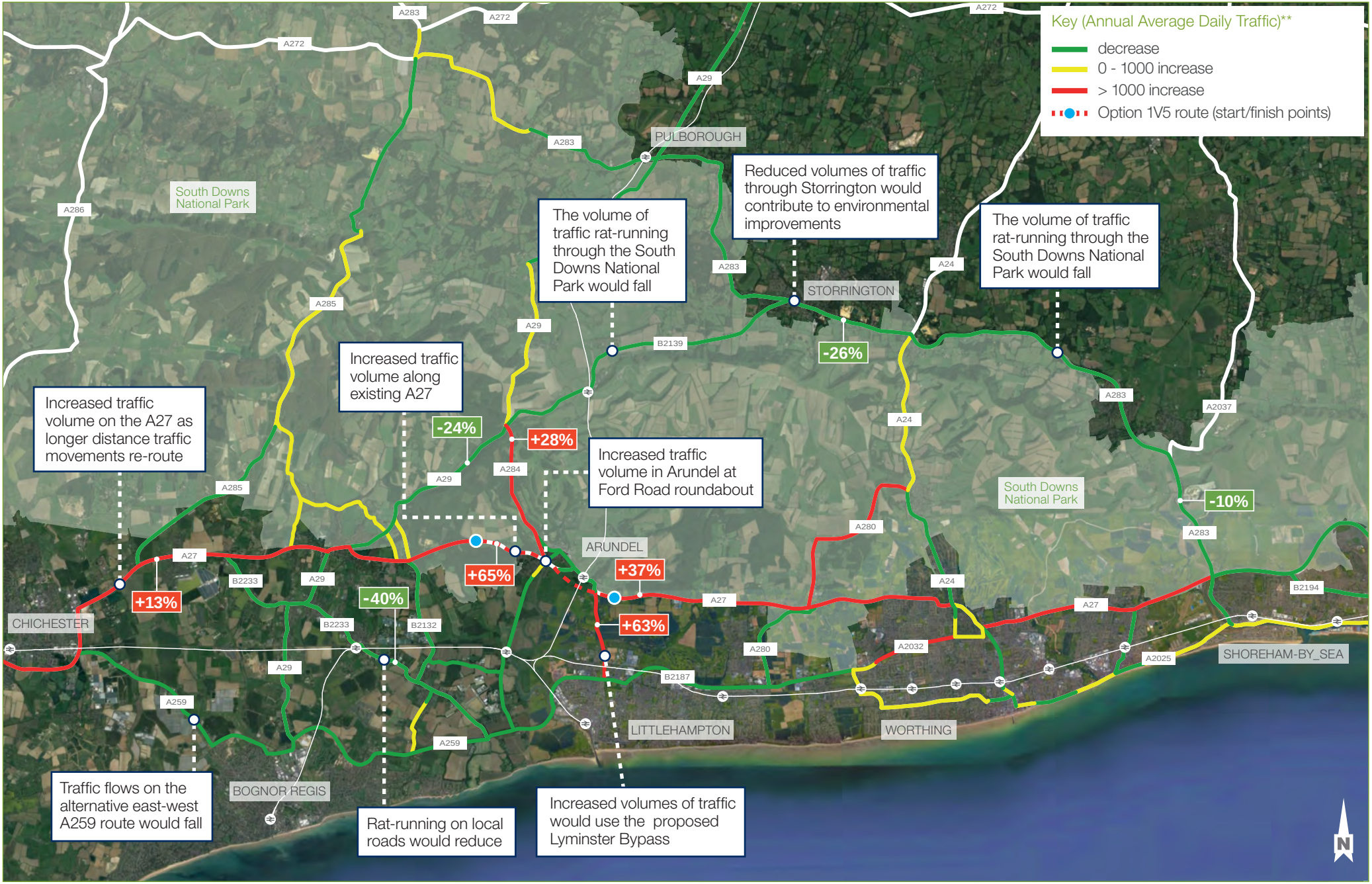
A27

Arundel Bypass

Traffic heat maps

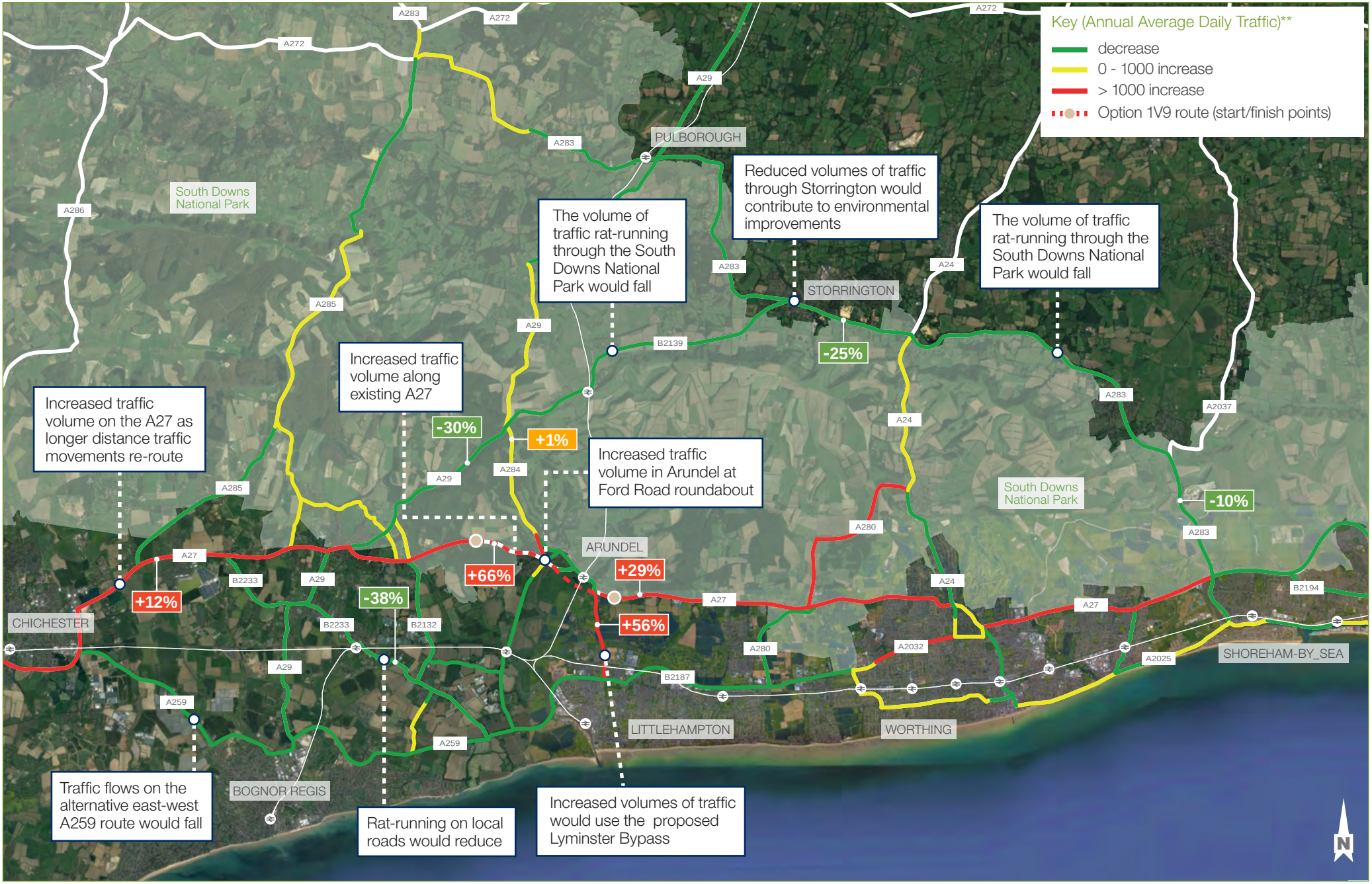
Change in traffic in 2041 compared to 'Do minimum'*: Cyan (Option 1V5)



This map is a diagrammatic representation. Not to scale.

*'Do minimum' refers to a scenario whereby the Arundel Bypass would not go ahead, but other improvements would be made elsewhere.
**Annual Average Daily Traffic - the daily total flow of vehicles (in both directions) averaged across the year.

Change in traffic in 2041 compared to 'Do minimum'*: Beige (Option 1V9)



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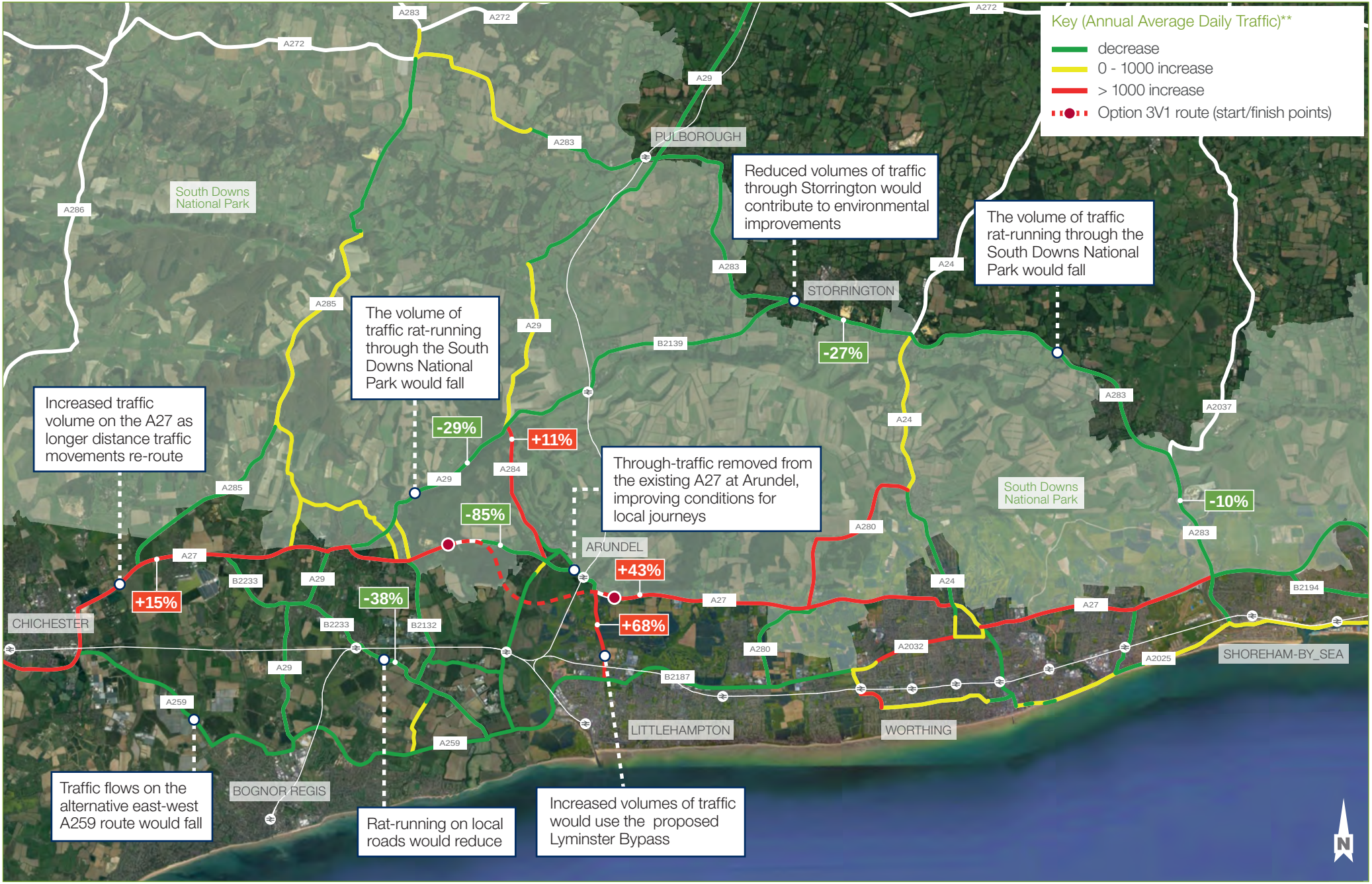
**Annual Average Daily Traffic - the daily total flow of vehicles (in both directions) averaged across the year.

Change in traffic in 2041 compared to 'Do minimum'*: Crimson (Option 3V1)



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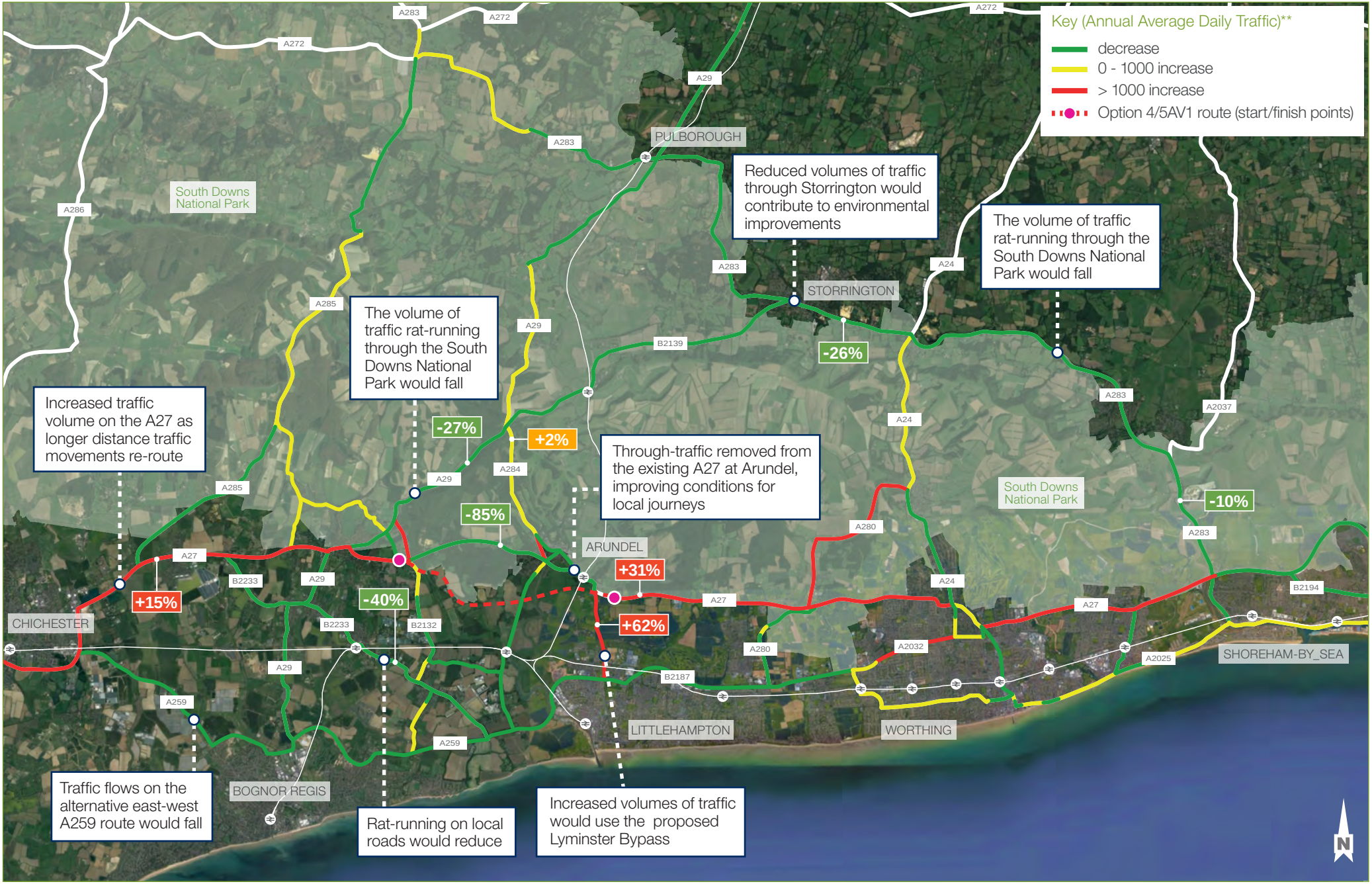
**Annual Average Daily Traffic - the daily total flow of vehicles (in both directions) averaged across the year.

Change in traffic in 2041 compared to 'Do minimum'*: Magenta (Option 4/5AV1)



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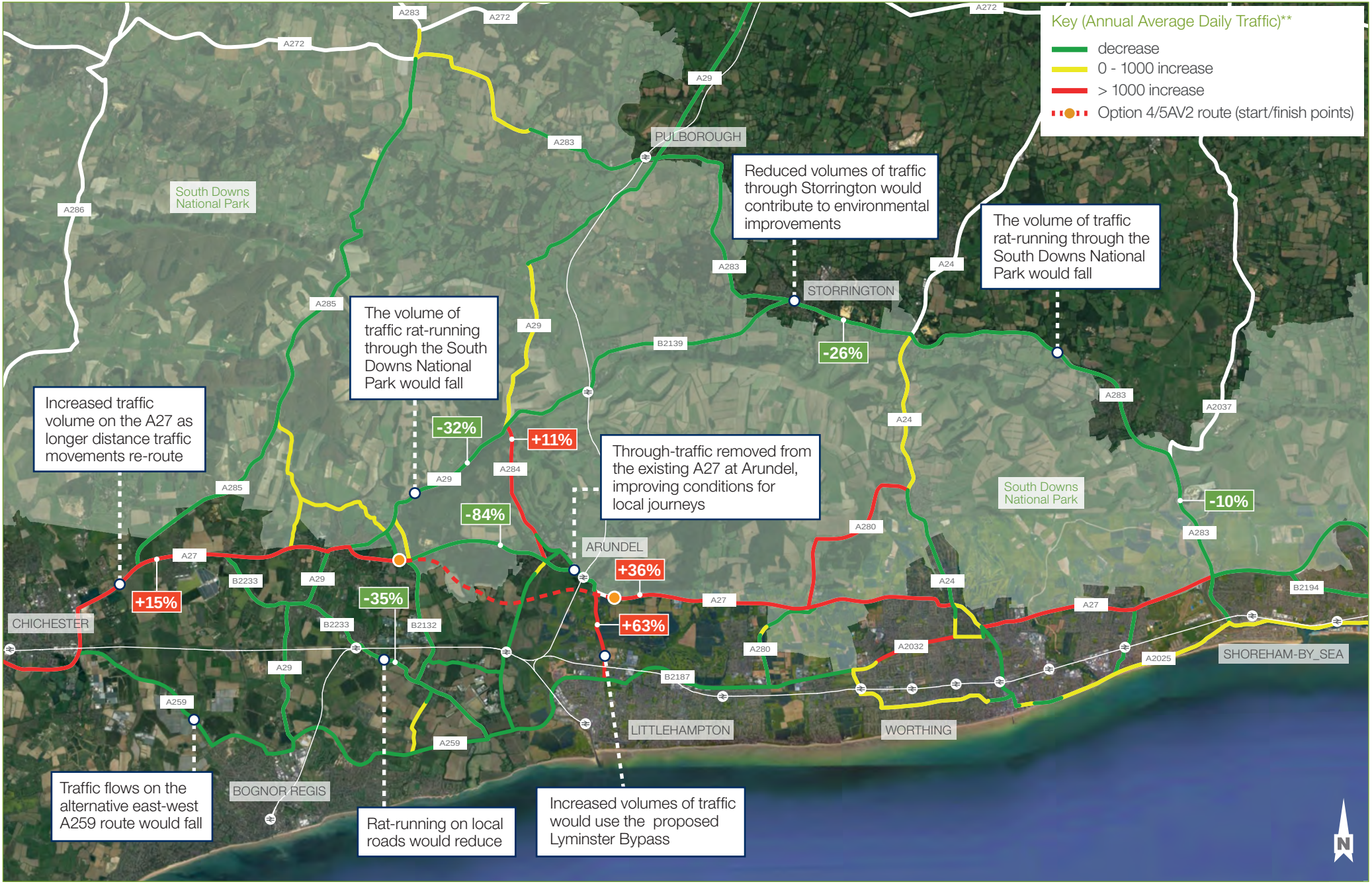
Change in traffic in 2041 compared to 'Do minimum'*: Amber (Option 4/5AV2)



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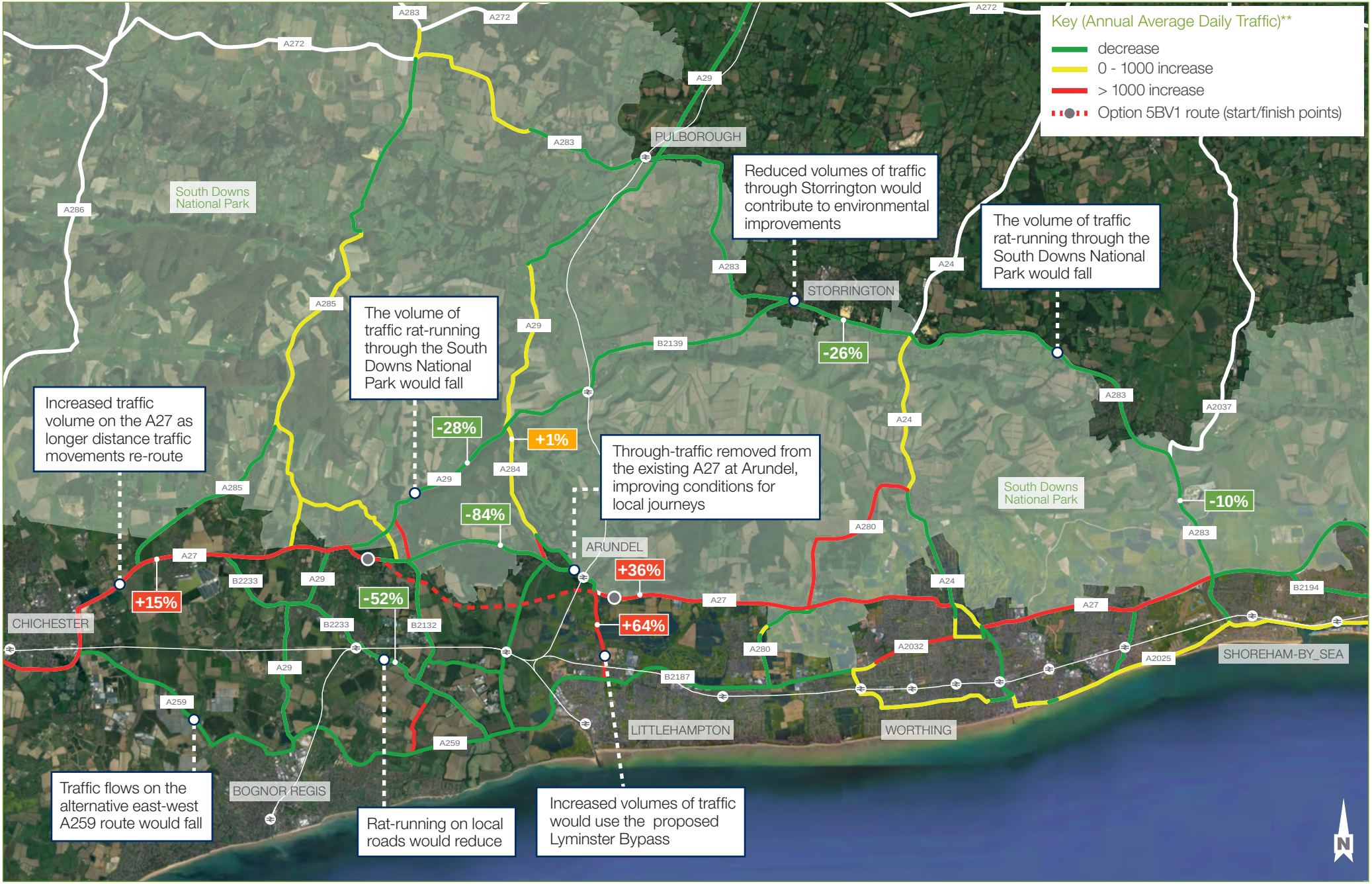
**Annual Average Daily Traffic - the daily total flow of vehicles (in both directions) averaged across the year.

Change in traffic in 2041 compared to 'Do minimum'*: Grey (Option 5BV1)



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A27 Arundel Bypass
Report on Further Consultation

Appendix B: Code descriptions (with associated frequencies from analysis)

Responses – number of coded comments

Code	Responses
Concerns about environmental impact (biodiversity – habitats, animals, woodland)	3,346
Concerns about environmental impact (ancient woodland)	2,869
Support 'Arundel Alternative' (wide single carriageway)	2,508
Concerns about climate change	2,160
Further consultation materials - misleading or incorrect information/biased/leading questions	1,970
Concerns about environmental impact (landscape - visual)	1,838
Protecting the environment should be main priority	1,672
Consider alternative route/location/timing	1,638
Spend money on alternatives - eg improved public transport/invest in sustainable transport	1,116
Concerns about impact on local villages/communities	1,080
Concerns about environmental impact (South Downs National Park)	1,053
Do not support scheme at all	981
Lack of bus services/public transport	941
Use this as an opportunity to improve walking, cycling, horse riding provision	909
Concerns about environmental impact (general)	805
Concerns about environmental impact (air quality)	734
Concerns about environmental impact/destruction (countryside)	679
New roads create more traffic	646
Concerns about environmental impact (noise and vibration)	526
Comments unrelated to scheme	499
Most affordable/cost effective/cheapest option	459
Encourage a move away from car use	448
Concerns about environmental impact (drainage and water - floodplains)	444
Do not support a particular option	428
Looks good/support/will help/provides a solution/the best of the six proposed options	423
Should not be dualled (particularly through the town)/should be single carriageway only	393
Concerns for health/well being	347
Less environmental impact (general)	320
Ford Road: current layout has lack of cycle paths and footpaths	308
Congestion/traffic flow (general)	307

Concerns about rat running	293
Concerns will just move the problem further down the A27	280
Will have greatest impact on traffic flow/congestion - general	269
Minimises impact on local villages/communities	258
Concerns about impact on Arundel (severance - splits Arundel in two)	242
Congestion (delays at either end of the scheme, i.e. Chichester & Worthing Lancing)	240
Further consultation materials (maps/visualisations/materials) need to be larger/include more detail/in more formats (fly-throughs etc)	236
Concerns about environmental impact (archaeology and cultural heritage)	228
Concerns about environmental impact (light pollution)	227
Concerns about impact on Binsted village	227
The sooner it happens the better/get on with it	222
Less environmental impact - (biodiversity – habitats, animals, woodland)	216
Concerns about impact on businesses	203
Waste of time/money	195
Concerns about road safety issues/dangerous (vehicles)	190
Further consultation process: concern that opinions won't be listened to/anti-campaigners are more vocal and have more influence	189
Congestion (Arundel)	186
Concerns about impact on future generations	186
Worst option for the community/residents (Binsted)	183
Less environmental impact/destruction (countryside)	179
Concerns about impact of construction (disruption)	170
Something needs to be decided as it has been delayed for over 30 years/long overdue	167
Will not improve congestion	160
Need for traffic calming measures (as part of proposals), eg. no through road signs/reduced speed limits (50/60mph)/speed cameras	158
Concerns about environmental impact (Binsted Woods)	157
Concern for safety issues/dangerous for pedestrians, cyclists and horse riders	155
Need a bypass	150
Worst option for the community/residents (Arundel)	144
Does not meet requirement for a proper dual carriageway bypass around Arundel	144
Least disruptive option	144

Further consultation materials: informative/well-presented/comprehensive	144
Cycle routes/footpaths/bridleways are needed and suitable crossing points	142
Concerns about impact on Walberton village	140
Questionnaire - too many yes or no questions/ repetitive questions/confusing	138
Further consultation process: poorly conducted	138
Does not offer a long-term solution/is not sufficient to meet future demand	137
Include 'Arundel Alternative' in consultation	136
Makes sense to follow line of existing route	130
Support viaduct	127
Less environmental impact (South Downs National Park)	124
Need to look at the A27 as a whole	124
Least affordable/cost effective/most expensive option	122
Congestion (Crossbush junction)	120
Will reduce accidents/improve road safety	116
Less environmental impact (air quality)	114
Offers poor value for money	114
Congestion (peak time)	111
Separates/divides communities (existing issue)	99
Worst option for the community/residents (Walberton)	96
Further consultation process: unhelpful staff/no local knowledge	95
Concerns about loss of land/gardens	94
Concern that scheme will encourage too much future development	93
Process too long/too many consultations	90
More information needed	88
Congestion (A27 congestion pushes traffic/congestion elsewhere i.e., local roads/villages)	83
Need to accommodate new housing developments being built in wider area	80
Concerns about impact on tourism in the local area	80
Further consultation process: appreciate opportunity to comment/ knowledgeable staff/good range of venues	79
Congestion (Ford Road roundabout)	78
The worst option	78
Less environmental impact (ancient woodland)	76
Impact of new housing on traffic	75

Traffic is only a problem at weekends/occasionally/clears quickly	73
Less impact on climate change	73
Poor rail connectivity	73
Too many vehicles on road	73
Traffic lights slow down traffic	72
Plant trees for mitigation	71
Concern about the need for houses to be demolished	70
Not suitable for trunk route/heavy volumes of traffic	69
Concerns about impact on quality of life	69
Most logical route/sensible option	69
Will improve the current situation	67
Concerns that all options will be over budget/over time	66
The money saved (compared with more expensive options) could be used to repair roads/improve public transport	63
Second preference	63
Unreliable journey times	62
Accesses onto/from the A27 (not enough)	62
Support the option that is best for the environment	62
Concerns about impact on Arundel (general)	60
Best option for the community/residents (Arundel)	59
Need to separate local and through traffic	58
People/property should be given priority over environment	58
Worst for accidents/road safety	57
Existing road is adequate/fit for purpose/no traffic issues	56
Concerns about closure of existing walking/cycling/horse riding provisions	56
Congestion (impacts on Storrington from A27 congestion)	54
Concerns about environmental impact (Arun Valley)	54
Concerns about proposed through-about	52
Has less of a negative impact than other options	52
Concerns about lack of access at Ford Road/need junction at Ford Road	52
Pedestrian crossings slow down traffic	51
Consider tunnelling	50
Consider impact of other residential/commercial developments on traffic volumes/flows	49
Build the best not the cheapest/spend wisely	49
Widen/redesign existing carriageway	48
Less environmental impact (noise and vibration)	47

Shortest/direct route	46
Less impact on businesses	45
Will not improve capacity/journey time of A27	44
More expensive and gives no extra benefits	44
Offers best long-term solution/future proof	44
Need new dual carriageway	44
Disruption to business journeys/deliveries	43
Need flyover/grade separated junction/longer term solution at Ford Road	42
Need to work with West Sussex County Council/other parties on wider network (e.g. A259)	42
Meets the requirement for a proper dual carriageway bypass around Arundel	41
Congestion (caused by events/holidays)	40
Negative impact on regional economy	39
Less impact on property/does not destroy property	38
Further consultation materials - maps/visualisations are inaccurate	37
Support offline option	37
Poor junction/design/road markings/signage needs improvement	35
Will reduce rat running on local roads	34
Best option for the community/residents (Binsted)	34
Comments about costs of consultation process	34
Improves capacity/journey time of A27	33
Positive impact on regional economy	33
Negative impact of A27 on businesses	33
Cheapest option is not the best solution	33
Further consultation materials - no information about expanding public transport	33
Short journeys/commuter traffic using road instead of alternatives (if it was available)	32
Ancient woodlands should not be given priority/not an issue	32
Need better solution for Ford Road roundabout (e.g. left turn on/off junction)	32
Will reduce traffic in Arundel	32
Concerns about impact on Tortington village	32
Concerns about increase in LGVs/HGVs	32
Oppose routes that impact on agricultural land	32
Will alleviate/ease peak time traffic/congestion	31

Include green bridges in the scheme proposals (to improve connectivity for wildlife habitats)	31
Most disruptive option	31
Will not improve pollution	30
Support the option that has the least impact on local communities	30
Oppose online option	30
Existing single carriageway causes congestion	29
Less environmental impact (landscape - visual)	29
Concerns about access to railway station	29
Concerns about job losses	29
Secure more funding	29
Does not remove traffic from the town/pushes more traffic into the town	28
Existing railway/river bridge structurally unsafe	28
Oppose embankment	28
Best for reducing severance/segregation	27
Concerns about impact on Arundel (too close to Arundel)	27
Worst option for the community/residents (Tortington)	27
Concerns about the effects on properties near the route (particularly house prices)	26
Ford Road - concerns about increasing numbers of HGVs	26
Best option for the community/residents (Walberton)	26
Don't care which option - just do something	25
Accesses onto/from the A27 (not safe)	24
Will improve health/well being	24
Concerns about impact on Arundel (town centre and businesses)	24
Further consultation process - concerned about changes to information during the further consultation period	24
Concerns that additional funding will not be found	23
Events/exhibitions - should have been more/longer	23
Less environmental impact (drainage and water - floodplains)	22
Opposed to building in a national park	22
Concerns about impact on local riding school	22
Need greater provision of bridges and underpasses	22
Any option with a roundabout cannot improve the traffic flow	21
Further consultation materials - problem with on-line materials, PDF/ questionnaire	20
Will need more work doing in the future/does not sufficiently cater for future housing growth	19
Oppose offline option	19

Quickest/easiest to build	18
Concerns about access to hospital	17
Will not reduce traffic in Arundel	17
Previously supported Option 5A	17
Less environmental impact (archaeology and cultural heritage)	16
Needs of regional economy	17
Concerns about impact on emergency services response times	16
Concerns about impact on Slindon village	16
Will have positive impact on tourism	16
Opposed to the option that is most damaging to the environment	16
Oppose viaduct	16
Further consultation process - not accessible	16
Will take traffic away from the centre	15
Create environmentally friendly areas under raised roadway (bat boxes, nest boxes etc)	15
Concerns about increasing traffic flow through a residential area	15
Will improve quality of life	15
Worst option for the community/residents (Fontwell)	15
Support online option	15
Comments regarding plans for the existing A27 after construction of new road	14
Should be public choice - environment belongs to everyone and should be cherished, not destroyed	14
Comments on benefits for future generations	14
Re-evaluate traffic signal timings at Crossbush junction	14
Time lost for staff travelling to work	14
Minimal disruption during construction	14
Unnecessary length	14
Do not see need for both Beige and Cyan options	14
Further consultation process - not advertised widely enough	14
Offers greatest reduction in journey time	13
Offers worst reduction in journey time	13
Existing roundabouts east and west of Arundel cause delays	13
A sensitively designed road and bridges would not have any detrimental effect on the landscape	13
Best for future growth/development/expansion	13
Consider impact of other infrastructure e.g. Lyminster Bypass	13
More weight should be given to Sussex Wildlife Trust and their views	13
Less environmental impact (Binsted Woods)	12

Need acoustic screening included in proposals for mitigation	12
Concerns about new development in Walberton Parish (Avisford Grange)	12
Concern that funding will be withdrawn	12
Concerns that the scheme won't go ahead	12
Do not include any at-grade crossings/junctions	12
Better than Cyan (Option 1V5)	12
Third preference	12
Accesses onto/from the A27 (too many)	11
Access to Crossbush junctions	11
Would require further improvements (and therefore expenditure) in the future	11
Option will be outdated within 10 years	11
Support the option that is best for Arundel town centre	11
Further consultation materials - more information should be available on-line, video simulations etc	11
Will not improve traffic speed	10
Create more areas dedicated to countryside	10
Consider/allow for future widening to accommodate more traffic	9
Only option that improves routes for all users	9
Structures to be striking/eye-catching design	9
Opposed to the option that has the most impact on local communities	9
Concerns about safety (minor side road connections/driver confusion)	9
Provide vehicle emissions and air quality information for all options	8
Capacity likely to be exceeded before other options	8
Replace crossing next to train station with footbridge closer to roundabout	8
Need to improve footpaths along River Arun	8
Events/exhibitions - should have had one in Worthing	8
Does not separate local and long distance/through traffic	7
Less environmental impact (Arun Valley)	7
Concerns about access to cricket ground	7
Best option for the community/residents (Tortington)	7
The easiest to gain acceptance for	7
Easier for pedestrians	7
Support working together for longer term benefit	7
Better than Beige (Option 1V9)	7
Better than Magenta (Option 4/5V1)	7
Better than Amber (Option 4/5V2)	7

Concerns about impact/access to Arundel Baptist Church	6
Need to focus on link to Littlehampton	6
Most weight should be given to the national park authorities and their views.	6
Walkers/cyclists/horse riders should not use new A27 - should provide alternative routes	6
Support the option that is best for journey time	6
Better than Grey (Option 5BV1)	6
Prefer option that takes traffic away from existing housing	6
Previously discounted option should be considered	6
Less environmental impact (light pollution)	5
Need visual screening included in proposals for mitigation	5
Ford Road - on-street parking	5
Dangerous section from Crossbush junction	5
Worst option for the community/residents (Slindon)	5
Arundel will be gridlocked in the future without bypass	5
Opposed to the option that has least benefit to Arundel town centre	5
School-related traffic	4
Need bigger junction where option re-joins the A27 to avoid congestion	4
Ford Road - concerns about increasing traffic (due to development)	4
Concerns about impact on Fontwell village	4
Less impact on job losses	4
Concerns about access to White Swan	4
Disruption no different to existing issues	4
Support the option that is best for walkers/cyclists/horse riders	4
Will have greatest impact on traffic flow/congestion - peak time	3
Best option for the community/residents (Fontwell)	3
Will cause least disruption to staff and business travel	3
Concerns about access to local businesses at Park Farm	3
Arundel deserves better	3
Support embankment	3
Add a bus lane/hard shoulder	3
Best long-term solution for the environment	2
Concerns that congestion at Crossbush (eastbound traffic) will move to Ford Road	2
Concerns about noise impact (housing near Ford Road roundabout)	2
Will make it safer for pedestrians and cyclists travelling to Arundel	2
Will not make it safer for pedestrians and cyclists travelling to Arundel	2

Better than Crimson (Option 3V1)	2
Worse than Cyan (Option 1V5)	2
Less direct (route curves at the western end/sharp bends)	2
Option previously supported - not available	2
Need traffic lights for Ford Road	1
Best option for the community/residents (Crossbush)	1
Need to improve access to Arundel town centre	1
Best option for the community/residents (Slindon)	1
Concerns about conflict between cyclists and pedestrians on shared paths	1
Need pedestrian crossing on Ford Road by bus stop	1
Concern that design standards used have been superseded	1
Opposed to the option that has the least journey time benefit	1
Opposed to the option that has the least benefit for walkers/cyclists/horse riders	1
Worse than Magenta (Option 4/5V1)	1
Previously supported Option 3	1
Previous PRA option (5A) not supported	1
Less environmental Impact (Tortington Common)	0
Concerns about environmental impact (Tortington Common)	0
Worst option for the community/residents (Crossbush)	0
Concerns about impact on Crossbush village	0
Need to ensure there is an entrance off the new road to Arundel Station	0
Would be very difficult to upgrade in the future	0
Worse than Beige (Option 1V9)	0
Worse than Crimson (Option 3V1)	0
Worse than Amber (Option 4/5V2)	0
Worse than Grey (Option 5BV1)	0
Concerns that drivers won't use it as it's a longer route	0
Previously supported Option 1	0

A27 Arundel Bypass
Report on Further Consultation

Appendix C: Responses to coded issues raised (those not included in section 7)

Appendix C – responses to remaining coded issues raised

Code description	Highways England response
Consider impact of other residential/commercial developments on traffic volumes/flows	The traffic modelling undertaken includes the Department for Transport's traffic growth factors and assumptions on local changes in development (new housing and employment). The results showed that, whichever option were to be taken forward, the new road would operate within capacity in 2041 (at 85-90% capacity for Option 1V9, which includes the signalised 'through-about' junction; and at 45-60% for the other options). Journey times are predicted to be between 6 and 11 minutes shorter.
Build the best not the cheapest/spend wisely	A number of factors are considered to identify a preferred route for the scheme. These include: the extent to which the design meets the scheme objectives, building cost and value for money that this would offer, environmental impacts, and how well the option fits with local plans and national planning policy.
Widen/redesign existing carriageway	Option 0B, considered as part of a long-list of proposals identified during stage 1 of the scheme, would have involved widening the existing A27 carriageway. This option was rejected because it would have had a significant impact on properties alongside the existing A27, there were difficulties in providing a suitable alignment and there would have been difficulties providing the large number of accesses and junctions that would have been required on the route. The Beige (Option 1V9) and Cyan (Option 1V5) dual-carriageway options presented at the further public consultation follow the existing A27 corridor from the River Arun to the end of the existing dual carriageway section west of Arundel.
Will not improve capacity/journey time of A27	The results of the traffic modelling showed that, whichever option were to be taken forward, the new road is predicted to operate within capacity in 2041 (at 85-90% capacity for Option 1V9, which includes the signalised 'through-about' junction; 45-60% for the other options). Journey times for all options are predicted to be between 6 and 11 minutes shorter.

Code description	Highways England response
More expensive and gives no extra benefits	A range of factors will be considered as part of the process to identify a new preferred route for the scheme, including: § The extent to which the design meets the scheme objectives § How well the chosen option fits with local plans and planning policy as set out in the National Networks National Policy Statement § Build cost and the value for money that this would offer § Stakeholder support and feedback from the public consultation With specific reference to the economic assessments, all our road schemes must demonstrate how the costs of the scheme compare to the benefits. This is known as the Benefit to Cost Ratio (BCR). As set out by the Department for Transport (DfT), benefits include journey time savings and safety improvements, while costs include the funding needed to develop the scheme, maintenance and construction fees and the purchase of any land required. The relative BCR ranges for each option were published on page 29 of the consultation brochure (included in Appendix A). We also calculate an overall Value for Money assessment, which includes more than just the BCR and also takes account of all expected effects, risks and uncertainty. Our Value for Money assessment showed that each option would represent 'Medium' value for money. Highways England considers the full range of information in our appraisal of the options. This includes the level of benefit relative to its cost (BCR and value for money), the total amount of economic benefit, and the quantity of transport benefits (such as total reductions in delay and improved journey time). In general terms, the more expensive options achieve overall greater levels of benefit than the less expensive options.
Need new dual carriageway	Congestion and delays around Arundel are already commonplace. Forecast population growth in the area means that these issues are expected to worsen in coming years in a 'do-nothing' scenario. Replacing the existing single carriageway section with a new dual carriageway will help resolve many of these issues.

Code description	Highways England response
Disruption to business journeys/deliveries	We continue to work closely with local business groups to inform the development of the scheme and understand that, as with other sections of the community, different views exist about the best long-term solution for the area. However, we remain confident that improving connectivity will help boost productivity and make the area more attractive as a place to invest. We are also aware that pockets of deprivation exist around the area. Improving the local infrastructure will help tackle this inequality by making it easier for people to access employment opportunities across the area. With specific reference to construction impacts, we'll work closely with local stakeholders, including the business community, to plan the works and keep any disruption to a minimum.
Need flyover/grade separated junction/ longer term solution at Ford Road	We took a fresh look at the full range of possible route alignments, after announcing our intention to conduct further consultation on the options. These were grouped and sifted, according to compliance with the scheme objectives and legal and national planning policy tests, including consideration of environmental impacts. The proximity of Ford Road to Arundel and the surrounding residential areas means there is insufficient space for a grade separated junction with the A27.
Need to work with West Sussex County Council/other parties on wider network (eg A259)	We operate, maintain and improve England's motorways and major A roads and work collaboratively with local highways authorities as appropriate, including West Sussex County Council, to identify and deliver complementary improvements that benefit both strategic and local routes. West Sussex County Council has been engaged from the outset on the A27 Arundel Bypass scheme and we look forward to continuing to work with the County Council as the scheme progresses. For example, we note that the County Council recognised that the preferred route design will need to be refined to ensure that access routes are maintained and, in some cases, ensure that any undesirable effects on the local road network are managed effectively. We look forward to working with the County Council to identify appropriate mitigation measures.

Code description	Highways England response
Congestion (caused by events/holidays)	We recognise concerns about congestion around Arundel caused by events and holidays. The visitor economy in West Sussex is a key driver of economic activity and is subject to the adverse impacts of constrained highway capacity, especially during busy holiday periods (Interim Scheme Assessment Report, August 2019). Forecast population growth in the area means that these issues are expected to worsen in coming years in a 'do-nothing' scenario. Replacing the existing single carriageway section with a new dual carriageway will help resolve many of these issues. The analysis we published as part of the consultation showed that a high proportion of traffic is predicted to use a new bypass in preference to the existing road and other routes to the north and south of Arundel. As a result, congestion would improve.
Negative impact on regional economy	We continue to work closely with local business groups to inform the development of the scheme and understand that, as with other sections of the community, different views exist about the best long-term solution for the area. However, we remain confident that improving connectivity will help boost productivity and make the area more attractive as a place to invest. We are also aware that pockets of deprivation exist around the area. Improving the local infrastructure will help tackle this inequality by making it easier for people to access employment opportunities across the area.
Less impact on property/does not destroy property	To a greater or lesser extent, all six options put forward for consideration have significant community and environmental sensitivities associated with them. We acknowledge that balancing the issues will not be easy, but we are committed to delivering the best long-term solution for the area. We look forward to continuing to work with the local authorities, other statutory bodies, community groups and others in order to do so.
Consultation materials - maps/visualisations are inaccurate	We recognise that some concerns were raised about the consultation materials and the way in which the process was conducted, while other respondents were very complimentary about the consultation. Public-facing materials included indicative maps and fly-through videos to help people understand the proposals. These were supplemented with other information such as text descriptions of the options. There were some suggestions that woodland areas in particular had not been accurately reflected. However, while only indicative, the maps were based on Ordnance Survey data and other government-issued data that were clearly labelled and available publicly. This base data was accurately reflected.

Code description	Highways England response
Poor junction/design/ road markings/signage needs improvement	More detailed design work will begin once the preferred route has been identified, and any negative impacts on the local road network will be assessed further during the next stage of the project, with mitigation proposals being developed accordingly.
Will reduce rat running on local roads	Congestion around Arundel results in some drivers seeking less suitable alternative routes, away from the existing A27. The effect of the various scheme options on rat runs through a broad cross section of routes have been depicted using the traffic 'heat maps', which were published during the further consultation (see Appendix A), including the B2233 Yapton Road through Barnham. In addition, section 9.5 of the Interim Scheme Assessment Report set out the change in flows on local roads such as Yapton Lane and Ford Road for all of the scheme options. One of the key effects of the scheme is to reduce the overall level of rat running on local roads within the area of the scheme.
Comments about costs of consultation process	Comments about the cost of conducting further consultation have been noted but, as new information came to light during the course of our work to develop the design of the previous preferred route, we felt it was important to give the local community the opportunity to comment on the revised options based on the latest information. The extent of engagement through the further consultation process demonstrates the level of interest in the scheme and we're grateful to all respondents who took the time to submit comments. We will continue working to deliver the best long-term solution for the area.
Negative impact of A27 on businesses	We continue to work closely with local business groups to inform the development of the scheme and understand that, as with other sections of the community, different views exist about the best long-term solution for the area. However, we remain confident that improving connectivity will help boost productivity and make the area more attractive as a place to invest. We are also aware that pockets of deprivation exist around the area. Improving the local infrastructure will help tackle this inequality by making it easier for people to access employment opportunities across the area.
Cheapest option is not the best solution	A number of factors are considered to identify a new preferred route, including: the extent to which the design meets the scheme objectives, building cost and value for money that this would offer, the effects on the heritage and cultural value of historic assets in Arundel, and how well the option fits with local plans and planning policy. Using Department for Transport and Highways England guidance, all the options presented at the public consultation are expected to deliver medium value for money considering both their costs and impacts.

Code description	Highways England response
Consultation materials - no information about expanding public transport	Page 10 of the further consultation brochure outlines information on public transport in the area. In summary, there is relatively low use of public transport and even a significant increase in public transport provision would be unlikely to solve the problems of queuing and congestion on the A27 around Arundel. Section 3.7 of the Interim Scheme Assessment report, which was published at the start of the further consultation, provides information on the lack of alternative modes of travel. The PCF Stage 2 Multi-Modal Study summarised the potential impact of public transport schemes and travel demand management. It concluded that whilst these options could move a small proportion of trips off the road network, the problems along the A27, and the objectives relating to the A27 Arundel Bypass, still had to be addressed.
Short journeys/ commuter traffic using road instead of alternatives (if it was available)	We are supportive of an increase in public transport, but we are not aware of any plans that would have a significant impact on the traffic levels along the A27 which would negate the need for intervention. Public transport operators also depend on good infrastructure and an improved A27 will help bus and coach operators to develop their services and will improve access to Arundel railway station. In line with our statutory duty, access will be maintained for pedestrians, cyclists and horse riders regardless of which option is taken forward. Some existing access routes may, however, need to be diverted. The scheme could also present opportunities to improve provision for walking, cycling and horse riding. These opportunities, which would include potential safety enhancements, will be explored further in the next stage of the process, once a new preferred route has been identified. Also, through our Designated Funds programme, we have specific funds available to improve the surroundings of the strategic road network in a way that supports and protects people and the things we value for quality of life, both now and in the future. In conjunction with local authorities, we're exploring opportunities to improve walking and cycling facilities along the A27.

Code description	Highways England response
Ancient woodlands (should not be given priority/not an issue	Ancient woodland and veteran trees are protected by national planning policy. We recognise that ancient woodland is irreplaceable and plants and animals in these areas depend on the stable and rare conditions that an ancient woodland provides. The design of the new preferred option will continue to be refined with the aim of avoiding ancient woodland loss insofar as possible, amongst other design objectives. Ancient woodland will continue to be included in the environmental assessments in further design stages due to its importance in national policy and as an environmentally sensitive habitat.
Need better solution for Ford Road roundabout (eg left turn on/off junction)	We received feedback from the 2017 consultation expressing interest in having a new junction with Ford Road. With the exception of Beige (Option 1V9), which would involve replacing the existing Ford Road junction with a new 'through-about' arrangement, the options put forward in this further consultation did not feature such a junction. The scheme design is flexible enough, however, that each of the 'offline' options could include a junction at Ford Road. As a result, this will be considered further during the next design stage, once we have identified a new preferred route.
Will reduce traffic in Arundel	The traffic volume analysis we published as part of the consultation (Chapter 12, Combined Modelling and Appraisal Report, August 2019) showed that risks relating to potential rat running through Arundel would be mitigated by the scheme. All options would reduce traffic volumes on the existing section of the A27 near Arundel station, with the 'offline' options forecast to result in a greater level of traffic volume reduction at Arundel than the 'online' options. This is due to high proportions of traffic forecast to re-route to use a new bypass in preference to the existing road and other routes to the north and south of Arundel. As a result, congestion would improve.

Code description	Highways England response
Concerns about impact on Tortington village	We understand the concerns that different sections of the community have raised about existing and potential future severance issues. Chapter 12 of the Environmental Assessment Report sets out our assessment of the options' impacts on population and health, while Chapter 11 of the final Scheme Assessment Report presents a summary of social and distributional impact appraisal of the scheme options. To a greater or lesser extent, all six options put forward for consideration have significant community and environmental sensitivities associated with them. Severance issues associated with Tortington were identified in Chapter 12 of the Environmental Assessment Report. Potential measures to address community severance (such as maintaining public rights of way) are provided in Section 12.9 of the Environmental Assessment Report. The report also identifies that there may be noise effects during the operational phase for existing properties in Tortington as a result of the 'offline' options. Typical noise mitigation measures that could be employed across the entire scheme footprint for all options are provided in Chapter 11 of the Environmental Assessment report and these measures will continue to be refined in further design stages for the new preferred option. We acknowledge that balancing these issues will not be easy, but we are committed to delivering the best long-term solution for the area. We look forward to continuing to work with the local authorities, other statutory bodies, community groups and others in order to do so.
Concerns about increase in LGVs/HGVs	Congestion around Arundel results in some drivers seeking less suitable alternative routes, away from the existing A27. The effect of the various scheme options on rat runs through a broad cross section of routes have been depicted using the traffic 'heat maps', which were published during the further consultation (see Appendix A), including the B2233 Yapton Road through Barnham. In addition, section 9.5 of the Interim Scheme Assessment Report set out the change in flows on local roads such as Yapton Lane and Ford Road for all of the scheme options. One of the key effects of the scheme is to reduce the overall level of rat running on local roads within the area of the scheme.

Code description	Highways England response
Oppose routes that impact on agricultural land	We continue to work closely with local business groups to inform the development of the scheme and understand that, as with other sections of the community, different views exist about the best long-term solution for the area. However, we remain confident that improving connectivity will help boost productivity. Potential effects on agricultural land holdings are considered in Chapter 12 of the Environmental Assessment Report. Best and most versatile agricultural land take is considered in Chapter 9 of the Environmental Assessment Report. Typical measures to avoid or reduce effects on agricultural land are presented in Section 12.9 of the Environmental Assessment Report. Mitigation measures will continue to be developed through further stages of the project for the new preferred option. With specific reference to construction impacts, we'll work closely with local stakeholders, including the business community, to plan the works and keep any disruption to a minimum.
Will alleviate/ease peak time traffic/congestion	The analysis we published as part of the consultation showed that a high proportion of traffic is predicted to use a new bypass in preference to the existing road and other routes to the north and south of Arundel. As a result, congestion would improve.

Code description	Highways England response
Include green bridges in the scheme proposals (to improve connectivity for wildlife habitats)	The development of environmental management measures (avoidance, mitigation, offsets, compensation, and enhancements) has been developed to a conceptual level in the Environmental Assessment Report, appropriate for the stage the scheme is at (PCF Stage 2). This follows DMRB guidance and Interim Advisory Notes (IANs) and is considered to be proportionate and appropriate to the current option selection stage of the project. We recognise that the area around Arundel is very special in environmental terms and, during PCF Stage 3, intend to take a landscape-led approach to balance the challenges of delivering improvements to the road network here as effectively as possible. These challenges include the need to reduce congestion and provide sufficient capacity on the A27 over the long-term, while minimising impacts on local communities and seeking to protect and enhance the quality of the surrounding environment, where possible. Once a new preferred route has been identified, we look forward to working closely with the relevant statutory bodies and other key stakeholders to inform our landscape-led approach and identify appropriate mitigation and enhancement measures as the project progresses. In the meantime, the development of the environmental management hierarchy and environmental constraints have been considered in the development of the current stage designs. A biodiversity mitigation approach document (EAR Appendix 8-12: Ecological Mitigation Approach) was prepared to outline the proposed approach to the next stage of the design of mitigation measures, which will be undertaken for the new preferred option at PCF Stage 3. This will include consideration of the appropriateness of implementing green bridges as part of the scheme.
Will not improve pollution	An air quality assessment, which is the recognised means of assessing air quality impacts for road schemes, was completed in accordance with the requirements of DMRB and Highways England guidance. The results and conclusions have been presented in Chapter 5, and accompanying appendices, of the Environmental Assessment Report. As outlined in the consultation brochure, there is predicted to be no significant adverse effect during the operational phase of any route option. There would be a low risk of any option not complying with EU ambient air quality limit values and nitrogen dioxide concentrations would be expected to reduce within the Storrington Air Quality Management Area.

Code description	Highways England response
Support the option that has the least impact on local communities	To a greater or lesser extent, all six options put forward for consideration have significant community and environmental sensitivities associated with them. We acknowledge that balancing these issues will not be easy, but we are committed to delivering the best long-term solution for the area. We look forward to continuing to work with the local authorities, other statutory bodies, community groups and others in order to do so.
Oppose 'online' option	We took a fresh look at the full range of possible route alignments, after announcing our intention to conduct further consultation on the options. These were grouped and sifted, according to compliance with the scheme objectives and legal and national planning policy tests, including consideration of environmental impacts. Our technical work concluded that six options, including the two 'online' options, should be put forward for consideration as part of this further consultation.
Existing single carriageway causes congestion	We recognise concerns about congestion around Arundel, the importance of the A27 to the area and the challenges that unpredictable travel times can present for different types of journey. Forecast population growth in the area means that these issues are expected to worsen in coming years in a 'do-nothing' scenario. Replacing the existing single carriageway section with a new dual carriageway would help resolve many of these issues.
Concerns about access to railway station	Regardless of which option is taken forward, access to Arundel railway station will be maintained.
Concerns about job losses	We continue to work closely with local business groups to inform the development of the scheme and understand that, as with other sections of the community, different views exist about the best long-term solution for the area. However, we remain confident that improving connectivity will help boost productivity and make the area more attractive as a place to invest. We are also aware that pockets of deprivation exist around the area. Improving the local infrastructure will help tackle this inequality by making it easier for people to access employment opportunities across the area.
Secure more funding	The Road Investment Strategy 1 (RIS1) budget allocated to the scheme at the time of the further public consultation was £100-£250 million. If there is an appropriate case to be made, we will explore options for securing additional funding in RIS 2, while also working with our suppliers to minimise scheme costs through value engineering and contractual efficiencies.
Concerns that additional funding will not be found	
Concern that funding will be withdrawn	

Code description	Highways England response
Does not remove traffic from the town/pushes more traffic into the town	To a greater or lesser extent, all six options put forward for consideration have significant community and environmental sensitivities associated with them. We acknowledge that balancing these issues will not be easy, but we are committed to delivering the best long-term solution for the area. We look forward to continuing to work with the local authorities, other statutory bodies, community groups and others in order to do so. The analysis we published as part of the consultation showed that a high proportion of traffic is predicted to use a new route in preference to the existing A27 and other roads to the north and south of Arundel. As a result, congestion would improve.
Existing railway/river bridge structurally unsafe	The condition of bridges/structures and other assets on the existing A27 would be considered as part of an agreement with WSCC about the 'detrunking' and transfer of responsibility of the existing A27. This agreement will be developed during the next stage of Scheme development.
Oppose embankment	The environmental assessments conducted to date assumed that the route would be built on an embankment across the River Arun floodplain. The assumption of an embankment was made as it was both a lower cost option and a higher environmental impact option. The higher potential environmental impacts meant a conservative, precautionary approach was taken to the assessments. The scheme options could all alternatively be built with a partial or full viaduct across the flood plain. We acknowledge the views from the Environment Agency, Forestry Commission, Natural England and South Downs National Park Authority in relation to the preference for a viaduct, as opposed to embankment design solution, on the grounds of visual impact, as well as operational benefits in the mitigation/minimising of biodiversity severance. A decision on this will be taken once a new preferred route is confirmed and more detailed design work is undertaken.
Best for reducing severance/segregation	To a greater or lesser extent, all six options put forward for consideration have significant community and environmental sensitivities associated with them. We acknowledge that balancing these issues will not be easy, but we are committed to delivering the best long-term solution for the area. We look forward to continuing to work with the local authorities, other statutory bodies, community groups and others in order to do so.

Code description	Highways England response
Concerns about impact on Arundel (too close to Arundel)	Four of the options presented at the further consultation proposed a route to the south of Arundel, which would reduce the community impacts on the town, while two followed the existing A27 corridor through Arundel. However, to a greater or lesser extent, all six options put forward for consideration have significant community and environmental sensitivities associated with them. We acknowledge that balancing these issues will not be easy, but we are committed to delivering the best long-term solution for the area. We look forward to continuing to work with the local authorities, other statutory bodies, community groups and others in order to do so.
Worst option for the community/residents (Tortington)	To a greater or lesser extent, all six options put forward for consideration have significant community and environmental sensitivities associated with them. Severance issues associated with Tortington are identified in Chapter 12 of the Environmental Assessment Report. Potential measures to address community severance (such as maintaining public rights of way) are provided in Section 12.9 of the Environmental Assessment report. The report also identifies that there may be noise effects during the operational phase for existing properties in Tortington as a result of the offline options. Typical noise mitigation measures that could be employed across the entire scheme footprint for all options are provided in Chapter 11 of the Environmental Assessment report and these measures will continue to be refined in further design stages for the new preferred option. We acknowledge that balancing these issues will not be easy, but we are committed to delivering the best long-term solution for the area. We look forward to continuing to work with the local authorities, other statutory bodies, community groups and others in order to do so.
Concerns about the effects on properties near the route (particularly house prices)	All potentially affected landowners were invited to attend a separate session at a number of the consultation events. This gave them the opportunity to discuss how the options could impact on their property. We will continue to engage with affected landowners on an individual basis once a new preferred route has been identified.

Code description	Highways England response
Ford Road - concerns about increasing numbers of HGVs	The A27 Ford Road roundabout is currently used by HGVs as an access point to the strategic road network (SRN). This includes traffic associated with the industrial estate to the south of Arundel, on Ford Road. The scheme would improve the capacity and performance of other primary access points to the SRN (A284 Crossbush junction). The traffic volume analysis published as part of the further consultation (Chapter 12, Combined Modelling and Appraisal Report, August 2019) showed that each option would have the general effect of reducing the level of rat running on local roads, including Ford Road. Therefore, the scheme would mitigate risks associated with the potential for increasing numbers of HGVs on Ford Road.
Don't care which option - just do something	These comments have been noted.
Accesses onto/from the A27 (not safe)	We will examine the design of the proposed junctions onto the scheme in more detail at the next stage of development taking into account the feedback received from local residents.
Concerns about impact on Arundel (town centre and businesses)	To a greater or lesser extent, all six options put forward for consideration have significant community and environmental sensitivities associated with them. We acknowledge that balancing these issues will not be easy, but we are committed to delivering the best long-term solution for the area. We look forward to continuing to work with the local authorities, other statutory bodies, community groups and others in order to do so. We continue to work closely with local business groups to inform the development of the scheme and understand that, as with other sections of the community, different views exist about the best long-term solution for the area. However, we remain confident that improving connectivity will help boost productivity and make the area more attractive as a place to invest.

Code description	Highways England response
Further consultation process - concerned about changes to information during further consultation period	Extensive analysis was completed ahead of this consultation to assess the options and in-depth information was published about the proposed options. Presenting this level of information in a clear and concise way that enabled respondents to submit informed comments was challenging, but we are pleased that nine out of 10 respondents who submitted a response form found the materials useful to some extent. Once corrections had been identified to the supporting technical documents during the consultation period, we worked quickly to publicise updated consultation materials and ensure that all consultees could access the latest information and provide feedback to inform the decision on the preferred route announcement. We recognise that some concerns were raised about the consultation materials and the way in which the process was conducted, while other respondents were very complimentary about the consultation. Similarly, a high proportion of attendees found our staffed exhibitions helpful, although others were less satisfied.
Events/exhibitions - should have been more/longer	A total of 10 further consultation exhibitions, including two in our consultation van, were held across the area over an eight-week period. The venues were selected according to a number of criteria, including accessibility by different modes of transport, ease of access for disabled people, capacity, layout, availability on required dates and location in proximity to the A27. The suitability of different locations was also discussed with the A27 Arundel Focus Group, which included local authority and statutory environmental body representatives. We ensured the exhibitions took place on different days of the week, including weekends, as well as at different times of the day. The exhibitions were all well-attended, but it's also important to note that they were only one of a range of channels through which people were able to access the information they needed about the proposals in order to respond to the consultation. We therefore consider the approach to be proportionate.

Code description	Highways England response
Opposed to building in a national park	We recognise the importance of the National Park and its special qualities, as outlined in the scheme objectives, and continue to engage with the South Downs National Park Authority to inform the development of the scheme and minimise/mitigate impacts as far as possible. Landscape and Visual Impact Assessment is one of a number of important environmental topics considered in the assessments, as set out in the Environmental Assessment Report. A range of other parameters (traffic and transport performance, benefit to cost ratio, safety etc) are also considered. The scope and methods for a bespoke assessment specific to the Special Qualities of the National Park were discussed with the South Downs National Park Authority. We subsequently prepared a specific assessment of the impacts of the scheme options on the special qualities of the National Park. The results of this assessment, which includes analysis of impacts on the Park's setting and the wider visual landscape, are provided in Environmental Assessment Report Appendix 1-1.
Concerns about impact on local riding school	More detailed design work will begin once the new preferred route has been identified, and any negative impacts on the public rights of way network will be assessed further during the next stage of the project, with mitigation proposals being developed accordingly.
Need greater provision of bridges and underpasses.	More detailed design work will begin once the preferred route has been identified, and any negative impacts on the local road network will be assessed further during the next stage of the project, with mitigation proposals being developed accordingly. We note that West Sussex County Council recognised that the preferred route design will need to be refined to ensure that access routes are maintained and, in some cases, ensure that any undesirable effects on the local road network are managed effectively. We look forward to working with the County Council as local highway authority to identify appropriate mitigation measures.
Any option with a roundabout cannot improve the traffic flow	Of the six options presented at the public consultation Beige (Option 1V9) is the only option which has an at-grade junction located along the route. The size and layout of the junction presented at the further consultation had been designed to accommodate traffic up to 15 years after opening. After this, the traffic forecasts predict there would be an increased risk of congestion returning with this option.

Code description	Highways England response
Consultation materials - Problem with online materials, PDF/ questionnaire	Extensive analysis was completed ahead of this consultation to assess the options and in-depth information was published about the proposed options. Presenting this level of information in a clear and concise way that enabled respondents to submit informed comments was challenging, but are pleased that nine out of 10 respondents who submitted a response form found the materials useful to some extent. A relatively small number of respondents commented that they had difficulty navigating the online portal that hosted the consultation materials. While it is reassuring that these respondents were able to submit comments, we strive to ensure our online information is presented in a clear and accessible way and that alternative means of responding are available for anyone who needs them. The overall response rate in this case represents a good level of engagement and we are satisfied that the approach was effective, but we keep the usability of our communications channels under review and these comments will help inform the planning of future engagement exercises.
Consultation materials - More information should be available online, video simulations etc	
Will need more work doing in the future/does not sufficiently cater for future housing growth	The traffic modelling that was undertaken included the Department for Transport's traffic growth factors, assumptions on local changes in development (new housing and employment) and changes to the certainty of other transport schemes within the local area. The results showed that, whichever option were to be taken forward, the new road is expected to operate within capacity in 2041 (at 85-90% capacity for Option 1V9, which includes the signalised 'through-about' junction; 45-60% for the other options). Journey times are predicted to be between 6 and 11 minutes shorter.
Oppose 'offline' option	We took a fresh look at the full range of possible route alignments, after announcing our intention to conduct further consultation on the options. These were grouped and sifted, according to compliance with the scheme objectives and legal and national planning policy tests, including consideration of environmental impacts. Our technical work concluded that six options, including four offline options, should be put forward for consideration as part of this further consultation.
Concerns about access to hospital	Access to the hospital would vary between the two 'online' options. For Cyan (Option 1V5), a new access would be created off the A284. For Beige (Option 1V9), there would be a left-in /left-out junction using the eastbound carriageway. For Crimson (Option 3V1), Amber (4/5AV2), Magenta (Option 4/5AV1) and Grey (Option 5BV1) the existing access to the hospital would remain the same as it currently is.

Code description	Highways England response
Needs of regional economy	We are confident that improving connectivity will help boost productivity and make the area more attractive as a place to invest. We are also aware that pockets of deprivation exist around the area and hope that improving the local infrastructure will help tackle this inequality by making it easier for people to access employment opportunities across the area.
Concerns about impact on emergency services response times	Replacing the existing single carriageway section with a new dual carriageway will help resolve many of the existing issues. The traffic modelling that was undertaken shows that journey times are predicted to be between 6 and 11 minutes shorter for all options. Our analysis also shows that a high proportion of traffic is predicted to use a new bypass in preference to the existing road and other routes to the north and south of Arundel. The traffic 'heat maps' we published during consultation, and which are available on our website (www.highwaysengland.co.uk/a27arundel), show how the options would help to resolve this issue.
Concerns about impact on Slindon village	We understand the concerns that different sections of the community have raised about existing and potential future severance issues. Chapter 12 of the Environmental Assessment Report sets out our assessment of the options' impacts on population and health, while Chapter 11 of the final Scheme Assessment Report presents a summary of social and distributional impact appraisal of the scheme options. Communities to the north of the scheme options, including Slindon, are considered unlikely to be affected by severance. Services could be accessed from these locations through other vehicular and public rights of way routes. There may be some slight noise related effects, however only Amber (Option 4/5AV2) was considered to present significant adverse effects. Measures to reduce noise impacts would continue to be refined during further stages of the project for the new preferred option at PCF Stage 3.
Will have positive impact on tourism	Tourism is a key contributor to the regional economy. West Sussex attracts, on average, 17 million visitor days per year, worth approximately £508 million to the local economy. We're confident that improving connectivity will make the area a more attractive place to invest and travel into.

Code description	Highways England response
Oppose viaduct	The environmental assessments conducted to date assumed that the route would be built on an embankment across the River Arun floodplain. The assumption of an embankment was made as it was both a lower cost option and a higher environmental impact option. The higher potential environmental impacts meant a conservative, precautionary approach was taken to the assessments. The scheme options could all alternatively be built with a partial or full viaduct across the flood plain. We acknowledge the views from the Environment Agency, Forestry Commission, Natural England and South Downs National Park Authority in relation to the preference for a viaduct, as opposed to embankment design solution, on the grounds of visual impact, as well as operational benefits in the mitigation/minimising of biodiversity severance. A decision on this will be taken once a new preferred route is confirmed and more detailed design work is undertaken.
Further consultation process - not accessible	There were a total of 10 further consultation exhibitions, including two in our consultation van, that were held across the area over an eight week period. The venues were selected according to many criteria, including accessibility by different modes of transport, ease of access for disabled people, capacity, layout, availability on required dates and location in proximity to the A27. We ensured the exhibitions took place on different days of the week, including Saturdays, as well as at different times of the day. The suitability of different locations was discussed with the Focus Group. The further consultation could be responded to via a variety of means. The main method to respond was to complete an online form, found via the project webpage. Alternatively, hard copies of the consultation response form were found in deposit points in the local area as well as at the exhibitions. This form could be posted via a freepost address or handed in at one of the consultation events. Respondents were also able to write their responses via a letter posted to the freepost address, or an email sent to the A27 Arundel project team.

Code description	Highways England response
Create environmentally friendly areas under raised roadway (bat boxes, nest boxes etc)	The development of environmental management measures (avoidance, mitigation, offsets, compensation, and enhancements) has been developed to a conceptual level in the Environmental Assessment Report. This follows DMRB guidance and Interim Advisory Notes (IANs) and is considered to be proportionate and appropriate to the current option selection stage of the project. Some measures, where pertinent and relevant to the evaluation of scheme options, have been developed in more detail. We recognise that the area around Arundel is very special in environmental terms and, during PCF Stage 3, intend to take a landscape-led approach to balance the challenges of delivering improvements to the road network here as effectively as possible. These challenges include the need to reduce congestion and provide sufficient capacity on the A27 over the long-term, while minimising impacts on local communities and seeking to protect and enhance the quality of the surrounding environment, where possible. Once a new preferred route has been identified, we look forward to working closely with the relevant statutory bodies and other key stakeholders to inform our landscape-led approach and identify appropriate mitigation and enhancement measures as the project progresses. In the meantime, the development of the environmental management hierarchy and environmental constraints have been considered in the development of the current stage designs. A biodiversity mitigation approach document (EAR Appendix 8-12: Ecological Mitigation Approach) was prepared to outline the proposed approach to the next stage of the design of mitigation measures, which will be undertaken for the new preferred option at PCF Stage 3. This will include consideration of the appropriateness of implementing green bridges as part of the scheme.
Concerns about increasing traffic flow through a residential area	The traffic volume analysis we published as part of the consultation (Chapter 12, Combined Modelling and Appraisal Report, August 2019) showed that the scheme has the general effect of reducing the level of traffic volume on local roads and through some sensitive residential areas. Should our further analysis during PCF Stage 3 indicate that issues may be caused by increasing traffic volumes on sensitive routes, then we will work with local communities and the local highway authority to mitigate issues where possible and appropriate. The traffic ‘heat maps’ we published during the further consultation, and which illustrate predicted impacts on traffic volumes, are available on our website (www.highwaysengland.co.uk/a27arundel)

Code description	Highways England response
Worst option for the community/residents (Fontwell)	We understand the concerns that different sections of the community have raised about existing and potential future severance issues. Chapter 12 of the Environmental Assessment Report sets out our assessment of the options' impacts on population and health, while Chapter 11 of the final Scheme Assessment Report presents a summary of social and distributional impact appraisal of the scheme options. Potential measures to address community severance in Fontwell (such as maintaining public rights of way and traffic management) are provided in Section 12.9 of the Environmental Assessment Report and these measures will continue to be refined in further design stages for the new preferred option. However, Fontwell village is further west than the western-most extent of all six options put forward, so effects on the village arising from the scheme are not expected to be significant in respect of severance and other environmental topics.
Comments regarding plans for the existing A27 after construction of new road	The future use of the existing A27 will be dependent on which option is taken forward as the new preferred route, and will be confirmed during the next stage of scheme development when we discuss with West Sussex County Council.

Code description	Highways England response
Should be public choice – environment belongs to everyone and should be cherished, not destroyed	We recognise that the area around Arundel is very special in environmental terms and delivering any improvements to the road network here will present challenges. Extensive field survey work has been completed to better understand the baseline environment (e.g. landscape, noise and air quality), habitats, foraging patterns and overall ecological values of the area. Baseline survey reports were published within the Environmental Assessment Report appendices. We understand the concerns that have been raised. We're committed to managing our estate in a 'wildlife-friendly' way and will continue to refine the scheme design to minimise these potential impacts, and to develop environmental mitigation and enhancement options, where practicable. We have good experience from across the country (working with Natural England, since the start of Road Period 1, we've produced a total of 41 management plans for sites of special scientific interest to help preserve protected habitats) and we look forward to working with the relevant statutory bodies and other key stakeholders to identify appropriate mitigation and enhancement measures as the project continues to develop. The results of the consultation activities and responses from the public will be taken into account during the option selection process. It's also worth noting that the Secretary of State for Transport will need to be satisfied that the scheme addresses the requirements of the National Policy Statement for National Networks (NN NPS), which includes strong protection for environmental values.
Comments on benefits for future generations	A new dual carriageway bypass will help ensure that the local infrastructure can cater for the planned population growth in the area. We continue to work closely with local business groups to inform the development of the scheme and understand that, as with other sections of the community, different views exist about the best long-term solution for the area. However, we remain confident that improving connectivity will help boost productivity and make the area more attractive as a place to invest. We are also aware that pockets of deprivation exist around the area. Improving the local infrastructure will help tackle this inequality by making it easier for people to access employment opportunities across the area.

Code description	Highways England response
Re-evaluate traffic signal timings at Crossbush junction	We have an ongoing programme to review timing plans at all signalised junctions every three years to maximise throughput. Crossbush junction was visited in November 2018. The signals are working as effectively as they possibly can but the capacity of the junction is limited by the current layout, and traffic frequently queues on the exit towards Arundel.
Time lost for staff travelling to work	We recognise concerns about congestion around Arundel, the importance of the A27 to the area and the challenges that unpredictable travel times can present for different types of journey. Forecast population growth in the area means that these issues are expected to worsen in coming years in a 'do-nothing' scenario. Our economic analysis specifically considers commuting and business-related travel, and the impacts the scheme is predicted to have on these specific journey purposes. Replacing the existing single carriageway section with a new dual carriageway will help resolve many of these issues and our analysis shows that all scheme options are predicted to improve conditions for these journey purposes once constructed. This would be the case for journeys on the A27 and overall across the wider local road network.
Minimal disruption during construction	We will develop construction methods, phasing and methodology in the future stages of the scheme's development. Working with local stakeholders, we will work to ensure that construction is carried out as efficiently as possible with the aim of minimising disruption. All road works will be carefully planned and managed to ensure road safety is maintained. We would estimate a three-year construction programme whichever option is taken forward.
Unnecessary length	We took a fresh look at the full range of possible route alignments, after announcing our intention to conduct further consultation on the options. These were grouped and sifted, according to compliance with the scheme objectives and legal and national planning policy tests, including consideration of environmental impacts. Our technical work concluded that six options should be put forward for consideration as part of this further consultation.

Code description	Highways England response
Do not see need for both Beige and Cyan options	We took a fresh look at the full range of possible route alignments, after announcing our intention to conduct further consultation on the options. These were grouped and sifted, according to compliance with the scheme objectives and legal and national planning policy tests, including consideration of environmental impacts. Our technical work concluded that six options, including the two Option 1 variants, should be put forward for consideration as part of this further consultation. It was decided that there were sufficient differences, in terms of environmental impacts and operational performance, between the two options in relation to proposed junction arrangements within Arundel.
Further consultation process – not advertised widely enough	A variety of methods were used to raise awareness of the further consultation. These included a letter delivered to more than 78,000 properties in the region, local newspaper advertising, social media activity, email bulletins to people who had registered for updates about the scheme, and posters displayed in local libraries and community venues. Ten staffed public exhibitions were held at different venues around the area, to give people the opportunity to ask specific questions of the project team, along with four unstaffed exhibitions where people could view a sample of the further consultation material. A range of other communications channels were also used to promote the further consultation more widely, and reach as many people who may have been interested in the scheme as possible. This included work to encourage responses from groups who may have been less accessible via more traditional channels: § Posters displayed at deposit points and other locations in the local community § Local press advertising: advertisements were published in both the West Sussex County Times and West Sussex Gazette § Social media: the further consultation was regularly publicised via Highways England's Facebook and Twitter accounts We therefore consider that the work to advertise the consultation was proportionate and, overall, we believe that the extent of engagement demonstrates that the approach was successful.
Offers worst reduction in journey time	Traffic modelling results show that all options are predicted to have a journey time saving of between 6 and 11 minutes.

Code description	Highways England response
Existing roundabouts east and west of Arundel cause delays	We recognise concerns about congestion around Arundel, the importance of the A27 to the area and the challenges that unpredictable travel times can present for different types of journey. Forecast population growth in the area means that these issues are expected to worsen in coming years in a 'do-nothing' scenario. Replacing the existing single carriageway section with a new dual carriageway will help resolve many of these issues.
A sensitively designed road and bridges would not have any detrimental effect on the landscape	The proposed scheme options lie within and adjacent to a national park, and partially across the floodplain for the river Arun. All six options under consideration would present a new and detracting feature in the existing environment. Any structures will be designed to minimise visual and aesthetic impact on the area. The design of the horizontal and vertical alignments for the main line of each Scheme option and its side roads and junctions consider, amongst other things, the surrounding topography; vegetation; existing landscape features (such as hedges, water features, woodland, and field systems); proximity of residential properties; and key views and vistas. The design may also be supplemented with measures such as vegetation planting and visual or noise barriers. The design of the selected scheme option will be assessed further during the next stage of the project, with mitigation proposals being developed accordingly.
Consider impact of other infrastructure (eg. Lyminster Bypass)	The traffic modelling that was undertaken included the Department for Transport's traffic growth factors, assumptions on local changes in development (new housing and employment) and changes to the certainty of other transport schemes within the local area. The impacts of other key transport infrastructure have been considered. Traffic forecasts and economic analysis have been produced to show the impact of the scheme with and without the A27 Worthing and Lancing scheme and with and without the Lyminster Bypass scheme. The forecasts show that in all scenarios the A27 Arundel Bypass offers transport and economic benefits.
More weight should be given to Sussex Wildlife Trust and their views	The consultation process for the A27 Arundel Bypass project has been open to members of the public and various statutory and non-statutory environmental bodies. All the responses to the consultation activities (including members of the public, non-statutory and statutory bodies) have been considered and will be taken into account during the option selection process.

Code description	Highways England response
Need acoustic screening included in proposals for mitigation	The development of environmental management measures (avoidance, mitigation, offsets, compensation, and enhancements) has been developed to a conceptual level in the Environmental Assessment Report. This follows DMRB guidance and Interim Advisory Notes (IANs) and is considered to be proportionate and appropriate to the current option selection stage of the project. Some measures, where pertinent and relevant to the evaluation of scheme options, have been developed in more detail. We considered the development of the environmental management hierarchy and environmental constraints in the development of the current stage designs. A biodiversity mitigation approach document (EAR Appendix 8-12: Ecological Mitigation Approach) was prepared to outline the proposed approach to the next stage of the design of mitigation measures.
Concerns about new development in Walberton Parish (Avisford Grange)	During the options selection stage, we are required to identify the zone of influence and identify 'other developments' within this zone. The zone of influence for the project is described in Chapter 17 of the Environmental Assessment Report. This is considered proportionate and in line with Highways England's normal practice. The assessment of inter-project cumulative effects will be undertaken in later stages of the project in accordance with the requirements of the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017. Grey (Option 5BV1) is the only option that would have a direct impact on part of the development at Avisford Grange. If this option is taken forward as the new preferred route, an alternative access to the development would most likely be required. A Cumulative Environmental Assessment will be undertaken at PCF Stage 3 for the new preferred option.
Concerns that the scheme won't go ahead	We are committed to delivering the best long-term solution for the area. We look forward to continuing to work with the local authorities, other statutory bodies, community groups and others in order to do so.
Do not include any at-grade crossings/ junctions	Of the six options presented at the public consultation, Beige (Option 1V9) is the only option which has an at grade junction located along the route. This option would replace the existing at grade Ford Road roundabout with a larger signalised junction. The size and layout of the junction presented at the further consultation has been designed to accommodate traffic up to 15 years after opening. After this, the traffic forecasts indicate there is predicted to be an increased risk of congestion returning with this option. In respect of walking, cycling and horse riding, access would be maintained for pedestrians, cyclists and horse riders across all six options, although some existing routes would need to be diverted.

Code description	Highways England response
Accesses onto/from the A27 (too many)	Direct access onto the new route would be kept to a minimum. For Cyan, Crimson, Amber, Magenta and Grey options, the only access would be at the junctions located at the ends of the scheme. In between, all local roads and public rights of way would be diverted to pass either above or below the carriageway. For Beige, additional access would be provided at Ford Road (a major, at grade signal controlled junction) and at Binsted/Tortington Lane and Arundel Community Hospital (left-in/left-out arrangement). At the next stage of development, there will be discussions with landowners affected by the scheme to confirm access requirements. The aim will be to avoid any further direct access to the new route in order to prioritise the strategic function of the A27.
Access to Crossbush junctions	The design of the junction at Crossbush would be developed in more detail at the next stage of the scheme development. We will undertake thorough traffic assessments to inform the design of the junction and more detailed proposals will be presented at the next consultation. The design of signing for the service area from the A27 would also form part of the next stage of scheme development. In respect of access during construction, the construction phase will be a guided by a Construction Management Plan, which will ensure disruption is kept to a minimum for local people, road users and businesses including access to the service area.
Would require further improvements (and therefore expenditure) in the future	The traffic modelling that was undertaken included the Department for Transport's traffic growth factors, assumptions on local changes in development (new housing and employment) and changes to the certainty of other transport schemes within the local area. The results showed that, whichever option were to be taken forward, the new road is predicted to operate within capacity in 2041 (at 85-90% capacity for Option 1V9, which includes the signalised 'through-about' junction; 45-60% for the other options). Journey times are estimated to be between 6 and 11 minutes shorter.
Option will be outdated within 10 years	

Code description	Highways England response
Will not improve traffic speed	The traffic modelling that was undertaken included the Department for Transport's traffic growth factors, assumptions on local changes in development (new housing and employment) and changes to the certainty of other transport schemes within the local area. The results showed that, whichever option were to be taken forward, the new road is predicted to operate within capacity in 2041 (at 85-90% capacity for Option 1V9, which includes the signalised 'through-about' junction; 45-60% for the other options). Journey times are estimated to be between 6 and 11 minutes shorter. The analysis we published as part of the consultation showed that a high proportion of traffic is predicted to use a new bypass in preference to the existing road and other routes to the north and south of Arundel. The traffic 'heat maps' we published during consultation, and which are available on our website (www.highwaysengland.co.uk/a27arundel), show how the options are predicted to help to resolve this issue.
Create more areas dedicated to countryside	We understand the concerns that have been raised. We're committed to managing our estate in a 'wildlife-friendly' way and will continue to refine the scheme design to minimise the potential impacts, and to develop environmental mitigation and enhancement options, where practicable.
Consider/allow for future widening to accommodate more traffic	The traffic modelling that was undertaken included the Department for Transport's traffic growth factors, assumptions on local changes in development (new housing and employment) and changes to the certainty of other transport schemes within the local area. The results showed that, whichever option were to be taken forward, the new road is predicted to operate within capacity in 2041 (at 85-90% capacity for Option 1V9, which includes the signalised 'through-about' junction; 45-60% for the other options). A dual carriageway will therefore provide sufficient capacity.
Structures to be striking/ eye-catching design	More detailed design work will begin once the preferred route has been identified.
Opposed to the option that has the most impact on local communities	To a greater or lesser extent, all six options put forward for consideration have significant community and environmental sensitivities associated with them. We acknowledge that balancing these issues will not be easy, but we are committed to delivering the best long-term solution for the area. We look forward to continuing to work with the local authorities, other statutory bodies, community groups and others in order to do so.

Code description	Highways England response
Concerns about safety (minor side road connections/driver confusion)	Safety is a key priority for us at Highways England. In line with our scheme objective to improve the safety of travellers along the A27 and, consequently, the wider local road network, it is forecast that each of the options put forward as part of the further consultation are predicted to lead to fewer accidents.
Provide vehicle emissions and air quality information for all options	An air quality assessment, which is the recognised means of assessing air quality impacts for road schemes, was completed in accordance with the requirements of DMRB and Highways England guidance. The results and conclusions have been presented in Chapter 5, and accompanying appendices, of the Environmental Assessment Report. As outlined in the consultation brochure, there would be no significant adverse effect during the operational phase of any route option. There would be a low risk of any option not complying with EU ambient air quality limit values and nitrogen dioxide concentrations would be expected to reduce within the Storrington Air Quality Management Area.
Capacity likely to be exceeded before other options	The traffic modelling that was undertaken included the Department for Transport's traffic growth factors, assumptions on local changes in development (new housing and employment) and changes to the certainty of other transport schemes within the local area. The results showed that, whichever option were to be taken forward, the new road is predicted to operate within capacity in 2041 (at 85-90% capacity for Option 1V9, which includes the signalised 'through-about' junction; 45-60% for the other options).
Replace crossing next to train station with footbridge closer to roundabout	This will be considered further in the next stage of scheme development, once the new preferred route has been identified.
Need to improve footpaths along River Arun	In line with our statutory duty, access will be maintained for pedestrians, cyclists and horse riders regardless of which option is taken forward. Some existing access routes may, however, need to be diverted. The scheme could present opportunities to improve provision for walking, cycling and horse riding. These opportunities, which would include potential safety enhancements, will be explored further in the next stage of the process, once a new preferred route has been identified.

Code description	Highways England response
Events/exhibitions - should have had one in Worthing	There were a total of 10 further consultation exhibitions, including two in a consultation van, that were held across the area over an eight-week period. The venues were selected according to many criteria, including accessibility by different modes of transport, ease of access for disabled people, capacity, layout, availability on required dates and location in proximity to the A27. We ensured the exhibitions took place on different days of the week, including Saturdays, as well as at different times of the day. The suitability of different locations was discussed with the Focus Group.
Does not separate local and long distance/ through traffic	All the options have been designed to limit the number of junctions and accesses to prioritise the strategic function of the A27.
Concerns about access to cricket ground	For Cyan (Option 1V5) and Beige (Option 1V9) routes, the existing direct access from the cricket ground to the A27 would be closed for safety reasons. A new access would be provided via new minor connector roads to a grade separated junction located near Long Lane. For the other routes, the existing access to the existing A27 would be retained.
Easier for pedestrians	In line with our statutory duty, access will be maintained for pedestrians, cyclists and horse riders regardless of which option is taken forward. Some existing access routes may, however, need to be diverted. The scheme could also present opportunities to improve provision for walking, cycling and horse riding. These opportunities, which would include potential safety enhancements, will be explored further in the next stage of the process, once a new preferred route has been identified. Also, we have specific funds available to improve the surroundings of the strategic road network in a way that supports and protects people and the things we value for quality of life, both now and in the future. In conjunction with local authorities, we're exploring opportunities to improve walking and cycling facilities along the A27. More information about this funding mechanism, known as Designated Funds, is available from the Highways England website: https://highwaysengland.co.uk/designated-funds/
Support working together for longer term benefit	There has been extensive engagement with local authorities, environmental bodies, community groups and other key stakeholders to inform the development of the scheme. We intend to keep working collaboratively with all interested parties to deliver the best long-term solution for the area.

Code description	Highways England response
Concerns about impact/access to Arundel Baptist Church	Access to the Arundel Baptist Church, located on Torton Hill Road, would not be affected by the scheme. The area where the church is located would experience an increase in noise levels with the Cyan (Option 1V5) and Beige (Option 1V9) options.
Need to focus on link to Littlehampton	The A27 Arundel Bypass scheme proposes improvements to Crossbush junction which connects with the A284 to/from Littlehampton. The scheme improves transport conditions at the Crossbush junction and would form part of a wider solution to improve access to Littlehampton. The A284 route is not part of the strategic road network. West Sussex County Council, as local highway authority for the A284, has plans in place to improve the route as part of the Lyminster Bypass scheme. Our analysis of the A27 Arundel Bypass scheme has considered forecast scenarios with and without the Lyminster Bypass. The forecasts show that in all scenarios the A27 Arundel Bypass offers transport and economic benefits.
Most weight should be given to the national park authorities and their views.	We recognise the importance of the National Park and its special qualities, as outlined in the scheme objectives, and continue to engage with the South Downs National Park Authority to inform the development of the scheme and minimise/mitigate impacts as far as possible. Landscape and Visual Impact Assessment is one of a number of important environmental topics considered in the assessments, as set out in the Environmental Assessment Report. A range of other parameters (traffic and transport performance, benefit to cost ratio, safety etc) are also considered. The scope and methods for a bespoke assessment specific to the Special Qualities of the National Park were discussed with the South Downs National Park Authority. We subsequently prepared a specific assessment of the impacts of the Scheme options on the Special Qualities of the National Park. The results of this assessment, which includes analysis of impacts on the Park's setting and the wider visual landscape, are provided in Environmental Assessment Report Appendix 1-1.
Non-motorised users should not use new A27 - should provide alternative routes	In line with our statutory duty, access will be maintained for pedestrians, cyclists and horse riders regardless of which option is taken forward. Some existing access routes may, however, need to be diverted. The scheme could also present opportunities to improve provision for walking, cycling and horse riding. These opportunities, which would include potential safety enhancements, will be explored further in the next stage of the process, once a new preferred route has been identified.

Code description	Highways England response
Support the option that is best for journey time	The results of the traffic modelling show that all options should see a reduction in journey times by between 6 and 11 minutes.
Prefer option that takes traffic away from existing housing	To a greater or lesser extent, all six options put forward for consideration have significant community and environmental sensitivities associated with them. We acknowledge that balancing these issues will not be easy, but we are committed to delivering the best long-term solution for the area. We look forward to continuing to work with the local authorities, other statutory bodies, community groups and others in order to do so.
Previously discounted option should be considered	We took a fresh look at the full range of possible route alignments, after announcing our intention to conduct further consultation on the options. These were grouped and sifted, according to compliance with the scheme objectives and legal and national planning policy tests, including consideration of environmental impacts. Our technical work concluded that six options should be put forward for consideration as part of this further consultation.
Need visual screening included in proposals for mitigation	The development of environmental management measures (avoidance, mitigation, offsets, compensation, and enhancements) has been developed to a conceptual level in the Environmental Assessment Report. This follows DMRB guidance and Interim Advisory Notes (IANs) and is considered to be proportionate and appropriate to the current option selection stage of the project. Some measures, where pertinent and relevant to the evaluation of scheme options, have been developed in more detail. We considered the development of the environmental management hierarchy and environmental constraints in the development of the current stage designs. A biodiversity mitigation approach document (EAR Appendix 8-12: Ecological Mitigation Approach) was prepared to outline the proposed approach to the next stage of the design of mitigation measures.
Ford Road – on-street parking	The traffic volume analysis we published as part of the consultation (Chapter 12, Combined Modelling and Appraisal Report, August 2019) shows that the scheme has the general effect of reducing the level of rat running on local roads, including Ford Road. Issues relating to on-street parking on Ford Road would need to be raised directly with the local highway authority.

Code description	Highways England response
Dangerous section from Crossbush junction	The scheme is predicted to reduce traffic levels on the existing A27 between Crossbush and Ford Road improving safe access for local traffic. The layout of the existing A27 would be discussed with West Sussex County Council as part of negotiations about the handover of responsibility in the next stage of development. This may include consideration of further safety improvements. Further information will be presented at the next consultation for further comment. A number of respondents expressed concerns about safety at the existing Crossbush junction. The scheme would replace the existing traffic signal junction with a new junction connected to the A27 with slip roads. The design will be developed in more detail at the next stage of scheme development and will be presented at the next consultation for further comment.
Worst option for the community/residents (Slindon)	To a greater or lesser extent, all six options put forward for consideration have significant community and environmental sensitivities associated with them. We acknowledge that balancing these issues will not be easy, but we are committed to delivering the best long-term solution for the area. We look forward to continuing to work with the local authorities, other statutory bodies, community groups and others in order to do so.
Arundel will be gridlocked in the future without bypass	We recognise concerns about congestion around Arundel, the importance of the A27 to the area and the challenges that unpredictable travel times can present for different types of journey. Forecast population growth in the area means that these issues are expected to worsen in coming years in a 'do-nothing' scenario. Replacing the existing single carriageway section with a new dual carriageway will help resolve many of these issues. The analysis we published as part of the consultation showed that a high proportion of traffic is predicted to use a new bypass in preference to the existing road and other routes to the north and south of Arundel. As a result, congestion would improve.
School-related traffic	We recognise concerns about congestion around Arundel, the importance of the A27 to the area and the challenges that unpredictable travel times can present for different types of journey. Forecast population growth in the area means that these issues are expected to worsen in coming years in a 'do-nothing' scenario. Replacing the existing single carriageway section with a new dual carriageway will help resolve many of these issues.

Code description	Highways England response
Need bigger junction where option re-joins the A27 to avoid congestion	More detailed design work will begin once the preferred route has been identified, and any negative impacts on the local road network will be assessed further during the next stage of the project, with mitigation proposals being developed accordingly.
Ford Road - concerns about increasing traffic (due to development)	The traffic modelling that was undertaken included the Department for Transport's traffic growth factors, assumptions on local changes in development (new housing and employment) and changes to the certainty of other transport schemes within the local area. The results showed that, whichever option were to be taken forward, the new road is predicted to operate within capacity in 2041 (at 85-90% capacity for Option 1V9, which includes the signalised 'through-about' junction; 45-60% for the other options). Journey times are expected to be between 6 and 11 minutes shorter. A new dual carriageway bypass will also help ensure that the local infrastructure can cater for the planned population growth in the area. The analysis we published as part of the consultation showed that a high proportion of traffic is predicted to use a new bypass in preference to the existing road and other routes to the north and south of Arundel. As a result, congestion would improve. The traffic 'heat maps' we published during consultation, and which are available on our website (www.highwaysengland.co.uk/a27arundel), show how the options are predicted to help to resolve this issue.
Concerns about impact on Fontwell village	Potential measures to address community severance in Fontwell (such as maintaining public rights of way and traffic management) are provided in Section 12.9 of the Environmental Assessment Report and these measures will continue to be refined in further design stages for the new preferred option. However, Fontwell village is further west than the western-most extent of all six options put forward, so effects arising from the scheme on the village are not expected to be significant in respect of severance and other environmental topics.
Less impact on job losses	We continue to work closely with local business groups to inform the development of the scheme and understand that, as with other sections of the community, different views exist about the best long-term solution for the area. However, we remain confident that improving connectivity will help boost productivity and make the area more attractive as a place to invest. We are also aware that pockets of deprivation exist around the area. Improving the local infrastructure will help tackle this inequality by making it easier for people to access employment opportunities across the area.

Code description	Highways England response
Concerns about access to White Swan	For Cyan (Option 1V5) and Beige (Option 1V9), the existing direct access from the White Swan to the A27 would be closed for safety reasons. A new access would be provided via new minor connector roads to a grade separated junction located near Long Lane. For the other options, the existing access to the existing A27 would be retained.
Support the option that is best for non-motorised users	In line with our statutory duty, access will be maintained for pedestrians, cyclists and horse riders regardless of which option is taken forward. Some existing access routes may, however, need to be diverted. The scheme could also present opportunities to improve provision for walking, cycling and horse riding. These opportunities, which would include potential safety enhancements, will be explored further in the next stage of the process, once a new preferred route has been identified. Also, we have specific funds available to improve the surroundings of the strategic road network in a way that supports and protects people and the things we value for quality of life, both now and in the future. In conjunction with local authorities, we're exploring opportunities to improve walking and cycling facilities along the A27.
Concerns about access to local businesses at Park Farm	For Cyan (Option 1V5) and Beige (Option 1V9), the existing direct access from Park Farm to the A27 would be closed for safety reasons. A new access would be provided via new minor connector roads to a grade separated junction located near Long Lane. For the other options, the existing access to the existing A27 would be retained.
Arundel deserves better	We acknowledge that balancing community and environmental impacts will not be easy, but we are committed to delivering the best long-term solution for the area. We look forward to continuing to work with the local authorities, other statutory bodies, community groups and others in order to do so.

Code description	Highways England response
Support embankment	The environmental assessments conducted to date assumed that the route would be built on an embankment across the River Arun floodplain. The assumption of an embankment was made as it was both a lower cost option and a higher environmental impact option. The higher potential environmental impacts meant a conservative, precautionary approach was taken to the assessments. The scheme options could all alternatively be built with a partial or full viaduct across the flood plain. We acknowledge the views from the Environment Agency, Forestry Commission, Natural England and South Downs National Park Authority in relation to the preference for a viaduct, as opposed to embankment design solution, on the grounds of visual impact, as well as operational benefits in the mitigation/minimising of biodiversity severance. A decision on this will be taken once a new preferred route is confirmed and more detailed design work is undertaken.
Add a bus lane/hard shoulder	There would be no additional benefit to bus travel by provision of a bus lane on the scheme as the route is not predicted to experience any congestion. The PCF Stage 2 Multi-Modal Study summarised the potential impact of public transport schemes and travel demand management, and concluded that whilst these options could move a small proportion of trips off the road network, the problems along the A27, and the objectives relating to the A27 Arundel Bypass, still had to be addressed. Section 3.7 of the Interim Scheme Assessment report, which was published at the start of the further consultation, provides further information.
Concerns that congestion at Crossbush (eastbound traffic) will move to Ford Road	We recognise the existing congestion issues at the Crossbush junction. The scheme plans to improve the capacity and performance of the Crossbush junction in all options we are considering. The traffic volume analysis we published as part of the consultation (Chapter 12, Combined Modelling and Appraisal Report, August 2019) shows that the scheme has the general effect of reducing the level of rat running on local roads, including Ford Road. Therefore, the scheme mitigates risks associated with the increasing levels of congestion at Crossbush junction, and the impact this may have on Ford Road.

Code description	Highways England response
Concerns about noise impact (housing near Ford Road roundabout)	A noise assessment, which is the recognised means of assessing noise impacts for road schemes, was completed in accordance with the requirements of DMRB and Highways England guidance. Significant adverse effects were identified in the Environmental Assessment Report at properties to the north of Ford Road roundabout for Cyan (Option 1V5) and Beige (Option 1V9). All options (except Cyan) were considered to have a significant adverse effect on properties to the south of the A27 and west of Ford Road roundabout. Typical mitigation measures to reduce noise impacts are considered in Chapter 11 of the Environmental Assessment Report (e.g. low noise surfacing and noise barriers). Mitigation will be further developed once more detailed design work progresses on the new preferred route.
Will not make it safer for pedestrians and cyclists travelling to Arundel	In line with our statutory duty, access will be maintained for pedestrians, cyclists and horse riders regardless of which option is taken forward. Some existing access routes may, however, need to be diverted. The scheme could also present opportunities to improve provision for walking, cycling and horse riding. These opportunities, which would include potential safety enhancements, will be explored further in the next stage of the process, once a new preferred route has been identified.
Option previously supported - not available	We took a fresh look at the full range of possible route alignments, after announcing our intention to conduct further consultation on the options. These were grouped and sifted, according to compliance with the scheme objectives and legal and national planning policy tests, including consideration of environmental impacts. Our technical work concluded that six options should be put forward for consideration as part of this further consultation. These include two Option 1 variants, Option 3V1 and Option 4/5AV2 that were very similar to the options put forward for consultation in 2018.
Need traffic lights for Ford Road	On the issue of provision of traffic lights at Ford Road junction with Beige (Option 1V9), traffic signals are proposed to enable the junction to operate satisfactorily up to 15 years after opening. The lights would also provide an opportunity for local traffic movements and to provide safe opportunities for pedestrians and cyclists to cross the route.

Code description	Highways England response
Need to improve access to Arundel town centre	We note that West Sussex County Council recognised that the preferred route design will need to be refined to ensure that access routes are maintained and, in some cases, ensure that any undesirable effects on the local road network are managed effectively. We look forward to working with the County Council as local highway authority to identify appropriate mitigation measures. The future use of the existing A27 is also dependent on which option is taken forward as the new preferred route, and will be confirmed during the next stage of scheme development.
Concerns about conflict between cyclists and pedestrians on shared paths	In line with our statutory duty, access will be maintained for pedestrians, cyclists and horse riders regardless of which option is taken forward. Some existing access routes may, however, need to be diverted. The scheme could also present opportunities to improve provision for walking, cycling and horse riding. These opportunities, which would include potential safety enhancements, will be explored further in the next stage of the process, once a new preferred route has been identified. Also, we have specific funds available to improve the surroundings of the strategic road network in a way that supports and protects people and the things we value for quality of life, both now and in the future. In conjunction with local authorities, we're exploring opportunities to improve walking and cycling facilities along the A27.
Need pedestrian crossing on Ford Road by bus stop	In line with our statutory duty, access will be maintained for pedestrians, cyclists and horse riders regardless of which option is taken forward. Some existing access routes may, however, need to be diverted. The scheme could also present opportunities to improve provision for walking, cycling and horse riding. These opportunities, which would include potential safety enhancements, will be explored further in the next stage of the process, once a new preferred route has been identified. Also, we have specific funds available to improve the surroundings of the strategic road network in a way that supports and protects people and the things we value for quality of life, both now and in the future. In conjunction with local authorities, we're exploring opportunities to improve walking and cycling facilities along the A27.

Code description	Highways England response
Concern that design standards used have been superseded	The version of the Design Manual for Roads and Bridges used was correct and appropriate at the time of the further consultation. It is being transformed into a consistent and concise format that is clear and easy to use, with content that is up to date and more efficient to maintain. The new version of the manual has now been published so these changes will be fully incorporated into the scheme in the next stage of development.
Worse than Magenta (Option 4/5V1)	These comments were option-specific and have been noted as part of the process to determine the most appropriate option to take forward.
Worse than Cyan (Option 1V5)	
Better than Crimson (Option 3V1)	
Better than Beige (Option 1V9)	
Better than Magenta (Option 4/5V1)	
Better than Grey (Option 5BV1)	
Better than Amber (Option 4/5V2)	
Better than Cyan (Option 1V5)	
Support offline option	
Support online option	
Best option for the community/residents (Fontwell)	

Code description	Highways England response
Best option for the community/residents (Crossbush)	
Best option for the community/residents (Slindon)	
Best option for the community/residents (Tortington)	
Best option for the community/residents (Walberton)	
Best option for the community/residents (Binsted)	
Opposed to the option that has least benefit to Arundel town centre	
Support the option that is best for Arundel town centre	
Will improve quality of life	
Will improve health/ Well-being	
Best long-term solution for the environment	
Less environmental impact (light pollution)	

Code description	Highways England response
Less environmental impact (Arun Valley)	
Less environmental impact (Binsted Woods)	
Opposed to the option that is most damaging to the environment	
Less environmental impact (archaeology and cultural heritage)	
Less environmental impact (landscape – visual)	
Less environmental impact (drainage and water – floodplains)	
Less environmental impact (noise and vibration)	
Will make it safer for pedestrians and cyclists travelling to Arundel	
Opposed to the option that has the least benefit for walkers, cyclists, horse riders	
Only option that improves routes for all users	

Code description	Highways England response
Will have greatest impact on traffic flow/ congestion - peak time	
Opposed to the option that has the least journey time benefit	
Offers greatest reduction in journey time	
Improves capacity/ journey time of A27	
Will take traffic away from the centre	
Will not reduce traffic in Arundel	
Will cause least disruption to staff and business travel	
Less impact on businesses	
Positive impact on regional economy	
Best for future growth/ development/expansion	
Quickest/easiest to build	
Less direct (route curves at the western end/sharp bends)	

Code description	Highways England response
Meets the requirement for a proper dual carriageway bypass around Arundel	
Shortest/direct route	
Disruption no different to existing issues	
The easiest to gain acceptance for	
Most disruptive option	
Third preference	
Offers best long-term solution/future proof	
Previously supported Option 3	
Previously supported Option 5A	
Previous PRA option (5A) not supported	

A27 Arundel Bypass
Report on Further Consultation

Appendix D:
Other written responses from organisations (vol.1)

Adur & Worthing Business Partnership
[redacted]
c/o Worthing Town Hall, Chapel Road
Worthing, BN11 1HA
[redacted]
Registered Office No: 3317078

A27 Arundel consultation team [redacted]

24 October 2019

Dear Colleagues,

As the Chair of the Adur and Worthing Business Partnership, I welcome the opportunity to comment on the scheme proposals to improve the A27 at Arundel. This response has been sent on behalf of the Adur and Worthing Business Partnership and it is requested that Highways England give due consideration to its contents before making its recommendations to the Secretary of State.

The Adur and Worthing Business Partnership brings together strategic leaders from business, education and the public sector to work collectively on economic issues that affect our places. Both the Adur and Worthing Business Partnership and its Executive Board aim to add value and focus on the key economic issues that support business development.

The Adur and Worthing Business partnership is pleased to see the A27 Arundel scheme progressing. Along with our colleagues in the Coastal West Sussex Partnership, we have looked at the options and we take the view that the Magenta route is preferred and note the Grey and Amber route are potentially viable alternatives. Our response notes that the Worthing/Lancing scheme needs to be delivered as well, preferably as soon as the Arundel scheme has started. As the planning gets more detailed, we will want to be consulted on the impacts on Worthing of the Arundel scheme, both on completion and during construction. We also expect the A259 construction to be deconflicted from the A27.

We are pleased to see that the routes with costs above nominal budget have been proposed, and therefore could be funded. We would expect the savings from Grey to Magenta being added to the starting point for budgeting the Worthing/Lancing scheme.

Yours sincerely

[redacted]
Chairman

[redacted]
Assistant Project Manager
Regional Investment Programme (South East)
Highways England
Bridge House
1 Walnut Tree Close
Guildford GU1 4LZ

Tuesday, 22 October 2019

[redacted]

As owners of the Hilton Avisford Park we note your letter to the General Manager of the Hotel regarding the A27 Arundel Bypass Scheme further consultation (copy attached). We have no record of receiving the Landowners letter and would appreciate you emailing a copy by return in order for us to follow the appropriate official process.

In the interim we have been informed by Hilton, who operate the Hotel on our behalf, that from a review of the proposed schemes both Option 4/5 AV1 Magenta and Option 5BV1 Grey would require acquiring land in our ownership, resulting in the loss of a significant number of holes in the current 18 hole golf course. This would entail the complete loss of the existing golf operation, which is an important component of the offering at the hotel, and is likely to put the viability of the existing Hotel in doubt.

We place on record our strong objection to these 2 Options, or any Option that results in the inability for us to maintain and operate a viable Hotel which is a significant local amenity and employer of over 100 people.

Yours sincerely,

[redacted]

Albitar Business Corporation
c/o Lina Consultant Services
Office No. 3
79 Baker Street
London W1U 6RG

[redacted]

HOWARD SMITH M.R.I.C.S.
CHARTERED VALUATION SURVEYOR

PUBLIC CONSULTATION RESPONSE A27 ARUNDEL BY-PASS
ON BEHALF OF

[redacted]

We are Partners in the business of AM Harriott & Son which owns land both to the east and west of the Arun Valley Railway and also are tenants of the Duke of Norfolk Estate and therefore, for all the routes proposed our interests, either as land owners or tenants, will be potentially affected.

As Highways England will already be aware we own land at Broomhurst Farm that lies both to the east and west of the Arun Valley Railway Line and as currently envisaged it would appear that with the exception of the Cyan and Beige routes our freehold asset is going to be severely compromised and we particularly have concerns in connection with the railway bridge over the Arun Valley Railway which links Broomhurst Farm together as the design drawings Ilustrated in the documents presented do not show sufficient detail as to potentially how much of our land will be affected and how many fields may well be severed. Attached are our plans from both Magic Maps and Google Earth illustrating the position of the railway bridge that links Broomhurst Farm together that is used extensively by the farm business. If the Cyan or Beige route is chosen there will be no affect on this bridge.

In addition, the published expected costs for four out of the six routes exceed the published budget costs and we are not certain that the necessary savings to these costs can be secured to bring any of those routes that start in excess of the budget costs within budget.

In connection with the construction itself any route that crosses the flood plain of the River Arun should be built as a Viaduct rather than an embankment as it reduces land take and is less environmentally sensitive than a solid embankment which will require regular maintenance at an enhanced cost and it is noticeable at this stage there appears to be no provisions within the design as to how road run off is to be managed which is a further concern in connection with potential land take.

We are therefore, in favour of Cyan 1V5 as the preferred route with a second choice of doing nothing. As published we do not believe that the Beige route is feasible with the the proposals of the Ford Roundabout acting as a block on continuous traffic flow and would suggest that this section should also be elevated to allow for continuous traffic flow. Our third preference is therefore the Beige route and we therefore reject the Magenta, Crimson, Orange and Grey routes.

[redacted]

Our least preferred options are Magenta, Crimson, Orange and Grey routes as they will destroy the environmental benefits established on our land which has been extensively grazed by both cattle and sheep over the last forty years and is therefore totally undisturbed and rich in flora and fauna. The way in which we have farmed our land has led to the abundance of this flora and fauna which will be destroyed if any of the above routes become the preferred route.

[redacted]

Howard Smith MRICS Chartered Surveyor
RICS Registered Valuer

Dated 23.10-19

HOWARD SMITH M.R.I.C.S.
CHARTERED VALUATION SURVEYOR

[redacted]

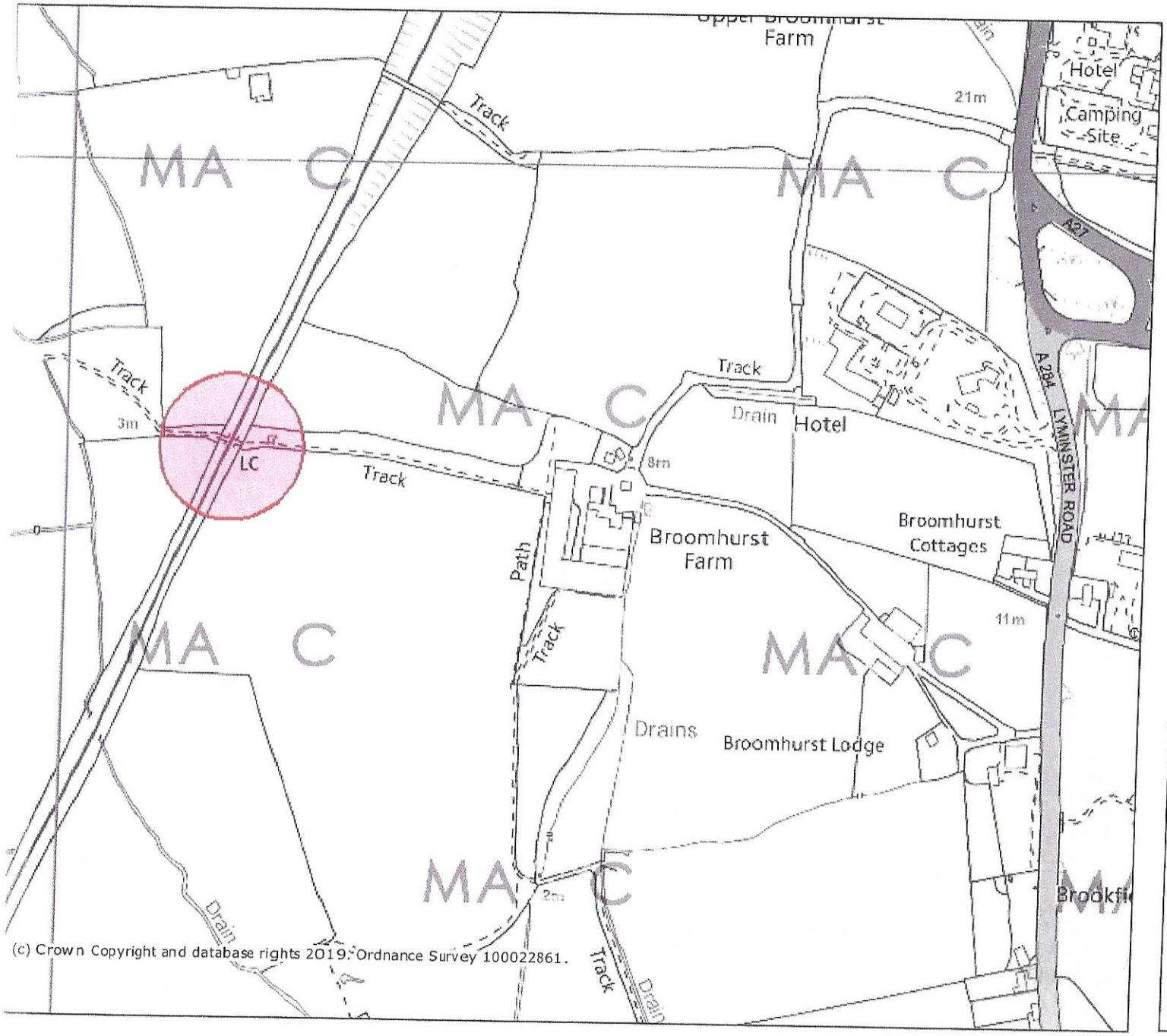
APPENDIX A

Magic Map plan showing Railway

[redacted]

MAGIC

Location of Railway Bridge



Projection = OSGB36
xmin = 501400
ymin = 105200
xmax = 503400
ymax = 106200

0 0.095 0.19
km

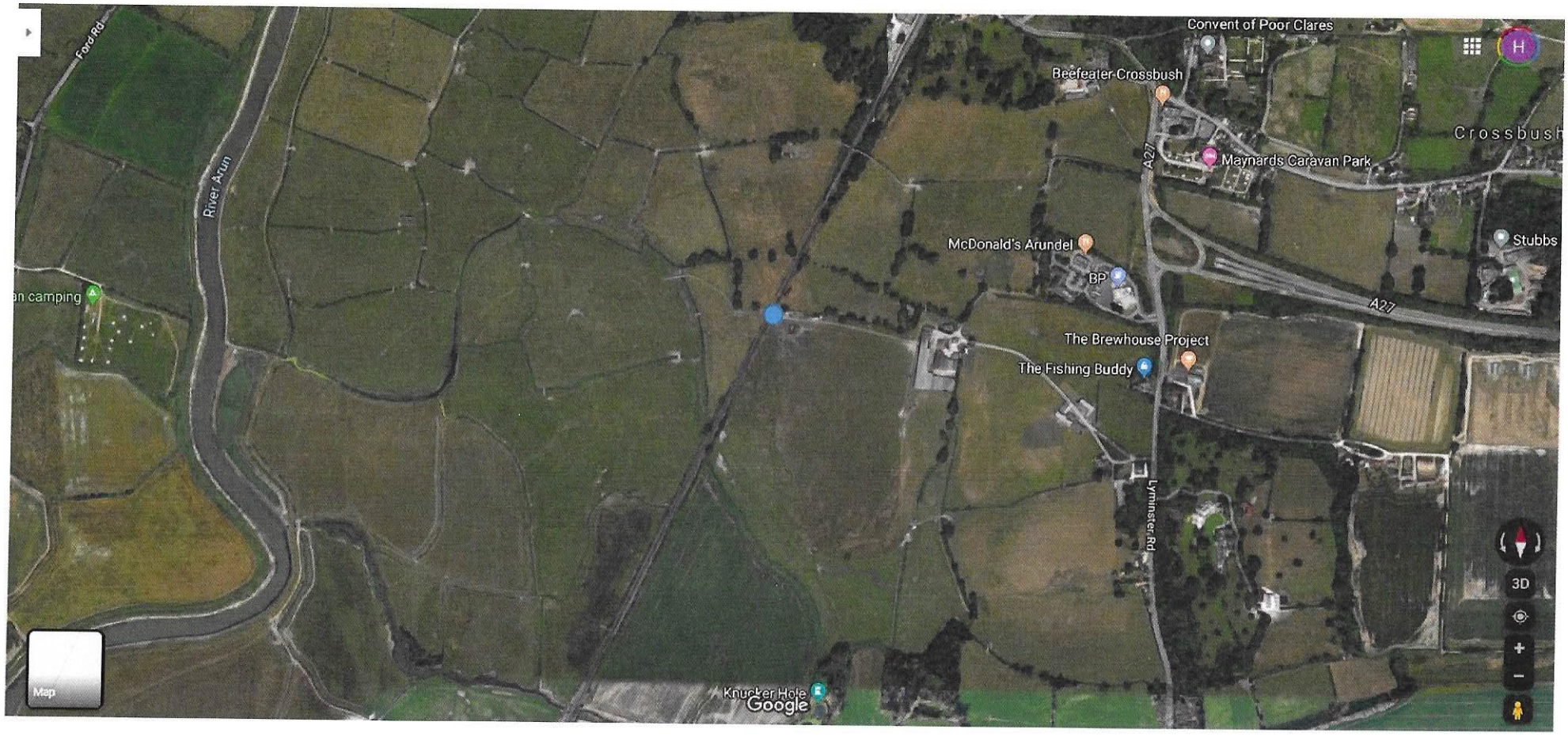
Map produced by MAGIC on 23 October, 2019.

APPENDIX B

Google Earth Plan

[redacted]

[redacted] - Location of Railway Bridge over the Arun Valley Railway Line indicated by the position of the Blue Circle



Date : October 2019

Project : A27 Arundel Bypass

[redacted]

DOCUMENT CONTROL

REV	ISSUE PURPOSE	AUTHOR	CHECKED	APPROVED	DATE
-	DRAFT	VL/LD/SE	CC/KM	DRAFT ONLY	16/10/19
-	DRAFT	VL/LD/SE	CC/KM	DRAFT ONLY	18/10/19
A	Final	VL/LD/SE	CC/SE	BC/KM	24/10/19

[redacted]

DISTRIBUTION

1.0 INTRODUCTION

1.1. Ardent Consulting Engineers has been commissioned by Linden Homes to provide representations regarding the A27 Arundel Bypass proposal option 5BV1 put forward by Highways England and its impact on the parcel of land east of Tye Lane, Walberton (hereafter known as 'the site').

1.2. In preparation of this statement, Ardent has reviewed the information downloaded from the website: www.highwaysengland.co.uk/projects/a27-arundel-improvement/ and Ardent cannot accept responsibility for the accuracy of this information.

1.3. This site which these representations relates to is application WA/44/17/OUT submitted on 20-06-17, with the application permitted 23-02-2018. The Section 106 was signed 22-02-18, with a deed of variation to the S106 signed 31-05-19. The detailed layout was approved on 16th April 2019 with the Approval of the Reserved Matters reference WA/95/18/RES. The approved scheme is for 175 dwellings, new vehicular access, together with associated car parking, landscaping & community facilities to include allotments, play space & community orchard. At the time of writing this report, construction works have commenced on the approved development.

1.4. The site is bound by Tye Lane to the west and Yapton Lane to the east. The approved site layout as shown in **Figure 1.3** indicates the approved layout and position of the houses along with the site access to serve the consented residential development is provided from Yapton Lane to the east. The proposed extent of highway adoption is shaded in pink.

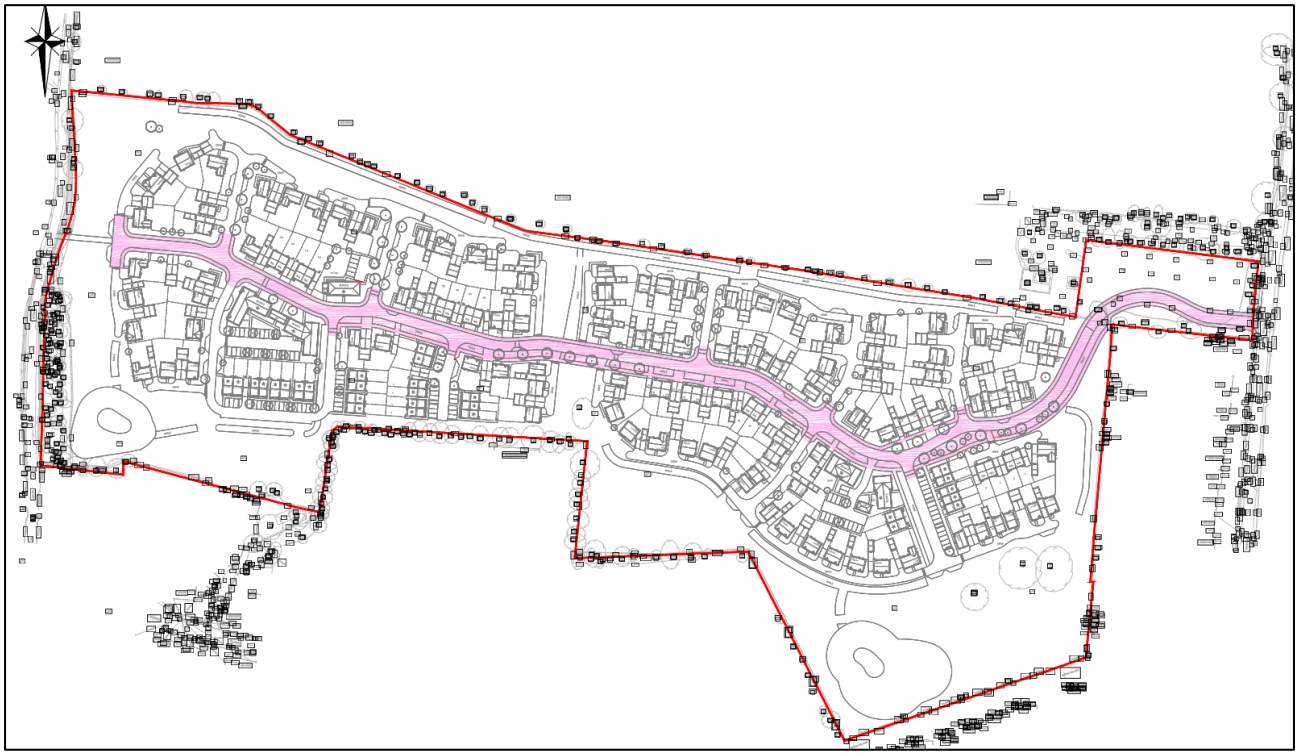


Figure 1.1 Consented Site Layout / Highway Adoption Plan

1.5. There are six different A27 Arundel Bypass proposal options as shown at **Figure 1.2** below, with alignment 5BV1 being the subject of these representations, as this alignment passes through the site.

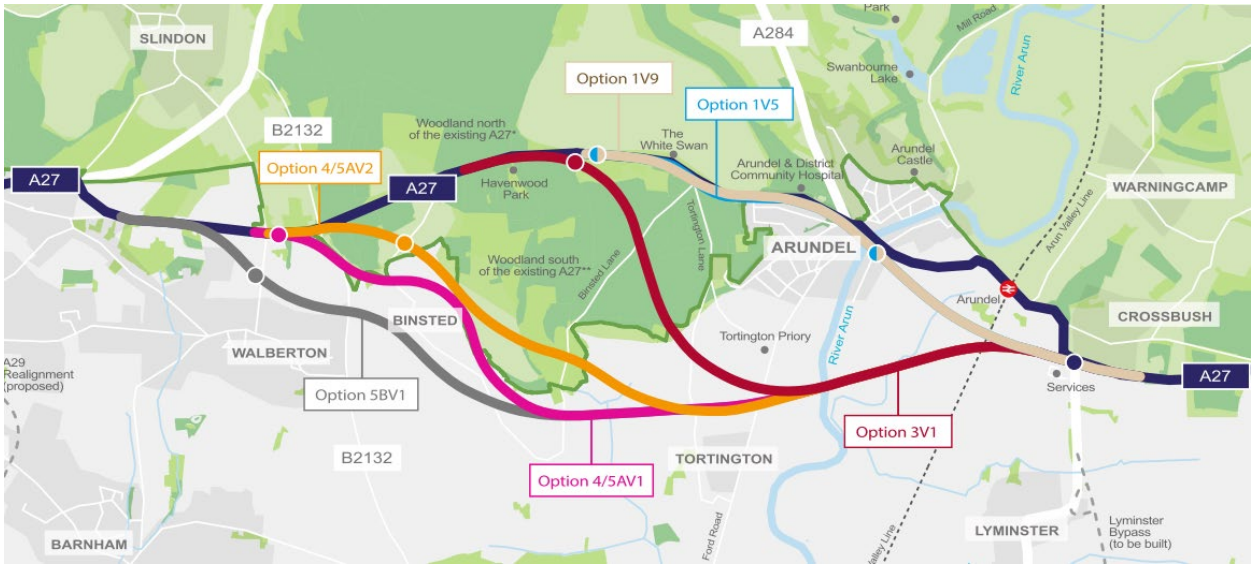


Figure 1.2 A27 Arundel Bypass Options Plan (Option 5BV1 in grey)

1.6. The site location (indicatively shown in red below) is set out in **Figures 1.3** and **1.4** alongside the alignment of the A27 Arundel Bypass proposal option 5BV1 (marked in black).

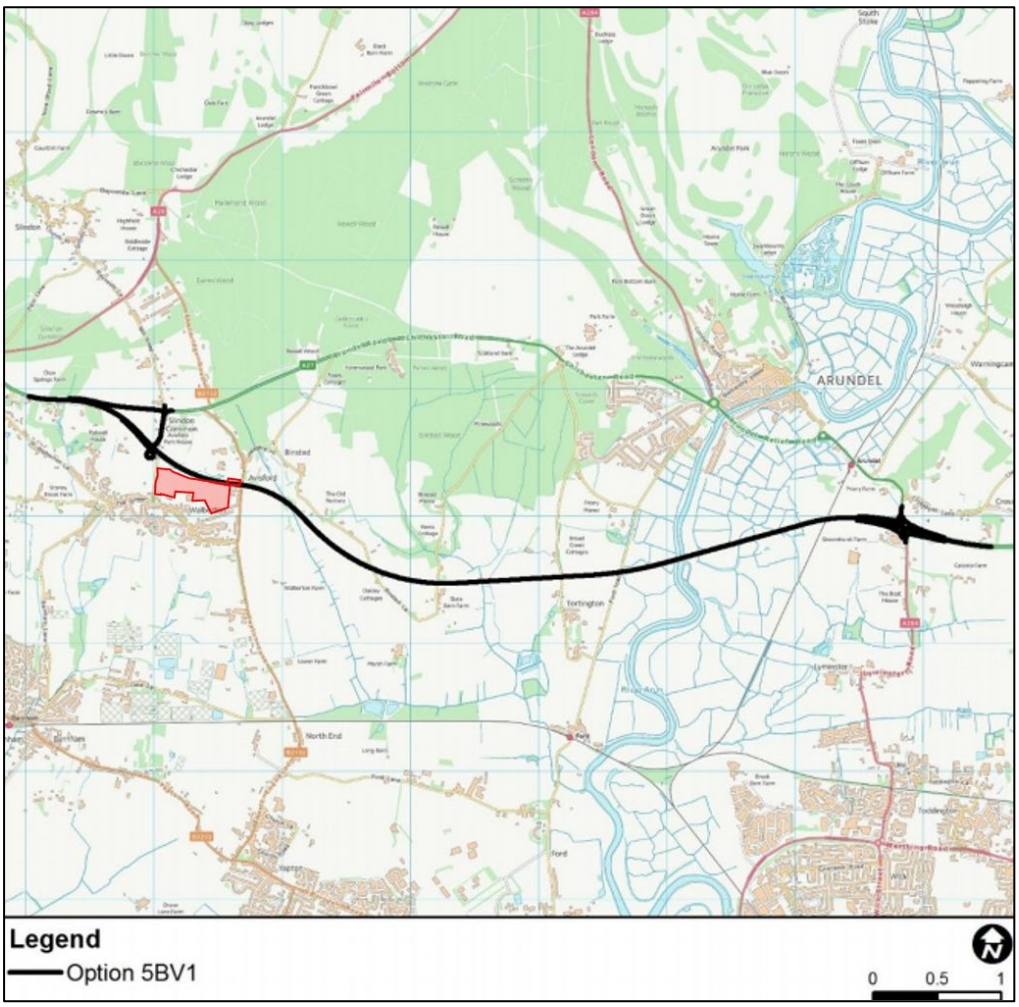


Figure 1.3: Site Location Plan

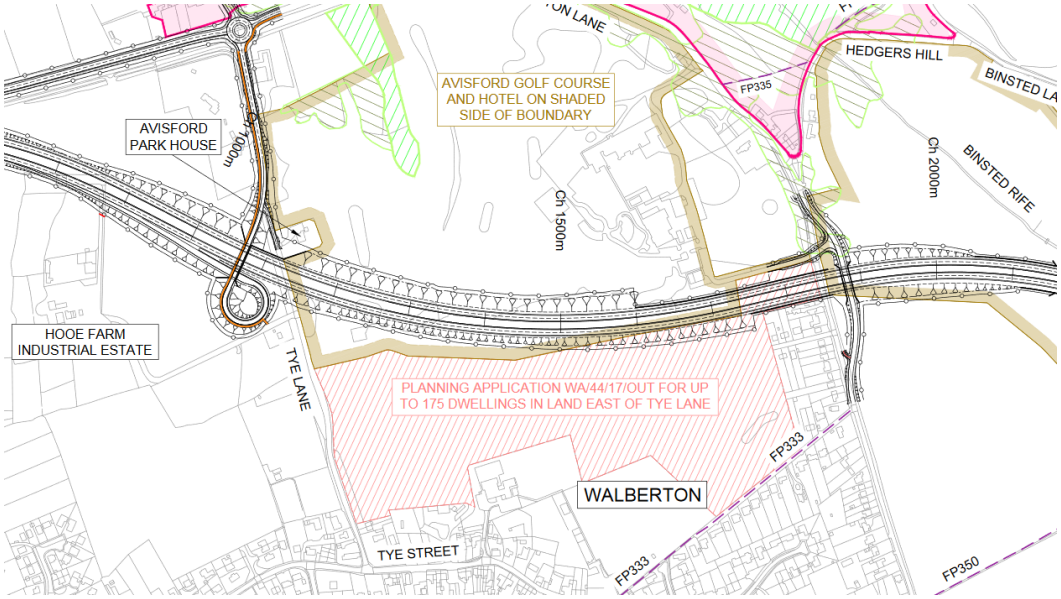


Figure 1.4: 5BV1 Alignment in proximity to site.

1.7. As shown in **Figure 1.4** above the application is referenced within the supplementary information provided by HE, showing the impact of potential alignment 5BV1 on consented planning application WA/44/17/OUT and WA/95/18/RES, with this alignment adversely affecting the approved vehicular access and houses that are currently under construction.

1.8. **Figure 1.5** below shows a view westward of this potential A27 alignment showing the impact on the site access, and site itself.

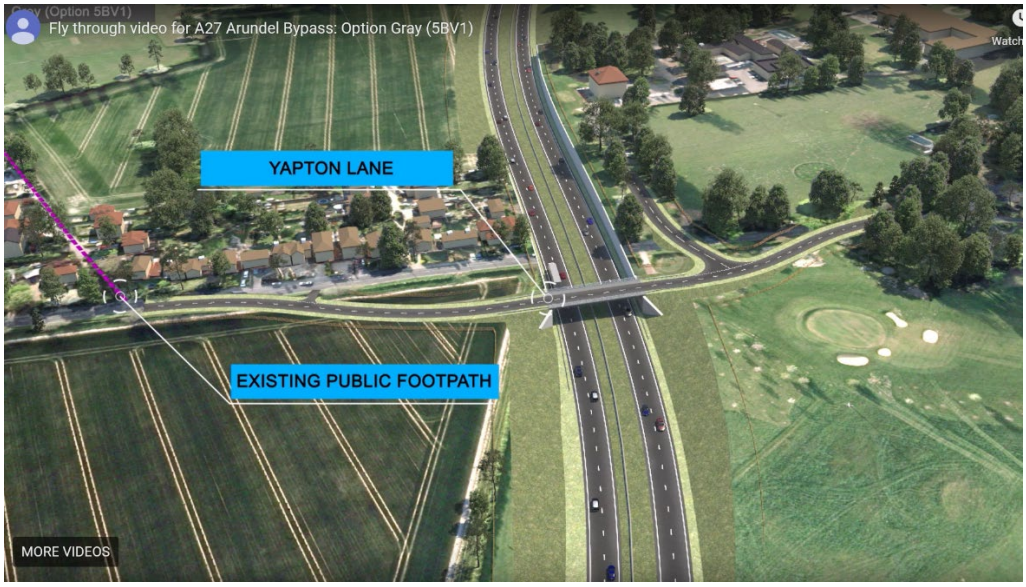


Figure 1.5: A27 Arundel Bypass Option 5BV1 facing west towards site.

1.9. The remainder of report reviews the Highways / Transportation, Flood Risk & Drainage and Noise implications for the site, relating to the Highways England A27 Arundel Bypass proposal option 5BV1

1.10. It is noteworthy that these new alignments impacting this scheme were only formally released on 13th September 2019 (1 year 7 months after the outline permission was granted and after the detailed scheme was formally approved in April 2019), with the previous alignment options released in 2018 having no direct impact on the scheme.

1.11. The purpose of this document is to highlight the key issues for Linden Homes in respect of Option 5BV1 given the relationship to the development site under construction. It is intended to be a summary document and Linden Homes reserved their right to make further representations at a later date.

2.0 HIGHWAYS / TRANSPORTATION

General Description

2.1 Option 5B V1 comprises approximately 8km of new dual two-lane carriageway located to the south of the existing A27. The proposed route would start at the eastern end of the A27 Crossbush Bypass and end at the A27 / A29 Fontwell (East) roundabout. The length of 8km compares to the other A27 bypass proposals as follows:

- Option 1V5/1V9 – 4.5km
- Option 3V1 – 6km
- Option 4/5AV1 – 7.2km
- Option 4/5AV2 – 6.9km
- Option 5BV1 – 8km

2.2 At the anticipated date of completion of the bypass the development site would be entirely built-out and occupied. The site is currently under construction.

Proposed Alignment

2.3 **Figure 3.2** illustrates that the proposed alignment of the A27 Arundel Bypass Option 5BV1 would entirely overlap / impact on the consented access to the site. This is the sole point of access to the site, as approved. This access has also been approved and is under construction at the time of writing. The alignment of the A27 would then run through the site on its northern boundary, directly impacting on the approved residential development of 175 new dwellings, and significant disruption to the dwellings which would have been built and occupied.

Severance

2.4 As part of Option 5BV1 a new grade separated junction would be provided connecting Tye Lane north of the route alignment and the existing A27 to the proposed A27. This would allow for movements from existing A27 westbound to the proposed A27 westbound and from the proposed A27 eastbound to the existing A27 eastbound only.

2.5 Tye Lane would be closed south of the proposed route to prevent it becoming a route to the proposed A27. The existing A27 between Copse Lane and Tye Lane would be retained to provide the eastbound off slip.

2.6 The Option 5BV1 route is over 1km longer than other options, therefore it crosses a greater number of existing roads and causes a greater number of 'Public Right of Ways' (PROWs) to be diverted. The severance of a total of six PROWs by Option 5BV1 are indicated at Appendices D-G of the HE SAR report (http://assets.highwaysengland.co.uk/roads/road-projects/A27+Arundel+Improvement/SAR/SAR+appendix+D+to+G.pdf)

2.7 The number of PROWs crossed by Option 5BV1 is double that of Option 1 V5 and Option 1 V9.

2.8 Option 5BV1 requires Tye Lane to be stopped up, resulting in the rerouting of exiting vehicular trips onto Yapton Lane and/or other local routes, increasing trips through the village.

Design Standards

2.9 At paragraph 8.6.1.1 of the Interim scheme assessment report HE reference design standards used, including TD 22/06 which is now superseded by CD 122. The junction at the 'Western Tie-In' of Option 5BV1 has been designed in accordance with the superseded TD 22/06 design standards, this will need to be reviewed.

2.10 In addition to the above it is noted that TD16/07 is superseded by CD 116 and TD 50/04 is superseded by CD 123 Geometric design of at-grade priority and signal-controlled junctions and previously published CD 116 Geometric design of roundabouts 6.2.7.

Impact on Journey Times / Highway Flows & Capacity / Delay

2.11 Option 5BV1 results in the greatest absolute increase of traffic along the A27, to the section west of Tye Lane, with flows in excess of 50,000, which represents an increase of almost 60% compared to do minimum at the point at which the new A27 Arundel Bypass ties into the existing A27 alignment.

2.12 In summary Option 1V5, Option 1V9, Option 3V1, Option 4/5AV1, Option 4/5AV1 and Option 5BV1 would all operate in 2041 with between 45% to 60% capacity. Option 1V9 would operate with a similar link capacity but overall capacity would be limited by the capacity of Ford Road Junction and would operate up to 85 to 90% capacity.

2.13 At the Crossbush Junction, the Highways England combined modelling and appraisal report indicates that the eastbound off-slip would operate slightly over capacity with an RFC of 0.88 for Option 5Bv1, however the report claims that this could be mitigated through design modifications in a future stage of scheme development. It is unclear if this has been accounted for in cost benefit analysis of the options, and if this is actually achievable.

Alternative Access

2.14 The Option 5BV1 would have substantial if not complete disruption to the site approved and under construction. This has the potential to affect not just Linden Homes but also the residents of the dwellings which will be occupied prior to the road being constructed. Should this option proceed, a new alternative access would need to be secured for the residents which would be acceptable in highway terms. This is likely to be challenging given the local road network in the village.

Construction Impact

2.15 The total construction duration for each option is set out below. This is an extract taken from a Highways England report, showing anticipated construction duration in months.

Option	Construction Durations
1 V5	36
1 V9	34
3 V1	36
4/5A V1	32
4/5A V2	32
5BV1	36

2.16 The above table shows that the construction of options 4/5A, 3V1 and 4/5A V2 is forecast to take the least time to complete. Option 5BV1, 3V1 and 1V5 are forecast to have the longest construction time.

Land Take Requirements

2.17 The amount of hardstanding that would be required in order to fulfil option 5BV1 would relate to approximately +8km of new dual two-lane carriageway. This equates to approximately an additional circa 2.5ha of additional hardstanding when compared to Options 4/5AV2; and an additional circa 10.5ha hardstanding when compared to Options 1V5/1V9

2.18 According to the HE information submitted there are approximately 41 existing properties physically positioned within the proposed alignment of Option 5BV1. This does not include the houses which form part of this site which would result in an additional 15 units being directly impacted.

2.19 Notwithstanding the above, it is considered that the entire site would be significantly impacted based on a 50-metre area either side of the proposed alignment of Option 5BV1, as set out by HE.

2.20 WEB TAG Unit A3 sets out criteria for assessment states that assessment comprising property counts should be undertaken for properties within 0-50m, 50-100m, 100-150m and 150-200m thresholds. This has not been provided in the information submitted, and needs to be considered.

Cost Benefit Analysis

2.21 The total cost of each option is outlined below. This is an extract taken from a Highways England report which shows that Option 5BV1 is estimated to have the highest construction cost.

Option	Narrow Range Lower Value	Central Estimate	Narrow Range Upper Value
Option 1V5	£200m	£255m	£295
Option 1V9	£195m	£249m	£290m
Option 3V1	£255m	£320m	£380m
Option 4/5AV1	£280m	£340m	£405m
Option 4/5AV2	£290m	£358m	£420m
Option 5BV1	£320m	£384m	£455m

2.22 An Analysis of Monetised Costs and Benefits (AMCB) for a 60-year appraisal period for the A27 Arundel Bypass options at the end of PCF Stage 1 has been undertaken by Highways England. These are included within the PCF Stage 1 Economic Assessment Report (April 2017). 'Option 5B' had the lowest Benefit to Cost Ratio (BCR) at PCF Stage 1.

2.23 The PCF Stage 2 'Further Consultation' summary of benefits and costs comprised travel time benefits from TUBA, accident benefits from COBALT,

construction delays, greenhouse gases, air quality and noise impacts and costs for the A27 Arundel Bypass options. Option 5BV1 had the lowest Benefit to Cost Ratio (BCR) at PCF Stage 2 'Further Consultation'.

2.24 The A27 Arundel Bypass options which performs most favourably in terms of initial BCR are Option 1V5 and Option 1V9 with a BCR of 1.70. This includes journey time and operating cost benefits, accident benefits, construction delay costs, greenhouse gases, air quality and noise. Options 3V1, 4/5Av1, 4/5AV2 and 5BV1 have BCRs of 1.64, 1.61, 1.66 and 1.52 respectively.

2.25 When the wider economic benefits are taken into account, Option 3V1 generates the highest BCR of 2.17, which is closely followed by Option 1V5 with 2.16. Option 1V9 and Option 4/5AV2 have a BCR of 2.06, with Option 4/5AV1 and Option 5BV1 having 2.02 and 1.95 respectively.

2.26 It is noteworthy that journey time savings are used as a proxy for all economic benefits, with other economic benefits added – leading to double counting, so the figures set out above should be treated with caution.

2.27 The BCR above also take into account traffic forecasting which generates an unrealistic estimate of growth, with a tendency to treat the 'central' scenario as the 'most probable' outcome.

Transport Guidance / Policy Review

2.28 The proposed A27 bypass option that is taken forward and the formal application process would need to have regard to national planning policy. In this instance the most pertinent points are set out below.

2.29 National Planning Policy Framework (NPPF) paragraph 102 states that transport issues should be considered from the earliest stages of plan-making and development proposals, so that "*…the environmental impacts of traffic and transport infrastructure can be identified, assessed and taken into account – including appropriate opportunities for avoiding and mitigating any adverse effects, and for net environmental gains;…"*.

2.30 Paragraph 5.23, of *"Highways England: Licence, Secretary of State for Transport statutory directions and guidance to the strategic highways company"* states HE should *"calculate and consider the carbon impact of road projects and factor carbon into design decisions, and seek to minimise carbon emissions and other greenhouse gases from its operations*".

2.31 Option 5BV1 results in the greatest length of road, greatest area of hardstanding, longest construction time, highest cost– as such this is not considered to accord with guidance from the NPPF nor the requirements of the HE license.

2.32 The DfT's 'Transport Analysis Guidance, The Transport Appraisal Process' (May 2018) document states that "Analysts should … assess the extent to which each of the identified constraints can or cannot be overcome (and how)." It is unclear if / how HE have undertaken this process in relation to the site and Option 5BV1. The DfT Transport Appraisal Process document goes on to state:

"In parallel with listing constraints, any opportunities to…have positive impacts on issues of wider concern, such as regeneration, should be noted.

Examples of opportunities could include…transport that opens up development land for regeneration or housing, enhancements to the environment, and so on."

2.33 Additionally, it cannot be disregarded that the Government has made it clear that there is a national shortage of housing and that the Country needs to be building 300,000 new homes a year. Option 5BV1 would substantially affect the delivery and occupation of 175 well needed new homes which have been approved through the planning process. This includes 53 affordable homes. It is well documented that the local and wider area is under pressure to provide

additional land for development and this option frustrates the delivery of this well needed housing.

3.0 FLOOD RISK AND DRAINAGE

Impact on fluvial and tidal floodplain of River Arun and its tributaries

3.1 The A27 currently crosses the fluvial and tidal floodplain of the River Arun, at Arundel, which is designated as a main river by the Environment Agency. The River Arun flows through Arundel in a southerly direction before discharging to the English Channel circa 6.5km downstream. Two tributaries of the River Arun, the Tortington Rife and the Binsted Rife located to the west of the river are additionally designated main rivers. In its current alignment, the A27 does not intersect with the Tortington Rife and only crosses the Binsted Rife upstream of where it is designated as a main river.

3.2 **Figure 3-1** below shows the proposed junction options over the Environment Agency's Flood Map for Planning.

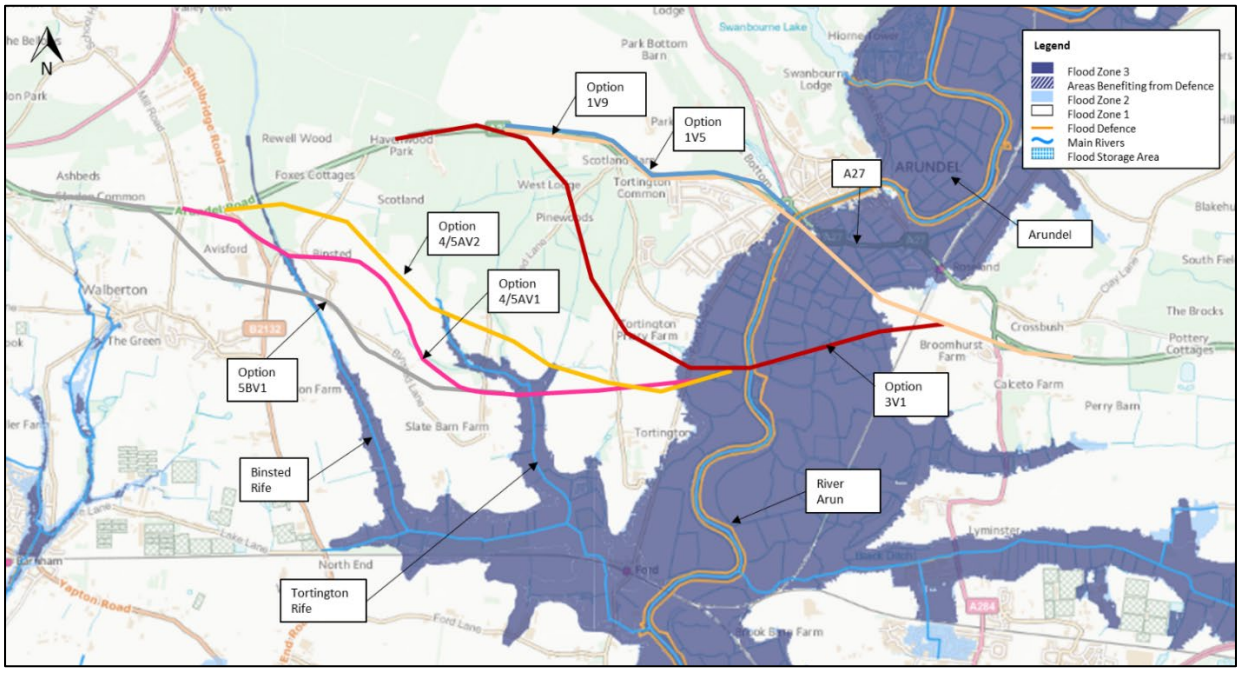


Figure 3-1 Environment Agency Flood Map for Planning

(fluvial and tidal flood risk)

3.3 The plan shows that bypass alignment options 1V9 and 1V5 would reuse the existing Arun crossing (or provide a new crossing at a similar location) and

would not cross any further watercourses, thus not posing a significant change to the impact on the River Arun. Furthermore, this crossing point is the shortest crossing of the tidal floodplain associate with the River Arun.

3.4 The remaining options (3V1, 4/5 AV1, 4/5 AV2 and 5BV1), however, propose to construct an additional crossing over the River Arun, which in turn entails crossing its fluvial and tidal floodplain (Flood Zone 3) for a length of circa 1.5km. This could result in a significant loss of floodplain storage, which, if not managed or compensated adequately could potentially have negative impacts on flood risk in the area. Provision of flood compensation for these options would require significant land take and costly mitigation measures. Additionally, the construction of a new crossing over the River Arun would substantially increase construction cost, while introducing a considerable risk of pollution to the main river during the construction phase.

3.5 Options 4/5 AV1 and 5BV1 additionally cross over the Tortington Rife and the Binsted Rife and their respective floodplains. Provision of clear span bridges over these two main rivers in order to maintain sufficient flow capacity would be costly.

Impact on ordinary watercourses and surface water flow paths

3.6 Options (4/5 AV1, 4/5 AV2 and 5BV1) cross a total of 17 ordinary watercourses including the Tortington Rife, the Binsted Rife and the Walberton Green to the west of the River Arun as they pass through a complex network of interconnected surface water channels. Culverting a high number of watercourses in the area will have the potential to disrupt local hydrology and hydrogeological connectivity, in turn having negative impacts on biodiversity and local habitats.

3.7 The aforementioned alignment options cross several areas which are identified in the Environment Agency's Risk of Surface Water maps as having a High risk of surface water flooding (refer to **Figure 3-2** below). Noticeably,

options (4/5 AV1 and 5BV1) cross a large surface water flow path ('High' risk) associated with the Tortington Rife.

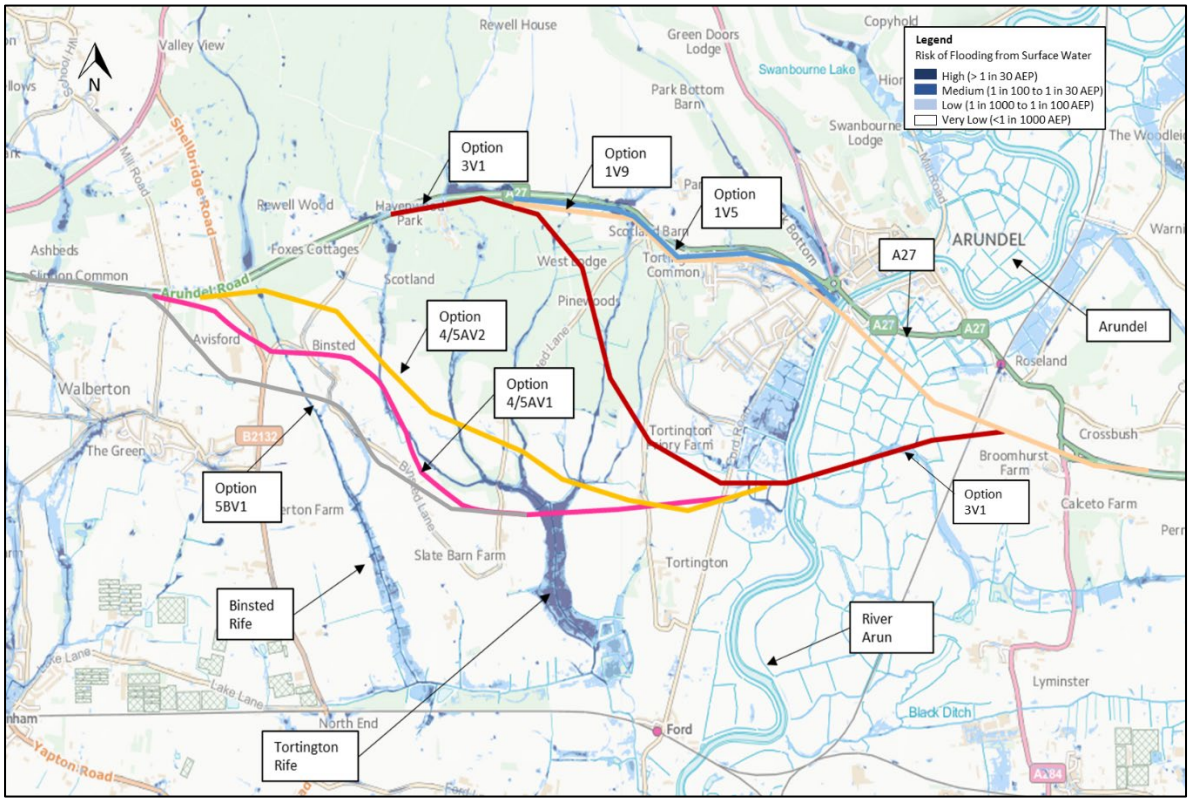


Figure 3-2 Environment Agency Risk of Surface Water Flooding Map

Drainage requirements and increase of surface water runoff

3.8 As stated in Section 2 of this report, Option 5BV1 comprises approximately 8km of new dual two-lane carriageway. This alignment option runs for a longer distance compared to the remaining alternatives, taking a larger area of undeveloped land and crossing a higher number of watercourses. The increase in impermeable areas (+circa 2.5ha when compared to the next longest option, and +circa 10.5ha when compared to the shorter options) associated to Option5BV1 would therefore generate the highest volume of surface water runoff, potentially increasing flood risk to nearby urban areas for the lifetime of the A27. This option would require the provision of the

highest volume of attenuation storage, increasing costs and reducing the sustainability value of the scheme. This option would additionally pose the highest risk of hydrocarbon pollution entering the most number of watercourses, in comparison to the remaining alternatives. Over the lifetime of the A27 this would incur a greater maintenance burden to ensure that any mitigation solutions remained operational and functional.

3.9 In summary, Option 5BV1 is the longest realignment option and therefore crosses a greater length of fluvial/tidal floodplain, a greater number of watercourses and would generate a greater volume of surface water runoff. If not adequately addressed, these elements could increase flood risk within the vicinity. Furthermore, addressing these issues will take more land to provide compensatory or attenuation storage and be more costly in terms of span bridges and culverts.

4.0 NOISE IMPACT

4.1 The Ardent noise assessment to support the application to discharge Condition 23 under application Reference WA/11/19/DOC included targeted baseline noise monitoring at two positions as shown in **Figure 4.1** below. Sound levels at these locations show very close correlation to the baseline measurements at a similar separation distance from the A27, namely LTML2 in the Highways England Environmental Assessment report Chapter 11 Noise and Vibration.

Figure 4.1 Highways England and Ardent Monitoring Positions

4.2 Ardent measurement Position 1 (ACE Pos1 in Figure 4.1) was also influenced during the day by activity at the adjacent Walberton & Binsted Primary School.

4.3 Sound level measurements (for Highways England) close to the A27, STML2, were taken during the day only. Measurements at LTML1 some 2.6km to the east resulted in sound levels some 5dB lower during the day than at STML2; night-time sound levels at LTML1 were 68dBL_{Aeq}. It is reasonable to assume the overnight sound levels at STML2 will be similar.

4.4 The Ardent noise assessment for the site demonstrated that the site was a low risk development site according to *ProPG: Planning and Noise.* When considering road traffic noise; standard glazing and ventilation by openable windows would be suitable to protect future residents' amenity during the day

and night. It was recommended that provision was made to allow windows to remain closed, with alternative ventilation, on properties abutting the school playing fields during the day.

4.5 Highways England noise and vibration report in paragraph 11.3.1.19 defines the Significant Observed Adverse Effect Level (SOAEL) as 63dB$L_{Aeq,16h}$ freefield or 68dB$L_{A10,18h}$ façade during the day. At night the SOAEL is defined as 55dB$L_{night,\ outside}$. They note the daytime SOAEL is derived from the Noise Insulation Regulations and at night the SOAEL is based on the level above which cardio vascular health effects become the major public health concern.

4.6 It is noted that noise barriers could provide a noise level reduction of between 5 to 10dB depending on the relative positioning of the barrier, the road and the properties. This is notwithstanding the visual impact or impact on resident amenity of these barriers given the relationship of the approved development on this northern boundary.

4.7 Option 5BV1 of the proposed A27 realignment runs along the majority of the northern boundary of the site. Figure 11-48 of the Highways England report shows the wider extent of long-term impact including across the site. Much of the site is in the red and orange contours, which indicate Major and Moderate Adverse impact.

4.8 Figure 11-54 of the Highways England report focuses on individual properties in Walberton it does not consider the approved development therefore the number of properties affected is significantly greater than referenced in the Highways England documents. Those properties to the NE corner of the site closest to Yapton Lane are predicted to experience a long-term Major Adverse impact as a result of the scheme. Properties slightly further to the south are predicted to experience a Moderate Adverse impact including Walberton & Binsted Primary School.

4.9 It is expected that free field sound levels at the closest properties on the site will be in the region of 75-80dBL_{Aeq} during the day and 68dBL_{Aeq} at night, based on the Highways England baseline measurement surveys. A well designed and positioned barrier can reduce sound levels to 65-75dBL_{Aeq} during the day and 58-63dBL_{Aeq} at night; although the night time reduction is likely to be lower at first floor level as the barrier will be less effective.

4.10 Sound levels of this order are above the SOAEL defined within the Highways England report during the day and night. It is expected that the majority of properties on the site will experience sound levels above the SOAEL if the 5BV1 alignment is brought forward.

4.11 It is acknowledged that a low noise road surface could reduce sound levels slightly however it is highly likely that future residents would be exposed to sound levels above the Highways England defined SOAEL.

4.12 The site would move from being a low risk to a high-risk development in accordance with ProPG. ProPG states:

> *"As noise levels increase, the site is likely to be less suitable from a noise perspective and any subsequent application may be refused unless a good acoustic design process is followed and is demonstrated in an ADS [Acoustic Design Statement] which confirms how the adverse impacts of noise will be mitigated and minimised, and which clearly demonstrate that a significant adverse noise impact will be avoided in the finished development."*

4.13 The permitted development incorporates design measures that are suitable for the existing acoustic environment. The realignment of the A27 along the 5BV1 route would lead to a significant change to noise levels across the site and would require fundamental design changes to provide suitable living conditions for future residents. These changes would include reliance on closed windows, which would be of enhanced specification and the introduction of alternative ventilation, which is likely to be mechanical ventilation.

4.14 Other measures could include; reworking of the layout if the construction had not been completed at that point and likely changes to the housing mix to provide on-site screening and significant barrier screening. It is highly likely that the site will be fully constructed by the time works are expected to start on the road scheme therefore reworking the site at this time will not be an option.

4.15 It is very likely that areas of the site will be significantly affected by high noise levels meaning that Highways England will have to consider a significant number of sensitive properties to ensure residential amenity is properly protected.

5.0 OTHER MATTERS

5.1 Trees – Option 5BV1 would result in the removal of a substantial row of mature and protected trees which form the boundary between the development site and the golf course. These trees have been carefully mitigated in the approved layout to ensure their long term protection and management. In addition, their removal would adversely affect the outlook from the approved plots.

5.2 Landscape Impact – whilst it is acknowledged the provision of a new road scheme would fundamentally change the landscape by virtue of its size, Option 5BV1 would result in an overly engineer visually intrusive feature in the landscape so close to the village of Walberton. This fails to protect and enhance the landscape and visual amenity of the site and the local area in general.

5.3 Heritage Impact – Option 5BV1 would result in a detrimental impact on the setting of the Grade II Listed Avisford Park and Gardens. This would fundamentally and irrevocably alter the setting of this former country house. There is no level of mitigation that could be provided which would minimise the impact of a dual carriageway running in close proximity to this building and through its setting.

5.4 Walberton Village itself is within a Conservation Area and includes a number of Listed Buildings, and again, this option brings the road in close proximity to the village changing its overall context and appearance.

6.0 CONCLUSIONS

6.1 Ardent Consulting Engineers has been commissioned by Linden Homes to provide representations regarding the A27 Arundel Bypass proposal option 5BV1 put forward by Highways England and its impact on the parcel of land east of Tye Lane, Walberton ('the site').

6.2 At the time of writing this report, construction works have commenced on the site for an approved residential development scheme of 175 dwellings, new vehicular access, together with associated car parking, landscaping & community facilities to include allotments, play space & community orchard.

Highways and Transportation

6.3 This report demonstrates that the alignment of proposal option 5BV1 (one of six options in total) passes through the site, which in the first instance would have a direct adverse impact on the access and a number of the houses approved and currently under construction. Secondly there would be significant disruption and impact on all future residents occupying all 175 new homes at the site if Option 5BV1 was taken forward.

6.4 Notwithstanding the above, this report has demonstrated that the Option 5BV1 is the least desirable in respect of the overall highways / transportation issues, including severance, traffic flows (on the A27 and local roads), junction capacity, construction duration, land take, cost and national guidance / policy.

Noise impact

6.5 This appraisal notes that the existing soundscape at the development site is suitable for residential development with minimal consideration of acoustics to achieve suitable sound levels.

6.6 The 5BV1 realignment option would lead to a significant adverse impact on the residential amenity of those new residents in the consented development site.

Flood Risk and Surface Water Drainage

6.7 In relation to flood risk and surface water drainage, this report concludes that bypass alignment options 1V9 and 1V5 would constitute the least disruptive of the options, as they would not pose a significant change to the impact on the River Arun and other watercourses in relation to the current scenario.

6.8 The remaining alternatives (3V1, 4/5 AV1, 4/5 AV2 and 5BV1), however, could result in a significant loss of floodplain storage, which could in turn have negative impacts on flood risk in the area. Provision of flood compensation for these options would require significant land take and costly mitigation measures. Additionally, the construction of a new crossing over the River Arun would substantially increase construction cost, while introducing a considerable risk of pollution to the main river during the construction phase.

6.9 This report highlights the fact that, amongst the least favourable options, Option 5BV1 is the longest realignment option and therefore crosses a greater length of fluvial/tidal floodplain, a greater number of watercourses and would generate a greater volume of surface water runoff. If not adequately addressed, these elements could increase flood risk within the vicinity. Furthermore, addressing these issues will take more land to provide compensatory or attenuation storage and be more costly in terms of span bridges and culverts.

Other matters

6.10 This report concludes that alignment 5BV1 would have significant detrimental impact on trees, landscape, heritage and on the village of Walberton itself which is situation within a conservation area.

Arun Countryside Trust CIO

Incorporating Mid Arun Valley Environmental Survey (MAVES)

24 October 2019

Dear Highways England,

Response to A27 Arundel Bypass further public consultation

As Chair of the Arun Countryside Trust I am attaching a Report on the Arundel Bypass options written by Consultant Ecologist [redacted] of Wildlife Splash Ltd. It makes the following major criticisms and points out many other ways in which the impacts on the very rich wildlife of the area have been misrepresented. Our sense is that these misrepresentations make it very likely that the public's choice of options has been affected.

1. Criticisms of the consultation brochure

a) The richness of the area's biodiversity has not been conveyed.

The Report points out that: 'The cumulative value of the site, with a high representation of species in decline, the important habitat connectivity, the rich assemblage of species and the rich assemblage of habitats has not been conveyed' (Para 5.9). 'Based on the information given in the consultation pamphlet, the reader would find it very difficult to understand the extent, richness and diversity of the wildlife and to usefully decipher which Options would be more damaging' (Para 5.13).

Also the consultation brochure fails to capture the biodiversity and status of rare and declining species that would be affected by the scheme 'A standard list of protected species is given, but at no point does it mention that the bats have been assessed at the level of national if not international importance, or that the invertebrates are of regional importance, or that Water Vole, Common Toad, Dormouse etc. are all represented well but declining nationally. The majority of the public have no idea of such things and cannot place a considered opinion without the facts being more transparent.' (Para 3.32).

b) Residual impacts are missing.

The information in the brochure has been drawn from two tables in the EAR – 'construction impacts' and 'operational impacts'. This gives the reader the misguided impression that there will be little lasting impact on wildlife within the Mid Arun Valley area with the exception of bats and barn owl. 'Residual impacts', i.e. that which would be permanently lost and cannot reasonably be avoided or mitigated for, are missing, although they were included in the 2017 EAR.

c) Lengths of new dual carriageway given are misleading.

The bulleted summaries state Cyan and Beige Options would feature 4.5 km of new dual carriageway (as opposed to 7.2, 6.9 or 8 km for the Magenta, Amber and Grey options respectively). But Beige and Cyan actually only require an approximate 1.7 km stretch of entirely new road, and the remainder is upgraded from the existing road. This is a very different scenario from that implied in the brochure and would mean a very different impact for wildlife – for instance, the Cyan and Beige options would require only a fifth of the length of entirely new road compared to the Grey option, and hence would be far less damaging for wildlife along this route.

d) Woodland impact figures have been miscalculated.

Woodland calculations for Cyan and Beige options appear to have been miscalculated (Para 2.10). An area classed as deciduous woodland, which would be needed for the junction for Cyan and Beige, is in fact a field currently grazed by sheep. As a result, the figures given indicate that Cyan and Beige options would have twice as much 'impact' on woodland compared with Magenta – this is incorrect.

Putting these figures in such a prominent position (p. 17 of the brochure) has given the incorrect impression that Cyan and Beige are more damaging overall than Magenta or Grey. In contrast the clear conclusion of the Report is that Cyan and Beige are actually the least damaging routes.

2. Criticisms of HE's data overall

a) Hidden impacts are not made clear.

'A major carriageway through the area will have a significant 'hidden' impact (i.e. not included in the mitigation for direct habitat loss) on the species present' (paras 3.40-1). The example of birds is given: research has shown that with a heavy traffic volume (c. 30,000 vehicles a day) bird presence and breeding is reduced for a distance of 1200m from a road. 'This is a significant loss of useful area when considering the Crimson, Magenta, Amber and Grey options, which would entail between 6km and 8km of entirely new roads as compared to approximately 1.7 km of entirely new road with the Beige/Cyan options.'

b) There is a lack of wildlife data on the Magenta and Grey routes.

For instance, bat surveys: bat data given by Highways England has concentrated on the woodland areas. Bat data on the Magenta and Grey routes has not been presented to an equal level with the other routes. 'Surveys have largely concentrated on the very important woodland assemblage of bats and their foraging areas. Surveys have not extended out to the west of the survey area along the Magenta and Grey Options, where the quality of the habitat is high.' (para 2.67)

We believe there is information available to Highways England that has not been presented. Bat surveyors who some of our Trustees spoke to, had maps of all the routes and stated they were checking them all. Local people know there is new bat information found by HE surveyors in the area of Binsted Rife valley, at the Old Rectory, at Mill Ball (both houses in Binsted) and the footpath area between Oakleys Barn and Morleys Croft (area damaged by both Magenta and Grey options), but it does not appear in the consultation data.

HE made a commitment to the South Downs National Park Authority that they would research routes outside the National Park to an equal level. This missing information means that HE have not fulfilled their undertaking to the South Downs National Park.

c) The biodiversity data appears to be used as a box-ticking exercise.

The conclusion to the Report suggests that the current scheme ignores species decline and climate change, and the described impacts on biodiversity are being used as 'a way of navigating the system in order to achieve an expensive and environmentally unsound infrastructure outcome come what may'. The accumulation of information by Highways England may amount to 'nothing more than a box-ticking exercise as with many other schemes'.

3. Conclusion

Based on the information in the Report, the Arun Countryside Trust cannot support any of Highways England's options. All of them cause unaffordable ecological damage in an age of Climate Change and less damaging options should be considered. The Trust also has serious doubts about the accuracy and completeness of the information that Highways England have made available to the public, and we consider that this prevents the public authorities and others from making an informed decision.

Yours sincerely,

[redacted]

Chair, Arun Countryside Trust

MAVES

The Mid Arun Valley Environmental Survey of the Arun Countryside Trust

RESPONSE TO THE A27 ARUNDEL BYPASS SCHEME OPTIONS 2019




Prepared by:

[redacted]

Consultant Ecologist and Botanist

[redacted]

CONTENTS

EXECUTIVE SUMMARY

- Following Highways England's (HE) publication of the six proposed A27 route Options; this report reviews Chapter 8 of the Environmental Assessment Report (EAR), Biodiversity. This is in order to establish whether the information is presented in an accurate and clear manner for consultation.

- This report was commissioned by MAVES (Mid Arun Valley Environmental Survey). MAVES is the environmental division of Arun Countryside Trust CIO (registered charity number 1180078). Partner organisations include the Sussex Wildlife Trust and Arundel Agenda 21.

The Environmental Assessment Report

- HE's EAR ends with two summary tables: the *Construction Phase likely significant effects* and the *Operational Phase likely significant effects*.

- The significant effects on species and habitats outlined in these two tables have been copied into the consultation pamphlet under the headings '*Construction*' and '*Operation*' with an explanation for operation as follows: '*operation refers to summer 2041 when the new road is expected to have been in place for 15 years'*.

- However, these published tables do not include the *residual* effects. These are the remaining environmental 'costs' of the project that could not be reasonably avoided or mitigated. These are a key consideration in deciding whether the project should be permitted or not.

- As such, the reader is wholly unaware of the real 'costs' of the project and may assume that the *operational* effects are all that remain. Yet it is the residual effects and the on-going operational effects that facilitate understanding of the Scheme impact on the local area and the wider countryside.

Construction effects (impacts)

- A number of irreplaceable habitats will be lost including a traditional orchard, ancient woodland, wood pasture and parkland, veteran trees and deciduous woodland. Many species will be impacted and require removal from the construction footprint. A large amount of habitat used by protected species will be lost.

Residual effects (impacts)

- In HE's 2017 EAR, a clear table of Residual effects (as per CIEEM 2018 guidelines) was provided with a clear conclusion yet the 2019 EAR is unclear, with the residual effects immersed in text and jumbled with the construction effects.

- There are significant residual effects for bats, Barn Owl, Hedgehog, Hazel Dormouse, Water Vole, woodland birds, woodland invertebrates, notable plants, grazing marsh (including reedbed and fen).

- HE states that, with the Crimson Option, Hedgehogs face road mortalities to the extent that the population may not sustain itself. This road mortality impact is not considered significant for Hedgehogs outside the woodland (although it was in 2017).

- HE's surveyors found that the assemblage of dead wood invertebrates was particularly important with many notable species present. This group is found in parts of the woodland with dead wood habitat and in hedgerows. HE has assigned significance of effect according to the amount of woodland in each Option – though this is not necessarily the case due to the large amount of dead wood habitat outside the woodland.

- Common Toad is not mentioned in residual impacts despite being included in 2017 due to a barrier (Amber Option) separating breeding sites from terrestrial sites. A barrier is also present in the Grey, Magenta and to a lesser extent Crimson Options.

- A revision of HE's residual effects has included habitats not stated in their 2019 EAR report, such as ancient woodland, veteran trees and Traditional Orchards (due to irreplaceability) and Brown Hare and Harvest Mouse due to barriers for dispersal and fragmentation.

Operational effects (impacts)

- HE only includes the Binsted Woods Complex (due to edge effects with some Options) bats and Barn Owls (close to the operational scheme) in their assessment of significant operational impacts.

- A revision of the operational effects has included more mobile species such as Common Toad, reptiles (Grass Snake and Adder), Badger and Hedgehog as these are highly mobile species and will continue to suffer road kills along the Grey, Amber, Magenta and, to a lesser extent Crimson Options as long as the road is in operation.

Connectivity & Severance

- The Arundel Water Vole population is central to a large interconnected habitat extending from Mid Sussex to the coasts at Climping Gap and at Chichester with implications for the wider population with additional barriers to dispersal.

- A Dormouse corridor survey along hedges radiating from the Binsted Woods Complex to the west has found Dormice and multiple nests as far as Binsted Rife demonstrating the importance of these corridors and possible negative implications for small and unstable Dormouse populations in the wider area from this large source population.

- The off-line options will present significant barriers to dispersal and cause avoidable habitat fragmentation. The Grey, Magenta and Amber Options will, in effect, with up to 8 km of new carriageway, turn the Binsted Woods Complex into an 'island' trapped between two busy roads.

- Barriers and fragmentation are likely to have a negative impact on some bats, Badger, Brown Hare, toads, reptiles (Adder and Grass Snake), Hedgehogs, Harvest Mice, Dormouse and Water Vole as well as some invertebrate species. Barriers limit movement between populations thus reducing gene flow and halting the recovery from local population declines (i.e. dispersing dormice).

- There are fifteen habitats of principal importance in the Mid Arun Valley (though some are fragments and corridors), which, by providing areas, ribbons and islands of good quality habitat throughout the area enable a high proportion of rare and declining species to survive in a largely farmed environment.

- Hidden impacts include the mortality of invertebrates when trying to cross a road; the avoidance of roads by some invertebrates; changes in invertebrate and floral assemblages due to pollutants and

run off by roads; a dead zone around a busy road devoid of breeding birds due to the noise of the carriageway. The Mid Arun Valley currently has a good representation of predatory birds such as Marsh Harrier, Peregrine, Red Kite, Short-eared Owl (all Annex 1 species) and Kestrel, Buzzard and Hobby. Impacts on the lower trophic levels are likely to reduce the abundance of predators.

Additional impacts

- The wider ranging impacts of the Scheme are likely to be negative for a number of species within and around the Scheme Options for a variety of reasons.
- Much emphasis has been put on the woodland bat assemblage but there is little information on bats outside the woodland across the landscape that may rely on commuting to the Binsted Woods Complex and its surrounding habitats in order to forage, such as a maternity colony of Serotine bats at Barnham (GB Red List Vulnerable).
- HE have failed to provide ecological data on bat activity in the Magenta and Grey route corridors to the same level as they provided for the other routes (see para 2.67).
- An emergence survey of buildings under the Magenta Option (Lake Copse) recorded five bat species including a Brown-eared species and Serotines.

Mitigation

- HE has stated that appropriate mitigation measures will be required to adequately mitigate the impact of habitat severance on protected species. These measures include the provision of wildlife crossing structures, underpasses and tunnels.
- HE acknowledge shortcomings in crossing structures due to lack of evidence as to the efficacy of such structures and thus (for bats and Dormice) the mitigation technique should be viewed as partly experimental. With the exception of Badger, there is a dearth of evidence of other mobile species using such structures i.e. Grass Snake, Harvest Mouse, toads etc.
- Yet, despite this knowledge of the ineffectiveness of such structures, HE state that for the range of other species in the area it may be necessary to construct multiple mitigation structures to ensure species are able to cross the scheme without being exposed to collisions with vehicles or to replace severed movement paths.
- Comments (regarding birds) such as '*there are ample areas outside the Scheme that will not be affected'* are worrying as most such areas (for breeding birds) are at carrying capacity (limited by suitable nest sites).
- There is no guarantee that mitigation measures in the form of translocation or habitat creation will work or be maintained etc. Such measures are only as good as the sub-contractor undertaking the work and are surrounded by uncertainty i.e. pond maintenance, succession, vandalism (owl boxes) etc.

Planning policy

- Planning Policy Guidance states that the purpose of the Environmental Assessment Report is that '*the local planning authority when deciding whether to grant planning permission for a project, which*

is likely to have significant effects on the environment, does so in the full knowledge of the likely significant effects, and takes this into account in the decision making process'.

- Planning Policy Guidance states that the purpose of the Environmental Assessment Report is *to ensure that the public are given early and effective opportunities to participate in the decision making procedures.'*

The clarity of information for public consultation

- The 2019 HE EAR is long, complex, unclear and inconsistent in places with some of the most relevant information buried in the text. A number of the residual and operational efffects are misguided. Unlike the HE 2017 EAR, there is no conclusion or clear table of residual impacts (the environmental cost of the Scheme) to aid readers.

- The information given in the public consultation pamphlet has been drawn from two tables in the EAR: the construction impacts and the operational impacts giving the reader the misguided impression that there will be little lasting impact on wildlife within the Mid Arun Valley area with the exception of bats and Barn Owl.

- The extent of the woodland loss with the Cyan and Beige Options has been misrepresented in the consultation pamphlet as has it has been counted as woodland when in fact it is an area of semi-improved grassland.

- The bulleted summaries state that the Cyan and Beige Options would feature 4.5 km of new dual carriageway as opposed to 7.2 km, 6.9 km or 8 km for the Magenta, Amber and Grey options respectively. However, if it was worded that the Beige and Cyan Options require an approximate 1.7 km stretch of new road, with the remainder (2.8 km) being upgraded from the existing road, although broadly similar, it presents a very different scenario.

- Based on the information given in the consultation pamphlet, the reader would find it very difficult to understand the extent, richness and diversity of the wildlife and to usefully decipher which Options would be more damaging.

Legislation and policy

- The legislation and policy framework is extensive with European directives feeding into national policies, which in turn feed into the National Planning Policy Framework. Yet, much of this legislation stipulates that biodiversity must not be reduced at the *national* level, or that a particular scheme or development must show *net gains* in biodiversity.

- Such legislation provides for the translocation of species to other areas, and often, the monitoring is for a limited time only. The protection of areas with important assemblages of species, with the exception of statutory and non-statutory sites, is not considered.

Conclusion

- Within the Mid Arun Valley, the natural habitats and landscape as at present managed, support rich biodiversity, including thriving bird communities, a large and stable Dormouse population, thousands of breeding toads, key reptile sites, a nationally important bat assemblage and several important invertebrate communities These communities have persisted for millennia, despite a changing world.

Mitigation and compensation (that may be maintained for 25 years and monitored for fewer years) are unlikely to result in net biodiversity gains for such a rich and largely interdependent assemblage.

- The current Scheme is being proposed against a backdrop of continual species decline in the face of yet another factor - **climate change** - resulting in a layer of unpredictability (i.e. ponds drying, cold snaps, localised flooding, lack of availability of prey source at critical times etc.)
- The numerous impacts mentioned in this report should not be used, as with other schemes, as a way of navigating the system in order to achieve an expensive and environmentally unsound infrastructure outcome come what may. If this were the case then the accumulation of information by HE would amount to nothing more than a 'box-ticking' exercise as with many other schemes.
- **The numerous impacts should be used as a way to navigate to the least damaging Option for Arundel and its rich assemblage of wildlife, which, evaluating the operational and residual effects is the Cyan or Beige Option.**

1 INTRODUCTION

BACKGROUND TO THE STUDY

1.1 HE has published six proposed options for the A27 Arundel Bypass scheme based on the latest available information. This report is a review of the Environmental Assessment Report Chapter 8, Biodiversity and evaluates whether the information is accurate, clear and informative.

1.2 This report was commissioned by MAVES (Mid Arun Valley Environmental Survey). MAVES is the environmental division of Arun Countryside Trust CIO (registered charity number 1180078). Partner organisations include the Sussex Wildlife Trust and Arundel Agenda 21.

HIGHWAYS ENGLAND'S ANALYSIS AND PRESENTATION

1.3 HE has commissioned a suite of habitat and species surveys within the Mid Arun Valley. These surveys are presented in the Environmental Assessment Report (EAR) Appendices to the Chapter 8, Biodiversity.

1.4 The biodiversity input into the public consultation pamphlet 'A27 Arundel Bypass Further Public Consultation Have Your Say' has been informed by the EAR, particularly two summary tables: the Construction Effects and Operation Effects.

AIMS

1.5 The aims of this report are as follows:

- To review HE's environmental impact analysis regarding the construction, operation and residual impacts (effects) of the Scheme.
- To review additional impacts which are routinely not captured in an environmental impact assessment.
- To ascertain whether the information presented in the public consultation document is clear, balanced and usefully informative.

2 HIGHWAYS ENGLAND ANALYSIS

BACKGROUND

2.1 HE has undertaken an analysis of the six Scheme options with the results presented in the Environmental Assessment Report, Chapter 8, Biodiversity. At the end of the report, where the conclusion would be expected, there are two tables summarizing findings. The first table summarizes the *Construction Phase likely significant effects*. The second table summarizes the *Operational Phase likely significant effects*.

2.2 Significant effects are those impacts that must be taken into account during the evaluation of features, and are based upon the extent of the impact and the importance of the feature (be it of local, county, regional or national importance).

2.3 The effects on species and habitats outlined in these two tables have been copied into the consultation pamphlet under the headings '*Construction*' and '*Operation*' with an explanation for operation as follows: '*operation refers to summer 2041 when the new road is expected to have been in place for 15 years'*.

2.4 However, these published tables do not include the *residual* effects. The effects that remain after all assessment and mitigation are the 'residual effects'. These are the remaining environmental 'costs' of the project that could not be reasonably avoided or mitigated. These are a key consideration in deciding whether the project should be permitted or not. For this reason, it is important that residual effects are clearly described in accordance with the system of effects.

2.5 As such, the reader is wholly unaware of the 'costs' of the project and may assume that the *operational* effects are all that remain in the area. Moreover, the effects published in the public consultation pamphlet are numerous and impossible to unpick in a meaningful manner. The written '*Environmental context'* of the consultation pamphlet (page 20) does little to elaborate or aid understanding.

2.6 Publiished guidelines for an Ecological Impact Assessment (CIEEM 2018) state that it should clearly and simply describe the significant effects of any project so that all interested parties understand the full implications of what is proposed.

2.7 The construction phase will impact on most species and habitats. Large areas of habitat will be lost and many species will be negatively impacted. However, it is a finite phase of the project and, once over, it is the residual effects and the on-going operational effects that facilitate understanding of the Scheme impact on the local area and the wider countryside.

THE CONSTRUCTION PHASE EFFECTS

2.8 The table below is copied from HE EAR Chapter 8 Biodiversity (2019). It lists the significant potential impacts (within and around the site) of the construction phase. Other impacts on surrounding statutory and non-statutory sites (neutral or positive) are included in the original table but they are not the focus of this report.

Table 1: *Construction phase likely significant effects (modified from HE EAR 2019)*

	Cyan/Beige 1V5/1V9	Crimson 3V1	Magenta 5AV1	Amber 5AV2	Grey 5BV1
Binsted Woods Complex	Large Adverse +	Very Large Adverse	Large Adverse +	Very Large Adverse	Neutral
Rewell Woods Complex	Large Adverse +	Large Adverse +	Neutral	Neutral	Neutral
Avisford Notable Road Verge	Neutral	Slight Adverse	Slight Adverse	Slight Adverse	Neutral
Ancient woodland HPI	Large Adverse +	Very Large Adverse	Moderate Adverse +	Very Large Adverse	Neutral +
Wood pasture and parkland HPI	Moderate Adverse +	Neutral	Neutral	Very Large Adverse	Neutral
Ancient or veteran trees HPI	Very Large Adverse	Neutral	Very Large Adverse	Very Large Adverse	Very Large Adverse
Deciduous woodland HPI	Large Adverse +	Very Large Adverse	Slight Adverse	Very Largo Adverse	Slight Adverse
Traditional Orchard HPI	Neutral	Neutral	Moderate Adverse	Neutral	Neutral
Grazing marsh (incl reedbed and fen) HPI	Moderate Adverse	Large Adverse +	Large Adverse +	Large Adverse +	Large Adverse +
River corridor HPI	Neutral	Neutral	Neutral	Neutral	Neutral
Other HPI habitats	Neutral	Neutral	Neutral	Neutral	Neutral
Amphibians GCN and Common Toad	Neutral	Neutral	Neutral	Neutral	Neutral
Aquatic ecology	Neutral	Neutral	Moderate Adverse	Moderate Adverse	Moderate Adverse
Badger	Neutral	Neutral	Neutral	Neutral	Neutral
Bats	Moderate Adverse	Very Large Adverse	Large Adverse	Very Large Adverse	Moderate Adverse
Breeding birds (wetland / arable)	Neutral	Neutral	Neutral	Neutral	Neutral
Breeding birds (woodland)	Slight Adverse +	Large Adverse +	Slight Adverse +	Moderate Adverse	Neutral
Barn Owl	Moderate Adverse	Moderate Adverse	Moderate Adverse	Moderate Adverse	Moderate Adverse
Hazel Dormouse	Moderate Adverse	Large Adverse +	Moderate Adverse	Large Adverse +	Moderate Adverse
Reptiles	Neutral	Neutral	Neutral	Neutral	Neutral
Invertebrates terrestrial	Moderate Adverse +	Very Large Adverse +	Slight Adverse +	Very Large Adverse +	Slight Adverse +
Water Vole	Neutral	Moderate Adverse	Moderate Adverse	Moderate Adverse	Moderate Adverse
Notable plants	Moderate Adverse	Large Adverse +	Large Adverse +	Large Adverse +	Large Adverse +

2.9 A number of irreplaceable habitats will be lost including a traditional orchard, ancient woodland, wood pasture and parkland, veteran trees and deciduous woodland. Much of the deciduous woodland is intermixed and of similar species composition to the ancient woodland and so, in effect, that too is an irreplaceable habitat.

2.10 The exact extent of deciduous woodland to be lost does not appear to have been presented accutately, for an area of semi-improved grassland with scattered trees (Figure 2 taken from Appendix 8.20 *Phase 1 Habitat Survey Baseline*) has been incorrectly classified as deciduous woodland in the Arboriculture Report (Appendix 7.3). Both are shown below in Figures 1 and 2

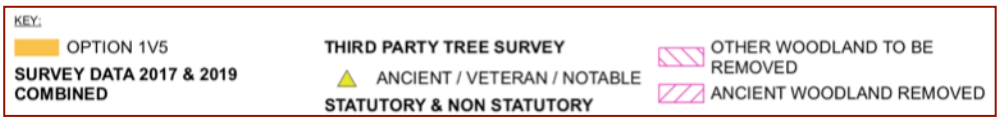
with the key from the arboricultural figure below. The Google Earth image also shows that, quite clearly, the area is a field with scattered trees and scrub and not deciduous woodland.

2.11 The information given in the public consultation brochure (page 17) is therefore inaccurate and misleading.

Figure 1: *HE Phase 1 map taken (copied from HE Phase 1 Report Appendix 8.20)*

Figure 2: *HE assessment of woodland and trees along the Cyan route (copied from HE Arboricultural Report Appendix 7.3)*

The accompanying key to Figure 2 above



2.12 HE has counted the veteran and ancient trees along all route Options and reached figures for each. However, this does not quite capture the complexity of this class of trees. The parameters

used to classify such trees have not been made clear and there are numerous 'notable' trees that do not quite reach the age class of ancient and veteran trees, but are over 3 m in circumference, have veteran features of importance to wildlife and are the next generation of veteran trees.

2.13 In the Highways England 2017 Environmental Assessment Report (Chapter 8) it was considered that the construction and operation would have a negative impact on Common Toad. In that report Table 8.14: *Summary of impacts on Great Crested Newt and Common Toad* states that '*Dependent on the size of the population affected a significant adverse effect at between the local level and the county level is possible for common toad and great crested newt (not yet confirmed as present). The risk of a significant effect at the county level is considered higher given the larger area of aquatic habitat affected and proximity to several common toad populations reported in the desk study.'*

2.14 HE is aware (from MAVES reports and correspondence) of the extremely high population of toads around the Grey, Magenta and Amber Options and yet have considered the impact (formerly significant up to the local level presumably for toads) during construction to now be '*neutra*l'.

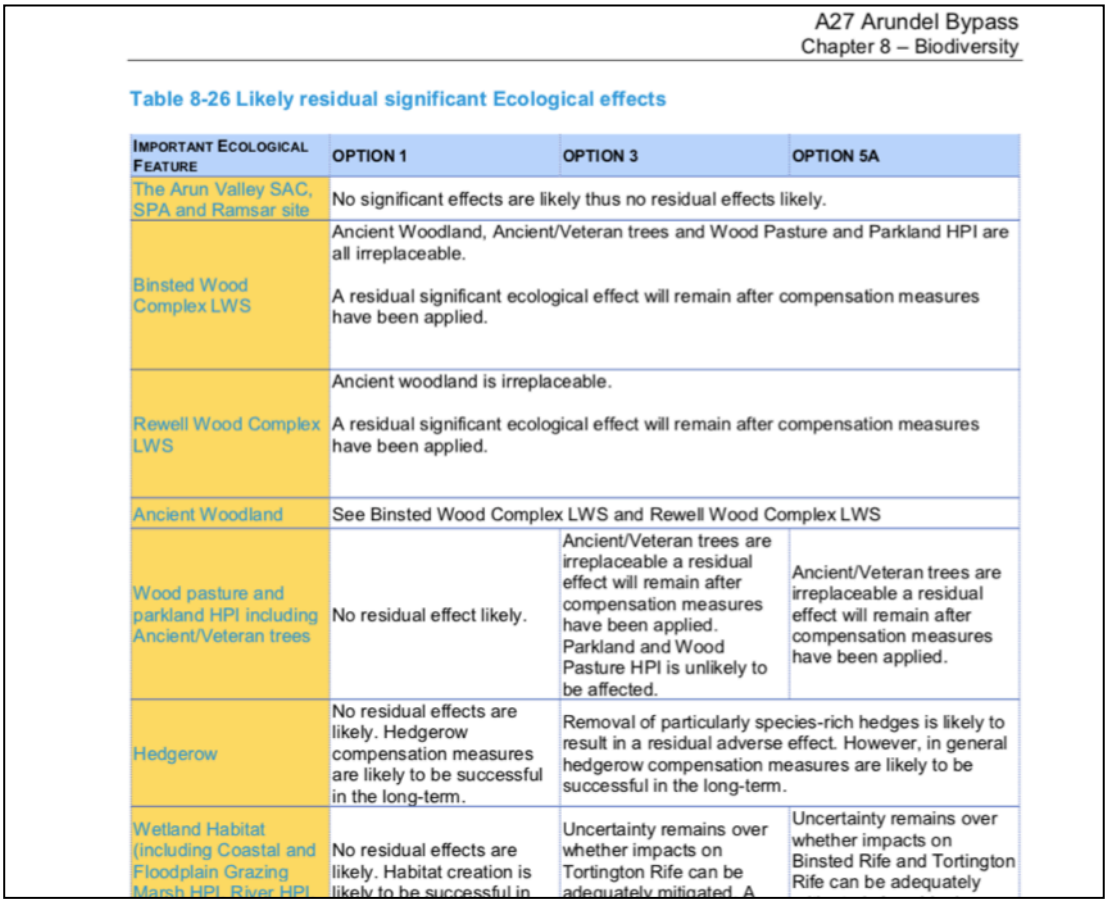
THE RESIDUAL EFFECTS

2.15 Residual effects, as previously stated, are those effects that remain following the application of mitigation measures to avoid or reduce adverse effects. Any residual impacts that will result in effects that are significant after the proposed compensatory measures, will be the factors considered against ecological objectives (legislation and policy) in determining the outcome of the application.

2.16 Ecological Impact Assessment (EIA) guidelines (IEEM 2018) state that that a summary table should be provided listing the significance of residual effects for each ecological feature, the compensation measures required and the means by which compensatory measures can be secured to allow the local planning authority to ensure that appropriate planning conditions / obligations are included with any consent.

2.17 A very clear table of the residual effects (Figure 3) was published in the 2017 EAR. This adds clarity to the understanding of the longer-term impacts after the construction phase has been completed.

Figure 3: *Likely significant residual ecological effects (HE 2017)*



A27 Arundel Bypass
Chapter 8 – Biodiversity

Table 8-26 Likely residual significant Ecological effects

IMPORTANT ECOLOGICAL FEATURE	OPTION 1	OPTION 3	OPTION 5A
The Arun Valley SAC, SPA and Ramsar site	No significant effects are likely thus no residual effects likely.		
Binsted Wood Complex LWS	Ancient Woodland, Ancient/Veteran trees and Wood Pasture and Parkland HPI are all irreplaceable. A residual significant ecological effect will remain after compensation measures have been applied.		
Rewell Wood Complex LWS	Ancient woodland is irreplaceable. A residual significant ecological effect will remain after compensation measures have been applied.		
Ancient Woodland	See Binsted Wood Complex LWS and Rewell Wood Complex LWS		
Wood pasture and parkland HPI including Ancient/Veteran trees	No residual effect likely.	Ancient/Veteran trees are irreplaceable a residual effect will remain after compensation measures have been applied. Parkland and Wood Pasture HPI is unlikely to be affected.	Ancient/Veteran trees are irreplaceable a residual effect will remain after compensation measures have been applied.
Hedgerow	No residual effects are likely. Hedgerow compensation measures are likely to be successful in the long-term.	Removal of particularly species-rich hedges is likely to result in a residual adverse effect. However, in general hedgerow compensation measures are likely to be successful in the long-term.	
Wetland Habitat (including Coastal and Floodplain Grazing Marsh HPI, River HPI	No residual effects are likely. Habitat creation is likely to be successful in	Uncertainty remains over whether impacts on Tortington Rife can be adequately mitigated. A	Uncertainty remains over whether impacts on Binsted Rife and Tortington Rife can be adequately

2.18 Section 8.9 of the current EAR Chapter 8 Biodiversity is entitled the 'Assessment of Likely Significant Effects.' The section starts by stating broad likely significant effects from the *construction* and *operation* phases of the Scheme. Each ecological feature is discussed in turn from designated sites to habitats and species. The term 'residual effect' is not used until halfway through the section, prior to which the distinction between 'construction' effects and 'residual' effects is unclear.

2.19 The significant residual effects have been extracted from the text in the EAR (2019) and are presented in Table 2 below with the HE reasoning in the following paragraphs.

Table 2: *Significant residual impacts extracted from text in the HE EAR*

Ecological Feature	1V5 / 1V9 Cyan/Beige	3V1 Crimson	4/5AV1 Magenta	4/5AV2 Amber	5BV1 Grey
Bats	Moderate Adverse	Very Large Adverse	Large Adverse	Very Large Adverse	Moderate Adverse
Barn Owl	Neutral	Neutral	Moderate Adverse	Moderate Adverse	Moderate Adverse
Hedgehog	Neutral	Slight Adverse	Neutral	Neutral	Neutral
Hazel Dormouse	Moderate Adverse	Large Adverse	Moderate Adverse	Large Adverse	Moderate Adverse
Water Vole	Neutral	Moderate Adverse	Moderate Adverse	Moderate Adverse	Moderate Adverse
Woodland birds	Slight Adverse	Large Adverse	Slight Adverse	Moderate Adverse	Neutral
Woodland invertebrates	Moderate Adverse	Very Large Adverse	Slight Adverse	Very Large Adverse	Slight Adverse
Notable plants	Moderate Adverse	Large Adverse	Large Adverse	Large Adverse	Large Adverse
Grazing marsh/reedbed/fen	Moderate Adverse	Large Adverse	Large Adverse	Large Adverse	Large Adverse

BATS

2.20 Paragraph 8.9.2.5 states that the construction and operation of the Scheme will have significant residual effects due to a lack of evidence as to whether roost replacements and measures that allow bats to cross schemes are successful. Additionally, the complex way in which bats use the environment is unpredictable.

2.21 Option 3V1 (Crimson) is likely to have the largest effect with a large loss of woodland habitat and severance of woodland habitat resulting in collisions with vehicles resulting in a Very Large Adverse effect.

2.22 4/5AV2 (Amber) would result in loss of Alcathoe roosts in Hundred House Copse and potential roosts in the Lag and the Shaw. It would sever flight lines used by rare bats including a flight line from a Barbastelle maternity roost. This would result in a Very Large residual effect.

2.23 Option 4/5AV1 (Magenta) will sever flight paths used by multiple bat species including rare bats resulting in potential collisions and there will be some loss of habitat resulting in a Large Adverse residual effect.

2.24 Options 1V9 and 1V5 (Cyan and Beige) could potentially result in the loss of roost sites uses by Bechsteins bats and would widen an operational road which may potentially reduce connectivity for rare bats. The residual effect is likely to be Moderate Adverse.

2.25 Option 5BV1 (Grey) is also considered to be likely to sever flight paths used by multiple species. However, it is considered that the severance is reduced as it is further away from the core foraging and roosting locations used by woodland bats. The residual impact is therefore considered to be Moderate Adverse.

BARN OWL

2.26 HE state that the Barn Owl is a low, slow-flying species and research has shown that where this species roosts or forages in close proximity to operating major roads it is likely that road traffic mortality will deplete local populations. A Moderate Adverse effect will therefore remain close to the orginal scheme.

2.27 HE commissioned surveys (EAR Appendix 8.4) show that there are 9 observed breeding sites within the vicinity of the road options. This high number is due to the length of the potential roads and the high quality of the landscape with abundant prey. There are also numerous potential breeding sites (usually a limiting factor for Barn Owls), most of which are in the vicinity of the Crimson, Amber, Magenta and Grey Options.

2.28 The HE report states '*Road construction can cause the direct loss and fragmentation of barn owl habitat resulting in indirect impacts such as the disruption or severance to established home ranges. However, the most significant impact comes after a new road becomes operational, affecting barn owls inhabiting the area up to one to 1.5 kilometres from the road. As a consequence, barn owls living within this distance of new roads commonly fall victim to road traffic. Following the death of these owls, recruitment of young barn owls which attempt to settle and breed in the newly vacant areas is insufficient to offset the high levels of road mortality*'.

2.29 Barn Owls will continue to fall victim to road collisions in the Mid Arun Valley as there will be a constant recruitment of young owls settling in the area due to the numerous high quallity roost and nest sites such as the nest site in Scotland Oak shown in Photograph 1 taken by Mike Tristram 05/06/19. The location map is below the photo showing its proximity to the Amber and Magenta route options.

COMMON TOAD

2.30 This species is not mentioned regarding residual impacts, however, in the HE 2017 EAR a residual Adverse impact was considered for the Crimson and Amber Options due to severance of the breeding ponds from terrestrial habitat. These two Options are combined in the second column of Figure 4 below.

***Figure 4**: Table 8.26: Likely significant residual ecological effects (Highways 2017)*

Amphibians	No residual effects are likely. Habitat creation is likely to be successful.	Uncertainty remains over whether habitat severance can be adequately mitigated. A residual adverse impact is probable.

Photograph 1: *Barn Owl nesting in a veteran Oak – Scotland Oak*

HAZEL DORMOUSE

2.31 HE EAR (para 8.9.2.29) state that due to the widening of the current carriageway and the loss of woodland a residual significant effect of Moderate Adverse is considered likely for Option 1V5 and Option 1V9 (Cyan / Beige) Options 3V1 (Crimson) and 4/5AV2 (Amber) as they will remove large areas of woodland and sever either the main block of woodland or corridors to the greater landscape. As there is much controversy and little evidence as to the efficacy of wildlife crossings such mitigation measures cannot be relied upon and therefore a Large Adverse

residual significant effect is likely. HE state that a residual impact of Moderate Adverse is expected with Options 4/5AV1 (Magenta) and 5BV1 (Grey) due to the smaller loss of woodland habitat (and presumably presence of corridors particularly for the Grey Option, though not stated).

HEDGEHOG

2.32 Paragraph 8.9.2.38 (HE EAR 2019) states that '*Owing to the large area of woodland loss associated with Option 3V1* (Crimson) *and broad area of severance, it is uncertain whether mitigation on hedgehog woodland habitat may be effectively delivered. Animals present in the severed parts of Binsted Wood Complex LWS will be exposed to mortality from road traffic, which may be unsustainable at the local population level. A Slight Adverse effect is likely'*.

2.33 In effect HE is saying that the woodland Hedgehog population may well become locally extinct. However, as '*operation*' refers to 2041 (as stated in the consultation brochure) it can be declared that there will be no impact (carried through to the Operation impacts list in the brochure). This is a clear example of why the residual effects should be stated.

2.34 Of concern is that in the HE 2017 EAR it was considered that there would be residual impacts for 'other notable mammals', (which includes Hedgehog) for *both* the Crimson and Amber Options due to habitat severance. The screen shot of this part of the residual impacts table is shown in Figure 5. The first column relates to the Cyan and Beige Options and the second and third column (combined) relates to the Crimson and Amber Options.

Figure 5: *Table 8.26: Likely significant residual ecological effects (Highways 2017)*

Other Notable Mammal Species	No residual effects are likely. Habitat creation is likely to be successful.	Uncertainty remains over whether habitat severance can be adequately mitigated. A residual adverse impact is probable.

WATER VOLE

2.35 Paragraph 8.9.2.35 (EAR Chapter 8) states that the construction of the Scheme is unlikely to have a significant adverse residual effect on the conservation status of Water Vole.

2.36 Yet the following paragraph (8.9.2.36) states that due to the disruption of larger areas of habitat triggering a greater mitigation requirement that would be technically more difficult to deliver '*a residual significant effect of Moderate Adverse is considered likely for Options 3V1* (Crimson), *Option 4/5AV1* (Magenta), *Option 4/5AV2* (Amber) and *Option 5BV1* (Grey)'.

WOODLAND BIRDS

2.37 HE state (EAR para 8.9.2.27) that there is uncertainty as to the impact of woodland removal on particularly a number of Birds of Conservation Concern Red List Species that are associated with mature woodland and dead wood habitat. This habitat clearly cannot be immediately replicated and so a Large Adverse significance of effect is likely for Option 3V1 (Crimson) which has the greatest extent of woodland loss and severance; a Moderate Adverse significance of effect is likely for 4/5AV2 (Amber) which results in lower amount of woodland loss but several instances of severance; and a Slight Adverse significance of effect for Option 1V5 (Cyan), Option 1V9 (Beige) and Option 4/5AV1 (Magenta) which have the least degree of woodland loss and severance.

WOODLAND TERRESTRIAL INVERTEBRATES

2.38 HE considers that there will be a residual impact on woodland terrestrial invertebrates (EAR para. 8.9.2.32). By the term 'woodland' terrestrial invertebrates, it is assumed that HE is referring to those associated with dead wood habitats as outlined in the invertebrate survey (EAR Appendix 8.22).

2.39 The HE invertebrate surveyors assessed habitats using ISIS Invertebrate Species-habitat Information System which generates a 'Specific Assemblage Types' score. This was originally developed to assess SSSI's in order to identify whether an assemblage associated with a location was in a 'favourable condition'.

2.40 Results showed four specific assemblage types (SATs) - rich flower resource (primarily hedgerows and boundary features along the Amber Option), bark and sapwood decay and heartwood decay (also mostly along the Amber Option) and scrub edge. These were all given 'favourable' condition. The report states that the presence of SATs with high numbers of representative species, especially those in favourable condition, provides an insight into the rarest and, often most unique invertebrate assemblages associated with an area.

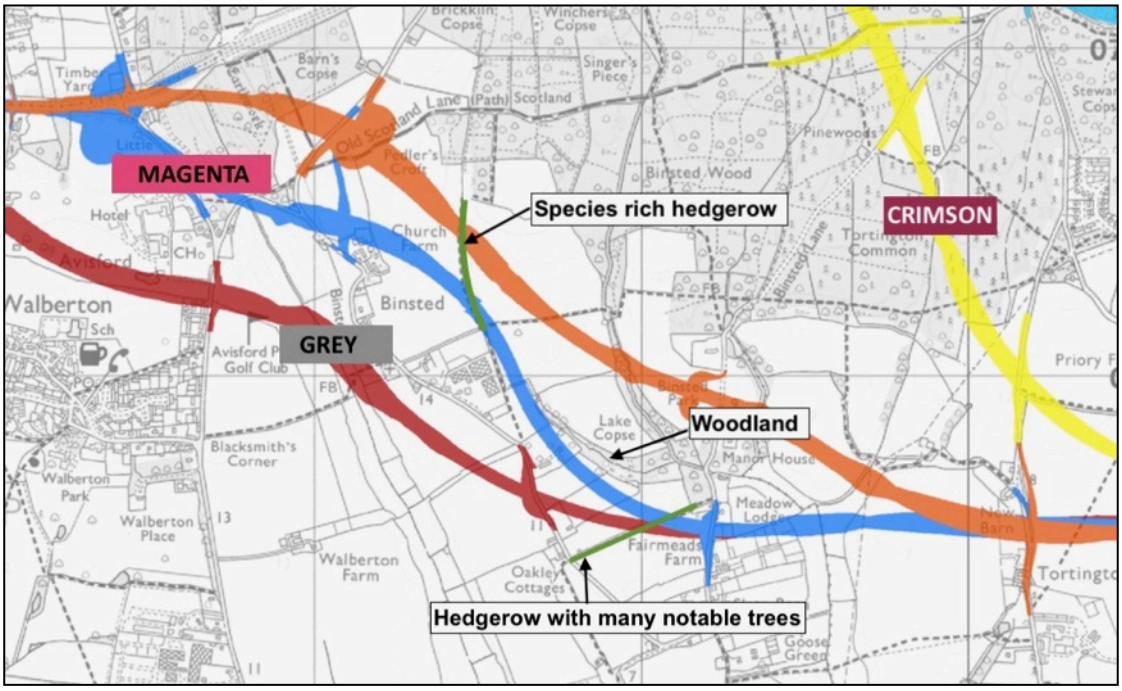
2.41 HE surveyors found 41 notable species of inverts with some crossover with MAVES findings but likely an underestimate. A total of 29% were associated with dead wood and 24% with short sward and bare ground habitat.

2.42 A MAVES survey (Grove 2016) of two hedgerows and Lake Copse (Figure 6) found high numbers of saproxylic (dead wood) invertebrates in the hedgerow with the notable trees and the woodland. Grove found 52 saproxylic species giving a Saproxylic Quality Index (which rates the importance of the dead wood habitat) of 434 (a good score). The 3 parallel hedgerows to the north of this "hedgerow of many notable trees" share many of the habitat corridor attributes of this hedgerow. All would be severed by Magenta and 2 would be severed and 1 impacted by Grey.

2.43 HE, however, have allocated the impact levels in accordance to the amount of intact woodland that each area has. However, the numerous old trees in the hedgerows must also be taken into account as these have both bark and sapwood decay and heartwood decay, as stated in the HE commissioned survey. This would immediately change the Magenta significance of effect from Slight Adverse to Large or Very Large Adverse and the Grey Option to Moderate or Large adverse – both dependant upon the number of trees with dead wood habitat.

2.44 The HE surveyors attribute the high representation of species associated with dead wood to the abundant dead wood habitat in close proximity to open areas with flowering shrubs and herbaceous species providing pollen and nectar for emerging adults. A wide dual carriageway would inhibit movement of newly emerged saproxylic invertebrates from deadwood habitats within the woodland to this herbaceous rich habitat, which mainly occurs along hedgerows outside the woodland (with the exception of spring time when some parts of the woodland floor are extremely species rich).

Figure 6: *Locations of beetle surveys undertaken by Grove*



OTHER MAMMALS

2.45 This refers to priority species or species of principal importance (UK BAP) listed under Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006 known to be in the area. Brown Hare and Harvest Mouse are present and will also be impacted negatively. These have not been included in HE surveys.

2.46 Harvest Mouse has been found breeding in a field with rough relatively species rich grassland intermixed with reedbed and sedge swamp at Meadow Lodge, and there is an old record for it in a wayleave within the Binsted Woods Complex. It is likely to move around the area using hedgerows and ditches. It would also have the opportunity to breed, undisturbed by grazing cattle, along some parts of Binsted Rife.

2.47 Brown Hare is seen very occasionally but consistently in the area, with a dead hare also recorded on Binsted Lane. This species is thought to cross quiet but not busy roads.

2.48 There is likely to be a residual negative impact on these species for both will be restricted in movement and unable to use different parts of the landscape as some may become unavailable i.e. a wayleave or a field of tall and unkempt vegetation at Meadow Lodge being cut. This will make local extinction more likely over time.

NOTABLE PLANT SPECIES

2.49 In paragraph 8.9.2.39 of the EAR, HE state that due to the uncertainty surrounding the complex requirements of rare plants the likely residual significance is Moderate Adverse for Options 1V5 and 1V9 (Cyan / Beige), Large Adverse for Option 3V1 (Crimson) (due to the Arun floodplain habitats), and a Large Adverse for Options 4/5AV1, 4/5A/V2 and 5BV1 (Magenta, Amber and Grey) due to the floodplain habitat and impacts on Binsted Rife and Tortington Rife.

COASTAL AND FLOODPLAIN GRAZING MARSH (INCLUDING LOWLAND FEN / REEDBED)

2.50 The impact for this habitat has been set by HE at exactly the same as for notable plant species. Uncertainty surrounds the impact that the Options will have on hydrology and the ability to recreate the most important areas of habitat impacted.

2.51 The major groundworks required for road construction just to the north of the area of wet woodland (HPI) with springs that feed Binsted Rife does not appear to have been taken into account. Additonally, the construction of structures to elevate the road onto bridges along the Magenta and Grey Options may impact on the hydrology of Binsted Rife as there are springs and knucker holes in the area.

SUMMARY

2.52 With the exception of bats and Barn Owl, considered to be permanently negatively impacted in the area ongoing until (and beyond) 2041, and therefore incuded in the published operational effects, none of the above information (i.e. the environmental cost of the project) has been made clear or stated wihtin the HE *A27 Arundel Bypass Further Public Consultation Have Your Say* pamphlet. This document is not transparent.

2.53 Moreover, the short list of operational effects, shown wihtin the HE *A27 Arundel Bypass Further Public Consultation Have Your Say* document and on Table 3 below, is questionable in its brevity.

Table 3: *Operational effects (from HE EAR)*

Ecological Feature	1V5 / 1V9 Cyan/Beige	3V1 Crimson	4/5AV1 Magenta	4/5AV2 Aber	5BV1 Grey
Binsted Woods Complex	Neutral	Large Adverse	Neutral	Large Adverse	Neutral
Bats	Moderate Adverse	Very Large Adverse	Large Adverse	Very Large Adverse	Moderate Adverse
Barn Owl	Neutral	Neutral	Moderate Adverse	Moderate Adverse	Moderate Adverse

2.54 The main argument for bats, for example, is that the success of structures used for bat crossings is experimental and not proven and so this very mobile group is likely to be negatively impacted whilst commuting across the landscape to feed.

2.55 The argument for Barn Owl is that it is low flying and therefore continued traffic collisions are likely and as such, a Moderate Adverse effect will remain close to the operational scheme.

2.56 The argument used for Hedgehogs, regarding residual impacts, is that as such a broad area of woodland is going to be severed (Option 3V1, Crimson), mitigation (presumably in the form of safe crossing places) will not be deliverable and therefore Hedgehogs will suffer high mortality from road traffic. Not withstanding the length of time for this species to become locally extinct, it should have been included in the *operational effects* table.

2.57 These points raise a number of questions as follows:

- Would not the same theory as applied to bats and Barn Owl apply to other mobile species moving across the landscape such as Common Toad, Grass Snake and Adder?

- Why has the mobility of these species not been taken into account in the environmental impact assessment?

- The movement of some species is dependant upon uninterrupted corridors, such as Grass Snake, Harvest Mouse and Dormouse. In this event, is each important hedgerow corridor going to have a usable underpass or overpass the width of a dual carriageway? There is very litlle evidence of species, with the exception of Badger, using such structures.

- As the broad severance within the woodland is considered to have a negative impact on a population of Hedgehog moving through the woodland, why isn't the broad severance outside the woodland considered to have a negative impact on species moving across the landscape and not necessarily using corridors? For example toads move in all directions in wet / damp conditions, Badger pathways (numerous in the Mid Arun Valley) are not necessarily near defined hedgerow corridors and Brown Hare moves across an open landscape.

2.58 To summarize, within the *operational* effects, HE has given, with the exception of bats and Barn Owl, no proper consideration for mobile species that make regular movements to, from, or across the Survey Area.

THE OPERATIONAL EFFECTS

2.59 This section gives some examples of species found within the Survey Area and reconsiders the operational effects of the Scheme Options.

BADGER

2.60 Very high levels of Badger activity in the Mid Arun Valley found by MAVES have been confirmed by HE surveyors (Appendix 8.3) who stated that the '*network of woodlands, pasture, arable habitats and hedgerows provide badgers with excellent habitat for sett creation and foraging as well as providing terrestrial linkages with suitable habitats in the wider landscape'*.

2.61 Either or any combination of main setts, subsidiary setts or outliers are in the path of the route Options (with the exception of the Cyan/Beige Options). An additional main sett (found by MAVES in 2019) has been constructed in the path of the Grey Option. The population density is extremely high. An additional outlier sett found by MAVES in 2018 within 30 m of the Magenta option became a breeding sett in 2019 (video available).

OPERATIONAL EFFECTS

2.62 Badger is a widespread species and its overall conservation status is stable. However, it is a protected species and the population density and the activity levels are so high within the Mid Arun Valley Survey Area that without the construction of barriers (such as mammal exclusion fencing) along the Crimson, Amber, Magenta and Grey Options, road mortalities would be unacceptably high.

2.63 There appear to be no plans in the mitigation sections of the EAR or the Mitigation Appendix (8.12) to incorporate fencing, other than in the vicinity of underpasses, and so, as with Barn Owls and bats, an on-going negative operational effect is likely

BATS

2.64 A total of 14 bat species have been recorded in the Mid Arun Valley including 3 Annex II species and one very rare bat species: Barbastelle, Bechstein's bat, Greater Horseshoe bat and Alcathoe bat. This community is thought to be of national, possibly international Importance.

2.65 HE surveyors (Appendix 8.6) captured and tagged a number of bats in order to ascertain flighlines and foraging activity. The majority of bats were caught within woodland. They were mostly foraging within and around the Binsted Woods Complex, though some were found to be moving both north and south out of the survey area (particulary Whiskered and Barbastelle). Daubentons bats, whose roosts were to the north of the survey area, had peripheral foraging within the survey area.

2.66 Bats are highly mobile utilising different roosts for different purposes, moving between roost sites and using corridors in the form of hedgerows, treelines and woodland edges to fly good distances (sometimes many kilometres) to access rich foraging areas. HE surveyors found a number of corridors and showed that Tortingon Lane is a 'key commuting feature' within the Field Survey Area for multiple bat species. It was also shown to have high levels of Barbastelle passes recorded in April (pre-maternity colonies) and September (post-maternity colonies) (Appendix 8.5).

OPERATIONAL EFFECTS

2.67 Surveys have largely concentrated on the very important woodland assemblage of bats and their foraging areas. Surveys have not extended out to the west of the survey area along the Magenta and Grey Options (acknowledged), where the quality of the habitat is high. The operational and residual effects are considered to be lower, particularly for the Grey Option due to being further from key foraging areas for the woodland bats. This may change with further survey effort.

2.68 An example of bats commuting to the area to forage is Serotines commuting from a maternity colony in Barnham (approximatley 3.5 km to the south west (Whitby 2016)). This is shown in Figure 7, though the commuting corridors to access the Survey Area were not established.

2.69 The flight paths are of critical importance to bats reaching productive foraging areas and, as such, bats in the wider area that are dependant upon the highly productive foraging areas around the woodland for survival must also be considered.

2.70 Just outside the woodland adjacent to Lake Copse, the owners of Mill Ball commissioned a bat emergence survey at their main dwelling (Boxall 2019). This was found to support Soprano Pipistrelles, Common Pipistrelles and a Long-eared bat species. Serotines and Nalthusius' Pipistrelles were also detected and could be roosting in the outbuildings. This is in the pathway of the Magenta Option.

2.71 Given the agricultural land to the south and west of the Binsted Woods Complex and the number of agricultural buildings with potential roost sites, it may be an important foraging area for bats commuting from the south and south west as it is the only large block of woodland in the wider area with a lot of productive and sheltered dark 'edge' habitat, for example, at the edge of the woodland, along wayleaves within the woodland and in shaws and hedgelines radiating from the woodland.

Figure 7: *Location of Serotine roost sites in Barnham that commute to the Binsted Woods Complex*

COMMON TOAD

2.72 Common Toad *Bufo bufo* was added to the UK BAP list due to serious declines in central and southern England. The following information has been extracted from JNCC *UK Priority Species data collation Bufo bufo version 2 updated on 15/12/2010.*

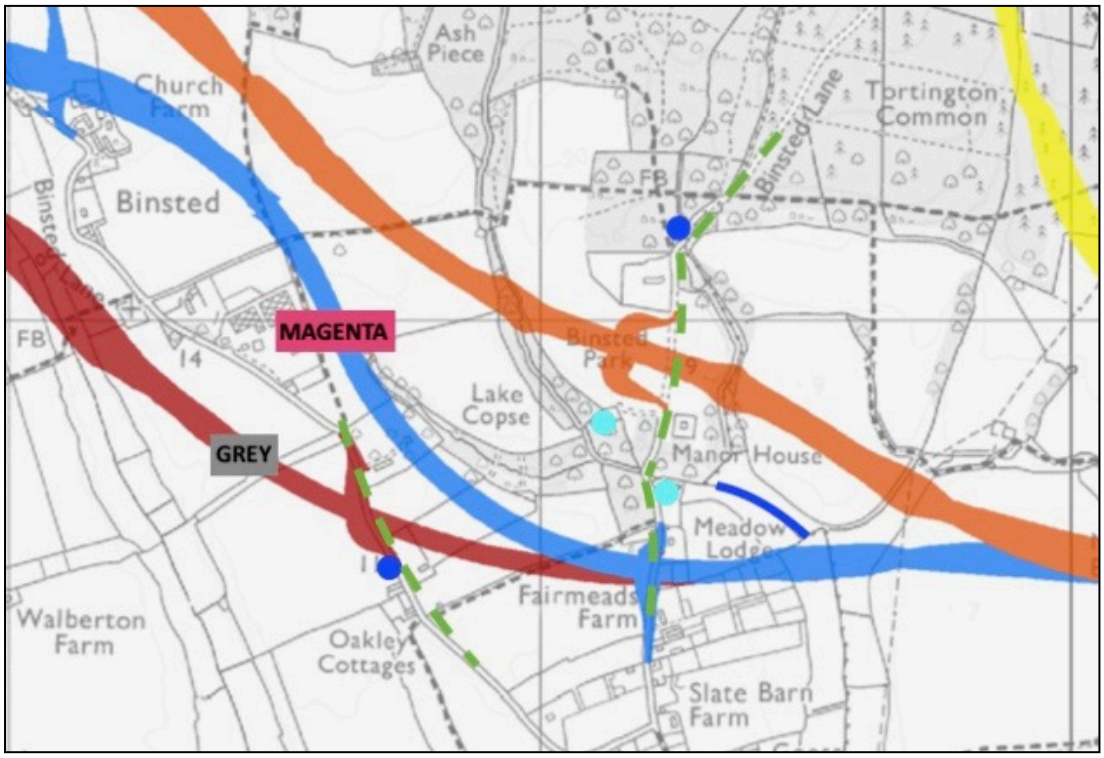
2.73 The reason for the inclusion as a UK BAP species (Species of Principle Importance) is the '*Serious decline demonstrated among many populations across large areas of S, E and C England where 50% or more of toad populations in rural areas have experienced recent declines (1985-2000) including extinction or near-extinction of some populations.'*

2.74 This document considers that wider action planning is necessary and states that '*This amphibian would benefit from recognition of its habitat and management needs at the wider landscape scale - both aquatic and terrestrial. Taking account of / or determining its presence during the early stages of local authority development plans, land allocation (particularly `brownfield sites`) and then development schemes. Habitat management schemes such as agri/env, highways schemes, and land management by public bodies could significantly enhance its current conservation status'.*

2.75 HE state that '*Common toads are a SPI and are widespread throughout the UK. They are considered to be of local importance'* (Para 8.6.4.104 EAR Chapter 8 Biodiversity). The continuing decline of Common Toad in the south and east is not mentioned.

2.76 HE did no surveys for this species despite the fact that there are three major Common Toad breeding sites are clustered in the area around the Grey, Magenta and Amber Options shown in Figure 9, together with two sites with lower numbers of Common Toads. HE, whilst undertaking Great Crested Newt surveys (Appendix 8.13), found toads in one of the woodland ponds to the north east of this area.

Figure 8: *Common Toad breeding ponds found by MAVES*



Dark blue areas – key breeding sites
Pale blue areas – water bodies with low numbers of toads seen
Green dashed areas – high numbers of toads on the lane

2.77 Toads are also found by the small woodland owners frequently and are known to be throughout much of the Binsted Woods Complex. The woodland floor comes alive during the breeding season as toads migrate towards the ponds. Common Toad is also found in gardens adjacent to Magenta e.g. Stable Cottage, Copperfield Cottage and Amber e.g. Kents Cottage.

2.78 Based on the Madonna Pond breeding population Paul Stevens, of the Arundel Wetland Centre, gave a 'conservative' estimate of a local population of 15,000. This was prior to the discovery of a large breeding site in the top of Tortington Rife and an additional major breeding site within a very large garden pond at Oakleys Barn (Grey Option) and so the population may well be higher.

2.79 Given the high population of breeding toads found to date in the western part of the survey area and the importance and connectivity of the terrestrial habitat within the Binsted Woods Complex, it may be that there are other important breeding sites for toads within the area, such as the potentially suitable ponds at Tortington and, to a lesser extent, some of the more suitable

ditches. If this were the case then there may be a large and important metapopulation of toads within the Mid Arun Valley.

2.80 It is clear from Figure 9 that this is a high and dispersed population of breeding toads. In order to access the various water bodies for breeding, toads will be moving in all directions through woodlands and across the landscape (including Binsted Lane). The Amber, Magenta and Grey Options pose significant barriers to dispersal and would result in extremely high mortality. Common Toad will also be moving through the entire woodland (based on records from small woodland owners) though the extent and density of movement in the eastern part of the Binsted Woods Complex is unknown.

OPERATIONAL EFFECTS

2.81 HE reports state that the Scheme is unlikely to have a significant adverse effect on Common Toads. It is stated that habitat can be created elsewhere in the form of ponds (and grassland).

2.82 The latest research by Froglife and the University of Zurich (Petrovan and Schmidt 2016) found that Common Toad has declined continuously in each decade since the 1980s. They conclude that given the declines, this species almost qualifies for International Union for the Conservation of Nature (IUCN) red-listing over this period (despite volunteer conservation efforts).

2.83 The Froglife and University of Zurich report states that declines could be linked to the general deterioration and fragmentation of the quality of the environment on a landscape scale and which cannot be offset by smaller improvements elsewhere, such as in well managed reserves.

2.84 Given the locations of the breeding ponds, the dispersed terrestrial habitat, and that Common Toad is very particular about where it breeds and habitually migrates to ancestral breeding ponds each year, there are likely to be on-going significant Adverse operational effects for this species.

REPTILES

2.85 All four species of ‘common’ reptiles have been recorded in the Mid Arun Valley. These species have all declined dramatically and are therefore given protection wherever they occur.

2.86 HE surveyors found 5 key reptile sites along the route options. These are denoted with green stars in Figure 9. The Key Reptile Site register is a mechanism designed by Froglife to promote the safeguard of important reptile sites. There are a number of criteria including and not limited to, for example, a site supporting 3+ reptile species; exceptional numbers of one species; 2 snake species etc.

2.87 The yellow stars in Figure 9 are additonal sites that MAVES consider to be likely candidates for additional Key Reptile Sites along the various options. The breakdown of species / numbers of each reptile at each site is given in Table 4.

Figure 9: *Key Reptile Sites (green stars) and potential Key Reptile Sites (yellow stars)*

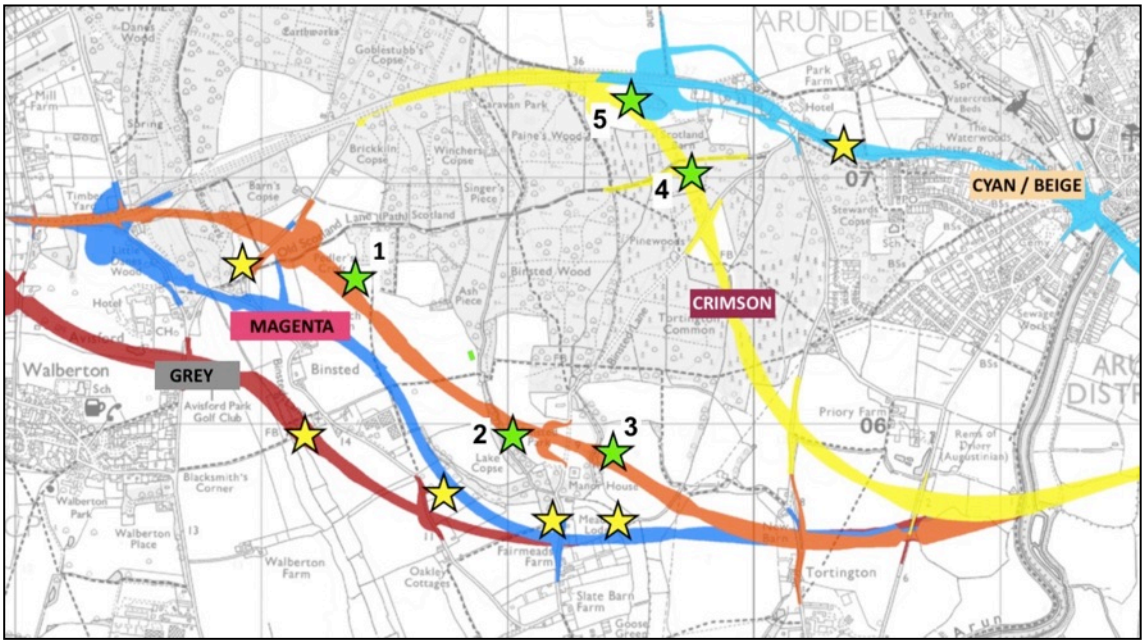


Table 4: *Numbers of reptiles found by HE surveyors at each location*

Species / location	1	2	3	4	5
Adder	0	4	0	0	0
Common Lizard	55	33	14	8	2
Grass Snake	1	17	12	5	2
Slow Worm	20	25	13	12	12

OPERATIONAL EFFECTS

2.88 HE state that scheme construction is unlikely to have a significant adverse residual effect on the conservation status of reptiles due to the ability to create habitat and translocate reptiles. It is also stated that if any of the off-line Scheme Options were used then mitigation measures would be required to restore connectivity (paragraphs 8.9.2.30-31 EAR Chapter 8).

2.89 Translocation may be suitable mitigation for Slow Worm and Common Lizard, both of which have relatively small home ranges; however no consideration has been given to the ranges of Grass Snake and Adder. These species are known to cover several kilometres in the course of an active season. They habitually travel between hibernation, foraging and breeding sites with Grass Snakes using communal traditional egg-laying sites year on year.

2.90 Adders are faithful to particular hibernation sites and will return from summer sites for the winter, tending to use communal hibernation dens, or hibernacula, with as many as several dozen snakes using an especially suitable site. Research has found that Adders will attempt to cross roads and are often killed doing so (Sherwood *et al*. 2002). Both these species have a relatively long life span of approximately 15 years.

2.91 Due to the size of the scheme and the range of Adder and Grass Snake and the high numbers of particularly Grass Snake found, even if these species are successfully removed from the

construction footprint, it is considered that there will be operational effects for these two species for the Crimson, Amber, Magenta and Grey Options.

3 ADDITIONAL IMPACTS

LANDSCAPE SCALE IMPACTS

3.1 Not-with-standing the long-term operational and residual impacts of the Scheme, in some cases it is feasible that there will be wider ranging impacts.

BATS

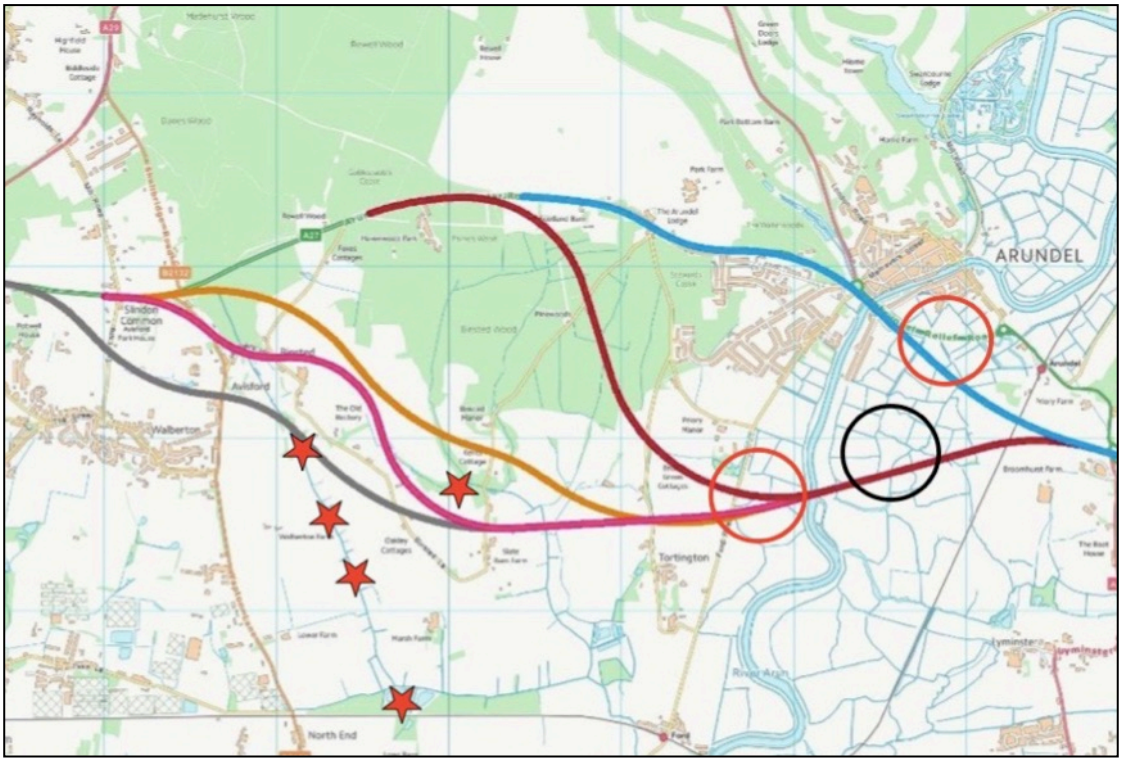
3.2 A review of the ordnance survey map of the area to the south of the current A27 shows much farmland but few pockets of woodland, and so the Binsted Woods Complex and its surrounds may be important for commuting bats from this wider landscape.

3.3 The four off-line scheme options would block a key commuting corridor to the south (Tortington Lane). The Amber, Magenta and Grey Options would, in effect, turn the Binsted Woods Complex (and its immediate surrounds) into an island isolating the area from bats in the greater landscape, who may depend on the resource.

WATER VOLE

3.4 Water Vole has been found throughout the Mid Arun Valley. The locations are shown in Figure 10 below with HE survey locations shown within circles (Appendix 8.19), with the black circle depicting the most field signs i.e. highest activity levels. MAVES findings are shown with stars – though these are 'ad hoc' sightings, as MAVES has not completed Water Vole surveys.

Figure 10: *HE and MAVES Water Vole signs and sightings*



3.5 HE surveyors concluded that the Field Survey Area should be viewed as a connected element in this wider wetland system and that there is abundant habitat to support both Water Vole and Otter.

3.6 A review of the relevant ordnance survey map shows that there is a corridor with a ditch and pond network potentially allowing movement of Water Vole from wetland areas in mid Sussex to as far as Chichester harbour without any significant barriers to dispersal.

3.7 HE state (EAR Chapter 8) that the highest impact will be across floodplain east of the Arun where watercourses are most likely to be culverted under the road. They state that this may impede Water Vole movement and cause severance of Water Vole populations on the Arun floodplain from a possible source population in the Arundel Wetlands Centre which may result in long-term decline.

3.8 Indeed, Water Vole Surveys in the late 1990's showed that this species had disappeared from the majority of the Arun Valley. In August 2005 171 animals were released at the Arundel Wetlands Centre site. These have dispersed far and wide since that time with wider Arun surveys showing that they had spread up and down stream. Studies by Dr Rowena Baker looking at genetic patterns showed that there were genes from the Arundel population as far as Amberley, where there were also genes from a population further North (likely Pulborough Brooks) mixing with the southern population.

3.9 This population is central to a large connected area of Water Vole habitat extending from Mid Sussex to the coasts at Climping Gap and at Chichester. As a result, fragmentation, leading to possible local extinctions and, more importantly impacting upon dispersal, could impact on the conservation status of this species over a far wider area.

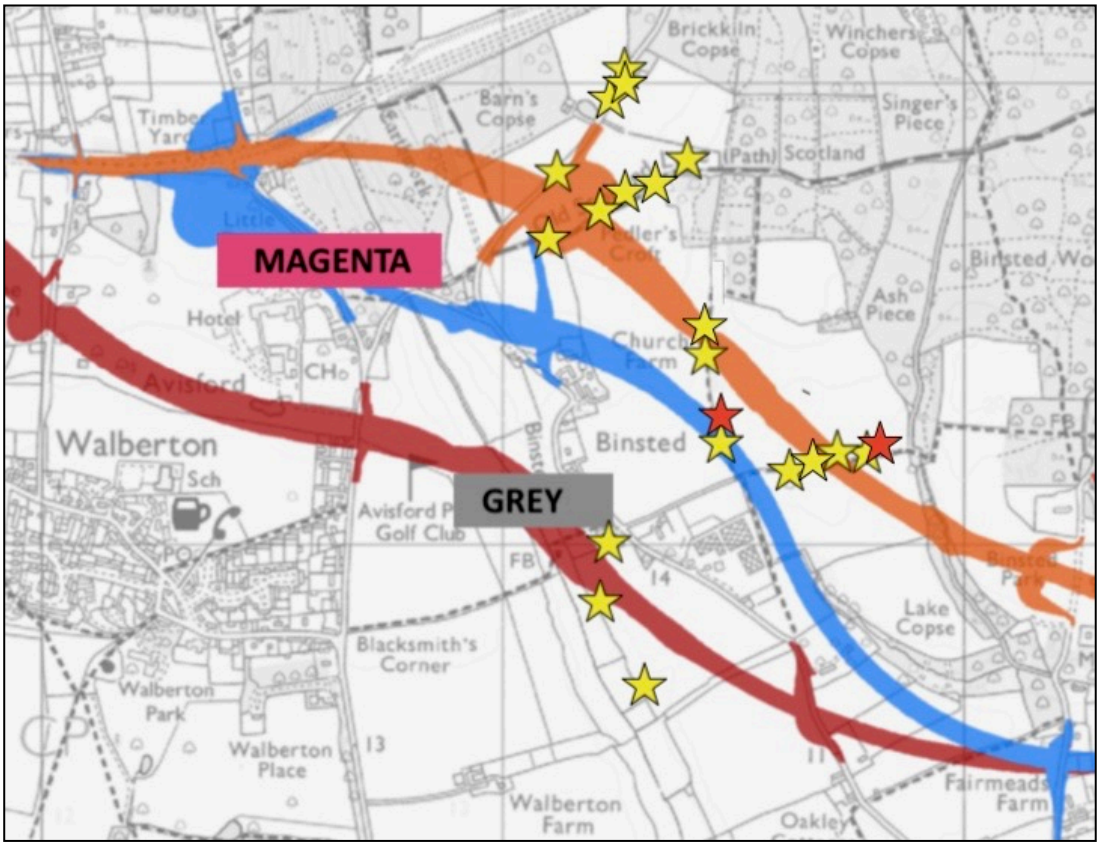
HAZEL DORMOUSE

3.10 The HE surveyors report (Appendix 8.14) states that '*The area west of the River Arun offers a very large area of high quality habitat occupied by hazel dormouse. It is possible that this hazel dormouse population may represent a core population, which may support smaller, more isolated sub-populations in the wider Desk Study Area. Such small populations which are vulnerable to extinction owing to factors such as weather, changes in habitat management or predation, have the possibility of being recolonised as they are directly connected to the population centred on the Field Survey Area'*.

3.11 MAVES have set up a corridor survey along several hedgerows radiating from the north west part of the Binsted Woods Complex. These have been checked four times in 2019 and on two occasions Dormice have been found. In addition, many Dormouse nests have been found extending along these corridors and down towards Binsted Rife (shown in Figure 11) showing constant and active dispersal from the woodland block.

3.12 The coastal plain to the south of the Binsted Wood Complex has few areas of woodland. However there are a number of copses and there is good connectivity with old hedgerows, and shaws. The population within the Mid Arun Valley is likely to be dispersing across the landscape.

Figure 11: *Dormouse dispersal corridors*



Yellow stars – Dormouse nests; red stars Dormice

3.13 Dormice have declined in both distribution and abundance in the 20th Century as a result of woodland loss and habitat fragmentation. The low population density of Dormice and its extremely slow rate of population increase make the Dormouse highly vulnerable to any change in its environment.

3.14 The impact of unseasonably wet and warm winters on the local population has been witnessed first hand through the National Dormouse Monitoring Programme within the Binsted Wood Complex. There have been high fluctuations in numbers year on year with a lack of breeding in the summer, producing litters into October and nest building in January, at times when sufficient food sources for successful breeding will be lacking.

3.15 The impact of roads on Dormouse is still not fully understood with some studies stating that this species will cross roads of up to 12 m including verges (Chanin and Gubert 2012) and others saying that wider roads are crossed but with high mortality. However, the impact of increased fragmentation coupled with the impacts of the changing climate seen locally is likely to be detrimental to this species.

BARRIERS AND FRAGMENTATION

3.16 HE has already implied that the Crimson Option would likely drive the woodland Hedgehog population to extinction in the Binsted Woods Complex. There is a realsitic possibility that, within a backdrop of climate change resulting in hightly unpredictable seasonal fluctuations in

temperature and rainfall, other species with relatively small or dispersed populations may decline over time and eventually become locally extinct.

3.17 The Cyan and Beige Options would result in the creation of approximately 1.7 km of new road over countryside, **and not the 4.5 km implied by HE in the consultation document**. This would result in one small area of floodplain grassland being trapped between two roads.

3.18 The Crimson route would create two fragmented areas of floodplain grassland: one to the east of the Arun and one to the west of the Arun. It would also divide the Binsted Woods Complex into two and cause a barrier to dispersal.

3.19 The Amber Option would create two fragmented areas of floodplain grassland: one to the east of the Arun and one to the west. It would divide the Binsted Woods Complex in two areas leaving two fragments of woodland: one at Hundred House Copse and one at Lake Copse, the Shaw and the Lag. The majority of the Binsted Woods Complex would become an 'island' separated from the remaining landscape and sandwiched between two busy roads.

3.20 The Magenta Option would create two fragmented areas of floodplain grassland: one to the east of the Arun and one to the west. It would create a tiny fragment of woodland at Barns Copse. It would turn the Binsted Woods Complex into an 'island' largely isolated between two busy roads and separated from the remaining landscape.

3.21 The Grey Option would create two fragmented areas of floodplain grassland: one to the east of the Arun and one to the west. It would turn the Binsted Woods Complex and its immediate area into an 'island' largely isolated between two busy roads and separated from the remaining landscape.

3.22 In additional the Crimson, Amber, Magenta and Grey Options would involve the creation of a new barrier across 6 km to 8 km of unspoilt countryside with a proven extremely high diversity and value of habitats and species.

3.23 Barriers may also limit the flow of individuals between populations with two major consequences. Barriers may slow or halt the recovery from local population declines since recruitment from neighbouring populations will be reduced and this will further increase the probability of local extinction. Barriers may also reduce gene flow between populations and increase inbreeding, reducing individual fitness and increasing the risk of local extinction. Gerlach & Musolf (2000) have shown that populations of bank vole are genetically different either side of a four-lane highway.

3.24 Species such as Brown Hare cannot survive in habitat fragments as they require wide open agricultural land to survive. It is well known that, for this reason, the density of busy roads has a negative effect on Brown Hare abundance (e.g. Roedenbeck, & Voser 2008). Other species as discussed in this report (i.e. Badger, toads, Hedgehog, reptiles and bats) will either be trapped in smaller areas of habitat or will be susceptible to (likely) fatal collisions if they try to move about the landscape. Other species such as Dormouse and Water Vole may not use structures provided for crossing or may be open to higher levels of predation whilst using such structures.

3.25 Habitat fragmentation is constantly cited as being one of the major threats to species. The first comprehensive review of the status of British mammal populations for over 20 years was

published in June 2018 (Mathews et al. 2018). This was to assess the trends in population status of mammals since 1995.

3.26 A number of species discussed in this report are found in the Mid Arun Valley: Dormouse (IUCN Red List Vulnerable), Hedgehog (IUCN Red List Vulnerable), Water Vole (IUCN Red List Endangered) and Harvest Mouse are all declining. The status of Serotine bat (IUCN Red List Vulnerable), Bechsteins bat and Barbastelle bat (IUCN Red List Vulnerable) is unknown but their habitats were found to be declining. The status of the Brown Hare was said to be currently stable although its habitat is declining.

3.27 The authors of the review conclude that '*The scale and nature of the impact associated with many potential future threats (e.g., major infrastructure developments; new housing allocations; increased traffic volume; and changes to farming practice in the face of climate change and altered subsidy scenarios) are extremely poorly characterised, and many of the approaches currently used to monitor them are not suitable for answering these questions. Almost nothing is known about the cumulative effects of such threats, with the loss of foraging habitat, decreased habitat connectivity, and increased light pollution being of particular concern. Most mitigation activities lack a robust evidence base, meaning that resource may be wasted on ineffective actions'.*

3.28 Should an off-line Option be decided upon for the A27, then these threats become reality within the Mid Arun Valley.

EROSION OF BIODIVERSITY

3.29 The Mid Arun Valley is a farmed landscape that has retained its high biodiversity and species richness due to the mosaic of habitats that intersperse the farmed area. The habitats are given in Table 5.

3.30 A number of these habitats are small and / or fragmented such as the coastal saltmarsh, lowland fen (intermixed with swamp, reedbed and grassland) and the traditional orchards. Two ponds (so far) are considered to be Habitats of Principle Importance due to their high populations of breeding toads (one of the selection criteria for pond HPI).

3.31 Moreover, as a consequence of the quality of these habitats which are found throughout the Mid Arun Valley Survey Area, large populations of protected, rare and declining species can be found. The main groups are shown in Table 6 below, though this does not capture the diversity and numbers of species found.

3.32 The consultation brochure fails to capture the biodiversity and status of these species. A standard list of protected species is given, but at no point does it mention that the bats have been assessed at national if not international importance, or that the invertebrates are of regional importance or that Water Vole, Common Toad, Dormouse etc. are all represented well in Arundel but declining nationally etc. **The majority of the public have no idea of such things and cannot place a considered opinion wihout the facts being more transparent**.

Table 5: *Mid Arun Valley habitats and importance*

Habitat	Importance	Comment
Ancient woodland HPI	National	Large area – high numbers of AWI and some rare plant species
Deciduous woodland HPI	National	Integrated with ancient woodland
Wet woodland HPI	National	3 areas – uncommon community in one area
Wood pasture / parkland HPI	National	2 areas
Veteran Trees (HPI)	National	Throughout area
Hedgerows & ancient shaws HPI	County	Radiating from woodland edges – many notable / veteran trees. Species rich verges.
Traditional Orchard HPI	County	2 orchards
Coastal / floodplain grazing marsh HPI	County	Large area
Reedbed HPI	County (in association with grazing marsh)	Throughout area in corridors along ditches – supports some less common species. Largest area is near bridge if built
Lowland Fen HPI	County (in association with grazing marsh)	Binsted Rife in a mosaic with other habitat types – some rare plant species on the SxRSI
River corridor HPI	County	Modified - some rare plant species
Chalk stream HPI (included with river)	County	Binsted Rife
Coastal saltmarsh HPI	Local	Fragments (one RDB species)
Arable Field Margins HPI	Local	Throughout area (three fields with a noteworthy diversity of Important Arable Plant Indicator Species – 4 RDB species).
Pond HPI	Local	High numbers of breeding toads

Table 6: Mid Arun Valley species / groups and importance

Species / group	Importance	Comment
Bats	National / international importance	Strong population with rare species
Invertebrates- terrestrial	Regional	Very high diversity including many rare / declining species
Dormice	County	Strong population (declining Nationally)
Reptiles	County	Many key reptile sites
Water Vole	County	Relatively strong population (declining Nationally)
Woodland birds	County	Many protected and declining species
Common Toad	County / local	High population / possibly metapopulation (declining Nationally)
Aquatic fish / invertebrates	County / local	Many pollution tolerant species / a few rare
Notable plants	County / local	Scattered throughout the area
Badger	Local	Extremely high population
Harvest Mouse	Local	Stable population (declining Nationally)
Hedgehog	Local	Stable population (declining Nationally)
Birds	Local	Many protected species

3.33 In addition to the obvious impacts of a major new carriageway that will erode biodiversity (i.e. direct mortalty from collisions, fragmentation, lack of ability to disperse with wider implications etc.) there are many hidden impacts that have not really been touched upon in the HE reports such as the impact of a fast road on birds.

BIRDS AND ROADS

3.34 HE surveys concluded that the following broad bird communities are present in the area: urban fringe and common garden species; woodland specialist; mosaic and scrub habitat; farmland specialist; raptors; and waterbirds (Appendix 8.10). The groups with the highest number of notable species are the waterbirds, the mosaic and scrub species and the farmland species.

3.35 HE surveys found 20 waterbird species within the Field Survey Area, 12 of which are considered notable (i.e. BoCC Red / Amber list, NERC S41, Schedule 1).

3.36 HE surveyors recorded 13 farmland birds, 9 of which are notable including the Corn Bunting (BoCC Red and NERC S41 (SPI)), Linnet (BoCC Red and NERC S41 (SPI)) and Mistle Thrush (BoCC Red). There are 14 mosaic and scrub species which include seven notable birds including three species associated with wet ditches: Cetti's Warbler (WaCA Schedule 1), Reed Bunting (BoCC Amber listed and NERC S41 (SPI)) and Cuckoo (BoCC Red listed and NERC S41 (SPI)). The Cuckoo is frequently recorded (by MAVES) along Binsted Rife, where it is thought to lay its eggs in the nests of Reed Warblers.

3.37 HE surveyors found 92 species of wintering birds (EAR, Appendix 8.11), which was attributed to the variety of habitat types present and the interconnected landscape. This includes 6 Annex 1 species: Kingfisher, Little Egret, Marsh Harrier, Peregrine, Red Kite, Short-eared Owl, which have been recorded on the Arun floodplain and the surrounding fields. The high number of raptors (also including Kestrel, Buzzard and Hobby) demonstrates a healthy environment with plenty of prey for these species.

3.38 The wintering birds survey (Appendix 8.11, para 4.1.1.8) mentions a hedgerow adjoining the Arun as being an important commuting route for passerines, though unfortunately the stated reference to the hedgerow is not in the report.

3.39 The greatest impact on individual species are likely to be on Barn Owl and Mute Swan. Mute Swan has a low flight, a long and low take off run and is slow to manoeuvre. There are reports of collisions on the existing bridge and this will likely increase should an additional bridge cross the river.

3.40 A major carriageway through the area will have a significant ‘hidden’ impact (i.e. not included in the mitigation for direct habitat loss etc.) on the species present. A 5-year research programme at Harvard University (Forman *et al*. 2002) concluded that birds might be strongly affected by traffic volume or changes in volume. With traffic of 15,000–30,000 cars per day (a two-lane highway), both bird presence and breeding were decreased for a distance of 700 m. A heavy traffic volume of ≥ 30,000 vehicles / day saw bird presence and breeding reduced for a distance of 1200 m from a road. This is due to factors such as a bird calling for a mate cannot be heard over the traffic noise, nor can a predator approaching.

3.41 This is a significant loss of useful area when considering the Crimson, Magenta, Amber and Grey Options which would entail between 6 km and 8 km of new road (as compared to approximately 1.7 km of new road with the Beige / Cyan Options).

3.42 The loss of breeding and wintering passerines will have a knock-on effect on raptors, and other predators (bird and mammal) as the prey density is reduced.

INVERTEBRATES

3.43 A recent literature review (Muñoz et al. 2015) found there to be high invertebrate mortality of some groups when crossing the road, with more impact at higher traffic volumes. They also found the unwillingness of many species to cross a road or live close to it. Roads were found to be major barriers for small or flightless species, though the response was variable for flying species. Moreover, both experimental and observational evidence support the idea that air pollutants and de-icing salt used for the road maintenance negatively affect insects.

3.44 Again, a decrease in the number of invertebrates would have repercussions through the trophic levels for a wide range of predators from birds to mammals and constitute part of a gradual erosion of species numbers and species diversity in the Mid Arun Valley.

SUMMARY

3.45 It has been demonstrated that the impact of roads on wildlife includes mortality from vehicle collisions, habitat destruction, habitat fragmentation and barrier effects. Other impacts include edge effects and habitat degradation or disturbance from light, noise and chemical pollution (not discussed in this report). Studies have shown that these impacts are not immediately obvious with multiple effects usually being cumulative in the long term and resulting in a gradual erosion of biodiversity (i.e.Balkenhol & Waits 2009).

3.46 The impact of many of these effects is very difficult to quantify and so they are largely ignored and not considered within mitigation. These ‘background’ impacts are largely invisible, but very real.

3.47 Mitigation attempts to lessen the degree of the more visible negative impacts, but there is a dearth of conclusive evidence to its efficacy.

MITIGATION AND COMPENSATION

3.48 There are a number of inevitable problems with mitigation – some of which have been touched upon in the HE EAR report. The main aims of mitigation are to compensate for habitat lost by creating habitat elsewhere, to translocate impacted species to newly created suitable habitat and to put structures in place that would aid the safe crossing of the road.

3.49 HE have stated that appropriate mitigation measures will be required to adequately mitigate the impact of habitat severance on protected species. These measures include the provision of wildlife crossing structures, underpasses and tunnels.

3.50 HE acknowledge shortcomings of crossing structures and state (HE EAR Chapter 8 para 8.8.3.13) that ‘*Although bats and hazel dormouse have been shown to use wildlife crossing structures evidence on the efficacy of such structures is not available and thus the mitigation technique should be viewed as partly experimental’*. This is unsatisfactory when there is a

nationally (possibly internationally population of bats and a large population of Dormice depending on habitat connectivity.

3.51 Likewise, there is virtually no evidence that species such as Grass Snake and Harvest Mouse would use enabling structures. They require continuity of habitat in order to move across a landscape.

3.52 In past schemes HE have used bat gantries (wood, metal and mesh structures) for bat crossings, as they are a far cheaper option to green bridges. Anna Berthinussen and John Altringham (2012) investigated whether bat gantries were effective. They found these to be ineffective and used by a very small proportion of bats, even up to nine years after construction. They reported that bats near gantries crossed roads along severed, pre-construction commuting routes at heights that put them in the path of vehicles.

3.53 A replicated study in 2014 at two bat gantries over a road in the UK (Berthinussen & Altringham 2015) found that one bat gantry was used by 3% of crossings bats and another was not used at all. At one gantry, significantly fewer bats used the bat gantry (3%, 1 of 35 bats) than crossed the road below at traffic height (80%, 28 of 35 bats). At the other gantry, no bats used the bat gantry to cross the road, but 4 bats crossed the road below at traffic height.

3.54 The report states that for the range of other species in the area it may be necessary to construct multiple mitigation structures to ensure species are able to cross the scheme without being exposed to collisions with vehicles or to replace severed movement paths. Yet this is despite inconclusive evidence to the efficacy of such structures. Moreover, each hedgerow is a severed corridor but some species, such as toads and Brown Hare, do not use such corridors.

3.55 Research has shown that other structures such as tunnels and underpasses are not effective unless they are combined with mammal fencing in order to stop mammals crossing the road anywhere. The fact that the report states that Hedgehog mortality will be unsustainable (EAR Chapter 8 para 8.9.2.38) on one hand and then states that there will be wildlife fencing to direct animals to designated crossings structures to minimise road mortality (EAR Chapter 8, para 8.8.3.18) is inconsistent. It also implies that fencing will only be close to crossing structures.

3.56 Comments in the report such as (regarding birds) '*there are ample areas outside the Scheme that will not be affected'* are worrying as most such areas (for breeding birds) are at carrying capacity (limited by suitable nest sites). In addition it is stated that if implementation measures to mitigate noise and vibration don't bring it down to an acceptable level then new habitat will be created. Such things are extremely hard to measure / quantify.

3.57 There is no guarantee that mitigation measures in the form of translocation or habitat creation will work or be maintained etc. Such measures are only as good as the sub-contractor undertaking the work and are surrounded by uncertainty i.e. pond maintenance, succession, vandalism (owl boxes) etc.

3.58 For example, the A6 Alvaston Improvement mitigation underestimated the size of the Great Crested Newt population and so the mitigation ponds were too small and also unsuitably designed so failed to hold water at critical times. After re-lining they became choked with vegetation due to a lack of maintenance. The population fell from approximately 300 to less than 10 after a second pond relining attempt (Sloman *et al.* 2017).

3.59 This highlights a number of the issues with mitigation as follows:

- Lack of methods to estimate actual population sizes – therefore the underestimation of potentially important populaitons.
- Mitigation design – limited by the ability of the subcontractor to design appropriate strctures and habitats.
- The limitations of artificial structures – pond linings leak, bat and bird boxes may be open to vandalism etc.
- The finite lifespan of artificial structures.

3.60 The points above only touch upon some of the problems with mitigation; there are many more not mentioned here.

BIODIVERSITY COMPENSATION

3.61 Biodiversity offsets are a form of compensation which may be considered when a scheme such as the A27 Arundel bypass is expected to have significant residual impacts on biodiversity despite planned mitigation measures.

3.62 The delivery of such compensation measures, including biodiversity offsets, is likely to involve access to land, or land purchase, outside the Scheme footprint and a commitment to long-term management through legal agreements. They therefore require early consideration in project design. However, none of this is clear in the documents.

3.63 As with the direct mitigation, the same potential problems with being able to achieve satisfactory results that would conclude in a net biodiversity gains for the project apply.

3.64 The mixed assemblage of habitats required to sustain the impacted biodiversity will not feasibly be replicated in another area which lacks the specifics e.g. geology, geography, hydrology and ancientness of this area.

4 REVISITING THE HIGHWAYS ENGLAND ASSESSMENT

4.1 Having reviewed the latest current information available regarding the proposed A27 Scheme, it is clear that there are three main things to consider:

1. The residual impact of the Scheme i.e. the environmental cost that cannot be compenstated.

2. The operational impact of the Scheme i.e. the on-going impact on species and habitats that are within the area.

3. The hidden costs of the Scheme i.e. those that will gradually erode the current species richness around the Scheme Options due to factors such as fragmentation, collisions, predator-prey relationships and inbreeding.

4.2 The revised significant ecological residual effects i.e. the environmental 'costs' of the project that cannot be compensated are shown in Table 7 below. The ancient and deciduous woodland, as integral, have been included within the Rewell Woods Complex and the Binsted Woods Complex in order to save duplicating the woodland habitat.

4.3 These significant residual effects include woodlands, wood pasture, unimproved grassland, veteran trees and traditional orchard that were not stated in the HE EAR as being residual effects, but clearly they are.

4.4 Significance levels are mostly those allocated by HE, but the following have been altered:

- The impact on Hedgehog has been extended to the Magenta, Amber and Grey Options.

- Other mammals known to be in the area, i.e. Harvest Mouse and Brown Hare, have been included (together) in the residual effects as it is unlikely and / or unproven that they will be able to move across the landscape and may succumb to impacts caused by isolation, fragmentation etc. discussed in Section 3 of this report.

- Grazing marsh, reedbed and fen is considered to be Very Large Adverse rather than Large Adverse for Options that are also likely to impact on the hydrology / pollution status of the Binsted Rife chalk stream.

4.5 No attempt has been made to change other significance levels awarded that cannot be realistically quantified at this time i.e. veteran trees and dead wood habitat along various Options for the saproxylic invertebrates.

4.6 The significance values have been colour coded to ease interpretation from red as the most significant to pale yellow. Neutral effects are left blank.

Table 7: The probable ecological residual significant effects

Ecological Feature	1V5 / 1V9 Cyan/Beige	3V1 Crimson	4/5AV1 Magenta	4/5AV2 Amber	5BV1 Grey
Rewell Woods Complex	Large Adverse	Large Adverse	Neutral	Neutral	Neutral
Binsted Woods Complex	Large Adverse	Very Large Adverse	Large Adverse	Very Large Adverse	Neutral
Avisford Road Verge LWS (unimproved grassland)	Neutral	Neutral	Slight Adverse	Slight Adverse	Slight Adverse
Wood Pasture	Moderate Adverse	Neutral	Neutral	Very Large Adverse	Neutral
Veteran trees	Very Large Adverse	Neutral	Very Large Adverse	Very Large Adverse	Very Large Adverse
Traditional Orchard	Neutral	Neutral	Neutral	Neutral	Neutral
Bats	Moderate Adverse	Very Large Adverse	Large Adverse	Very Large Adverse	Moderate Adverse
Barn Owl	Neutral	Neutral	Moderate Adverse	Moderate Adverse	Moderate Adverse
Hedgehog	Neutral	Slight Adverse	Slight Adverse	Slight Adverse	Slight Adverse
Other mammals – Harvest Mouse, Brown Hare	Neutral	Slight Adverse	Slight Adverse	Slight Adverse	Slight Adverse
Hazel Dormouse	Moderate Adverse	Large Adverse	Moderate Adverse	Large Adverse	Moderate Adverse
Water Vole	Neutral	Moderate Adverse	Moderate Adverse	Moderate Adverse	Moderate Adverse
Woodland birds	Slight Adverse	Large Adverse	Slight Adverse	Moderate Adverse	Neutral
Woodland invertebrates	Moderate Adverse	Very Large Adverse	Slight Adverse	Very Large Adverse	Slight Adverse
Notable plants	Moderate Adverse	Large Adverse	Large Adverse	Large Adverse	Large Adverse
Grazing marsh/reedbed/fen	Moderate Adverse	Large Adverse	Very Large Adverse	Very Large Adverse	Very Large Adverse

4.7 Given such factors as have been revealed in surveys about the high population densities of species, key breeding sites, the logic applied by HE to some species and not others and the movement of species across the landscape, the revised operational effects table shown in Table 8 is more realistic.

4.8 More mobile species such as Common Toad, reptiles (Grass Snake and Adder), Badger and Hedgehog have been added to the operational effects as these are highly mobile species and will continue to suffer road kills as long as the road is in operation. There is no guarantee that translocations will be successful and so the impact around the Scheme must be included.

4.9 Though population levels will inevitably decline for all these species, possibly significantly (i.e. toads and Badger), it is unlikely that Badger, Common Toad and Grass Snake will suffer local extinctions, although Adder and Hedgehog may. Local extinctions of other notable / Red List species with small populations have the potential to occur in the long term as a result of the ecological severance of a new offline dual carriageway.

4.10 The greatest impact for all mobile species, would be the off-line Options, as they sever the landscape interrupting the movement patterns of many species.

Table 8: Significant operational effects of the proposed route Options

Ecological Feature	1V5 / 1V9 Cyan / Beige	3V1 Crimson	4/5AV1 Magenta	4/5AV2 Amber	5BV1 Grey
Binsted Woods Complex	Neutral	Large Adverse	Neutral	Large Adverse	Neutral
Badger	Neutral	Slight Adverse	Slight Adverse	Slight Adverse	Slight Adverse
Bats	Moderate Adverse	Very Large Adverse	Large Adverse	Very Large Adverse	Moderate Adverse
Barn Owl	Neutral	Neutral	Moderate Adverse	Moderate Adverse	Moderate Adverse
Common Toad	Neutral	Slight Adverse	Slight Adverse	Slight Adverse	Slight Adverse
Hedgehog	Neutral	Slight Adverse	Slight Adverse	Slight Adverse	Slight Adverse
Reptiles (Grass Snake and Adder)	Neutral	Moderate Adverse	Moderate Adverse	Moderate Adverse	Moderate Adverse

4.11 The information in the above tables should have been made clear for the public consultation. These are the impacts of the various Scheme Options that will persist into the future and contribute to the gradual degradation and erosion of habitats and biodiversity around Arundel with further reaching impacts in some groups.

5 CONCLUSIONS

THE ENVIRONMENTAL ASSESSMENT REPORT

5.1 Planning Practice Guidance (PPG) states that

> '*The purpose of EIA is to protect the environment by ensuring that the local planning authority when deciding whether to grant planning permission for a project, which is likely to have significant effects on the environment, does so in the full knowledge of the likely significant effects, and takes this into account in the decision making process.'*

And that

> '*The aim of Environmental Impact Assessment is also to ensure that the public are given early and effective opportunities to participate in the decision making procedures.'*

5.2 The 2019 HE EAR is long, complex and unclear in places. Some elements have not been or only partially been taken into account. The connectively of ecological networks has only been partially considered, and there is no proper consideration for mobile species that make regular movements to, from, or across the site. As a result, some of the significant effects of the various Scheme Options are misguided.

5.3 Some of the necessary information is buried within the text with just the construction and operation effects tabulated. The residual effects are unclear and not tabulated.

5.4 The mitigation, although at a preliminary stage, is ambiguous in places. Moreover, each residual effect should be set out clearly with outline proposed compensation for that feature.

5.5 Unlike the 2017 EAR there is no conclusion or a clear summary. The 2017 EAR conclusion includes the following paragraphs:

> '*This assessment has identified adverse residual ecological effects which are likely to arise from each of the Scheme Options. For the majority of designated sites, habitat and species, Option 1 is likely to have the least potential for ecological impacts of the Scheme Options.*
>
> *Option 3 and Option 5A are likely to generate numerous significant adverse, residual ecological impacts. Comparing Option 3 to Option 5A - Option 3 has the greater ecological impact, particularly in respect of Ancient Woodland, the woodland bat assemblage and hazel dormouse. Option 5A would still significantly impact all of these features, albeit to a lower degree. Option 5A is more damaging that Option 3 in the context of impacts on Wood Pasture and Parkland HPI, Ancient/Veteran trees, Coastal and Floodplain Grazing Marsh HPI and a range of species groups including farmland birds, amphibians, water vole and notable mammal species'*.

5.6 A conclusion aids the reader's understanding of a complex document, however, the level of clarity with a clear conclusive summary has not been demonstrated for the current consultation.

THE CONSULTATION PAMPHLET

5.7 The information given in the public consultation pamphlet has been drawn from two tables in the EAR: the construction impacts and the operational impacts. This gives the reader the misguided impression that there will be little lasting impact on wildlife within the Mid Arun Valley area with the exception of bats and Barn Owl.

5.8 The residual impacts are key to understanding the environmental cost of a Scheme, yet these are not mentioned in the 2019 EAR (unlike the 2017 EAR). If there is one thing that is likely to influence a consultee's choice of which option to prefer, it would be a clear understanding of what would be permanently lost and impacted.

5.9 The cumulative value of the site with a high representation of species in decline, the important habitat connectivity, the rich assemblage of species and rich assemblage of habitats has not been conveyed.

5.10 The woodland calculations for the Cyan and Beige Options appear to have been miscalculated (Paragraph 2.10).

5.11 The bulleted summaries state that the Cyan and Beige Options would feature 4.5 km of new dual carriageway as opposed to 7.2 km, 6.9 km or 8 km for the Magenta, Amber and Grey options respectively. This sounds broadly similar, **however if it was pointed out that the Beige and Cyan Options require an approximate 1.7 km stretch of entirely new road, with the remainder (2.8 km) being upgraded from the existing road, it presents a whole different scenario**.

5.12 The Grey Option, for example, would require nearly 5 times the length of entirely new road to be laid across unspoiled countryside compared with the Cyan and Beige Options..

5.13 Based on the information given in the consultation pamphlet, the reader would find it very difficult to understand the extent, richness and diversity of the wildlife and to usefully decipher which Options would be more damaging.

LEGISLATION

5.14 The legislation and policy framework is extensive with European directives feeding into national policies, which in turn feed into the National Planning Policy Framework. Yet, much of this legislation stipulates that biodiversity must not be reduced at the *national* level, or that a particular scheme or development must show *net gains* in biodiversity.

5.15 Such legislation provides for the translocation of species to other areas, and often, the monitoring is for a limited time only. The protection of areas with important assemblages of species, with the exception of statutory and non-statutory sites, is not considered.

SUMMARY

5.16 Within the Mid Arun Valley, the natural habitats and landscape as at present managed, support rich biodiversity, including thriving bird communities, a large and stable Dormouse population, thousands of breeding toads, key reptile sites, a nationally important bat assemblage and several important invertebrate communities. These communities have persisted for millennia, despite a changing world. Mitigation and compensation (that may be maintained for 25 years

and monitored for fewer years) are unlikely to result in net biodiversity gains for such a rich and largely interdependent assemblage.

5.17 The current Scheme is being proposed against a backdrop of continual species declines in the face of yet another factor - climate change - resulting in a layer of unpredictability (i.e. ponds drying, cold snaps, localised flooding, lack of availability of prey source at critical times etc.).

5.18 The numerous impacts mentioned in this report should not be used, as with other schemes, as a way of navigating the system in order to achieve an expensive and environmentally unsound infrastructure outcome come what may. If this were the case then the accumulation of information by HE would amount to nothing more than a ‘box-ticking’ exercise as with many other schemes.

5.19 The numerous impacts should be used as a way to navigate to the least damaging Option for Arundel and its rich assemblage of wildlife, which, evaluating the operational and residual effects is the Cyan or Beige Option.

REFERENCES

Berthinussen A, Altringham J. (2012) Do Bat Gantries and Underpasses Help Bats Cross Roads Safely? PLoS ONE 7(6): e38775. doi:10.1371/ journal.pone.0038775

Berthinussen A, Altringham J. (2015) WC1060: Development of a cost-effective method for monitoring the effectiveness of mitigation for bats crossing linear transport infrastructure. Department for Environment, Food and Rural Affairs (DEFRA), UK report.

Boxhall T. (2019) Mill Ball Phase I and II Ecological Survey. Ecosupport, private publication.

Chartered Institute for Ecology and Environmental Management. (2018) Guidelines for ecological impact assessment in the UK and Northern Ireland. CIEEM.

Chanin, P. and Gubert, L. (2012) *Common dormouse (Muscardinus avellanarius) movements in a landscape fragmented by roads.* Lutra 55 (1): 3-15.

Forman, RTT Sperling D, Bissonette JA, Clevenger AP, Cutshall CD, Dale VH, Fahrig L, France R, Goldman CR, Heanue K, Jones JA, Swanson FJ, Turrentine T, Winter TC. (2003) Road ecology: science and solutions. Island Press, Washington.

Gerlach G, Musolf K. (2000) Fragmentation of landscape as a cause for genetic subdivision in bank voles. *Conservation Biology* **14**, 1066-1074.

Grove Katherine. (2016) The Beetles of Binsted Wood. Private publication.

Highways England (2019) A27 Bypass Appendix 7-3 Arboriculture Report

Highways England (2019) A27 Bypass Appendix 8-3: Badger Baseline Survey Report.

Highways England (2019) A27 Bypass Appendix 8-4: Barn Owl Baseline Survey Report

Highways England (2019) A27 Bypass Appendix 8-5: Bat Activity (BCT) Baseline Survey Report.

Highways England (2019) A27 Bypass Appendix 8-6: Bat Radiotracking Baseline Survey.

Highways England (2019) A27 Bypass Appendix 8-10: Breeding Bird Interim Baseline Survey Report.

Highways England (2019) A27 Bypass Appendix 8-11: Wintering Birds Baseline Report.

Highways England (2019) A27 Bypass Appendix 8-12: Ecological Mitigation Approach.

Highways England (2019) A27 Bypass Appendix 8-13: Amphibian 2019 Update Survey Report.

Highways England (2019) A27 Bypass Appendix 8-14: Hazel Dormouse Baseline Survey Report.

Highways England (2019) A27 Bypass Appendix 8-19: Otter and Water Vole Baseline Survey Report.

Highways England (2019) A27 Bypass Appendix 8-20: Phase 1 Habitat Survey Baseline Report.

Highways England (2019) A27 Arundel Bypass Appendix 8-22: Terrestrial Invertebrate Interim Baseline Survey Report.

Highways England (2017) A27 Bypass Environmental Assessment Report Chapter 8 – Biodiversity.

Highways England (2019) A27 Bypass Environmental Assessment Report Chapter 8 – Biodiversity.

Highways England (2019) A27 Arundel Bypass Further Public Consultation Have Your Say.

JNCC (2010). UK Priority Species data collation *Bufo bufo* version 2 updated on 15/12/2010. http://www.archive.jncc.gov.uk/_speciespages/2106pdf (accessed 08/10/19).

Muñoz PT, Torres FP & Megías AG Biodiversity Conservation (2015) 24: 659. https://doi.org/10.1007/s10531-014-0831-2

Mathews F, Kubasiewicz LM, Gurnell J, Harrower CA, McDonald RA, Shore RF. (2018) *A Review of the Population and Conservation Status of British Mammals: Technical Summary*. A report by the Mammal Society under contract to Natural England, Natural Resources Wales and Scottish Natural Heritage. Natural England, Peterborough.

Petrovan SO, Schmidt BR. (2016) Volunteer Conservation Action Data Reveals Large-Scale and Long-Term Negative Population Trends of a Widespread Amphibian, the Common Toad (Bufo bufo). PLoS ONE 11(10): e0161943. doi:10.1371/ journal.pone.0161943

Roedenbeck IA & Voser P. (2008) Effects of roads on spatial distribution, abundance and mortality of brown hare (*Lepus europaeus*) in Switzerland. European Journal of Wildlife Research 54: 425.

Sherwood Bryan, Cutler David, Burton John A. (2002) *Wildlife and Roads: The Ecological Impact.* (Occasional publication of the Linnean Society of London). Imperial College Press.

Sloman L, Hopkinson L and Taylor I. (2017) *The Impact of Road Projects in England* Report. CPRE publication.

Whitby D. (2016) Bat Survey, Trapping Survey Binsted Woods, Arundel. AEWC Ltd. Private publication.

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Document Information

Wildlife Splash Limited has prepared this report, with all reasonable skill, care and diligence within the terms of the Contract with the client.

Surveys and research have been conducted to the best of our ability during the given timeframe. However, no method can completely eliminate the possibility of obtaining partially imprecise or incomplete information. We disclaim any responsibility to the client and others in respect of any matters outside the reasonable scope of works.

This report is confidential to the client and we accept no responsibility of whatsoever nature to third parties to whom this report, or any part thereof, is made known. Any such party relies on the report at their own risk.

ACKNOWLEDGEMENTS

The wealth of wildlife within the Mid Arun Valley has astounded the Highways England contracted surveyors with comments such as ‘I cannot believe how much is here’ and ‘I have never had to survey such a diverse site’ and ‘every time I turn round there is something else to record’. Unfortunately, personal feelings of awe and wonder are not allowed to creep into standard reports, and if they do, they are edited out.

MAVES surveys, work and talks have continued throughout 2019 and we still marvel at the dancing butterflies, basking lizards, dozing Dormice and birdsong ringing in our ears.

We would like to give immense thanks to those who have undertaken surveys in 2019 – [redacted] and his team of volunteers.

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I would like to once again thank [redacted] from the Sussex Biodiversity Records Centre, for his never ending patience sorting through our records and answering undending queries.

Finally, thank-you to all the landowners of the Mid Arun Valley area who have given us all a free reign over the area night and day.

We would like to express our thanks to all our speakers who have generously given up their time to lead informative walks and support our series of Talks: [redacted]

We would like to thank all those who have very generously made donations to MAVES in order to fund this very important work:

South Downs National Park Authority
Brooklands
Woodlands.co.uk
Noor Wood
The Woodland Owners of Tortington Common
Arundel Agenda 21
Walberton History Group
HMP Ford

Arun District Bridleways Group

Please reply to:

[redacted]

To: Highways England – A27 Arundel Consultation

via email: A27ArundelBypass@highwaysengland.co.uk

Dear Sirs

I am responding on behalf of the Arun District Bridleways Group to the recent consultation on six options proposed for the A27 Arundel Bypass.

On the section between Crossbush and Fontwell, the issue for most equestrians to the south of the A27 is that the A27 currently poses a complete block to access to bridleways in the South Downs National Park. The area of the coastal plain to the south of the A27 is devoid of bridleway access with the exception of BW 338 Old Scotland Lane. Bridleway 392 from Walberton, and Bridleway 336/3667 from Binsted, cross the A27 at grade, across 4 lanes of traffic going 70 mph – therefore for many years they have been rendered unusable.

Access to the SDNP via the underpass at Fontwell may have been considered sufficient when installed, but the increase in traffic on local roads since, and now proposed, means it Is now too dangerous to reach for most equestrians except those right on its doorstep. It is too far away for other equestrians anyway, as it takes too long to get to it, get onto the South Downs, make a ride and return, than riders have available around work commitments or daylight hours in winter. Increasingly, therefore, riders are forced to transport their horses by road to a place they hope

they might find a parking space north of the A27 in order to ride. This is unacceptable and equestrianism south of the A27 suffering severely as a result.

Proposals for improvements to bridleway access (a bridleway being open to walkers, horse riders and cyclists) are not detailed in this Consultation and therefore it is not possible to make an informed judgement of the impact upon bridleway users of the various options until they are.

The Group raises whether the case to run a new four lane road through current beautiful countryside south of the A27, despoiling it with visual, air and noise pollution, is sufficiently proven in terms of the estimated improvement in travel times to warrant the planned expenditure. Perhaps a more modest option with much more emphasis on improvements for non-motorised means travel and leisure opportunities might be appropriate.

What the Bridleways Group would like to see achieved as part of this project are:

(a) A new safe access across the A27 at Walberton, such as at Potwell Copse (BW 392).

(b) A new safe access across the A27 along the Binsted section.

(c) A route along the north side of the existing A27 west of Arundel to near Shellbridge Road, linking all the currently truncated and unusable bridleways (associated with (b))

(d) Access for equestrians to any east/west route proposed for NMUs along the stretch between Arundel and the road to Blakehurst (currently no bridleway here).

(e) A bridleway bridge provided in any place the proposed route crosses FP 342 or its link road from Binsted Church - as an Order has recently been made to upgrade this footpath route to bridleway & restricted byway.

(f) The upgrade of FP 350 to Bridleway to facilitate direct access from Walberton to Binsted and the new bridleway (342). Some proposals indicate Hedgers Hill Road will become bridleway, but it has not been considered that Yapton Lane is too dangerous to ride & cycle along, with many HGVs.

(g) Provision of a bridleway route from the south so users can access bridleways and the South Downs National Park.

(h) Not to have access to Binsted blocked to NMUs from the south or west by any proposed option.

(i) Provision of a junction at Ford on any offline option – helping to alleviate unsuitable traffic on local rural roads.

(j) Using opportunities for diversion of routes, or negotiation with landowners, to upgrade or provide more routes locally available to all NMUs and not just thinking to divert it at current FP status.

Apologies for not using the set online pro-forma but this really was not a suitable vehicle to express adequately NMU requirements from this scheme.

I hope these comments will be carefully considered. Thank you.

Yours sincerely

[redacted]
Chair of Arun District Bridleways Group

ARUN
DISTRICT COUNCIL
www.arun.gov.uk

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Maltravers Road
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BN17 5LF

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DX: 57406 Littlehampton
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e-mail: [redacted]

Highways England
FREEPOST A27 ARUNDEL

Please ask for: [redacted]

Our Ref: NL/sjq

Dear Sir/Madam

A27 Improvement Scheme at Arundel – Further Consultation Response

Thank you very much for the opportunity to response to your Further Public Consultation exercise.

A special meeting of the Full Council took place on 10 October 2019 at which Councillors had a full debate on the Highways England Consultation.

Arun District Council confirms that it is overwhelmingly in support of improvements to the A27 at Arundel for the reasons set out in the Highways England document, in particular around the positive economic impact on Arundel, the surrounding area and its contribution to the wider strategic transport network.

There is also overwhelming support from the Council for an offline solution. Of the options put forward by Highways England the Council supports Option 4/5V1, Magenta. This is seen as providing the best balance in terms of least impact on residents and least loss of ancient woodland, whilst achieving the overall aims of the project.

There is no support for routes 1V5, 1V9, 4/5V2 and %BV1 (Cyan, Beige, Amber and Grey). Whilst there is limited support for Crimson, as this could deliver a number of the improvements needed, the Council recognises the environmental impact on areas designated as ancient woodland. It was therefore not seen as the best route.

The Council has considered a number of other factors and would strongly urge Highways England to consider the following:

a) To consider all potential opportunities on any preferred route corridor, which would further reduce the impact upon residents and the environment. I know that you will be undertaking this as part of your work leading to Stage 3 and beyond, but officers will be available to discuss any and all opportunities to limit the impact of the Improvements to residents and the environment. It follows that b) will be the focus of your ongoing work but this issue has been a key "ask" for many years and iterations of Bypass proposals; it is perhaps more important now than ever before.

b) To construct any bypass and consequential embankment, viaducts and bridges to the highest possible architectural standard and to take appropriate account of any potential flooding issues.

Continued....

c) To consider amending any 'off-line' preferred route to provide a junction between the proposed A27 Bypass and Ford Road to improve accessibility to and from communities (existing and proposed) south of the South Coast Mainline Railway and the residential amenity of residents in Ford Road, Arundel. The issue of a junction with Ford Road is seen by all as critical to the wider area. A southbound junction would to reduce rat-running, provide for the extra traffic generated by new development to the south and allow for HGVs to get onto the trunk network sooner, as well as providing resilience and relief to the A259. A northbound access/egress arrangement is not supported, as this would compound the current congestion at the north end of Ford Road.

d) The Council would welcome further investigation into the routing of Footpath 2207 at Crossbush, with the potential for an on-line footbridge rather than a diversion that is routed close to the Arun Valley Railway. It is unclear why the crossing of FP2207 over the new road at Crossbush has been dealt with in the proposals by way of a diversion (under the railway bridge). Other crossings have been provided with a footbridge; this seems a location where a footbridge could span the cutting with minimal intrusion into the views, as well as avoiding directing users towards a potentially dangerous location.

e) The Council would encourage Highways England to consider using the port of Littlehampton and the River Arun to barge aggregate and other construction materials to the construction site.

f) The Council would encourage Highways England to support, through their 'Designated Funds', the creation of a cycleway between the South Downs National Park via Arundel to the coast, along the River Arun and improved parking for commuters, tourists and residents at Ford Railway Station.

With regard to these issues, I will expand upon them as follows:

e) It seems to be a sensible matter to consider using the River to help reduce the carbon footprint of the scheme and to save some traffic congestion on roads local to the construction site.

f) The use of your designated Funds towards supporting a riverside north/south cycleway would be very much welcomed in many ways; for the benefit of commuters, visitors to the South Downs National Park, and residents and visitors generally.

In summary, I would again thank you for the opportunity to respond to your Further Public Consultation and confirm that Arun District Council's preferred option, with overwhelming support, is for Option 4/5AV1 (the Magenta route). I would also say that there is continuing officer availability to help provide the best outcome for the District as a whole.

Yours faithfully

[redacted]

Chief Executive

Arundel Angmering and Findon Labour Party

Response

to the consultation by Highways England

on the A27 Arundel Bypass

October 2019

1. At the end of August Highways England launched a new consultation on possible routes for the suggested Arundel Bypass. Responses to the consultation have been requested by the end of October 2019.

2. The Consultation Document outlines six possible routes, referred to as the Cyan, Beige, Crimson, Magenta, Amber and Grey routes. (see map at end)

   All the schemes are for two lane, dual carriageway roads, with the national speed limit of 70 mph.

3. Two of the proposed routes (Cyan and Beige) follow alignments close to the line of the existing Bypass. The other four all follow an alignment well to the south of the town. These four routes all involve a bridge further down the Arun Valley, approached by either an embankment or a viaduct on each side.

4. This consultation follows a previous consultation that was halted in 2018 following proceedings for judicial review launched by local residents and by the South Downs National Park Authority.

5. The previous consultation focussed on a preferred route which ran through Binsted Woods and Tortington Common. The then proposed route involved extensive loss of ancient woodland, and this loss was the main focus of the judicial review launched by local residents. In addition, the National Park Authority argued that Highways England had only considered route alignments that lay within the National Park, and had

   > *'excluded from the consultation a route outside the boundary purely on cost grounds.'*

   Highways England have responded to this issue by including in the current consultation two routes, Grey and Magenta. The Grey Route lies completely outside the National Park and the area of ancient woodland. It would, however, have a major impact on the village of Walberton.

The Magenta Route skirts the National Park boundary, and the area of ancient woodland, very closely. It would have a destructive impact on the village of Binsted.

6. There is also a longer term context. Previous proposals for an Arundel Bypass with a bridge across the Arun Valley were were turned in 2003 by the then Secretary of State for Transport, Alastair Darling, on the grounds that

> *'…the Arundel bypass would cut across water meadows damaging an area of outstanding beauty…'*
>
> (Hansard, 09.07.2003)

The view of Arundel from the south is widely recognised as exceptional. Although destruction of this view was the reason for rejection of the 2003 scheme, this issue is not addressed in the current consultation document.

7. Local organisations within Arundel have expressed differing points of view:

   - The campaign group 'One Arundel' has consistently argued that the existing A27 divides the town in two, splitting the more recent development around the Ford Road from the historic centre. They have now endorsed the Magenta Route.

   - Arundel Alternative argue for a more limited approach, building a single carriageway, 40 mph road from the Crossbush junction to Fitzalan Road, close to the existing bridge.

8. Wider transport and environmental considerations

Highways England is a delivery agency and is not responsible for wider issues of transport policy – the climate emergency, sustainability, encouraging the use of and improving public transport, etc. So these questions are largely absent from the Consultation Document.

9. RESPONSE

The objectives of any proposals must include:

- Respect for the wider environmental objectives of transport policy, including responding effectively to the climate emergency;

- Avoiding the destruction of Ancient Woodland;

- Preserving the open view of Arundel from the watermeadows to the south of the town;

- Minimizing the separation of communities;

Reconciling these objectives is not straightforward.

Arundel Branch Labour Party therefore responds to the consultation as follows:

- Road building should only be considered in the context of an integrated transport policy. Recognizing the Climate Emergency, such a policy should include:

    - Minimizing the need to travel;
    - Improving public transport;
    - Better connectivity between bus and rail services;
    - More dedicated walking and cycle routes

- Any new road should be built as a 40mph single carriageway;

- The Crimson and Amber options, which involve substantial destruction of Ancient Woodland, should be rejected;

- Although the Magenta option has a less destructive impact on the woodland, it would still have a considerable effect: a dual carriageway road running round the edge of the woods would fundamentally change the environment and habitat.

  In addition, the Magenta route would destroy the village of Binsted.

  The Magenta option should therefore be rejected.

- The Grey route would inflict considerable damage on the village of Walberton and should be rejected.

- All four ‘southern’ options (Crimson, Amber, Magenta and Grey) involve a bridge and either an embankment or a viaduct across the Arundel water meadows. In this respect

they are identical to the scheme rejected by the Secretary of State in 2003 for this reason.

Destroying the view of Arundel from the South would compromise its historic landscape. These options should be rejected for this reason.

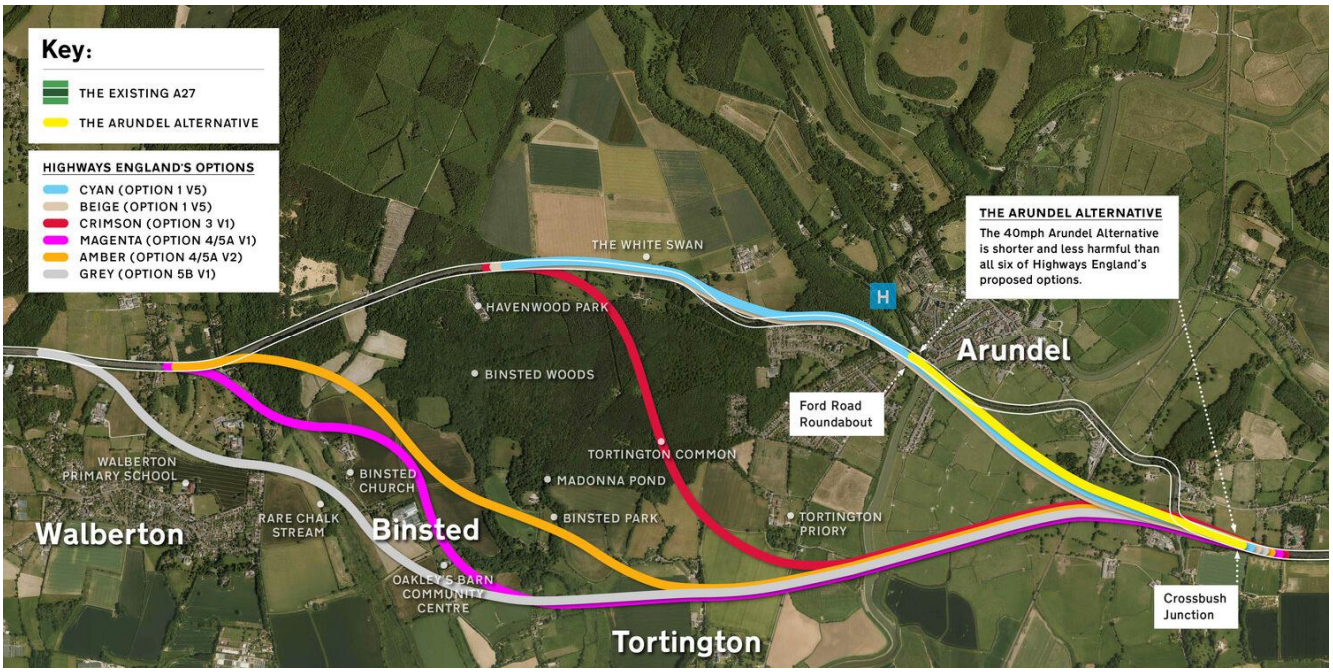
- This leaves the two options, Cyan and Beige, which follow most closely the line of the existing A27, and do not involve building a major bridge and earthworks further down the Arun Valley. As put forward by Highways England, these are seen as 70mph, dual carriageway roads.

  The scheme put forward by Arundel Alternative is a more limited version of these. It includes some measures to separate through traffic from local traffic. It also includes two alternative proposals for improvement at the Ford Road roundabout, to give better links for pedestrians between the two parts of Arundel.

  The more limited version of the Cyan and Beige options put forward by Arundel Alternative is therefore our preferred solution, with the maximum done to improve links between the two parts of the town.

[redacted]
Chair, Arundel, Angmering and Findon Branch Labour Party
18 October 2019

Arundel Bypass
2019 Consultation
Proposals



From: [redacted]
Sent: 01 September 2019 20:48
To: [redacted]
Subject: A27 Arundel Bypass
Importance: High

Dear Valerie

Arundel Arboretum Limited, [redacted]

You may recall meeting [redacted] and me at our business premises – Arundel Arboretum during the consultation period last time for the Arundel bypass.

[redacted] and I visited the public consultation on Friday last week, and were extremely shocked and dismayed to discover that now 3 of the proposed routes will have a massive impact on our land – and in particular the cyan and beige routes.

Whilst we fully appreciate the thankless task of trying to come up with a route for the proposed bypass that will offer value for money and be the most environmentally sound route, together with many other considerations, we are aghast that nobody contacted us prior to these public consultations to at least let us know how massively affected our business premises will be.

The cyan and beige routes are of a huge concern to us. We are a small business working hard in very trying times for our industry and feel that as a courtesy we should have been at least consulted or given advance warning of the potential affect on our business, and not find out at the public consultation stage.

We both appreciate that you are probably not the right person to direct this email to, so we would be grateful if you could pass it to the relevant people so that they are aware of our extreme concern with these two proposed routes and the detrimental effect it will have on our business if one of these is chosen.

We are also writing to our local MP, The Rt. Hon. Nick Herbert so that he is aware of our concern.

Kind regards
[redacted]

[redacted]

Arundel Bypass Neighbourhood Committee

Secretary: [redacted]

Response to A27 Arundel Bypass public consultation

Contents

Executive Summary

1. The consultation has ignored the Climate and Biodiversity Crisis.

Transport produces a third of the UK's carbon emissions. Carbon emissions will be increased by each of the options (EAR, Chapter 14, Tables). There must soon be a shake-up of transport policy, including (as suggested by the head of Friends of the Earth) the scrapping of Highways England and the creation of an integrated transport body to replace it. This would mean the abandonment of schemes like the one at Arundel which severely damage biodiversity and increase carbon emissions.

Highways England have failed to include the Arundel Alternative in the consultation. This is a practical, much cheaper, wide single carriageway, short bypass scheme put forward by local people which would alleviate the occasional traffic jams at Arundel without causing more traffic and carbon emissions by an excessive increase of road capacity. ABNC supports this scheme which should be part of an integrated package of improvements to all forms of transport.

2. The consultation is faulty.

The consultation is biased in favour of the 'offline' options. The data contains errors which either confuse responders, or misleadingly make the online options seem more damaging than the offline options. The survey form is open to fraud. The survey form is confusing about which parts to fill in if you are filling it in on behalf of an organisation (only part D, or the whole form). There is no 'none of the above' option in many questions. The assumption that the Worthing-Lancing scheme is done means the BCR figures (giving much better scores than without the Worthing-Lancing scheme) are unrealistic. There is no clarity about the budget.

3. ABNC objects to all Highways England's options.

The history of the National Park boundary shows all the options are unacceptable. Landscape character guidelines such as the Landscape Character Assesssment for the National Park and the landscape guidance of West Sussex County Council would be directly contradicted by a scheme such as Crimson, Magenta, Amber or Grey.

4. ABNC especially objects to the Magenta option.

It would devastate Binsted, a historic village partly in the National Park, which possesses all the National Park's Special Qualities. The data provided by Highways England have hidden the damage Magenta would do to Binsted.

This is an out-of-date, extremely damaging scheme which should be cancelled.

A. The consultation ignores the Climate and Biodiversity Crisis

1. The Climate Crisis

To be consistent with Paris agreement and the IPCC report we need to limit global warming to 1.5 degrees, or face catastrophic climate change. It is estimated that the UK will need to see a reduction in traffic volumes between 20 and 60 percent by 2030. Instead the government projects that traffic will increase by up to 50% by 2050 and plans to spend 30 billion of public money between 2020-2025 on roadbuilding to facilitate this.

Highways England are still doing nothing but 'plan for vehicles', using the outdated method of 'predict and provide'. Transport for the South-East, the local transport body, says quite rightly in its draft Strategy that planning for vehicles must stop and planning must be for people, with 'modal shift and an integrated transport policy'. Transport for the South East's new 'Strategic Goals' would be much better goals for Highways England to be aiming for:

'Economy: improve productivity and attract investment to grow our economy and better compete in the global marketplace. Society: improve health, safety, wellbeing, quality of life, and access to opportunities for everyone. Environment: protect and enhance the South East's unique natural and historic environment.'

The policy paper 'Getting the Department for Transport on the right track' by Friends of the Earth[1] points out that: 'Unfortunately since 2010 there has been a shift in UK transport policy goals away from reducing carbon. Currently, enhancing economic development and reducing congestion are primary goals of transport policy. There has been a move back to a policy of building more road infrastructure, in the belief that this will deliver on current goals. This belief persists despite scant evidence of benefit to local economies and a wealth of evidence stretching back nearly one hundred years that building more roads increases traffic.'

The structure and governance of Highways England by the Department for Transport are a legacy of this return to antiquated thinking. Highways England's purpose is to build roads. The CEO of Friends of the Earth, Craig Bennett, recently visited the Arundel area to see what the bypass plans would destroy. He said that Highways England ought to be scrapped and replaced by a body which would look at transport in the round. [2]

2. Misguided publicity ignores the Climate Crisis

Highways England's publicity for the Arundel scheme includes two films called 'Arundel and the A27' – an animation and a video of interviews – which demonstrate HE's antiquated 'predict and provide' policy.

For instance, they say 'Local businesses are losing out on millions of pounds a year due to congestion. It impacts productivity, causing unreliable deliveries, unreliable journey times, and the

[1] https://policy.friendsoftheearth.uk/insight/getting-department-transport-right-track

[2] https://www.littlehamptongazette.co.uk/news/people/arundel-bypass-global-environmental-group-calls-for-highways-england-to-be-scrapped-1-9100367.

perception that the region is hard to get to.' New roads do not solve congestion. Traffic increases and congestion eventually returns. Chichester and Worthing remain congested. Their congestion would be made worse with an increase of traffic at Arundel.

We have checked the 'millions of pounds' statement with the West Sussex Growers Association. It is based on a misuse of their data.

One interviewee says tourists can't see all the attractions of the area (beaches, Goodwood, Arundel Castle, sailing and watersports, hotels, bars) in one day. Calling for investment in road infrastructure to enable this kind of visitor behaviour is unrealistic and oblivious of the declared climate and biodiversity emergencies. This kind of all-in-one-day tourism destroys the very things people come to see.

HE say the scheme will bring four key benefits. The first is economic growth. But economic growth must be sustainable, i.e. not involve ruining the environment by building damaging new roads.

The films also contain blatant untruths. Another key benefit is stated to be that the road will 'limit air and light pollution, protecting our local environment.' On the contrary - any new dual carriageway at Arundel would severely damage 'our local environment', damaging the National Park, villages, woodland, historic countryside, and the Arun valley. Air and light pollution across the area would increase.

3. The Biodiversity Crisis

The UK is one of the most nature-depleted countries in the world. See the State of Nature Report 2016 (page 6, https://www.rspb.org.uk/globalassets/downloads/documents/conservation-projects/state-of-nature/state-of-nature-uk-report-2016.pdf).

Highways England itself states that 'The loss of biodiversity is a widespread national and international issue - with a number of species becoming extinct in the UK in recent years': https://www.gov.uk/government/publications/biodiversity-plan. Highways England also acknowledges that roads contribute to declining biodiversity.

Highways England's solution to the crisis is this: 'We know, from Government data, we're likely to have a historic trend of declining biodiversity on our network. Our objective is to slow the rate of biodiversity loss in Roads Period 1, moving to a neutral position in Roads Period 2 (where we're maintaining the biodiversity value of the network at a steady level). Ultimately we want to be improving the biodiversity value of the network.' This is too little, too weak, and too late. The emergency is now.

Their own data show that the effects on biodiversity of the Amber and Magenta routes (the old Preferred Route, and the route Local Authorities have misguidedly supported) are from Large Adverse to Very Large Adverse (brochure, p.25). Highways England will not be announcing any detailed mitigation plans for any of the options at this stage.

This means the biodiversity impact of all options is unknown (Approach to Consultation, page 12), and respondents have been unable to rank the options in this crucial impact. The mention of 'value engineering' as a way of making the high cost options practicable means that options such as 'green bridges' and animal culverts would be stripped out of the plan as too expensive.

4. Biodiversity data incomplete

The levels of impact on biodiversity are now well documented for the original 3 route Options in the 2017 consultation. But HE have included the new options (Magenta and Grey) within the EIA without surveys for protected species and habitats. For instance, the hedgerow corridors and foraging areas extending to the west from the woodland area have not been surveyed. Impacts are therefore 'assumed' rather than 'assessed'. It is one of these options, Magenta, which Local Authorities are now supporting, without sufficient data on loss of biodiversity.

There is a lack of information on two key aspects:

- the fundamental requirement (by many species) of a number of different habitats in order to survive, requiring movement across the landscape; and
- the exceptionally high biodiversity value of the area.

This part of the South Downs National Park (i.e. the woodland) is the 'heart' of the surrounding landscape with arteries (in the form of numerous corridors) radiating out. They are functionally linked and the severance of these linkages will have a high negative impact on a wide range of Biodiversity Action Plan and legally protected species that suggested mitigation will provide ineffective compensation for.

The net biodiversity value of the 'integrated' Mid Arun Valley (i.e inside and outside the NP) is exceptionally high. Surveys have shown that it has both high species diversity (from bats to invertebrates) and high populations within some of those species. It includes a high proportion of groups and species known to be in terminal decline – i.e. farmland birds, Water Vole, Hedgehog, Harvest Mouse – many of which rely on habitat connectivity and the ability to disperse.

This is a 'working' landscape which is able to function as it has for centuries and retain its high wildlife value, due to good quality habitats throughout – i.e. diverse ancient woodland with veteran trees, floodplain grassland, wetlands, wildflower corridors and field margins - linked by corridors of species rich hedgerows (with veteran trees) and wet ditches and rifes. Both woodland and wetland biodiversity will be impoverished if these two habitat types and their connectivity corridors are severed.

A major carriageway severing the National Park woodland from its many arteries will have a high negative impact, gradually eroding the species richness and diversity both within and external to the NP and resulting in a significant net loss in biodiversity.

The biodiversity information given in the consultation, though including a lot of data, has not led Highways England, the MP or local councils to the right conclusions. The right conclusion would be that all the offline options are too damaging and should not be taken forward.

5. The 'Arundel Alternative'

Instead of building a long new dual carriageway which would increase carbon emissions, cause a significant net loss of biodiversity, and severely damage the environment, Highways England should be looking more closely at the more modest scheme put forward by local people, now called the 'Arundel Alternative'.[3] The Arundel Alternative is a much shorter section of wide single carriageway

[3] www.arundelalternative.org.

new road from the Crossbush roundabout to the Ford Road roundabout, with a 40mph speed limit. This is an acceptable road-building solution which would enable traffic to flow better by cutting out five of the six pinch points along the present A27 east of Ford Road, without damaging the very high quality countryside to the south and west.

Highways England has summarily rejected this scheme in the consultation, not by name, but with a one-page statement that a single carriageway would not be acceptable because it does not provide a large enough increase in capacity for their predicted increase in traffic. As Craig Bennett of Friends of the Earth put it on his visit to the HE display at Arundel: 'That's the whole point.' Increases in capacity bring more traffic and increases in carbon emissions.

ABNC supports the Arundel Alternative, which should be part of an integrated scheme of transport improvements including walking, cycling, better access over major roads, and improvements to public transport.

B. Faults in the consultation

1. Pro-offline bypass bias of the consultation

The consultation is clearly biased against a near-online solution. The Cyan and Beige options, now at 50-70 mph where the previous consultations had 40mph, are designed to be unacceptable, and are clearly not reasonable in the location. An elevated road (Cyan) or an 8-13 lane junction at Ford roundabout (Beige) would be eyesores in the centre of Arundel. These were clearly designed to generate fear and therefore to make people go for an offline option.

A similar bias was demonstrated at the 2017 consultation with the ludicrous walking and cycling 'bridge' at the Ford junction, which everyone focused on - as they knew people would. The bias is also shown in the publicity accompanying the consultation, the erroneous, and highly misleading, figures for woodland impact, and in the problems with naming the routes and errors of naming.

2. Pro-offline bypass bias in the scheme's publicity

The Consent Order signed by HE in 2018 required the further consultation to be full and open and carried out lawfully and in compliance with the laws of procedural fairness.

Highways England produced two videos as publicity for the consultation. Both are called 'The A27 at Arundel'. One is an animation, the other consists of interviews. The filmed interviews include speakers from OneArundel, but no other community groups are represented, and no environmental groups. OneArundel is a pro-offline-bypass pressure group which claimed 600 members in 2017. Its aim is to move the A27 far away from Arundel regardless of the consequences. It does not represent the range of opinion in Arundel, or the communities such as Walberton, Binsted and Tortington which would be affected by a new bypass. As a company funded by the taxpayer, Highways England should be non-partisan and accountable to all.

According to the Highways England website, 132 key stakeholders sent in written responses to the 2017 consultation. Only 5 were invited to contribute to this video. This is highly unbalanced.

3. Pro-offline bypass bias shown by error in the woodland figures

The crude figures given by HE of woodland 'impacted' are much larger for the online routes (Cyan and Beige) than for Magenta, Amber and Grey. The woodland figures given (highlighted, with space around, with a 'logo' of a hand holding a leaf, in italics to catch the eye) include: Beige 7.44ha; Cyan 8.37ha; Magenta 3.51ha. Absurdly, this has been taken by Arundel Town Council and others to mean they are more damaging to the environment than Magenta.

These woodland figures are incorrect. The maps for woodland lost to Cyan and Beige (Figures 2-1 and 2-2 of the EAR, Appendix 7.3) show an area of woodland where the junction would be built, but the similar maps for the four offline options show it as open land. It was once woodland, but was cleared some years ago and is now pasture. The other diagrams reveal that HE were fully aware that this field is not woodland. When it was woodland, it was not 'ordinary woodland', but an abandoned remnant of a plantation of ornamental trees which had been grown there to be lifted for commercial sale.

The figures of woodland impact for Cyan and Beige should be considerably lower and almost the same as those for Magenta. By putting these erroneous figures in a prominent position in the brochure, implying that Cyan and Beige are more environmentally damaging than Magenta, HE have misled the public.

See Appendix 1 for a more detailed comment on the too-large figures of woodland impacted for Cyan and Beige.

4. Pro-offline bypass shown by crude comparison of woodland and SDNP figures

Aside from this major error, to compare the online and offline routes simply by the crude figures of how much woodland or SDNP area is taken (as in the consultation brochure) is highly misleading. The crude figures give no weight to the difference between

- The very damaging impact of a new road and its effect on woodland and on areas in and near the SDNP where, at present, there is no road, and
- The much lesser impact of taking already degraded woodland and SDNP area alongside the existing A27.

All the Special Qualities are present in abundance in all the areas, both inside and outside the SDNP, at present pristine and intact, which Crimson, Amber, Magenta and Grey would go through.

The Special Qualities of the National Park hardly exist by the side of a major road such as the A27 west of Ford Road roundabout, which would be widened by Cyan and Beige. It is therefore extremely misleading to calculate the impact of the routes simply by the hectarage of the area of the National Park that would be destroyed, as is done in the consultation brochure, especially as the incorrect hectare estimates given imply wrongly that the offline routes are less damaging than the online routes.

5. Pro-offline bypass bias shown by route names confusion and errors

The decision not to use the colour names for the routes in the SAR and EAR, but names such as 4/5AV1 for Magenta and 4/5AV2 for Amber, appears to be deliberate obfuscation to hide the large

amount of information in these documents which makes the true damaging nature of the options, especially the offline options, clear.

Naming errors noted in the EAR, Appendix 7.1 (Landscape Effects Schedule), and EAR, Appendix 1.1 (Effects on the Special Qualities of the National Park), raise questions about the accessibility of the whole EAR to the consulted public, and the motives of Highways England in making the naming so confusing. See Appendix 2 for a list of the errors. So many errors in just two Appendices checked for consistency suggest there may be many more. In both Appendices, some of the descriptions given for Magenta are incorrect for Magenta but correct for Amber, and vice versa.

A reply received from Highways England on 14.10.19 to some of these points says that in several cases 'Binsted Park was used as a point reference instead of Binsted'. This is unacceptable, as Amber goes through Binsted Park, while Magenta does not – but both go through Binsted village. It is also not a convincing explanation, because Binsted Park is not a point location, but a park; correctly named on many maps in common use, it is the curved field area surrounded by woodland which was created in about 1800 as a 'pocket park' to be viewed from Binsted House, defined as 'Historic Parkland' by Historic England.[4]

6. Inclusion of Worthing-Lancing scheme affects the Cost Benefit Analysis figures

HE says that the traffic volumes and journey times at Arundel are similar with and without the Worthing-Lancing scheme. However, the inclusion of the "paused" scheme in the do-minimum network has a large impact on the economic return to the Arundel scheme. Without the Worthing-Lancing scheme, BCRs would range from 1.78 for Cyan to 1.46 for Amber and Grey. These two schemes would be classed as having a Low return, and would not normally be approved. If the Worthing-Lancing scheme is included, benefits would be increased by between 21% and 42%, and BCRs would be increased to between 1.95 and 2.16. Only Grey would have a BCR less than High.

The Magenta route would have a BCR of 1.54 without the Worthing-Lancing scheme, and a BCR of 2.02 with it. This increase in benefits is hard to understand. See Appendix 3 for more details of the contradiction between these figures.

7. Lack of clarity about the budget

There is considerable concern about the mixed messages that have been received from HE about the affordability of the options.

Only one option is within the budget of £250m – Beige. The Cyan option is almost affordable. The others are well over budget. But opinions are being sought on all the options. The brochure says 'The cost ranges published within this consultation are early estimates based on work done to date and do not represent out final costs for the project' (p. 56). Even so, the question in the survey

[4] The error of trying to use Binsted Park as a point location may be connected to errors in the consultation documents that hide the true location of Binsted Park – as in the 2017 consultation. The name 'Binsted Park' appears in a label on a consultation map (Scheme Assessment Report, Appendix A, Fig. 8.4) but the label's arrow points to the site of Binsted Manor (the new house on the site of Binsted House), not to Binsted Park.

form asking people to choose between Cyan and Beige in the event that none of the other options is affordable implies that none of the other routes may be affordable.

HE representatives have been assuring people that all the options are affordable. The consultation literature does not indicate this, but makes it seem unlikely by giving in a footnote (survey form, Question B1) ways in which the unaffordable options might be made affordable: 'Through securing additional funding, value engineering and contractual efficiencies.' 'Securing additional funding' is too vague to give a clear indication of whether the over-budget routes are affordable. Additional funding from where, from whom, how much, and if it is promised why was it not included in the budget?

'Value engineering' is a euphemism meaning 'cutting corners'. 'Contractual efficiencies' is much the same. For instance, embankments might be made steeper so as to use less earth. Green bridges and animal culverts might be left out. Such 'engineering' would make for an even more damaging scheme in this very sensitive area.

8. The survey form is open to fraud

Since the paper form is anonymous, and only asks for a postcode, it would be very easy for one person to fill in multiple forms. The online form could also be filled in multiple times by the same person. No names are asked for and although an email address can be given it is not required.

The form includes a long statement about GDPR and how Highways England will not misuse your personal information. But no personal information is asked for. GDPR has been used by HE as an excuse for not requiring unique identification (e.g. name and address or phone number) for each response. However this is not a valid excuse. HE has a sufficient organisational reason to require personal information, i.e. to avoid fraud.

In a consultation about a project of this magnitude, which will affect so many people's lives if it goes ahead, it should have been possible to design a process where each respondent was identifiable and their personal information was protected.

9. The form is confusing about filling it in for an organisation

The form offers a part A-C for a personal response and a part D for a response from an organisation. It says (A1) 'The first part of this questionnaire is for you to provide your personal views. If you are responding on behalf of a local business, charity or community organisation, represent a statutory body or are an elected representative, please ensure you also complete section D of the response form.'

It won't be possible, when analysing the forms, to tell whether, if part D has been filled in, parts A-C also represent the views of the organisation, or are the personal answers of the person filling it in for that organisation. It would have been far better to say 'If responding for an organisation please complete a separate form from your personal one, and complete all sections A-D on behalf of the organisation'.

This means the personal views of people who fill in a whole form for an organisation may not have been received.

10. The form gives no 'none of the above' answer in multiple choice questions

In the multiple choice questions, the only option other than ticking a route is to tick 'Don't know' or 'Do nothing'. It is severely restricting not to have a 'None of the above' option, and not to have an 'Other' option and a text box in which to state the 'Other'.

There are three free comment boxes where they could say what they really want, but it is not clear that a response will be counted if the multiple choice questions are left unanswered. It is possible that they would just be ignored, i.e. not counted, but they should really be scored as a 'none of the above'.

These faults, added together, give no confidence that Highways England's interpretation of the consultation will be 'fair and open', as they undertook the consultation should be in the Consent Order signed in 2018.

C. ABNC objects to all Highways England's options, especially the offline options

The new Arundel Bypass consultation threatens a large amount of beautiful countryside. The history of the National Park boundary shows why no option is acceptable. More recent landscape planning guidance shows that any of the offline routes would so comprehensively conflict with the guidance that it might as well be torn up.

1. The first SDNP boundary proposed included all the areas the bypass could go through

When the proposals for a South Downs National Park were first examined in February 2001, the Countryside Agency's consultants, Landscape Design Associates (LDA), said the following areas met the 'natural beauty' and 'excellent opportunities for recreation' criteria, and recommended them for inclusion in the new National Park:[5]

- Arundel Town,
- the watermeadows down to the railway,
- all the woodland south-west of Arundel, and
- the area 'between Walberton and the Arun valley', i.e. Binsted and Tortington villages south of the woods.

The woods at Binsted and Tortington were recommended for inclusion in a section called 'Central Wooded Chalk Uplands', and LDA noted that they were better for recreation than the woods north of the A27. The area 'from Walberton to the Arun' was recommended for inclusion in a section

[5] This report, Core Document 36 in the SDNP Public Inquiry, has disappeared from DEFRA's archives, though it is listed in the catalogue. Did the Countryside Agency, or another agency, suppress that document because it showed that disinterested consultants thought a much larger area met the criteria for the National Park than that included in the draft and designated boundaries?

called 'Coastal Lowlands'. It is thus crystal clear that it is the countryside south of the woodland at Binsted and Tortington that is being recommended for inclusion.

The recommendations can be found in 'Area of Search for the South Downs National Park', Landscape Design Associates, February 2001. No southern boundary was suggested for 'Walberton to the Arun valley', but as the railway was suggested as the boundary at Arundel, it would also have made a strong boundary at Binsted and Tortington.

LDA also commented that it was 'especially desirable to designate' the areas they had recommended for inclusion, for five reasons, including their closeness to conurbations, their ability to act as 'gateways' to the National Park, their accessibility, and the fact that this would take pressure off more remote areas further into the Park.

2. Bypass consultants influenced the more restricted draft boundary chosen

A paper for the Countryside Agency by Marian Spain (titled AP 01/04), dated 2001, repeated LDA's recommendations. But the 'draft boundary' (July 2001) included only included the main block of Binsted Woods and five fields – although all of Binsted Woods was an SNCI. At Tortington it only included the whole of Tortington Common.

The Government's Bypass consultants Halcrow said in their Progress Note, May 2002, that they had been looking at bypass routes 'south of Binsted Woods'. They said: 'A series of alternative alignments south of Binsted Woods are being examined as part of the Strategy Development Plan. These avoid the National Park but may impact upon SNCI areas.' Halcrow were going by the 'contracted' draft boundary of 2001. The boundary appears to have been 'contracted' at Tortington and Binsted to allow bypass routes such as those suggested by Halcrow (similar to today's Magenta and Amber) to be outside the Park. The National Park had not yet been created. The bypass routes proposed by Halcrow had no official existence. This was a major planning mistake.

LDA commented in the February 2001 report that the boundary in this area required 'particular scrutiny and refinement' because of the bypass plans. At the time the Preferred Route was what is now the Crimson Route. Excluding recommended areas, that are 'especially desirable to designate', apparently to allow for a different bypass route does not amount to 'particular scrutiny and refinement'.

Some adjustments were made to this contracted boundary, but only a small addition was made. Arundel town and the watermeadows were omitted. Tortington common was in, then out, then in again due to bypass decisions. At Binsted, an addition consisting of the left-out parts of the SNCI woodland and five more fields was accepted by the Inquiry Inspector, but this was far less than LDA had recommended for inclusion and stated was 'especially desirable' to designate.

This whole sequence of events makes the new consultation seem slightly absurd, and possibly a waste of time. Highways England are trying to push through a bypass partly in a National Park, or if just outside it (most of Magenta, Grey) massively affecting its setting, when all the countryside the bypass would go through – including Arundel, the watermeadows, the woodland, and Tortington and Binsted villages - is of National Park quality. This high quality, if properly acknowledged, should prevent an offline bypass getting through the planning process.

Even worse, the Magenta route, which is arguably the most damaging to Binsted village, passing through it from one end to the other very close to 5 listed properties and leaving what would become a 'ghost village', was created by the National Park boundary. Because of the existence of the National Park designation, Magenta attempts to skirt the National Park, avoiding most of the woodland but severely impacting the village itself, which is interspersed with the woodland in a way that is typical of very old, intact countryside.

If the Magenta route is built Binsted village will have been destroyed by the National Park boundary – surely not the intention of those who proposed National Parks and developed the legislation protecting them.

3. Recent landscape guidance: reasons to reject Crimson, Amber, Magenta and Grey

Recent planning guidance on landscape supports the need to conserve, enhance and protect countryside at Binsted and Tortington, both inside and outside the National Park, and therefore to reject Crimson, Amber, Magenta and Grey routes.

3.1: SDNP Local Plan

The Autumn 2015 SDNP Draft Local Plan seeks to 'ensure that development outside the National Park does not have a detrimental impact on its setting or otherwise prejudice the achievement of the National Park purposes' (Chapter 5).

3.2: South Downs Integrated Landscape Character Assessment [6]

The South Downs Integrated Landscape Character Assessment (SDILCA) states: 'Changes beyond the final boundary…all contribute to change within the South Downs. …It is vital that all local, regional and national policies consider the implications of change beyond the National Park boundary on its distinctive character and qualities.'

The SDILCA classifies the SDNP's included land at Binsted and Tortington as part of Landscape Type B, 'Wooded Estate Downland'. Almost all the features claimed to be typical of this type of landscape are present in Binsted and Tortington both inside and outside the National Park.[7] Crimson, Amber, Magenta and Grey routes would directly contradict all the management objective for this Landscape Character Type: 'The overall management objective should be to conserve the large-scale landscape mosaic of woodland … and farmland, and the deeply rural secluded character.' This is a very good description of Binsted and Tortington both inside and outside the National Park.

Under this 'Objective' are 'Landscape Management Considerations' which include: 'Conserve the large scale mosaic of … ancient woodlands and hedgerows that enclose open arable fields, all of which creates a bold, distinctive identity.' 'Conserve and manage the intact hedgerow network with hedgerow trees which are of biodiversity interest and create a strong landscape pattern linking into

[6] http://www.southdowns.gov.uk/wp-content/uploads/2015/03/ILCA-Technical-Document.pdf.
The SDILCA was first drafted in 2005, during the planning period for the South Downs National Park, and revised in 2011. It is intended to guide change and development 'so that it does not damage the characteristics or value of the landscape'.

[7] The only exception is tall brick or stone estate walls.

the woodland as well as contributing to seclusion and enclosure.' 'Avoid 'improvements' that would alter the rural character of the unmarked lanes.' 'Conserve historic designed landscapes, and their settings, encouraging the management/ restoration of permanent pasture, parkland trees, avenues and clumps of trees.' 'Conserve the very low density of settlement and road access, and consequent strong sense of remoteness associated with the Wooded Estate Downland.' Crimson, Amber, Magenta or Grey directly conflict with these guidelines.

3.3 West Sussex Landscape Management Guidelines and Strategy

The West Sussex Landscape Management Guidelines were updated in May 2019.[8] The area including Binsted and Tortington is called SC8. Their aims include (my numbering):

1. 'Conserve and enhance the undeveloped rural character of the area.'
2. 'Maintain and enhance the historic character of the area, including historic parks, earthworks, and historic field patterns.'
3. 'Conserve and enhance the character and setting of small villages and hamlets.'
4. 'Conserve hedgerows and allow for growth of hedgerow trees.'
5. 'Conserve the rural character of the Binsted Valley to the east [of the SC8 area].'
6. 'Conserve and enhance the historic features of Binsted, especially in the vicinity of the golf course.'
7. 'Conserve and enhance the streams and their sides in the Binsted Valley.'

1, 2 and 3 would be contradicted by all the offline routes. On point 6, the 'historic features of Binsted…in the vicinity of the golf course' include St Mary's church, Church Farmhouse and Quince Cottage (all listed Grade 2), also the Old Rectory and Stable Cottage ('buildings and structures of character'), all very close to the Magenta route. The Black Horse Pub, a thriving local business next to the golf course, would be right next to the Magenta route and also an access road to it.

The Grey route would have the worst effect on aims 4, 5 and 7 and would also destroy part of the golf course. The Binsted Valley includes a wooded, steep-sided portion to the north of the golf course which would be severely damaged by Magenta.

The Guidelines are to be read in conjunction with the Strategy for the West Sussex Landscape, 2005. This starts with a 'Landscape Vision', which states in the present tense those 'action points' which WSCC claims to be putting into effect. They include (my numbering):

1. 'Character and local distinctiveness are recognised, valued and celebrated.'
2. 'Diverse character of landscape is nurtured, conserved and enhanced as part of a thriving economy.'
3. 'Change is accommodated in ways which reinforce and restore character.'
4. 'The rich diversity of wildlife habitats and national heritage of woodland, trees and hedges…are being conserved and enhanced.'
5. 'Protection and conservation of historic landscape features and archaeological sites continues. Well managed historic landscapes provide continuity with the past.'
6. 'There is a high degree of accessability to the countryside which is enjoyed by all social groups.'

[8] http://www2.westsussex.gov.uk/environment/heritage/SC6_UpperCoastal.pdf.

After the Vision for the whole county come Visions for the five National Character Areas. The Vision for the South Downs character area includes:

7. 'Where Down meets Town to the south, the setting of the South Downs remains unaffected by new development.'
8. 'Areas presently noted for their tranquillity are surviving, because the intrusive effects of …transport infrastructure have been minimised.'
9. 'The landscape is managed as a major resource for informal recreation, but without loss of tranquillity.'
10. 'Highly distinctive features of the chalk downland, such as…historic parklands…and other historic and archaeological monuments and their settings, continue to be protected and are conserved.'

Crimson, Amber, Magenta and Grey routes conflict massively with these guidelines.

3.4 The National Park Statutory Purposes and Special Qualities

The Statutory Purposes of the South Downs National Park are: 'Purpose 1. To conserve and enhance the natural beauty, wildlife and cultural heritage of the National Park. Purpose 2. To promote opportunities for the understanding and enjoyment of its special qualities.' These must be taken into account by Highways England in designing road schemes. The SDNPA's Position Statement of July 2014 stated (2.1) that 'Any proposed schemes must take into consideration all potential impacts on the special qualities of the National Park and look to improve rather than damage the special qualities'.

Far from improving them, the offline routes would severely damage the National Park's Special Qualities. See Section D below for more details.

D. ABNC especially objects to the Magenta route

Amber, Grey and Magenta routes would all ruin Binsted village. Our MP, Arundel Town Council, Arun District Council and West Sussex County Council are all supporting Magenta. This is the worst of the three for the village. Amber cuts through its northern part, Grey through the southern part, and Magenta through the middle.

1. What would be lost at Binsted

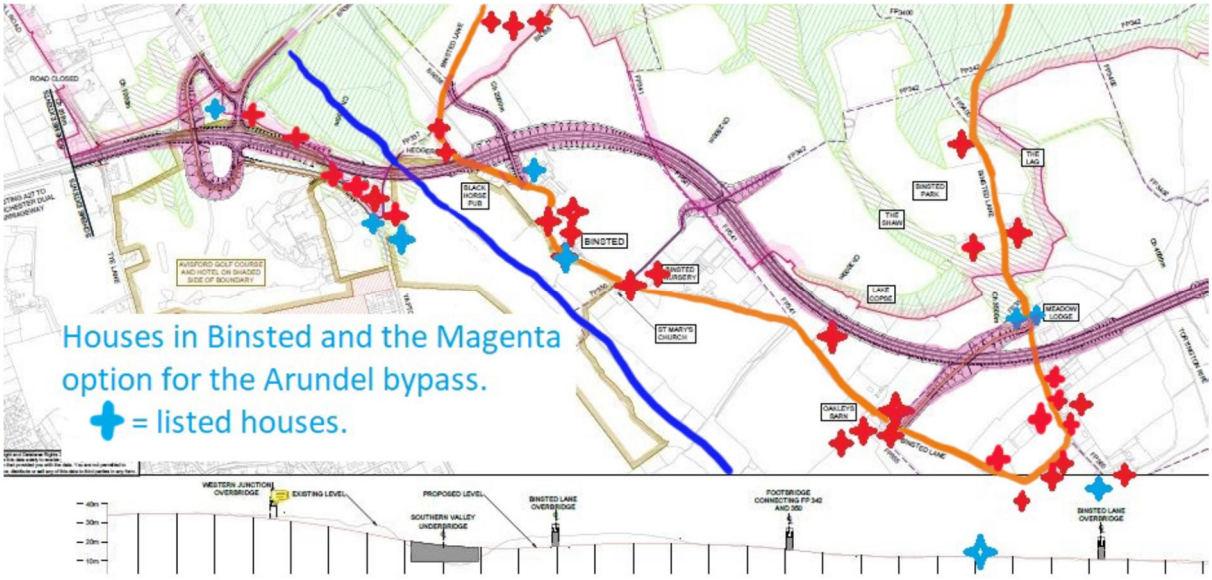
A resident's description of Binsted gives an idea of what would be lost there if Magenta was built: 'Binsted is a place lost in time and a rare haven of peace in the Arun coastal plain. Everyone who lives here does so because they enjoy the tranquillity and relative isolation which also attracts many visitors from around the county. Its 38 houses are scattered along a U-shaped lane that adjoins the existing A27 at both ends. This configuration may give the impression that our village has no hub

but it has a strong community spirit, bonded ever closer in recent years as we unite to fight the appalling threat that the Arundel Bypass has imposed on all of us.

'We have an arts festival and three community events each year - the Strawberry Fair held in and around the Flint Barn, which raises funds for local charities and the upkeep of the church, the Harvest Supper also held at the Barn and a village Christmas party. The Magenta route goes straight through the Strawberry Fair field next to the barn. It also slices through both sides of the U, dividing the village in three, and cutting off the only road between Binsted and Walberton. Access along the rest of Binsted Lane would be a ridiculously contorted affair and the three bridges over the dual carriageway would provide the only connection with our neighbours and the National Park. Our wildlife would not have that choice.'

Binsted's U-shaped lane partly explains its feeling of being 'lost in time'. The lane's shape, which does not connect with the outside world except to the north, is a result of its historic isolation as a parish cut off on three sides by brooks and marshes. The parish contained all that was needed – pasture, meadow, water, rich agricultural land in the centre, and massive woods to the north, west and east.

Figure 1: West end of Magenta and Binsted village



Many villages 'nucleated' or rearranged themselves with a central built-up area in the 7th to 9th centuries. Binsted never did this. Its layout dates back to Anglo-Saxon times. The Victoria County History points out that its woodland (the 100ha of Binsted Woods) have been in 'much the same places' since the Domesday Book. The small fields in southern Binsted, and the intricate edge of the woods with copses and shaws radiating into the fields, are characteristic of very old, historic countryside. Two small fields surrounded by woodland are 'assarts' – fields claimed from the woodland in mediaeval times. Binsted Park is a gentleman's part from the 18th century. Magenta would destroy this ancient countryside.

2. Misleading presentation of data

Highways England have hidden the damage Magenta would do to Binsted by their presentation of data. As a Binsted resident writes, 'The maps and description of the route in the latest SAR by Highways England are misleading - there is no mention that Magenta actually passes through the middle of Binsted, weaving in and around some houses and passing through others. It just merely says that it crosses Binsted Lane....and passes behind some residential properties.'

A resident writes: 'The Highways England maps and materials presented by Highways England do not show Binsted as the thriving community we are.' Another resident writes: 'The maps that Highways England have published name only 3 random houses, our 12th century church, Binsted Nursery and the pub. The other 35 homes, small holdings, businesses and Community Barn are nowhere to be seen and Binsted Lane, which defines and ties our scattered settlement together, is barely discernible.'

Another sees the omissions as deliberate: 'If the MP and Arundel Town Council have made their decision regarding their support of the very controversial Magenta option based on the information supplied by Highways England then they need to look again. The information given is both inaccurate and very deliberately misleading. After the judicial review of 2017 we now all know that Highways England are not above omitting relevant information and facts. The maps I have seen at many of the local meetings do not show the many houses and businesses affected.'

Deep in an obscure Appendix, hidden by using number and letter names instead of the colour names of the routes, there are summaries of the effects on individual listed houses.[9] But they are absurd, and state damage would be minor when life in the house neighbouring the road would be unliveable – and a major change from the present situation where the house is part of a historic village in beautiful countryside partly in the National Park.

3. Damage to Slindon and Walberton ignored

Another resident points out the damage Magenta would cause to Slindon and Walberton.
'One of the justifications for the offline routes is to reduce the rat running through downland villages. In promoting Magenta, it is quite clear that Highways England, Nick Herbert and others, have forgotten about Slindon, a downland village which is a conservation area with numerous listed buildings, largely owned by the National Trust and within the South Downs National Park. Part of Slindon will become the north-south corridor to the A27, Yapton Lane and further south, damaging Walberton village and causing rat-running in its Conservation Area. The junction at Slindon on the A29 will become a death trap.'

[9] EAR, Appendix 6-2, 1222201: 1274878, says of options 4/5V1 (Magenta) and 4/5V2 (Amber) that the result of the road will be Neutral for Church Farm and Glebe Cottage – both listed grade 2, both at present set in idyllic farmland backed by huge woods. Church Farm would be right next to Magenta with an access road up another side of the property. 1221993: the effect of Magenta on Morleys Croft and Meadow Lodge is said to be 'Moderate Adverse' – both are listed Grade 2, in an idyllic setting right on the edge of the National Park and woodland, and both would be right next to the overbridge for Binsted Lane for Magenta.

4. Incorrect figures quoted in brochure

As well as misleading maps, Highways England have hidden the damage to Binsted and also Tortington by merely quoting in the brochure the crude amounts in hectares of woodland or National Park land that the various routes would take. Higher amounts are given for Cyan and Beige routes than for Magenta. Those extraordinary woodland figures are wrong (see Section B3 above). They include taking 4 hectares of woodland to make a new junction on Cyan and Beige for the Arundel Hospital. But that area – the Arundel Arboretum – was cleared years ago and is now pasture. If those illusionary four hectares are deducted, the woodland impact of Beige, Cyan and Magenta comes out the same. See Appendix 1 for a fuller note on this woodland error.

The truth is that a new dual carriageway through the countryside would do incalculably more damage to woodland and the National Park than widening the existing A27. The woodland by the present A27 is already degraded and the National Park Special Qualities are not present. In the areas the offline routes would go through, pristine woodland would be damaged and vital wildlife corridors would be severed.

5. Binsted, Tortington and the National Park Special Qualities

As for the National Park Special Qualities, Binsted and Tortington – initially recommended to be within the National Park in their entirety - have all these and more. They would be severely damaged by Magenta.

Special Quality 1: 'Diverse, inspirational landscapes and breathtaking views.' Both Binsted and Tortington are diverse and inspirational landscapes. The National Park boundary includes mainly their wooded areas (and ten fields in Binsted). Woods, shaws, hedges, streams, ponds, ditches, and fields, with many listed houses and the varied and intricate woodland edge, make the areas outside the National Park more diverse than the areas within it.

Special Quality 2: 'Tranquil and unspoilt places.' Landscape historian Simon Jenkins' book on landscape said the English countryside made him 'marvel at how much that is varied remains varied, informal, unmistakeably old. There are places where England looks as it has for centuries and where people…gather to find and declare it beautiful.' Binsted and Tortington are two of those places – tranquil, unspoilt, and all the more appreciated for being so close to populous areas.

Special Quality 3: 'A rich variety of wildlife and habitats including rare and nationally important species.' This is true of both Binsted and Tortington, both inside and outside the National Park. The ongoing environmental surveys by MAVES (Mid Arun Valley Environmental Surveys, www.maves.org.uk) show that the biodiversity of the area is extremely rich. Protected species such as bats, dormice and water voles move freely between the wooded areas within the National Park, and the other habitats such as hedges, ditches, ponds, fields and shaws in the countryside outside the woods. Crimson, Amber, Magenta and Grey routes would sever the foraging habitats of the area's wildlife and cause local species extinctions. We are in the midst of a biodiversity crisis and a mass extinction event.

Special Quality 4: 'An environment shaped by centuries of farming and embracing new enterprise.' Both Binsted and Tortington have an environment shaped by centuries of farming. Binsted's

mediaeval farming layout round a U-shaped lane, with the largest fields in the centre of the parish where the mediaeval 'open fields' were, is still evident today. Both have land-based contemporary businesses: Binsted has horticulture, a pub, kennels, shepherding, and small businesses in the Church Farm buildings; in Binsted woods there is an archery club, and bushcraft and nature experience courses. Tortington has a retreat centre at Brookwood, a conference centre at Tortington Priory, and an equine hospital.

Binsted's and Tortington's enterprises would be devastated by Magenta. In Tortington, retreats could not take place next to a busy dual carriageway. In Binsted, the Black Horse pub would be hemmed in on two sides by the Magenta route and an access road on an overbridge. The kennels business would have to close and its owner says: 'We have built our family business up over the last 35 years, my late father-in-laws legacy to be handed down to my own daughter. This is not a business that can be moved to another premises, we would lose everything, our home, our business, our own employment and that of our staff.' One resident sums up: 'At the moment, I am finding it very difficult to believe that anyone could have the lack of humanity to support a scheme which will have such a shattering impact on people's lives.'

Special Quality 5: 'Great opportunities for recreational activities and learning experiences.' Both Tortington and Binsted supply these with their many footpaths and bridle paths through changing scenes and habitats, both inside and outside the wooded areas. These would be disrupted by Crimson, Amber, Magenta and Grey routes. Access might remain but the pleasure of the recreational activities in this quiet, unspoilt area would be lost. MAVES (now part of the Arun Countryside Trust) runs guided walks, bat detector sessions, volunteer activities such as hedge laying and pond clearance, and training as a licensed dormouse surveyor, in both Binsted and Tortington. These would cease if a dual carriageway was built through the area.

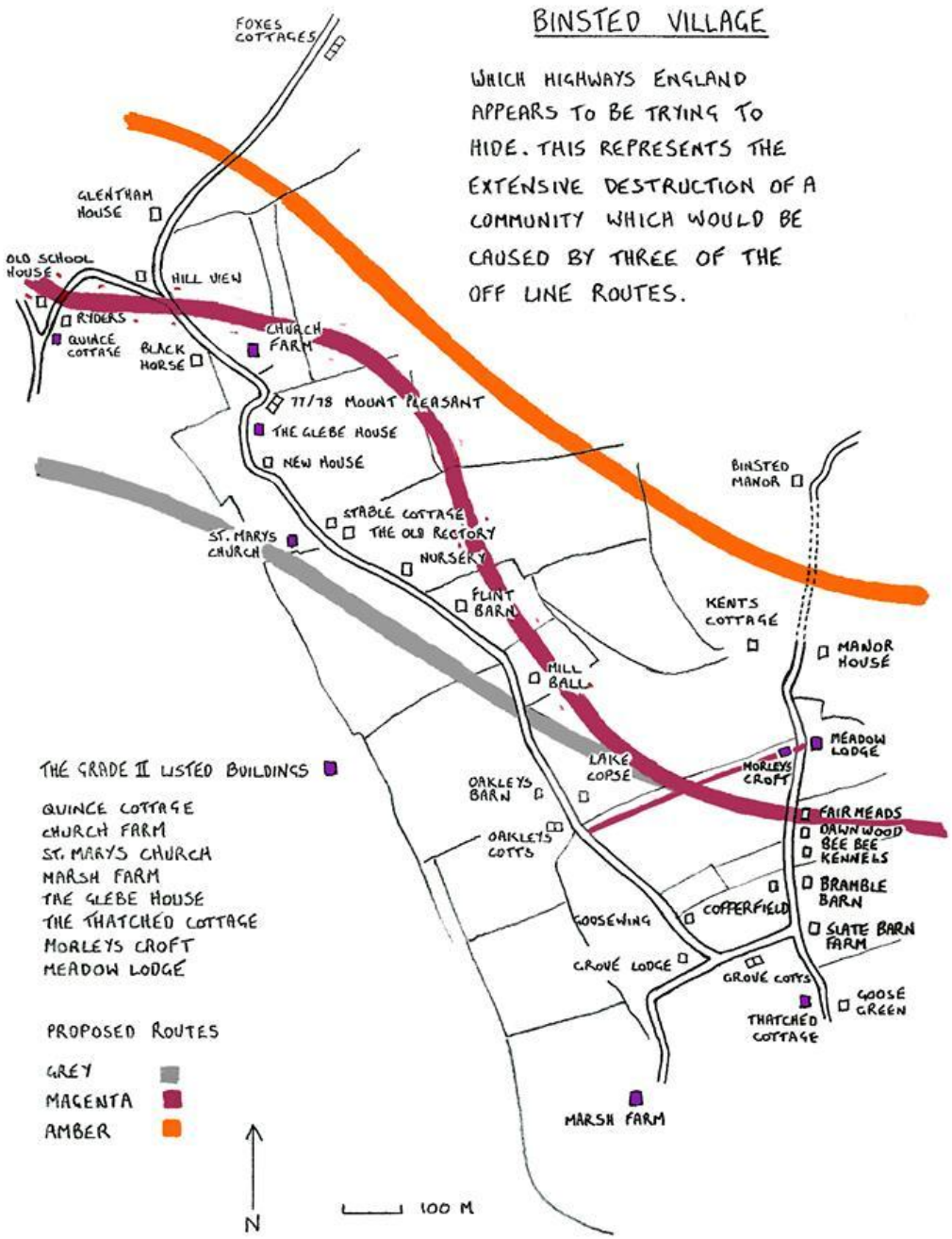
Special Quality 6: 'Well-conserved historical features and a rich cultural heritage.' Binsted and Tortington are rich in history and well-conserved listed buildings, including both 12th-century churches. An Anglo-Saxon Moot Mound, where Binsted Hundred met, was identified in Binsted in 2017.[10] Moot mounds, where they still exist, are of national importance (HER, 'Alstoe Moot Mound'). Together with Scotland Lane, the eastern access track to the Moot Mound, and the 'hollow way' leading to it from the west, these discoveries form a 'landscape of governance'.[11] The Moot Mound is within the South Downs National Park and Scotland Lane forms part of the boundary. This 'landscape of governance' would be partially destroyed by Magenta, Amber and Grey routes.

Two mediaeval tile kilns in Binsted have been excavated, one in the 1960s and one in 2005.[12] One is within the National Park, one just outside it. One would probably be destroyed by the Magenta route and the other is very close to both Amber and Magenta routes. Together they show Binsted is a historic 'industrial landscape' and these should be preserved. Amber, Magenta and Grey routes would mean a stop to the Binsted Arts Festival which is in its fifth year.

[10] [redacted], 'Identifying the meeting place of Binsted Hundred near Arundel, West Sussex', Sussex Archaeological Collections, 155, 2017, pp. 97-102.
[11] https://www.ucl.ac.uk/archaeology/research/landscapes-governance
[12] The 2005 excavation is described in Worthing Archaeological Society's Journal, summer 2005.

Special Quality 7: 'Distinctive towns and villages, and communities with real pride in their area.' Both Binsted and Tortington are distinctive villages. Binsted has produced its own 'village book', 'Binsted and Beyond' (2002), and website, www.binsted.org, where there are more details of its artistic life. Tortington had an Augustinian priory, subject of 'Tortington and the Black Canons', by Boxgrove History Group and John Luffingham, Phillimore, 2002.

Figure 2: Binsted village and Grey, Amber and Magenta routes, drawn by a local resident



Both have strong communities with real pride in their area. Friends of Binsted Church have been running the Binsted Strawberry Fair for 32 years to raise money for charities and the fabric of the church, with over 1000 visitors each year. Magenta destroys the fields where the event takes place. Friends of Tortington Church also run events to help preserve the fabric of their church. Crimson, Magenta, Grey and Amber routes would mean these events could no longer happen.

This major damage to the National Park Special Qualities cannot be conveyed simply by giving the hectarage of the area of National Park destroyed by each route.

Conclusion

Roman roads were notable for striding through the countryside in a straight line, completely ignoring local features such as Celtic fields. So much so, that if ancient field systems are cut through by a Roman road it helps to date them as before the Roman invasion. The Magenta route, now chosen by Local Authorities, would trample the surrounding villages and countryside in a similarly brutal manner – but with much more devastating impact on people, landscape and wildlife due to modern scale, noise, speed, and light and air pollution.

Magenta makes a slight deviation at Binsted to put more distance between it and 900-year-old Binsted Church. But this would make absolutely no difference to the fact that the Magenta route would, as one West Sussex County Councillor put it, 'eviscerate' Binsted.

Up to 20 homes would be compulsorily purchased, according to Jason Hones, the HE project manager (radio interview, 22 October). The heart of the village would be gone and its strong community and generations-old culture would be dispersed and destroyed.

Its history as a unified, isolated parish, cut off by watercourses on three sides and with its U-shaped lane connecting its three farms so that all had access to woodland, meadow, pasture and arable land, would no longer be visible in its layout and a source of the opportunity to 'look back in time'.

Its hidden history as a historic industrial area, with two and probably many more mediaeval tile kilns and a plantation of 800-year-old coppiced ash trees at Hundred House copse nearby to provide fuel, would be lost, with probable destruction of one or even both tile kilns and the extraordinary ash trees.

Its recently discovered visible history as the centre and meeting-place of 'Binsted Hundred', a unit of Anglo-Saxon local government, with its moot mound or 'Hundred House' next to the eponymous copse, and its access road via the mediaeval track of Scotland Lane, would disappear and be lost to future research. Moot mounds, where they remain, are of national importance.[13]

Houses would also be compulsorily purchased at Tortington and its historic village ruined. Walberton and Slindon villages would suffer increased noise and traffic because drivers would be attracted to the new four-way junction at the west end (Magenta). Yapton Lane (B2132), already overloaded and with long queues caused by the new full level crossing, would be packed solid.

This could be the scheme which causes the demise of Highways England by being a national focus for 'how not to do it'. HE is already under investigation by the National Audit Office for its conduct in

[13] Historic England, entry for Alstoe Moot Mound.

the 2017 consultation and for not observing the Nolan Principles of Public Life. To attempt to push through a maximally damaging scheme such as this when there is global recognition of the Climate Crisis and the need to reduce emissions will cause activism on a large scale and, hopefully, the long-needed change to a more sensible way of doing things and an integrated transport policy.[14]

Many areas in London, such as Covent Garden, were saved at the last minute from a destructive road scheme in the 1970s and the capital is now unthinkable without them. ABNC hopes the inevitable change of policy will come in time to save Binsted and Tortington, two historic, flourishing villages, and the superb wildlife area of which they form a part.

The brutal and destructive Magenta route should not be built and will not be built. Something needs to be done, and the Arundel Alternative scheme could provide it.

Appendix 1: Misleading Entry in Brochure about Impact on Trees

The Consultation Brochure contains a table (p. 17) that gives the impact of the six options on woodland. The impact on Cyan is put at 8.37ha and that of Beige at 7.44ha. These figures are about double the stated impact of Magenta and 50% more than Amber, and therefore give the impression that the two on-line options do much more damage to woodland than the two main off-line options.

Cyan and Beige follow the line of the existing A27 from Ford Road westwards to the present dual carriageway. For much of this distance the road is lined with Ancient Woodland, and widening the road would remove a strip of woodland. Detailed tables showing the area, and number of trees, affected by each option are given in an appendix. They show that 1.09ha of Ancient Woodland would be taken by Beige and 1.95ha by Cyan, which includes a new road from Binsted Lane East to the junction west of the White Swan and a new entrance to Arundel Hospital.

In addition to the Ancient Woodland taken by these roadworks, 3ha of ordinary woodland is said to be removed to construct the compact interchange at the western end of the options. A hectare of buffer zone 15 metres wide is added, giving a total take of 4ha of woodland for this junction. A buffer zone is also placed along the road where it runs through Ancient Woodland, adding 2.32ha to the area of AW affected by Beige and 2.42ha to the area affected by Cyan. The areas of woodland taken by each option are shown on Figures 2-1 to 2-6 of Appendix 7.3, and the woodland affected is marked in yellow.

The patch of yellow that indicates the woodland taken by the western junction of Beige and Cyan appears, however, to be superimposed on an area of open land on the map Figures 2-1 and 2-2. Figures 2-3 to 2-6 confirm that this is open land. It was once used for raising commercial ornamental tree varieties for transplanting, but the remaining unsold ornamental trees were felled some years ago and it is now pasture.

It appears, therefore, that the land on which the western junction would be built is not woodland at all. It is difficult to understand how an indication of an area of woodland to be felled could be

[14] See https://www.littlehamptongazette.co.uk/news/politics/magenta-route-for-arundel-bypass-backed-after-die-in-protest-1-9115186.

printed where a map shows open ground. The result of this action is that the area of woodland affected by Beige and Cyan has been over-stated by 4ha in the Consultation Brochure. This error will have discouraged consultees from choosing the on-line options. It may therefore have had a significant effect on the consultation process.

Appendix 2: Naming errors in two documents in the EAR

Colour names are inserted in brackets in Appendix 2 for clarity, but do not appear in the original documents.

a) Mistakes in Appendix 7.1

Appendix 7.1 is a table, called 'Landscape Effects Schedule', which analyses the landscape effects of the routes in different LCAs (Landscape Character Areas). Wood name errors are also included.

Error 1

In the second section of the Table, under 'LCA2: Fontwell Upper Coastal Plain', in the section on 4/5VA1 (Magenta) the following is incorrect: '…the option would continue across a well contained section of fieldscape towards Binsted Manor, while modifications would be screened from the wider receiving environment by the surrounding woodland and mature field boundary vegetation.'

Magenta does not 'continue across a well contained section of fieldscape towards Binsted Manor'. This is a correct description of Amber, not Magenta. Magenta would be entirely outside the woods after the section across Hedgers Hill (which is correctly described). The comment about screening is therefore inapplicable.

Error 2

The same section incorrectly states of 4/5VA1 (Magenta): 'Continuing eastwards from Binsted Park the route returns to cutting passing under Tortington Lane.' Magenta does not pass through Binsted Park so it cannot 'continue eastwards from Binsted Park'. This is a correct description of Amber, not Magenta. The previous paragraph in the section is a correct description of Magenta.

Error 3

In the second section of the Table, under 'LCA2: Fontwell Upper Coastal Plain', the section on 4/5VA2 (Amber) states: 'This option would be located in the central and eastern area of this character area, cutting a diagonal swathe through the north-west section of Binsted Wood and skirting south of its southern section. It wold pass diagonally between the extensive and connected ancient woodlands of Paine's Wood and Tortington Common and the fieldscape and woodland of [sic] crossing Binsted Park on its approach to the Arun river floodplain.'

Amber does not 'skirt south of Binsted Woods' southern section'. This is a description of Magenta.

Error 4: Wood name error in Magenta section

In the section on Magenta, 'The south west corner of Binsted Wood would be removed in a diagonal swathe' (of Magenta) is incorrect. Magenta skirts the southernmost parts of Binsted Woods. The correct wood name, 'Little Dane's Wood', is used earlier in the paragraph.

HE now appear to use 'Binsted Wood' to describe Binsted Woods (the group of 18 named woods within Walberton Parish, i.e. the western part of the Binsted Woods Complex LWS, the part that is not Tortington Common).

This is confusing, because one of the 18 named woods in Binsted Woods is called Binsted Wood (north of Binsted Manor) and it is not affected by any of the bypass routes. The error may stem from OS maps where 'Binsted Wood' appears over the correctly named wood, but seems to have been taken to refer to the whole of Binsted Woods. 'Binsted Wood' sometimes appears to be used incorrectly where the correct wood name should be used, as here.

Error 5: Wood name error in Amber section

Amber would not 'pass diagonally between the extensive and connected ancient woodlands of Paine's Wood and Tortington Common'. Paine's wood is a small wood adjacent to the A27. The only route that passes between Paine's Wood and Tortington Common is the Crimson route.

b) Mistakes in EAR Appendix 1.1, 'Special qualities of the South Downs National Park' (final document in the EAR)

Error 6: Description error in Table 3.3

Table 3.3 summarizes the effects of each option on Special Quality 1, 'Inspirational landscapes and breathtaking views'.

The section summarizing the effects of 4/5AV1 (Magenta) states: 'Exerts greatest influence on user experience of the landscape…where it intrudes into the SDNP boundary at Hedger's Hill and Binsted Park'. Magenta does not 'intrude into the SDNP boundary at Binsted Park' – Amber does.

The same mistake is made lower down in the same section where it states: 'Significant adverse effects …including within the SDNP at Hedger's Hill and Binsted Park'. Magenta is not within the SDNP at Binsted Park. Amber is. Magenta does intrude into the SDNP at Hedger's Hill, so these statements appear to be a conflation of the effects of Magenta and Amber.

Error 7: Description error in Table 4.2

The section on Special Quality 2, 'A rich variety of wildlife and habitats', in the same document includes Table 4.2, which is about the effects on bats. It states that Option 4/5AV2 (Amber) will 'sever hedgerows and woodland used as flight paths south of the Binsted Wood Complex LWS, severing the LWS from farmland south of the Field Survey Area which is used by multiple species for foraging'. But Amber passes through the Binsted Wood Complex LWS, not south of it. It fragments Binsted Park, woodlands the Lag and the Shaw, and cutting off Lake Copse. This statement about Amber is true of Magenta (which skirts the woodland), but not Amber.

Error 8: Description error in Chapter 5, on Special Quality 3, 'Tranquil and unspoilt places'

Chapter 5, at para 5.8.2.21, states Option 4/5AV1 (Magenta) would 'introduce a new source of light…around Hedgers' Hill, and in Binsted Park'. But Magenta does not go through Binsted Park. Amber does. The reference to Hedger's Hill is correct for Magenta, so this sentence appears to confuse the two routes.

Error 9: Description error in Chapter 5

Para 5.8.2.34 states that Option 4/5AV1 (Magenta) 'would create a significant new component within the SDNP at Binsted'. This is a correct description of Amber, not Magenta.

Error 10: Description error in Chapter 5

Para 5.8.2.35 states that Option 4/5AV2 (Amber) 'would create a new, elevated component in a small section of the SDNP at Hedger's Hill'. This is a correct description of Magenta, not Amber.

Error 11: Description error in Chapter 5

Para 5.9.1.3 states that Option 4/5AV1 (Magenta) 'intrudes into' the SDNP boundary at Binsted Park. It doesn't. Amber does.

Error 12: Description error in summary table of Chapter 5

Describing Option 4/5AV1 (Magenta), the summary it says it 'intrudes into the SDNP boundary at … Binsted Park'. Magenta does not intrude into Binsted Park. Amber does.

Appendix 3: Inclusion of Worthing-Lancing Scheme in Do-Minimum Network

The present appraisal of the six options for the Arundel bypass includes the improvements at Worthing and Lancing, proposed in 2017, in the do-minimum network in which the Arundel schemes are evaluated. This change was made possible by HE altering internal guidance in 2018, so that schemes which were included in a published Road Investment Strategy should normally be considered "more than likely" to be built and included in any do-minimum network (Revised Traffic Forecasting Guidance, Transport Planning Group, 7 January 2018).

However, HE's proposals for improvements at Worthing-Lancing have effectively been abandoned, though HE prefers to say they have been "paused". A letter from Jim O'Donnell, chief executive of HE, to Sir Peter Bottomley MP and Tim Loughton MP of November 8 2018 reveals that HE and the Department for Transport have been instructed by the Minister for Roads to prepare a new scheme for Worthing-Lancing which integrates improvements to the A27 with improvements to the local road network. The "paused" scheme was included in the Roads Investment Strategy (RIS) 1; the new scheme may be included in the RIS2, but it will have to compete with other proposals, in other places, for inclusion. Nothing has yet been published about the new scheme for Worthing-Lancing, and the RIS2 programme itself has not been published. It is therefore uncertain whether any scheme for Worthing-Lancing will be accepted for RIS2 and the constituents of such a scheme are unknown. But if it is accepted as part of the roads programme, it will be part of the so far unpublished RIS2.

The abandoned Worthing-Lancing scheme should not therefore form part of the do-minimum network at Arundel. The HE guidance indeed states "We should not include RIS2 schemes until such point as they become published in RIS2". The network for Arundel cannot contain any proposals for Worthing-Lancing unless and until they are published in RIS2. Its publication is expected later this year; if it includes the new Worthing-Lancing scheme, HE would have to revise its model for Arundel if it wanted to incorporate it in the network. The new Worthing-Lancing scheme is likely to differ significantly from the old one.

The inclusion of the "paused" scheme in the do-minimum network has a large impact on the economic return to the Arundel scheme. Without the Worthing-Lancing scheme, BCRs would range from 1.78 for Cyan to 1.46 for Amber and Grey. These two schemes would be classed as having a Low return, and would not normally be approved. If the Worthing-Lancing scheme is included, benefits would be increased by between 21% and 42%, and BCRs would be increased to between 1.95 and 2.16. Only Grey would have a BCR less than High. The Magenta route would have a BCR of 1.54 without the Worthing-Lancing scheme, and a BCR of 2.02 with it.

The large effect on benefits is surprising, because HE says that the Arundel scheme would have a broadly similar effect on traffic volume and journey times throughout the network, with or without the Worthing-Lancing scheme. HE has been asked to explain this contradiction and to explain how the large increase in benefits is generated. Their reply lacks detail, and merely states that the exclusion of the Worthing-Lancing scheme results in greater capacity constraints on the adjacent strategic road network, resulting in poorer road network performance. It is surprising that this effect produces so large an increase in benefits.

It seems that the Worthing-Lancing scheme should not have been included and consultees have been misled by exaggerated BCR figures.

Arundel Riding Stables

To: Highways England by email

A27 Arundel Bypass – further consultation

Dear Sir

We are writing in response to the current further consultation over the route and scheme to be chosen for the Arundel Bypass.

Before going into detail about our views we would like to draw your attention to one overiding point. The scope of the scheme, as defined by the Dept. of Transport's Road Investment Strategy is "the replacement of the existing single carriageway road with a dual carriageway bypass, linking together the two existing dual carriageway sections of the road." The land take required by the two 'inline' options, routes 1V5 and 1V9, could not meet this most basic requirement without destroying our business, blighting Arundel by fundamentally dividing it into two communities and creating unacceptable levels of air pollution close to where people live. **Neither of these two routes could reasonably be said to meet the definition of a 'bypass', and thus should immediately be removed from consideration.**

If the budget that has been set can only be achieved with routes 1V5 and 1V9 then it is clear that the budget setting process has failed to align with the defined scope of the scheme. If the budget cannot be altered to allow for a scheme that matches its own defined scope then it would be better for Arundel's residents and businesses to do nothing.

The consultation process and questionnaire seeks the personal views of local residents and road users. Whilst these are clearly relevant, our views are informed by being presented with a choice of schemes that present **an existential threat to our business** and the future employment of the seven people for whom it provides a livelihood. We are therefore not completing the survey form, although we will address some of the questions in it from our perspective.

The key points we would like to make are these:

1. We do not appear to have had any contact from you, or your consultants, by which we could have enabled you to understand the economic impact of the options that are being presented. It is very clear locally that you have had extensive contact with residents and businesses in the Binsted area and yet have sought none with us. I would be grateful if you would both explain why this has been the case and act to put it right as soon as possible.
2. The South Downs National Park Authority appears to have had a good deal of influence on your presenting yet further options, including the 'inline' ones. Whilst you and they they present their objectives as primarily environmental, we must remind you that the SDNPA also has a **duty** "to foster the social and economic health of their area" consistent with their two purposes.
3. Our business falls into the National Park and will be destroyed by either of the 'inline' routes. The National Park cannot and should not be 'protected' from all development and will only be marginally affected by our preferred routes: 4/5AV1 or 2. National Parks are still part of the national economy and their designation does not render them sacrosanct.

4. The special qualities of the South Downs include its vibrant and thriving communities. Dividing Arundel, even though it is on the edge of the National Park, would be detrimental to this special quality.
5. Putting in place a short-term inline solution will be a waste of tax payers' money, as it will prove to be inadequate in just a few years. Building it will prevent any road improvement programme from doing the job properly in the foreseeable future. Much will have been lost or destroyed, and for very little gained.
6. It might be argued that good design could mitigate some of the worst effects of the inline routes. There may be a small element of truth in this, once the scheme is completed. However, the period of construction would render our business unviable and both it, and the employment it supports, would be gone once the construction phase was concluded.
7. No part of the summarised scheme appraisal reproduced in your consultation document appears to take any account of the economic damage that the inline routes would bring to Arundel. Indeed, the limited and high level 'economic assessment' in the consultation document is in stark contrast to the extensive environmental appraisal. Have you carried out any local economic impact assessment at all?
8. Your assessment of benefits and impacts appears only to consider the impact on local residents and businesses during the proposed 34 to 36 month construction phase. Are the lives of the people who live in close proximity to the inline routes of no value to you, or perhaps just of lesser value than those with strident voices in the small communities at the western end of the non-inline routes?

We look forward to hearing from you and to the damaging route options 1V5 and 1V9 being removed from further consideration.

Yours faithfully

[redacted]

[redacted]

Response to Highways England A27 Arundel Bypass Public Consultation:

- **It was resolved by Arundel Town Council 10th October 2019 to support the proposed option 4/5AV1Magenta Route as set out in the Highways England (13/9/2019 revision),**
- **Accepting that this route is partly within the South Downs National Park we encourage Highways England during the next stage (Design of the Chosen Route) to see if there is scope to design the junction at the west end of the scheme to prevent rat running across the junction from Yapton Lane up through Shellbridge Road, Slindon.**
- **Bearing in mind the planned increase in housing numbers at Ford, Arundel Town Council recommends careful consideration of a junction (e.g. onto A27 only from either direction) between the new A27 and Ford Road to avoid any increase in traffic along Ford Road into Arundel via the Ford Road roundabout**
- **Arundel and its surroundings are rural and agricultural with buildings of architectural significance which both residents and visitors come to enjoy. We would encourage Highways England to design and construct the scheme to the highest standards of design, use of materials and least impact during the construction stages.**
- **Arundel Town Council supports the proposals for Walking, Cycling and Horse Riding as well the promotion of alternative active travel options. We encourage additional proposals to provide a footpath/cycleway from Arundel to Ford station and a footpath/cycleway joining the SDNP via Arundel to the South Coast Cycleway and the Coast along the river Arun.**

REASONS FOR NOT SUPPORTING OPTIONS OTHER THAN MAGENTA

The Cyan and Beige On-Line Options

These two routes have common advantages and disadvantages and are therefore considered together.

Advantages

- **These are the lowest cost options to build**
- **They are the shortest and most direct routes to link the existing dual carriageway on either side of Arundel.**

Disadvantages

- **Cyan and Beige are not by-passes, they are on-line through-passes which run through the heart of Arundel, separating the community.**

This was Highways England's own conclusion in its "*A27 Arundel Bypass Scheme Assessment Report*" (2018) published in May 2018, which concluded that a similar route (Option 1) running through the town did not meet the stated Road Investment Strategy's intention to provide a by-pass.

- **The disadvantages of the on-line through-passes were identified in Highways England's "*A27 Arundel Bypass Preferred Route Announcement*" published in May 2018, when it was explained, in respect of the on-line Option 1 that:**

"Widening the A27 through the centre of Arundel would increase severance i.e. the feeling of division in the town, and overall there were fewer safety benefits to be gained.

We also had concerns over the ability of the improved road to deal with anticipated future traffic volumes, particularly at Ford Road junction.

The option therefore failed to meet the scheme objectives.

We considered design changes that could help to mitigate for this, but they would impact significantly on both the environment and the local community. The potential design changes would also increase the cost of the scheme and lower the overall value for money"

We discounted the option on these grounds".

Also, historically it was not a bypass

" In the 1970s, when this bypass was first in planning, the Duke of Norfolk reluctantly agreed to release some of his land for the construction of a southern bypass for Arundel, but made it an absolute condition that the new road would be called a "relief road" and not a bypass. He was insistent that, if the scheme were referred to as a bypass, Arundel would not get one. He also made it a condition that, once the new bypass was built, the existing one running close to the town must be returned to open land. "

Search for **A27 Arundel roads.org.uk**

These points apply to Cyan and Beige as much as they did to Option 1 in 2017 and 2018. Arundel Town Council does not believe that these options should have been put forward in the 2019 consultation.

- **These routes would significantly affect the greatest number of houses. With Beige there would be 429 houses within 100m of the road and with Cyan there would be 427 houses within 100m of the road. This is much higher than the corresponding figures for the other routes: Crimson 24 houses, Magenta 70 houses, Amber 76 houses, Grey 98 houses).**
- **They would result in significantly lower levels of economic benefit, and almost 20% less benefit than Magenta.**
- **They would result in the smallest improvement in journey time and congestion**
- **They would result in some of the smallest improvements in road safety.**
- **Both options have serious environmental disadvantages, adding 1.9km of additional road through the South Downs National Park, more than double the impact of Magenta.**
- **Both options would damage more hectares of ancient woodland than Magenta, Amber or Grey. Cyan would destroy 8.37 hectares and Beige 7.44 hectares, with only Crimson causing more destruction.**
- **Both Options would impact badly on the important cultural and heritage assets in Arundel. For example, some 250 designated cultural heritage assets have been recorded within the inner and wider study area. Of these, over 200 are designated as being of national importance, including 5 Scheduled Monuments, 4 Grade 1, 7 Grade II* and 205 Grade II Listed Buildings. In contrast, the Crimson, Amber, Magenta and Grey Options all have far fewer designated heritage assets in the study areas.**
- **Both Options could exacerbate the flood risk to properties in the vicinity of the Ford Road roundabout. This is already the area at greatest surface water flood risk in Arundel, and the new bridge and its connection to the roundabout would need to be built directly over the course of Spring Ditch, which is one of the most important flood-related watercourses in this vicinity of the town.**
- **During the 3-year construction period for Cyan and Beige, Arundel would experience traffic disruption, pollution and noise, which would significantly reduce the number of visitors and shoppers who come to the town. This will not only have an impact on important visitor attractions such as Arundel Castle, but will cause potentially irreparable damage to Arundel's retail sector which is sustained by visitors.**
- **Cyan and Beige both rely on the existing A27 bridge over the River Arun, which is in a poor physical state and will need to be replaced or extensively renovated.**

Conclusion

Although the Cyan and Beige on-line through-pass option may be the cheapest, in practice they are likely to be the very worst Options. They will irreparably damage the historic town of Arundel, which is described as the 'jewel in the crown' of West Sussex and 'the gateway to the South Downs' and cause a 65% increase in the traffic at Ford Roundabout. These options would result in a permanent separation of Arundel into two communities. They will also damage the environment. But critically they do not meet the objective of providing a by-pass at Arundel which has given rise to the project in the first place.

Arundel Town Council will not support the adoption of either Cyan or Beige option.

The Crimson Option

Advantages

- **This route would reduce the traffic in Arundel by an estimated 85%[1] compared to the 'do minimum' option, reducing the use of the town as a rat-run.**
- **It would be the safest route in terms of accident reduction**
- **It would have a beneficial effect in reducing the severance of Arundel into two communities**
- **It would deliver substantial economic benefits, circa £350m**
- **It has the lowest number of houses (24) within 100m of the construction site**

Disadvantages

- **Crimson has the greatest environmental impact, with 2.3km of roadway through the South Downs National Park, and the loss of 20.57 hectares of Ancient Woodland. Traffic through the South Downs National Park would increase by 71% compared to the 'do minimum' option.**

Conclusion

Because of the environmental impact, Arundel Town Council does not advocate the Crimson route. However, it would prefer this route to Cyan or Beige because it believes that the health and well-being of the residents of the town should rank higher than the environmental issues.

The Grey Option

[1] All traffic estimates from WSCC Highways, Planning and Transport directorate, October 2019

Advantages

- **It is the straightest option and results in the 2nd largest (to Amber) greatest improvement in safety.**
- **None of the route would be within the South Downs National Park.**
- **It would reduce the level of traffic passing through the South Downs National Park by 84%**
- **It would reduce the volume of traffic in Arundel by an estimated 84%, reducing the use of the town as rat-run.**
- **It would have the lowest impact on woodland (1.49 hectares)**
- **It would be the best route in relation to reduced travel times, reduced congestion and improved journey time reliability.**
- **It would affect many fewer properties (76% fewer) than the Cyan or Beige routes.**
- **It would have a beneficial effect in reducing the severance of Arundel into two communities**
- **It would deliver the highest level of economic benefits, circa £378m.**

Disadvantages

- **It is the most expensive of the six Options to construct.**

Conclusion

This is the clearly the preferred option if priority is given to the environmental impact and economic benefit. However, there are some disadvantages to other, smaller local communities, and for this reason we do not advocate this route.

The Amber Option

Advantages

- **It would reduce the volume of traffic in Arundel by an estimated 84%, reducing the use of the town as a rat-run**
- **It would deliver the 2nd highest level of economic benefits, circa £377m**
- **It would produce the greatest reduction in traffic accidents**
- **It would affect many fewer houses (83% fewer) than the Beige or Cyan options**
- **Apart from Grey, Amber and Magenta produce the greatest improvement in journey times.**

Disadvantages

- **1.97 km of roadway through the South Downs National Park.**
- **The loss of 5.3 hectares of woodland**

Conclusion

- **Arundel Town Council have noted the view of the South Down National Park Authority that Amber would result in a greater direct loss of ancient woodland, veteran trees, other wood pasture and parkland than Magenta. It therefore advocates Magenta, rather than Amber.**

17.10.2019

[redacted] **Mayor of Arundel**

[redacted]
County Officer
Campaign for Better Transport – East Sussex
[redacted]

19th October, 2019

Dear Highways England

A27 – Arundel Proposals

Campaign for Better Transport – East Sussex (CBT – E Sx) objects to, and rejects the Highways England proposals; demands no new route through the National Park; and demands a full evaluation of alternatives, including the 'Arundel Alternative' (proposed by the Arundel Bypass Neighbourhood Committee), and non-road options.

Reasons:

- Highways Englands options are all highly damaging to the unique qualities of the National Park and its setting and habitats - as would be any new route through the National Park.
- There is no weight of evidence that compels anyone to conclude that the road construction proposals are measures appropriate to solve any of the described problems: the proposals are highly likely to create further problems.
- There is evidence to suggest that a combination of land use planning and transport measures together would be an appropriate response to meet local, regional, national and international needs in a rapidly changing political environment. This combination of 'land use' and 'transport' planning is emerging in the current Transport for the South East (TfSE) strategy in preparation.

'Fewer and cleaner vehicles' – are among the recommendations of the Science and Technology Select Committee report of July 2019, along with 'shared' transport buses – trains – and increasing levels of walking and cycling. (**Clean Growth: Technologies for Meeting the UK's Emission Reduction Targets - attached):**

Recommendations for change - Transport

The transport sector is now the largest-emitting sector of the UK economy. The Government should bring forward the proposed ban on sales of new conventional cars and vans to 2035 at the latest. This ban should explicitly cover hybrid as well as internal combustion engines. There are significant emissions associated with the manufacture of vehicles. In the long-term, widespread personal vehicle ownership does not appear to be compatible with significant decarbonisation. ***The Government should not aim to achieve emissions reductions simply by replacing existing vehicles with lower-emissions versions.***

Alongside the Government's existing targets and policies, it must develop a strategy to stimulate a low-emissions transport system, with the metrics and targets to match. This should aim to reduce the number of vehicles required, for example by: promoting and improving public transport; reducing its cost relative to private transport; encouraging vehicle usership in place of ownership; and encouraging and supporting increased levels of walking and cycling.

In the near-term, the Government must also reconsider the fiscal incentives for consumers to purchase both new and used vehicle models with lower emissions, and develop a strategy by the time of the Spring Statement 2020 to use vehicle excise duty and other incentives to drive the purchase of vehicle models with lower average emissions.

In the light of the above, we should adopt policies to plan for reclaiming the space created through a future scenario of lower traffic volumes and using it for nature, housing, recreation, small businesses and other needs.

In the real (UK) world, 17 – 59 year olds are driving fewer miles **(Report: Centre for Research into Energy Demand Scenarios – CREDS, July 2019 – attached)** – ('Change in car driver miles per head, per year by age group and area type, P52, Fig 11).
We may be pushing at an open door if we **quickly improve** the quality of alternatives to the private car. The quicker the better as a rising proportion of new sales (25%) are large, inefficient SUVs (CREDS Report – para 3 p51). This fruits of this improvement will be greatly diminished by major new roads and the consequent pressure for more space for more vehicles.

Also in the real world (of 2012) portrayed in the **Parsons Brinkerhoff report,** traffic volumes both east and west of Arundel, and west of Worthing, had fallen since 2007 **(Corridor Feasibility Study, Fig 4-3, p.33 - attached).**
In the same table, Travel To Work Area volumes were up to twice the level of the three locations above. This would suggest that, along the A27 for the entire study area, the biggest wins in the battle to ease congestion and create a sustainable and inclusive transport system lie within the discrete TTWAs on the south coast. This requires major investment in sustainable, healthy alternatives and critically, integrated development planning. This, at the moment, is sorely lacking with frequently weak and ineffective application of National Planning Policy Framework (NPPF) recommendations on comprehensive provision of sustainable modes of transport. Put simply, there are too many 'car dependent' developments. Highways England's schemes would be at best irrelevant and more likely, highly damaging to the environment, local economies and any sense of social equity. More roadspace frustrates efforts to 'right the wrong'.

The Lake District National Park has been recommended by the recently published '**Landscapes Review' (Julian Glover – not attached)** as a pilot for a 'low carbon' transport strategy. We think the South Downs National Park would be at least equally as well qualified to become a 'test bed' and could logically include the High Weald AONB within the strategic remit. This could potentially deliver 'access for all' in the coastal towns' 'Travel to Work Areas' greatly benefiting urban communities and their rural hinterlands through better bus and rail links through a lens of 'integrated development plans'.

Conclusion: The need to reduce carbon emissions and reverse habitat destruction and extinction of species are widely acknowledged and in stronger focus than ever before. Expanding road space as suggested by Highways England would take us in the wrong direction and have a negative impact on the quality of life in both rural and urban communities.

We commend the already submitted SCATE Report 'A New Transport Vision for the Sussex Coast'.

[redacted] County Officer, Campaign for Better Transport, East Sussex.

House of Commons

Science and Technology Committee

Clean Growth: Technologies for meeting the UK's emissions reduction targets

Twentieth Report of Session 2017–19

Report, together with formal minutes relating to the report

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Science and Technology Committee

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Summary

In 2015, the states party to the United Nations Framework Convention on Climate Change (including the UK) agreed that they would seek to restrict the increase in the global average temperature to "well below 2°C above pre-industrial levels" and pursue "efforts to limit the temperature increase to 1.5°C above pre-industrial levels". The Intergovernmental Panel on Climate Change has warned that global warming of 2˚C above pre-industrial levels could lead to increased risk of droughts and flooding, sea level rises, ecosystem change and consequent species loss and extinction on land and in the sea, reduced productivity for agriculture and fishing and climate-related poverty and disease. The UK was the first country to legislate for legally binding greenhouse gas emissions targets and earlier this year became the first country in the G7 to legislate for net-zero emissions. Since 2000, the UK has achieved greater decarbonisation than any other country in the G20. It has outperformed its first (2008–2012) and second (2013–2017) carbon budgets by around 1% and 14% respectively, and is on track to outperform its third carbon budget (2018–2022). However, the Committee on Climate Change has warned that the UK is not on track to meet its fourth (2023–2027) and fifth (2028–2032) carbon budgets.

The UK's progress

There are a number of areas in which Government policy to support the deployment of low-carbon technologies has been delayed or cut back. For example:

- the 'plug-in grant' for low-emissions cars was reduced from £4,500 to £3,500 for the lowest-emissions cars in October 2018, and cut completely for other low-emissions cars;
- the 'feed-in tariff' for low-carbon power generation was closed in April 2019 without a successor scheme in place;
- the Energy Companies Obligation scheme was restricted to vulnerable households only in November 2018, despite the Government conceding that this would "result in lower carbon emissions reductions being achieved"—the Government consulted on "building an 'able-to-pay' market for energy efficiency" in October 2017 and said that it would respond in 2018, but a response has still not been published; and
- following the cancellation of the 'zero-carbon homes' policy in 2015, the Government pledged in 2018 to consult on changes to Part L of the building regulations (covering energy performance of buildings) in order to support the development of low-carbon heating technologies—however, this consultation has still not been launched (although the Chancellor announced in the 2019 Spring Statement that a 'Future Homes Standard' would be introduced to deliver homes with "low carbon heating and world-leading levels of energy efficiency", but only by 2025).

Achieving the Government's key targets will require an acceleration of deployment of low carbon technologies:

- the Government wants "almost every car and van to be zero emission" by 2050, which is equivalent to removing almost 20,000 conventional cars every week on average, from now until 2050, whereas around 1,200 new ultra-low emissions vehicles were registered each week in 2018;
- the Government also wants "as many homes as possible to be EPC Band C by 2035 where practical, cost-effective and affordable". This would equate to improving the energy efficiency of around 20,000 English homes (just under 40 per English constituency) per week until 2035—in contrast, the Committee on Climate Change reported that around 2,400 energy loft or wall insulations were installed per week in 2017;
- the Government has said that "by 2050, we will also likely need to fully decarbonise how we heat our homes", which would require at least 15,000 homes to transfer to a low-carbon heating system every week until 2050—this compares to a projection of 220 low-carbon heat systems being installed each week under the Government's 'Renewable Heat Incentive' from now until 2021; and
- the Government has set out its "aspiration" to reach woodland cover of 12% in England by 2060, which would require the net growth of around 120 hectares of woodland per week—in 2018, net woodland growth was around 20 hectares per week.

Recommendations for change

Transport

The transport sector is now the largest-emitting sector of the UK economy. The Government should bring forward the proposed ban on sales of new conventional cars and vans to 2035 at the latest. This ban should explicitly cover hybrid as well as internal combustion engines. There are significant emissions associated with the manufacture of vehicles. In the long-term, widespread personal vehicle ownership does not appear to be compatible with significant decarbonisation. The Government should not aim to achieve emissions reductions simply by replacing existing vehicles with lower-emissions versions.

Alongside the Government's existing targets and policies, it must develop a strategy to stimulate a low-emissions transport system, with the metrics and targets to match. This should aim to reduce the number of vehicles required, for example by: promoting and improving public transport; reducing its cost relative to private transport; encouraging vehicle usership in place of ownership; and encouraging and supporting increased levels of walking and cycling.

In the near-term, the Government must also reconsider the fiscal incentives for consumers to purchase both new and used vehicle models with lower emissions, and develop a strategy by the time of the Spring Statement 2020 to use vehicle excise duty and other incentives to drive the purchase of vehicle models with lower average emissions.

Heating and energy efficiency

Domestic, commercial and industrial heating is responsible for around a third of the UK's overall emissions, which is unchanged from 2009. The decarbonisation of heating will be critical to the UK achieving its long-term emissions reductions targets, but there remains considerable uncertainty surrounding what mix of low-carbon heating technologies represents the best decarbonisation pathway for the UK, or what mix the Government will pursue. The Government must urgently develop a clearer strategy for decarbonising heat. This will require large-scale trials of different heating technologies operating in homes and cities to build the evidence base required for long-term decisions. The Government must commit now to large-scale trials of low-carbon heating technologies, convening relevant stakeholders to determine what evidence must be gathered and to co-ordinate existing work. It should further support the deployment of low-carbon heating technologies by setting out a clear roadmap by the time of the Spring Statement 2020 for rebalancing levies on electricity and gas, to better reflect the emissions intensities of each fuel.

Emissions associated with heating can also be reduced through energy efficiency measures such as improved insulation. Previous initiatives to encourage domestic energy efficiency improvements in the 'able-to-pay' market have failed because they have focused too narrowly on providing financial support for specific interventions. The Government's new energy efficiency policy must provide all homeowners with the incentive to make energy efficiency improvements to their property, with particular thought given to lower income households, as well as the financial means to do so. By the time of the Spring Statement 2020 the Government should consider adjusting Stamp Duty so that it varies according to the energy performance of the home as well as the price paid for it. The Government should additionally establish a 'Help to Improve' scheme by July 2020 that offers matched funding and interest-free loans to homeowners, to cover the costs of making energy efficiency improvements.

Power generation

Power generation was responsible for around 15% of the UK's greenhouse gas emissions in 2018. The power generation sector has achieved significant decarbonisation over the course of the last carbon budget period, accounting for 75% of the UK's total emissions reductions between 2012 and 2017. Nevertheless, the Committee on Climate Change has made clear that "further reduction in the emissions intensity of power generation […] remains the lowest-cost path towards economy-wide decarbonisation". Although onshore wind power and large-scale solar power are low-cost and low-carbon, the deployment of new installations of these technologies has fallen drastically since 2015. The Government must ensure that there is strong policy support for new onshore wind power and large-scale solar power projects for which there is local support and projected

cost-savings for consumers over the long-term. The Government should actively encourage and support local authorities to adopt planning practices that promote local support for such renewable energy projects.

The Government must additionally develop mechanisms to promote community ownership and profit-sharing of low-carbon projects, such as joint ventures, split ownership or shared revenue. The delay between the end of the feed-in tariff scheme and the start of the Smart Export Guarantee scheme has caused unnecessary disruption to the smart energy and small-scale generation market. The Government must ensure that it reviews the functioning of the Smart Export Guarantee scheme by the end of 2020, and should be ready to include a minimum price floor if there is evidence of a lack of market competitivity—for example, if uptake of tariffs is not significantly greater than the current number of tariffs or if the tariffs offered are significantly lower than wholesale electricity prices.

Market regulation

Regulation of UK energy markets will play a key part in the development of a smart and flexible energy system. The energy markets regulator has an explicit duty to protect consumers' interests in the reduction of gas- and electricity-supply emissions of targeted greenhouse gases, alongside other considerations such as minimising costs. However, there is no specific link between the regulator's objectives and the UK's emissions reduction targets. The Government should consider the case for amending the energy market regulator's principal objective so that it explicitly includes ensuring that regulations align with the emissions reduction targets set out in the Climate Change Act 2008.

Ofgem must ensure that its second price control framework does not dilute its support for innovation and that the framework should further enable and incentivise network operators to innovate as part of their core business, rather than through standalone projects. Ofgem should work with network operators, energy suppliers and flexibility services providers to ensure that flexibility systems are always considered and deployed ahead of infrastructure construction, where possible and affordable.

Local authorities

Local authorities also have a vital role to play in the UK's decarbonisation. Many local authorities are pursuing emissions reductions projects, but the capacity and capability for decarbonisation at the local level varies. The Government should introduce a statutory duty on local authorities in England and Wales by Green Week 2020, to develop emissions reduction plans in line with the national targets set by the Climate Change Act 2008, and to report periodically on progress made against these plans.

In preparation for this new obligation, the Government should establish centralised support to help local authorities develop decarbonisation strategies and deliver initiatives aimed at reducing greenhouse gas emissions. It should also support local authorities' access to low-cost, long-term finance in order to enable the delivery of such strategies.

Consumers

There is also an important role for consumers. Although public support for measures to reduce emissions appears high, this is not always matched with awareness of what actions consumers can take to support decarbonisation. The Government should publish an easily-accessible, central guide for members of the public explaining what measures individuals and households can take to support the UK's decarbonisation. It should re-introduce a telephone and visiting advice service in England which offers bespoke advice on measures such as residential energy efficiency and low-carbon heating and transport.

Greenhouse gas removal

The Government's new ambition, to reach net-zero emissions by 2050, will probably require the active removal of at least 130 million tonnes of carbon dioxide from the atmosphere annually by 2050. This is significantly greater than the extent of greenhouse gas removal envisioned in any of the Government's previous 'illustrative pathways' to meeting its original 2050 target, and is also at the limit of what is expected to be reasonably deliverable. The step-change in greenhouse gas removal required will necessitate a significant increase in current support for greenhouse gas removal technologies. Some urgently require research and development, whereas others could be deployed at scale now with the correct support. The Government should be ready to increase funding for research, development and demonstration of greenhouse gas removal technologies. It must also ensure that it is seizing currently available opportunities for greenhouse gas removal, and should develop an effective framework for managing and incentivising forestation and land use management to achieve net emissions removals.

Carbon capture and storage has been widely identified as a key technology for decarbonisation in several sectors. The Energy Technologies Institute estimated, prior to the UK's net-zero emissions ambition, that meeting the UK's original 2050 emissions targets without the use of carbon capture and storage would incur an additional £30bn in costs. Industry must have clarity on the framework through which it can invest in carbon capture, usage and storage (CCUS), as well as the timetable for the Government's CCUS Action Plan. The Government must provide greater clarity on the details of its action plan, including on: what it considers to be deployment at scale; what constitutes cost-effectiveness or sufficient cost-reduction; how it expects to share costs with industry; and what the major milestones for the plan are, as well as when they are expected to be achieved. The Government should learn from previous carbon capture and storage projects and ensure that a sufficient number of projects, of sufficient scale, are undertaken to optimise the chance of successful deployment, and that the knowledge gained from publicly-funded work is publicly accessible.

A just transition

The decarbonisation of the UK's economy is critical for the environment and is a legally-binding target for the Government. Although decarbonisation offers opportunity for economic growth, it will inevitably also entail costs. The Committee on Climate Change has estimated that achieving net-zero emissions could cost around 1–2% of GDP by 2050. It is important that these costs are shared fairly among citizens. The Government

must ensure that its policies for achieving net-zero emissions consider the economic impacts on individuals. For example, the Government should aim to cover the costs of measures through progressive means rather than through energy bills. In line with the Government's focus on 'place' in its Industrial Strategy, the Government should include the potential for supporting economic growth in disadvantaged regions in its determination of where to locate demonstration projects and other initiatives.

Our inquiry

4. As part of this inquiry, we launched a call for evidence on 23 July 2018, seeking written submissions regarding technologies for meeting Clean Growth emissions reduction targets. We received over 80 pieces of written evidence and took oral evidence from 27 witnesses including academics, trade associations, relevant advisory bodies, energy network operators, the Committee on Climate Change and the Minister of State for Energy and Clean Growth, Rt Hon Claire Perry MP. We also visited National Grid System Operator and SSE (an energy distribution network operator) to learn more about the challenges and opportunities of decarbonisation for transmission and distribution networks respectively, and we visited the Local Energy Oxfordshire project in Oxford to learn more about community energy projects. To assist us in our work, we appointed Dr Jonathan Radcliffe, who leads the Energy Systems and Policy Analysis Group at the University of Birmingham, as a Specialist Adviser for our inquiry.[13] We are grateful to everyone who contributed to our inquiry.

Aims of this Report

5. We recognise that action is required across the economy if the UK is to meet its carbon emissions targets. We could not cover every aspect of this in an inquiry spanning four evidence sessions so we have focused on what we feel to be the most important areas for Government action. Nonetheless, we encourage the Government to deliver across the economy and support the work of the Committee on Climate Change and other organisations in working towards reducing the UK's carbon emissions.

6. In this Report, we make recommendations for what the Government should do to support the development and deployment of technologies that can reduce the UK's emissions, in general and for specific sectors of the economy.

13 Dr Jonathan Radcliffe declared his interests on 22 January 2019: employee of the University of Birmingham, current recipient of public research funding from UK Research and Innovation and UK government departments, and previous recipient of industry funding.

2 UK Greenhouse Gas Emissions

7. This Chapter examines the UK's emissions reductions since the passage of the Climate Change Act 2008 as well as future emissions reductions targets.

Historic emissions

8. Since 2000, the UK has achieved greater decarbonisation than any other country in the G20.[14] It has outperformed its first (2008–2012) and second (2013–2017) carbon budgets by around 1% and 14% respectively.[15] However, the Committee on Climate Change has noted that "the majority (around 80%) of the [overachievement against the second carbon budget] has occurred due to changes in the UK's share of the EU Emissions Trading System cap, rather than a reduction in actual emissions".[16] The Government itself has acknowledged that the overachievement arising from these changes "is purely an accounting impact and not related to actual UK emissions".[17] Furthermore, significant emissions reductions in some sectors, such as transport and heavy industry, coincided with the 2008 recession and have not substantially reduced any further since then.[18] These factors, and the lack of progress against key policy indicators, led the Committee on Climate Change to conclude in February 2019 that "policies failed to produce expected reductions in emissions" during the second carbon budget period, and that the overachievement against the UK's emissions reductions targets was "not due to policy".[19]

9. Progress on emissions reductions has also been concentrated in relatively few sectors of the UK economy. In particular, the UK has achieved significant decarbonisation of the power generation sector, mostly as a result of coal power increasingly being replaced by gas-fired and renewable power. This has helped to drive a fall in power sector emissions of 55% since 2012, representing 75% of the UK's total emissions reductions over that period.[20] However, in contrast to the power generation sector, emissions from the transport, domestic and agricultural sectors have fallen only slightly—or in some cases have even risen—since 2012.[21] Numerous submissions to our inquiry, such as those from the Energy Systems Catapult, National Grid and UK Research and Innovation, flagged that progress towards the next carbon budgets would require significant acceleration in emissions reductions from these other sectors.[22]

14 PwC, 'Time to get on with it: The Low Carbon Economy Index 2018' (2018), p8
15 Department of Energy and Climate Change, 'Final Statement for the First Carbon Budget Period' (2014) and Department for Business, Energy and Industrial Strategy, 'Final Statement for the Second Carbon Budget' (2019)
16 Letter from Lord Deben to Rt Hon Claire Perry MP, 15 February 2019
17 Department for Business, Energy and Industrial Strategy, 'Updated Energy and Emissions Projections 2018' (2019), p20
18 Department for Business, Energy and Industrial Strategy, '2017 UK greenhouse gas emissions: final figures—data tables' (2019), Table 3
19 Letter from Lord Deben to Rt Hon Claire Perry MP, 15 February 2019
20 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p30
21 Department for Business, Energy and Industrial Strategy, 'Alternative Format 2018 UK greenhouse gas emissions: provisional figures—data tables' (2019), Tables 1 and 4
22 For example, see: Cadent (CGE0015), para 1; National Grid (CGE0019), paras 3.1–3.2; Energy Systems Catapult (CGE0029), para 6; Decarbonised Gas Alliance (CGE0032), para 9; The Royal Society (CGE0056), para 13; UK Research and Innovation (CGE0058), para 4; and Durham Energy Institute (CGE0065), paras 1–2

10. The Climate Change Act 2008 allows the Government to decide to carry forward any outperformance of a carbon budget to the following budget period.[23] With the second carbon budget having been outperformed by the equivalent of 383.9 million tonnes of carbon dioxide (383.9 $MtCO_2e$), the Government could have decided to carry forward the whole of, or part of, this amount to the third carbon budget. In March 2019, our Chair wrote to the Clean Growth Minister encouraging the Government not to use its power to carry forward any of the over-achievement of the previous carbon budget,[24] on the basis that:

- future carbon budgets were set in accordance with advice from the Committee on Climate Change that assumed overachievements in previous budgets would not be carried forward;[25]
- the overachievement of the second carbon budget was mostly not attributable to Government policies;[26]
- the most cost-effective path to meeting the UK's emissions target for 2050, as determined by the Committee on Climate Change, was more stringent even than existing carbon budgets;[27]
- the states party to the United Nations Framework Convention on Climate Change (including the UK) agreed in 2015 that they would seek to restrict the increase in the global average temperature to "well below 2°C above pre-industrial levels" and pursue "efforts to limit the temperature increase to 1.5°C above pre-industrial levels",[28] which is more ambitious than the long-term emissions targets by which the existing carbon budgets had been set;[29] and
- we had heard from several stakeholders during our inquiry of the importance of urgency in emissions reductions.[30]

11. The Government subsequently wrote to the Chairman of the Committee on Climate Change on 6 June to state that it had decided to provisionally carry forward 88$MtCO_2e$, pending advice from the Committee on Climate Change on "technical changes to the baseline used to measure our emissions".[31] This refers to anticipated changes in how the UK calculates and reports its emissions: to fully include emissions from peatland; and to reflect international standardisation of the method used to determine the equivalent warming potentials of difference greenhouse gases.[32] It would appear that 88$MtCO_2e$ of the 384$MtCO_2e$ total outperformance was carried forward provisionally as this represented the amount not attributable to changes in the UK's share of the EU Emissions Trading

23 Climate Change Act 2008, section 17
24 Letter from Rt Hon Norman Lamb MP to Rt Hon Claire Perry MP, 20 March 2019
25 Committee on Climate Change , 'The Fourth Carbon Budget' (2010), pp31–32; Committee on Climate Change, 'The Fifth Carbon Budget' (2015), p115; and Letter from Lord Deben to Rt Hon Claire Perry MP, 15 February 2019
26 Letter from Lord Deben to Rt Hon Claire Perry MP, 15 February 2019
27 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p18
28 United Nations, 'Paris Agreement' (2015)
29 Committee on Climate Change, 'Building a low-carbon economy–the UK's contribution to tackling climate change' (2008), Part I
30 For example, see: Greenpeace (CGE0022), para 2; Royal Academy of Engineering and allied institutions (CGE0055), para 9; Royal Society (CGE0056), para 4
31 Letter from Chris Skidmore MP to Lord Deben, 6 June 2019
32 Committee on Climate Change 'Net Zero: The UK's contribution to stopping global warming' (2019), p139

System cap.[33] The Government clarified that it had "no intention of using [any of the] overperformance to meet Carbon Budget 3" and stated that the carry-forward would "be released once it is clear that it will not be needed to address any technical changes in the baseline".[34]

12. **The UK has achieved world-leading emissions reductions for over two decades. However, this has not been exclusively the result of Government policies. The Government has decided to carry forward the equivalent of 88 million tonnes of carbon dioxide from the second carbon budget to the third, as permitted by the Climate Change Act 2008, pending advice from the Committee on Climate Change on technical changes to how the UK calculates and reports its emissions. *The Government must not use outperformance of the second carbon budget to weaken its targets for subsequent carbon budgets. As soon as possible after the Committee on Climate Change's advice on technical changes to the UK's emissions baseline, the Government should unambiguously declare its commitment to follow that advice.***

13. The accounting frameworks of the United Nations Framework Convention on Climate Change, and of the UK's domestic carbon budgets, are based on the concept of "territorial emissions".[35] Territorial emissions comprise greenhouse gas emissions emitted from within a country's territory, excluding emissions associated with international aviation and shipping. The main alternative to territorial emissions is to count "consumption emissions", which comprise the greenhouse gas emissions associated with any products or services consumed within a country. The Department for Environment, Food and Rural Affairs has published estimates of the UK's consumption emissions since 1997.[36] While the UK's territorial emissions fell 37% from 1997 to 2016, its consumption emissions fell by just 9% in the same period.[37]

14. The Decarbonised Gas Alliance warned us that one cause of the discrepancy between reductions in territorial and consumption emissions was that "too much" of the UK's territorial emissions reductions had "occurred due to offshoring of manufacturing".[38] For example, it highlighted the closure of the Redcar steelworks in 2015, which caused almost half of the emissions reductions from UK industry in 2016.[39] Several others, including Drax Group and the Royal Academy of Engineering and allied organisations, made similar points, and warned that less efficient manufacturing processes internationally could mean that such "offshoring" of UK heavy industry could lead to higher net emissions globally.[40] The Minister of State for Energy and Clean Growth, Claire Perry MP, argued that the UK

33 Department for Business, Energy and Industrial Strategy, 'Updated Energy and Emissions Projections 2018' (2019), p20

34 Letter from Chris Skidmore MP to Lord Deben, 6 June 2019

35 Department of Energy and Climate Change, 'Alternative approaches to reporting UK Greenhouse Gas Emissions' (2015)

36 Department for Environment, Food and Rural Affairs, 'UK's Carbon Footprint 1997–2016' (2019)

37 Department for Business, Energy and Industrial Strategy, '2016 UK greenhouse gas emissions: final figures—data tables' (2018), Table 1 and Department for Environment, Food and Rural Affairs, 'UK's Carbon Footprint 1997–2016' (2019), p3

38 Decarbonised Gas Alliance (CGE0032), paras 7–8

39 Committee on Climate Change, 'Meeting Carbon Budgets: Closing the policy gap—2017 Report to Parliament'(2017), p93

40 For example, see: Drax Group plc (CGE0025), para 35; Royal Academy of Engineering and allied institutions (CGE0055), para 10; and Johnson Matthey (CGE0066), para 9

was also reducing its emissions through increased resource efficiency and highlighted the UK's improved performance on consumption emissions since 2007,[41] over which period they had fallen by 21%.[42]

15. Lord Deben, Chairman of the Committee on Climate Change, told us that territorial emissions were used to monitor emissions internationally, and in the UK's domestic carbon budgets, because they can be measured more accurately and are easier for a country to influence than consumption emissions.[43] However, he said that consumption emissions figures were important for highlighting the global nature of climate change and the importance of actions in the UK that have international consequences, arguing that ultimately "you need both" measurements. Following an inquiry into consumption-based emissions reporting in 2012, the Energy and Climate Change Committee similarly wrote:

> We accept that territorial emissions should remain the basis for international climate negotiations. However, the UK Government's emphasis on territorial emissions means that the responsibility for reducing emissions embedded in the products that we import lies with the—often, developing—countries where the goods are manufactured […] We recommend that [the Department of Energy and Climate Change] increase the extent to which they consider consumption-based emissions when making policy.[44]

In its response to that Committee, the then Government said that it would "take steps to increase the prominence of consumption-based emissions on websites, and in statistical releases, where both territorial emissions and consumption emissions could be presented".[45] However, consumption emissions were not mentioned in the Clean Growth Strategy or in the Government's latest annual emissions statement.[46]

16. **Progress against the UK's emissions reductions targets must not be achieved by 'offshoring' UK industry and displacing the UK's territorial emissions to be counted instead in its consumption emissions. The Government should do more to meet its commitment to increase the prominence of consumption emissions statistics in its publications.** ***The Government should include consumption emissions alongside territorial emissions in all future publications on UK emissions. It should consider the impact of all policies on consumption emissions as well as territorial emissions, and ensure that progress is not achieved by 'offshoring' emissions to other countries to the detriment of the global environment. We do not accept that territorial emissions should be the sole basis for international negotiations. The United Kingdom's decarbonisation targets should also include consumption emissions.***

41 Q422
42 Department for Environment, Food and Rural Affairs, 'UK's Carbon Footprint 1997–2016' (2019)
43 Q32
44 Energy and Climate Change Committee, Twelfth Report of Session 2010–2012, 'Consumption-Based Emissions Reporting', HC 1646, paras 53 and 80
45 Energy and Climate Change Committee, Second Special Report of Session 2012–2013, 'Consumption-Based Emissions Reporting: Government Response to the Committee's Twelfth Report of Session 2010–12', HC 488, pp4–5
46 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017) and 'Annual Statement of Emissions for 2017' (2019)

Net-zero emissions

17. In 2015, the states party to the United Nations Framework Convention on Climate Change (including the UK) agreed that they would seek to restrict the increase in the global average temperature to "well below 2°C above pre-industrial levels" and pursue "efforts to limit the temperature increase to 1.5°C above pre-industrial levels".[47] The Intergovernmental Panel on Climate Change has since said, in 2018, that "climate models project robust differences in regional climate characteristics" between global warming of 2˚C compared to 1.5˚C, including:

- increased regional risk of droughts and flooding;
- sea level rises of an estimated additional 0.1m, requiring faster adaption in coastal areas and small islands;
- increased amounts of ecosystem change, ocean acidification, and consequent species loss and extinction on land and in the sea;
- reduced productivity for agriculture and fishing; and
- increased spread of climate-related poverty and disease.[48]

The Panel further stated that, in order to meet the ambition of 1.5˚C, net global emissions would probably have to reach zero by 2045–2055. In response to a request for advice from the UK, Scottish and Welsh Governments on how the UK could achieve such a target,[49] the Committee on Climate Change subsequently concluded in 2019 that the UK could achieve net-zero emissions by 2050 "with known technologies, alongside improvements in people's lives, and within the expected economic cost that Parliament accepted when it legislated the existing 2050 target".[50] It recommended that the UK legislate "as soon as possible" to strengthen its emissions reductions targets and set a new target of zero overall emissions by 2050.[51]

18. On 12 June 2019, the Government laid a statutory instrument modifying the Climate Change Act 2008 to strengthen the UK's 2050 greenhouse gas emissions target, from a reduction on 1990 levels of 80% to a reduction of 100%, *i.e.* to reach net zero greenhouse gas emissions by 2050.[52] This was approved by Parliament on 26 June 2019,[53] making the UK the first country in the G7 to legislate for net-zero emissions.[54] The Prime Minister (Rt Hon Theresa May MP) stated, however, that the UK would conduct an assessment of its strengthened target within the next five years, to "confirm that other countries are taking similarly ambitious action".[55] She also stated that the UK would "retain the ability to use international carbon credits", arguing that "using international credits within an appropriate monitoring, reporting and verification framework is the right thing to do

47 United Nations, 'Paris Agreement' (2015), Article 2
48 Intergovernmental Panel on Climate Change, 'Global Warming of 1.5˚C: Summary for Policymakers' (2018)
49 Letter from Rt Hon Claire Perry MP, Roseanna Cunningham MSP and Lesley Griffiths AM to Lord Deben, 15 October 2018
50 Committee on Climate Change, 'Net Zero: The UK's contribution to stopping global warming' (2019), p11
51 Committee on Climate Change, 'Net Zero: The UK's contribution to stopping global warming' (2019)
52 Draft Climate Change Act 2008 (2050 Target Amendment) Order 2019
53 The Climate Change Act 2008 (2050 Target Amendment) Order 2019 (SI 2019/1056)
54 'Britain to become first G7 country with net zero emissions target', Reuters, 11 June 2019
55 'PM Theresa May: we will end UK contribution to climate change by 2050', Prime Minister's Office, accessed 16 June 2019

for the planet, allowing the UK to maximise the value of each pound spent on climate change mitigation". Carbon credits allow countries to transfer emissions reductions between themselves so that one country that has overachieved on its emissions reductions targets can offset a country that has not met its emissions reductions targets, and are permitted under Article 6 of the Paris Agreement.[56] The Committee on Climate Change has acknowledged that carbon credits could lower the overall cost of global emissions reductions by facilitating greatest effort in countries best-suited to making them (for example due to land, biomass or solar resources).[57] However, it argued that domestic action would do more to improve air quality and reduce technological costs, and therefore recommended that the UK should "aim to meet the recommended net-zero target in 2050 without use of carbon units if possible".[58]

19. **We commend the Government for adopting a net-zero emissions target, in line with the 2015 Paris Agreement. It is vital now that this ambition is backed up with policies to ensure that the UK meets its targets.** ***The Government must develop and act on policies to ensure that the UK is on track to meet a 2050 net-zero emissions target. It must seek to achieve this through, wherever possible, domestic emissions reductions. However, it should also work to develop robust international frameworks for carbon units trading, to ensure that effective and efficient methods for reducing global emissions are supported where available.***

20. In its request for advice on a UK target for net-zero emissions, the Government explicitly excluded "carbon budgets already set in legislation" from the scope of its request.[59] In its report, the Committee on Climate Change stated that it did "not recommend changes to the fourth or fifth carbon budgets at this time" and instead said that "the priority now should be to strengthen policy to ensure that the fourth and fifth budgets are outperformed in preparation for a tougher sixth carbon budget".[60] However, the Committee on Climate Change went on to say that it "will consider whether the fourth and fifth carbon budgets should be tightened in legislation as part of our advice on the sixth carbon budget".[61]

21. **We commend the Government on responding promptly to the Intergovernmental Panel on Climate Change's 2018 report on 1.5˚C global warming, by asking the Committee on Climate Change (CCC) for advice on net-zero emissions. However, it is disappointing that the Government excluded existing carbon budgets from the scope of this advice.** ***The Government should explicitly state, in advance of the CCC's advice on the sixth carbon budget, its willingness to amend the fourth and fifth carbon budgets in line with the CCC's cost-effective path to net-zero emissions by 2050 if recommended to do so.***

22. Following his oral evidence to us, allegations of a conflict of interest were published in the press regarding Lord Deben's positions as the Chairman of the Committee on Climate Change and as the Chairman of Sancroft International, a sustainable business

56 United Nations, 'Paris Agreement' (2015), Article 6
57 Committee on Climate Change, 'Net Zero: The UK's contribution to stopping global warming' (2019), pp130–132
58 Committee on Climate Change, 'Net Zero: The UK's contribution to stopping global warming' (2019), p132
59 Letter from Rt Hon Claire Perry MP, Roseanna Cunningham MSP and Lesley Griffiths AM to Lord Deben, 15 October 2018
60 Committee on Climate Change, 'Net Zero: The UK's contribution to stopping global warming' (2019), p263–264
61 Committee on Climate Change, 'Net Zero: The UK's contribution to stopping global warming' (2019), p30

consultancy.[62] We subsequently wrote to the Committee on Climate Change and to Lord Deben personally, seeking clarification on any potential conflict of interest and any measures in place to address this.[63]

23. **Lord Deben, the Chairman of the Committee on Climate Change, gave evidence to our Committee. He did not declare his interest as the Chair of Sancroft International. This company has had amongst its clients Drax, the largest recipient of renewable energy subsidies in the country, and Johnson Matthey, who are about to make a huge investment in electric vehicles. These should have been declared to the Science and Technology Committee.**

62 'Tory peer in £600,000 conflict of interest: Climate Change chief John Gummer faces calls to quit over payments from 'green businesses' to his family firm where daughter he famously fed a beef burger during the height of the BSE crisis is a director', Mail on Sunday, 2 February 2019

63 Letter from Rt Hon Norman Lamb MP to Chris Stark, 25 February 2019; Letter from Chris Stark to Rt Hon Norman Lamb MP, 11 March 2019; Letter from Rt Hon Norman Lamb MP to Lord Deben, April 2019; and letter from Lord Deben to Rt Hon Norman Lamb MP, 6 June 2019

3 The Clean Growth Strategy

24. The Government published its 'Clean Growth Strategy' in October 2017, setting out how it intended to meet the fourth and fifth carbon budgets.[64] This Chapter assesses the strategy as a whole, with specific sectors being discussed in subsequent chapters.

Policy gaps

25. Professor Jim Watson, Director of the UK Energy Research Centre, and Malcolm Brinded, representing the Royal Academy of Engineering and allied institutions, both praised the commitment expressed in the Clean Growth Strategy to meeting the UK's emissions targets.[65] Several stakeholders, such as the Renewable Energy Association, also pointed to what they perceived to be a lack of urgency in the strategy, or a mismatch between the ambition of the strategy and the Government's current policies.[66] When it published the Clean Growth Strategy, the Government estimated that the quantifiable policies proposed within it, if implemented, could lead to the UK achieving 94% and 93% of the emissions reductions needed to meet its fourth and fifth carbon budgets respectively (compared to baseline emissions in 1990).[67] The Government's most recent projections have updated this to 95% and 93% respectively.[68] The Minister for Energy and Clean Growth, Claire Perry MP, told us, however, that she considered the projected shortfall to be "small", and argued that since the projections were calculated she had seen "an acceleration of focus and policy delivery and a further reduction in cost":

> The Committee will have seen things like the spring statement and the announcement that we want all new homes from 2025 to be built without fossil fuel heating, which is an example of a policy for which we have costed no carbon reduction at all […] I am confident that we will meet these budgets within the timeframes we are given.[69]

Chris Skidmore MP, interim Clean Growth Minister, subsequently wrote to us to list the main policies whose emissions reductions potential had not yet been included in the Government's projections:

- the Future Homes Standard;
- the Offshore Wind Sector Deal;
- the Industrial Energy Transformation Fund;
- the industrial energy efficiency scheme;
- the deployment of carbon capture, usage and storage at scale during the 2030s;

64 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017)
65 Qq39 and 41
66 For example, see: Renewable Energy Association (CGE0026), para 23; Decarbonised Gas Alliance (CGE0032), para 10; E.ON (CGE0036), para 13; Environmental Defense Fund Europe (CGE0042), para 1; Durham Energy Institute (CGE0065), para 3
67 HM Government, 'The Clean Growth Strategy' (2017), p40
68 Department for Business, Energy and Industrial Strategy, 'Updated Energy and Emissions Projections 2018' (2019), p20
69 Q415

- the upgrade of all fuel poor homes to Energy Performance Certificate Band C by 2030 where practical, cost-effective and affordable;
- a ban on sales of new conventional petrol and diesel cars and vans by 2040;
- an ambition to remove all diesel-only trains from the network by 2040;
- an ambition to make cycling and walking the natural choices for shorter journeys, or as part of a longer journey by 2040;
- implementation of the smart systems plan; and
- exploration of new and innovative ways to manage emissions from landfill.[70]

26. The projected shortfall in emissions reductions was highlighted by Chris Stark, Chief Executive of the Committee on Climate Change, who warned us that there were "gaps in the policies that needed to be filled if we wanted to meet the fourth and fifth carbon budgets" and that there was additionally "lots of risk attached to those policies that the Government had already made".[71] Malcolm Brinded, representing the Royal Academy of Engineering, the Energy Institute and other engineering institutions, told us that there was widespread agreement that the UK was "not going to meet the carbon budgets on the trajectory [it is] on".[72] Although the UK has achieved the greatest decarbonisation of the G20 nations since 2000, its rate of decarbonisation has been slowing and it fell to fourth place among G20 nations for annual reductions in 2017.[73] Lord Deben, Chairman of the Committee on Climate Change, told us that if he "were to put [his] finger on the thing that [he was] most worried about on climate change, it would be the lack of urgency".[74] The Minister for Energy and Clean Growth, Claire Perry MP, argued, however, that the UK had "the most detailed plan for emissions reduction" internationally and that although she "absolutely agree[d] that we need to raise our ambition", "you have to have a really detailed plan to do that".[75]

Deploying existing technologies

27. Numerous submissions to our inquiry highlighted the importance of supporting the deployment of existing technologies as well as the development of less mature technologies.[76] For example, the Royal Academy of Engineering and allied institutions told us that "innovative policy making that works to break down silos and drives large-scale deployment of existing low-carbon solutions is more urgent than policy focused on the development of new technologies".[77] They argued that a "comprehensive review of incentives and regulations is required" to support this. Achieving the Government's key targets would require an acceleration of deployment of low carbon technologies:

70 Department for Business, Energy and Industrial Strategy (CGE0089)
71 Q2
72 Q39
73 Department for Business, Energy and Industrial Strategy, '2018 UK Greenhouse Gas Emissions, Provisional Figures' (2019), p3 and PwC, 'Time to get on with it: The Low Carbon Economy Index 2018' (2018), p8
74 Q4
75 Qq455–457
76 For example, see: ABB (CGE0010), section 1.3; Nuclear Industry Association (CGE0018), para 5; E.ON (CGE0036), para 16; Royal Academy of Engineering and allied institutions (CGE0055), para 2.1; The Royal Society (CGE0056), para 7; Durham Energy Institute (CGE0065), para 19; and Centre for Research into Energy Demand Solutions (CGE0070), para 17
77 Royal Academy of Engineering and allied institutions (CGE0055), para 17

- the Government wants "almost every car and van to be zero emission" by 2050,[78] which is equivalent to removing almost 20,000 conventional cars every week on average, from now until 2050,[79] whereas around 1,200 new ultra-low emissions vehicles were registered each week in 2018;[80]

- the Government also wants "as many homes as possible to be EPC Band C by 2035 where practical, cost-effective and affordable",[81] which Tim Lord, Director of Clean Growth at the Department for Business, Energy and Industrial Strategy, clarified to us represented a "very significant majority of homes".[82] This would equate to improving the energy efficiency of around 20,000 English homes (just under 40 per English constituency) per week until 2035[83]—in contrast, the Committee on Climate Change reported that around 2,400 energy loft or wall insulations were installed per week in 2017;[84]

- the Government has said that "by 2050, we will also likely need to fully decarbonise how we heat our homes",[85] which would require at least 15,000 homes to transfer to a low-carbon heating system every week until 2050[86]—this compares to a projection of 220 low-carbon heat systems being installed each week under the Government's 'Renewable Heat Incentive' from now until 2021; and[87]

- the Government has set out its "aspiration" to reach woodland cover of 12% in England by 2060,[88] which would require the net growth of around 120 hectares of woodland per week—in 2018, net woodland growth was around 20 hectares per week.[89]

28. Although the rate of deployment may reasonably be expected to grow over the long timescales in question, there are also a number of areas in which Government policy to support the deployment of low-carbon technologies has been delayed or cut back. For example:

78 Department for Transport, 'The Road to Zero' (2018), p2
79 Department for Transport, 'Vehicle Licensing Statistics: Annual 2018' (2019), p3; Committee analysis
80 Department for Transport, 'Vehicle Licensing Statistics: Annual 2018' (2019), p1; Committee analysis
81 Department for Business, Energy and Industrial Strategy, 'The Clean Growth Strategy' (2017), p13
82 Q470
83 Ministry of Housing, Communities and Local Government, 'English Housing Survey Headline Report 2017–2018' (2019), Annex Table 2.7; Committee analysis—the National Infrastructure Commission has similarly estimated that the potential for cost-saving energy efficiency improvements equates to "21,000 improvements being installed every week between now and 2035": National Infrastructure Commission, 'National Infrastructure Assessment' (2018), p45
84 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p85
85 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy', p75
86 There were 24m properties with gas meters in 2016, which will not include some off-grid properties that use fossil fuels to heat their homes—Department for Business, Energy and Industrial Strategy, 'Sub-National Electricity and Gas Consumption Statistics' (2018), p22; National Grid similarly told us that "if decarbonisation of heat is to be successful, around 20,000 homes a week between 2025 to 2050 will need to move to a low carbon heat source"—National Grid (CGE0019), para 3.4
87 National Audit Office, 'Low-carbon heating of homes and businesses and the Renewable Heat Incentive' (2018), para 1.17
88 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy', p107
89 Forestry Commission England, 'Corporate Plan Performance Indicators' (2018), p11

- the 'plug-in grant' for low-emissions cars was reduced from £4,500 to £3,500 for the lowest-emissions cars in October 2018, and cut completely for other low-emissions cars;[90]
- the 'feed-in tariff' for low-carbon power generation was closed in April 2019 without a successor scheme in place;[91]
- the Energy Companies Obligation scheme was restricted to vulnerable households only in November 2018,[92] despite the Government conceding that this would "result in lower carbon emissions reductions being achieved"[93]—the Government consulted on "building an 'able-to-pay' market for energy efficiency" in October 2017 and said that it would respond in 2018,[94] but a response has still not been published;[95] and
- following the cancellation of the 'zero-carbon homes' policy in 2015,[96] the Government pledged in 2018 to consult on changes to Part L of the building regulations (covering energy performance of buildings) in order to support the development of low-carbon heating technologies[97]—however, this consultation has still not been launched (although the Chancellor has announced that a 'Future Homes Standard' would be introduced to deliver homes with "low carbon heating and world-leading levels of energy efficiency", but only by 2025).[98]

Developing less mature technologies

29. Although many of the technologies required for decarbonisation are ready for large-scale deployment, the Government and others have identified several important technologies that should be supported through research and development, large-scale demonstration and commercialisation.[99] These include low-carbon heating technologies, carbon capture and storage, long-term energy storage technologies, small modular nuclear reactors and hydrogen as a fuel.

30. The Government's Clean Growth Strategy highlighted £2.5bn of investment being put into low carbon technologies between 2015 and 2021.[100] This funding aligns with the UK's

90 'Changes to the Plug-in Car Grant', Department for Business, Energy and Industrial Strategy, accessed 27 May 2019—the plug-in grant is a discount on the price of brand new low-emission vehicles, awarded through a grant the Government gives to vehicle dealerships and manufacturers

91 'About the FIT scheme', Ofgem, accessed 27 May 2019—the feed-in tariff awarded owners of small-scale renewable power generation technologies payments for every unit of power generated and every unit supplied to the grid

92 The Electricity and Gas (Energy Company Obligation) Order 2018 (SI 2018/1183); see also Department for Business, Energy and Industrial Strategy, 'Energy Company Obligation 2018–2022' (2019), p10

93 Department for Business, Energy and Industrial Strategy, 'Energy Company Obligation: ECO3, 2018 to 2022' (2018), p11

94 Department for Business, Energy and Industrial Strategy, 'Call for Evidence: Building a Market for Energy Efficiency' (2017)

95 'Building a market for energy efficiency: call for evidence', Department for Business, Energy and Industrial Strategy, accessed 27 May 2019

96 HM Treasury, 'Fixing the foundations: Creating a more prosperous nation'(2015), p46

97 Department for Business, Energy and Industrial Strategy, 'Clean Growth—Transforming Heating: Overview of Current Evidence' (2018), p9

98 Chancellor of the Exchequer, 'Spring Statement 2019: Written Ministerial Statement' (2019), p4

99 For example, see: Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), p53 and Energy Systems Catapult (CGE0029), para 10

100 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), p17

participation in 'Mission Innovation', a commitment made at the 2015 Paris conference on climate change to double spending on clean energy research and development from 2015 to 2020.[101] The £2.5bn is broken down into:

- up to £505m for the 'Energy Innovation Programme',[102] which aims to accelerate the commercialisation of innovative clean energy technologies and processes across six themes, into the 2020s and 2030s;
- up to £1.2bn for funding awarded through UK Research and Innovation, including through the Energy Systems Catapult and the Offshore Renewable Energy Catapult;
- up to £246m for the Faraday Challenge,[103] which aims to support the research and development of battery technologies for electric vehicles; and
- up to £620m to be awarded through Government departments.[104]

31. The UK Energy Research Centre argued that "several analyses of public research and development spending on energy in the UK and in other countries have concluded that spending is much too low—particularly when compared to the scale of the challenge posed by climate change".[105] Professor Jim Watson, Director of the UK Energy Research Centre, conceded that it was "very difficult to assess" the 'correct' amount to spend on research and innovation for low-carbon technologies, and that the "international evidence […] is quite thin".[106] Nevertheless, he said that analyses tended to conclude that "budgets should be increased by about five times, sometimes ten times".

32. Of the £2.5bn outlined in the Clean Growth Strategy, £1.14bn (44%) was for "basic and applied research", £900m (35%) was for "technology development" and £530m (21%) was for "technology demonstration".[107] The Government explained that:

> The Government is often more active at earlier stages of innovation, through investment in research, education and skills. Later on, private firms play a bigger role, bringing new technologies to market.[108]

Nevertheless, the Committee on Climate Change has warned that the Government's innovation programme was "generally focused at early-stage innovation: research, development and some demonstration", and that in order "to drive commercialisation and cost reduction successfully, it must be supported by funding and policies to drive deployment and learning-by-doing".[109] Many expressed similar opinions to us.[110] The UK

101 'Overview', Mission Innovation, accessed 26 May 2019
102 'Energy Innovation', Department for Business, Energy and Industrial Strategy, accessed 26 May 2019
103 'Faraday battery challenge: Industrial Strategy Challenge Fund', UK Research and Innovation, accessed 26 May 2019
104 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy', p50
105 UK Energy Research Centre (CGE0057), para 6—the Centre cited J. Pless *et al.*, 'Inducing and accelerating clean energy innovation with 'Mission Innovation' and evidence-based policy design', Working Paper (2018) and Research Councils UK, 'Investing in a brighter energy future: Energy Research and Training Prospectus' (2013)
106 Q42
107 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), p52
108 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), p49
109 Committee on Climate Change, 'An independent assessment of the UK's Clean Growth Strategy' (2018), p10
110 For example, see: Carbon Capture and Storage Association (CGE0023), para 10; Energy Systems Catapult (CGE0029), paras 12 and 26; Decarbonised Gas Alliance (CGE0032), para 38; UK Energy Research Centre (CGE0057), paras 7 and 16; Energy Technologies Institute (CGE0061); and Johnson Matthey (CGE0066), para 4

Energy Research Centre compared the time that it could take for new technologies to develop from early stage research through to commercialisation (typically three to four decades[111]) with the time left for meeting the fourth and fifth carbon budgets (five to fifteen years), concluding similarly that "policies to demonstrate, scale-up and commercialise existing technologies are perhaps more important [than fundamental research and development] if the UK is to successfully comply with carbon budgets in the 2020s and 2030s".[112] Damitha Adikaari, Acting Director of Science and Innovation for Climate and Energy at the Department for Business, Energy and Industrial Strategy, told us that "in the next iteration of this effort", demonstration "is where the focus will be".[113]

33. In particular, we heard that it would be important to have co-ordinated, large-scale trials rather than smaller, fragmented projects.[114] Johnson Matthey, a multinational chemicals and sustainable technology company, told us that "scale is critical", arguing that funding for projects greater than £100m in scale would be more effective than the same overall money spent on a larger number of projects of around £10m-scale.[115] Malcolm Brinded, representing the Royal Academy of Engineering and allied institutions, explained that "you cannot do a big system design and understand what we mean by that without trying it":

> It is not something that you can do on a desk study and in theory; it is about how consumers respond and how all the integrated system reacts, particularly taking advantage of what big data, smart equipment and grids will enable consumers to do and how consumers will then respond, when it is coupled with clear price signals.[116]

Guy Newey, Director of Strategy and Performance at the Energy Systems Catapult, acknowledged that there were already "dozens" of demonstration projects in place but said that the "key challenge" was to "bring those together in big demonstrations testing the huge questions" such as low-carbon heating, nuclear power and carbon capture and storage.[117] Both Mr Newey and Professor Watson highlighted that the Government would have to accept that some demonstration projects would also be unsuccessful.[118]

Co-ordinating development and deployment

34. Dr Jonathan Radcliffe, who leads the Energy Systems and Policy Analysis Group at the University of Birmingham and acted as the Specialist Adviser for our inquiry, told us that the deployment of new technologies "is a complex, non-linear process, with feed-backs and feed-forwards" and that it "requires support across the innovation process, with a combination of support for early stage research and development, demonstration

111 R. Gross *et al.*, 'How long does innovation and commercialisation in the energy sectors take? Historical case studies of the timescale from invention to widespread commercialisation in energy supply and end use technology', Energy Policy vol 123 (2018)
112 UK Energy Research Centre (CGE0057), paras 7 and 16
113 Q458
114 For example, see: ABB (CGE0010), section 2.0; Greenpeace UK (CGE0022), para 7; Energy Systems Catapult (CGE0029), paras 10, 12 and 20; UK Hydrogen and Fuel Cell Association (CGE0034), para 10; Royal Academy of Engineering and allied institutes (CGE0055), para 2.2; Energy Technologies Institute (CGE0061); and Qq47–52
115 Johnson Matthey (CGE0066), para 2
116 Q67
117 Q52
118 Qq50–51

activities and market mechanisms".[119] Guy Newey, Director of Strategy and Performance at the Energy Systems Catapult, made the similar point that if the Government "does not get the market structures right, there is a real risk that it will just be supporting isolated innovation projects", and would not achieve the system-change required:

> The lesson from the electricity system in the UK is that you need to get the innovation spend—the earlier-stage research and development stuff—lined up with the market mechanisms, and then you can see extraordinary cost reductions in technologies. If you do not do that, you will end up spending bits and bobs of money, but quite significant sums of public money, that will not lead to the kind of change you need.[120]

35. The most commonly referenced example in our written evidence of a technology whose development and deployment had been supported effectively was offshore wind power.[121] The cost of offshore wind power has fallen from around £160/MWh in 2011 to around £60/MWh today,[122] over which time the total generation capacity has increased from 1.8GW to 8.2GW.[123] The most important aspects of the support that has enabled this development were frequently identified as:

- clear, long-term targets for cost reduction and deployment;
- stable support mechanisms to create new markets, such as the Renewable Obligation scheme and contracts for difference framework; and
- constructive partnerships between Government and industry, enabled by industry councils and dedicated innovation co-ordinating bodies.

The Committee on Climate Change has similarly said:

> Offshore wind deployment exemplifies how clear goals, an ambitious strategy and well-designed mechanisms, can encourage and enable the market to reduce cost and help to build wider economic co-benefits. These lessons should be applied more broadly—to meet the challenges […] in transport, industry, buildings and agriculture.[124]

36. **The Government's own projections suggest that the UK is not currently on track to meet its existing emission targets, although we note that there are several significant policies and ambitions that have not yet been included in these calculations. Nevertheless, the rate of deployment of several key low-carbon technologies is significantly lower than what is required to meet the Government's ambitions, and various stakeholders—including the Committee on Climate Change—have expressed**

119 Dr Jonathan Radcliffe (CGE0041), para 12

120 Q46

121 For example, see: Menter Mon (CGE0002); Scottish Carbon Capture and Storage (CGE0021), section 6; Carbon Capture and Storage Association (CGE0023), para 29; Energy UK (CGE0024), para 8; Drax Group plc (CGE0025), para 39; Energy Systems Catapult (CGE0029), para 23; Decarbonised Gas Alliance (CGE0032), para 42; E.ON (CGE0036), para 34; UK Energy Research Centre (CGE0057), paras 21–22; UK Research and Innovation (CGE0058), para 17; Johnson Matthey (CGE0066), para 7; RenewableUK (CGE0067), section 1; Dolphin N2 (CGE0069), para 3.5.1.1;

122 Committee on Climate Change, 'Costs of low-carbon generation technologies' (2011), p3–4 and Department for Business, Energy and Industrial Strategy, 'Contracts for Difference Second Allocation Round Results' (2017)

123 Department for Business, Energy and Industrial Strategy, 'Energy Trends: renewables' (2019), Table 6.1

124 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p11

concern at the current and projected rate of progress of the UK's decarbonisation. In order to meet the fourth and fifth carbon budgets, emissions reductions cannot continue only in sectors that have decarbonised successfully so far, and must be significantly accelerated in sectors such as transport, heating and agriculture that have made little progress. The step-change in decarbonisation required will need policies to support the deployment and roll-out of existing technologies alongside, and co-ordinated with, significant research, development and demonstration of less mature technologies.

Technologies for export

37. In addition to the need for decarbonisation, the Clean Growth Strategy noted the "enormous potential economic opportunity" of clean growth with "an estimated $13.5 trillion of public and private investment in the global energy sector alone […] required between 2015 and 2030 if the signatories to the Paris Agreement are to meet their national targets".[125] However, despite highlighting this opportunity, the ambitions and policies in the Clean Growth Strategy focused heavily on deployment in the UK.

38. Professor Jonathan Gibbins, Director of the UK Carbon Capture and Storage Research Centre, argued that it was important to consider "how effective technology developments and investments in deployment in the UK are in influencing global outcomes", saying that "technologies that convince other countries they can go to net zero are quite valuable".[126] Malcolm Brinded, representing the Royal Academy of Engineering and allied institutions, similarly told us that exporting low-carbon technologies to emerging economies offered "a huge opportunity to have much greater impact [on climate change], probably at lower cost, than just continuing to drive down our own targets", but highlighted that these opportunities did "not get much focus" in the Clean Growth Strategy.[127] Indeed, none of the fifty "key policies and proposals" in the Strategy addressed emissions reductions outside the UK.[128] Mr Brinded acknowledged that "at a niche level the UK is quite good at this", but argued that "we could do much more":

> There are some programmes from the Department for International Development and so forth and some companies in the UK whose whole focus is on, for example, mobile home solar systems in Africa and south Asia, which are now attracting tens or hundreds of millions in support. The UK is very well placed here […] but we could do much more to support an incubator system and infrastructure and the small- to medium-enterprises and innovators delivering these solutions on the ground. That requires more money on a more sustained basis, and an integrated strategy between the Department for Business, Energy and Industrial Strategy, the Department for International Development, the Department for Transport and the Department for International Trade.[129]

125 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), p8
126 Q408
127 Q39
128 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), pp12–16
129 Q75

Professor Jim Watson, Director of the UK Energy Research Centre, indicated that he agreed "with a lot of that",[130] while Dr Nina Skorupska, Chief Executive of the Renewable Energy Association, said that, although different Government departments were "beginning to" improve support for export opportunities, "we still have to do a lot more".[131]

39. The Government published an 'International Research and Innovation Strategy' in May 2019, which included elements addressing sustainability.[132] However, this focused on international collaboration on research and innovation, rather than export opportunities for British technologies and companies.

40. **The UK can simultaneously achieve economic growth and global emissions reductions through the export of low-carbon technologies to other countries. This potentially offers global emissions reduction at lower cost than the same level of reduction in the UK. However, opportunities for delivering emissions reductions outside of the UK were not included in the 50 key policies and proposals of the Government's Clean Growth Strategy. When it laid legislation strengthening the UK's long-term emissions reduction targets, the Government said that it would review the net-zero target within five years, to review the extent to which other countries had followed the UK's lead in setting and acting upon decarbonisation targets.**

41. ***Ahead of its review of international reaction to the UK's net-zero target, the Government should actively encourage other countries to take similarly ambitious action. It should develop a strategy by the end of 2020, identifying opportunities for the UK to encourage and support decarbonisation in other countries, and prioritising action that will achieve the greatest global emissions reduction. This should include cross-Government action to support British companies exporting technologies that can deliver emission reductions abroad.***

42. Tim Lord, Director of Clean Growth at the Department for Business, Energy and Industrial Strategy, told us that "there is a huge amount of cross-Government collaboration" on clean growth, including across the Treasury, the Ministry for Housing, Communities and Local Government and the Department for Transport.[133] The Minister for Energy and Clean Growth, Claire Perry MP, added:

> I think the fact that I do attend Cabinet, that we have a clean growth cross-Government strategy, and that for the first time ever we saw a green-focused financial statement, should give the Committee reassurance that it is absolutely percolating across Government.[134]

Nevertheless, the Minister is situated in one Government Department and is not a Cabinet Minister.[135]

43. ***The Government should increase the number of Ministers across Government Departments working on climate change, including a new Ministerial role at the Foreign and Commonwealth Office with explicit responsibility for delivering multi-lateral action internationally on climate change. Reflecting the critical importance***

130 Q79
131 Qq292–293
132 HM Government, 'International Research and Innovation Strategy' (2019)
133 Q502
134 Q457
135 'Ministers', HM Government, accessed 9 July 2019

of mitigating climate change, and to improve cross-Government co-ordination, the Minister charged with co-ordinating the UK's action on national and international decarbonisation should be a full Cabinet Minister.

4 Decarbonising power generation

44. This Chapter examines the Government's policies for decarbonising the power generated by the UK, covering large-scale renewable power technologies such as onshore and offshore wind farms, small-scale renewable power technologies such as rooftop solar panels, and conventional and emerging nuclear power technologies.

Overview

45. Power generation was responsible for around 15% of the UK's territorial greenhouse gas emissions in 2018.[136] The power generation sector has achieved significant decarbonisation over the course of the last carbon budget period, mostly as coal power generation has been replaced by gas and renewable power generation, and improved efficiencies have reduced demand.[137] Overall, emissions from the power generation sector fell by 59% between 2008 and 2017,[138] and emissions reductions in this sector accounted for 75% of the UK's total emissions reductions between 2012 and 2017.[139]

46. The Committee on Climate Change has made clear that "further reduction in the emissions intensity of power generation […] remains the lowest-cost path towards economy-wide decarbonisation".[140] Eliminating the UK's remaining coal power emissions, as the Government has pledged to do by 2025,[141] would reduce the UK's total emissions by a maximum of a further 4.5%.[142] This compares to overall reductions of around 13% required to meet the fourth carbon budget.[143] Although the proportion of electricity generated from coal has decreased substantially in the UK, natural gas—another, less carbon-intensive, fossil fuel—supplied 40.4% of the UK's electricity in 2017.[144] Low-carbon power generation technologies include onshore and offshore wind power, solar power, wave and tidal power, geothermal power and nuclear power (the Intergovernmental Panel on Climate Change has estimated that the full lifecycle emissions associated with nuclear power are comparable to renewable power technologies such as wind power).[145] Together, these provided around 50.1% of the UK's electricity supply in 2017.[146]

136 Department for Business, Energy and Industrial Strategy, '2018 UK Greenhouse Gas Emissions, Provisional Figures' (2019), p6
137 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p56
138 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p53
139 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p11
140 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p68
141 Department for Business, Energy and Industrial Strategy, 'Implementing the End of Unabated Coal by 2025' (2018)
142 Department for Business, Energy and Industrial Strategy, 'Provisional UK greenhouse gas emissions national statistics: 2018' (2019), Tables 1 and 2; Committee analysis
143 Department for Business, Energy and Industrial Strategy, '2018 UK Greenhouse Gas Emissions, Provisional Figures' (2019), p3 and Carbon Budget Order 2011 (SI 2011/1603); Committee analysis
144 Department for Business, Energy and Industrial Strategy, 'Digest of United Kingdom Energy Statistics 2018' (2018), p117
145 Intergovernmental Panel on Climate Change, 'Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change' (2014), p539
146 Department for Business, Energy and Industrial Strategy, 'Digest of United Kingdom Energy Statistics 2018' (2018), p117

47. The Government has stated its intention to "regulate the closure of unabated coal power generation units by 2025".[147] Seven of the UK's eight operating nuclear power stations are also scheduled to close by 2030.[148] Across all power generation technologies, around two-thirds of existing power stations are expected to close by 2030.[149] Against this backdrop of planned power station closures, the demand for electricity is anticipated to grow substantially, in particular as sectors such as transport and heating electrify.[150] In total, the Committee on Climate Change has estimated that the amount of low-carbon electricity generated each year will have to more than double during the 2020s, requiring the generation of 130–145TWh of additional low-carbon energy by 2030 (taking into account the generation capacity expected to close by 2030).[151] Were this to be met using just one low-carbon power generation technology, this would be equivalent to increasing the current generation from onshore wind power by a factor of 5.7, offshore wind power by a factor of 7.6, solar power by a factor of 13.0, or nuclear power by a factor of 3.0.[152] National Grid System Operator, which is responsible for balancing the supply and demand of electricity in Great Britain, has similarly estimated that the UK will need to more than double its low-carbon power generation capacity by 2030, and increase it by a factor of between 3.1 to 3.8 by 2050 to reach its existing emissions targets (corresponding to increases of around 50GW and 100–130GW respectively).[153]

48. The Minister of State for Energy and Clean Growth, Claire Perry MP, indicated to us that the Government expected the main components of this future low-carbon power generation supply to consist of offshore wind power, nuclear power and gas power used in combination with carbon capture and storage.[154] As part of its 'Industrial Strategy', the Government agreed sector deals with the nuclear and offshore wind power industries.[155] The nuclear sector deal has four main aims:

- to reduce the cost of new-build projects by 30% by 2030;
- to reduce the estimated costs of decommissioning by 20% by 2030;
- to increase female participation to 40% of the workforce by 2030; and
- to achieve up to £2bn of new domestic and international contracts by 2030.[156]

The offshore wind sector deal aims to:

- increase the UK content of new wind turbines to 60% by 2030;
- increase female participation to 33% by 2030; and
- increase exports fivefold to £2.6bn by 2030.[157]

147 Department for Business, Energy and Industrial Strategy, 'Implementing the End of Unbated Coal by 2025' (2018), p3
148 'Country Nuclear Power Profiles—United Kingdom', International Atomic Energy Agency, accessed 17 April 2019
149 National Infrastructure Commission, 'Smart Power' (2016), p5
150 National Grid Energy Systems Operator, 'Future Energy Scenarios 2018' (2018), p3
151 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p59
152 Current generation taken from Department for Business, Energy and Industrial Strategy, 'Digest of UK Energy Statistics 2018' (2018); Science and Technology Committee analysis
153 National Grid System Operator, 'Future Energy Scenarios' (2018), p96
154 Q440
155 HM Government, 'Industrial Strategy: Nuclear Sector Deal' (2018) and 'Industrial Strategy: Offshore Wind Sector Deal' (2019)
156 HM Government, 'Industrial Strategy: Nuclear Sector Deal' (2018), p7
157 HM Government, 'Industrial Strategy: Offshore Wind Sector Deal' (2019), p4

The offshore wind sector deal also entails up to £250m investment from industry to build the UK supply chain and up to £557m from the Government to finance new offshore wind capacity. In place of a sector deal, the Government has published a carbon capture, usage and storage 'action plan'.[158] This committed to "the UK having the option to deploy carbon capture, usage and storage at scale during the 2030s subject to the costs coming down sufficiently".[159]

49. The Government has estimated that the offshore wind sector deal could lead to the deployment of 30GW of new generation capacity by 2030,[160] corresponding to around 100TWh of low-carbon electricity per year (compared to the 130–145TWh the Committee on Climate Change estimated that the UK would need).[161] The Government did not estimate the new generation capacity that the nuclear sector deal would deliver. However, given the £18bn value of the new 3.3GW (~25TWh/yr) reactor at Hinkley Point C, the Government's ambition for £2bn of domestic and international contracts to be won by 2030 suggests that the nuclear sector deal will not deliver significant proportions of the UK's additional power needs.[162] The Minister told us that "nuclear has a part to play in the [future energy] mix" but said that the Government has to "spend taxpayers' money wisely".[163] It therefore seemed as though the Government planned to meet the bulk of the UK's additional power generation needs through the 2020s by installing new offshore wind power. Indeed, Dr Robert Gross, co-Director of the UK Energy Research Centre, told us that "the only really big show in town between now and 2030 is the offshore wind sector deal".[164]

50. The Offshore Renewable Energy Catapult advised us that the Government's target for offshore wind was "very achievable, with much of the 30GW in the pipeline in one form or another".[165] Professor Keith Bell, co-Director of the UK Energy Research Centre, further told us that it was "entirely credible" that the UK could deploy the low-carbon power generation capacity it would need to fulfil its fourth and fifth carbon budgets, and indicated that it was already "well on the way" to achieving this.[166] The Committee on Climate Change, however, has estimated that the announced Government investment in renewable power would provide an additional 60TWh per year by 2030, and that the new nuclear reactor at Hinkley Point, if built, would provide 25TWh per year.[167] This would leave a 'gap' of 50–60TWh by 2030. Dr Nina Skorupska, Chief Executive of the Renewable Energy Association, similarly told us that the UK was "not on track" to deploying the low-carbon power generation required for its fourth and fifth carbon budgets.[168]

51. Dr Gross said that the Government's aims were "perfectly achievable" but said that the focus on offshore wind power meant that the UK was therefore "very largely putting all of [its] eggs in that basket".[169] The Committee on Climate Change has warned that

158 HM Government, 'The UK Carbon Capture Usage and Storage deployment pathway: An Action Plan' (2018)
159 HM Government, 'The UK Carbon Capture Usage and Storage deployment pathway: An Action Plan' (2018), p7
160 HM Government, 'Industrial Strategy: Offshore Wind Sector Deal' (2019), p4
161 Committee analysis assuming a load factor of about 40%, which offshore wind has consistently achieved since 2013—Department for Business, Energy and Industrial Strategy, 'Digest of UK Energy Statistics 2018' (2018), p185
162 'Hinkley Point C contract signed', Department for Business, Energy and Industrial Strategy, accessed 30 May 2019
163 Qq441–442
164 Q232
165 Offshore Renewable Energy Catapult (CGE0081)
166 Q232
167 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), pp59 and 64
168 Q232
169 Q232

the Government's power generation decarbonisation strategy was not "credible" because of the "significant risks associated with it" and the lack of "multiple plausible pathways to achieve the necessary level of decarbonisation".[170] It therefore recommended that the Government develop "robust contingency plans that allow for additional low-carbon generation to be brought forward in the event of delay or cancellation of planned projects, or imports of electricity below projected levels".[171] This appears to be warranted, given the recent uncertainty surrounding nuclear power projects.[172]

Managing intermittent renewable energy

52. Renewable power generation is generally 'intermittent', meaning that its output is variable and uncontrollable. For example, wind turbines only generate power when the wind is blowing. Although this poses challenges to the UK energy system, Duncan Burt, Director of Operations at National Grid System Operator (which is responsible for balancing supply and demand on the electricity transmission system—the core network that transfers high-voltage power between power stations and local distribution networks), told us that "it is very easy to get to very high levels of renewable generation and to 100% zero carbon generation over the next six or seven years for regular periods of operation".[173] Indeed, National Grid Electricity System Operator has stated its ambition to be able to operate the grid using entirely 'zero-carbon' power sources by 2025, subject to sufficient generation (this contrasts to the Government's statement that "one possible pathway to 2032 […] could be achieved by growing low carbon sources such as renewables and nuclear to over 80% of electricity generation).[174] In fact, Great Britain is already achieving increasing periods of zero-carbon power generation. For example, on 8 May 2019, Great Britain met its electricity demands for over a week without using coal power—for the first time since the Industrial Revolution—and later that month went two weeks without coal power.[175] The UK Energy Research Centre has further reported that, although "the additional costs of adding variable renewable generation to an electricity system can vary quite dramatically […] they are usually modest, with higher costs normally the result of inflexible or sub-optimal systems".[176]

53. **We commend National Grid Electricity System Operator for its ambition to be able to manage a 'zero carbon' electricity grid by 2025. This goes significantly beyond the Government's projections for possible renewable power deployment by 2032, and indicates that any 'over-delivery' on the deployment of low-carbon power generation in the 2020s will not be incompatible with the electricity transmission system. *We urge distribution network operators to adopt a similar ambition to National Grid System Operator, of operating a zero carbon grid by 2025. Ofgem should work with distribution network operators to ensure that the regulatory framework required to allow this***

170 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), pp74 and 78
171 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p83
172 'Toshiba's UK withdrawal puts Cumbria nuclear plant in doubt', BBC News, 8 November 2018 and 'Nuclear plant in Anglesey suspended by Hitachi', BBC News, 17 January 2019
173 Q297
174 National Grid System Operator, 'Zero Carbon Operation 2025' (2019) and HM Government, 'Clean Growth Strategy' (2017), p96
175 'UK has first coal-free week for a century', BBC News, 9 May 2019 and 'Britain in two-week coal-free record', BBC News, 31 May 2019
176 UK Energy Research Centre, 'The costs and impacts of intermittency—2016 update' (2017), p1

is in place. If sufficient progress is not made we urge the Government to consider strengthening Ofgem's mandate to require the distribution network operators to speed up the investment and upgrading of the distribution networks required.

54. **The Government has indicated that it expects requirements for new power generation capacity to be met through offshore wind power, nuclear power and gas-fired power with carbon capture and storage. There is considerable risk that these technologies may not provide the generation capacity required.** ***The Government must set out in its response to this Report how it intends to monitor and address any potential shortfall in power generation capacity, and ensure that this can be achieved with low emissions and costs.***

Large-scale renewable power

New generation capacity

55. The Government has said that its "main mechanism for supporting low-carbon electricity generation" is through 'contract for difference' agreements (see Box 1).[177] These have supported the deployment of 5.5GW of renewable power generation capacity since they started in 2015,[178] and were identified by several witnesses as having been an important factor in the falling costs of renewable power technologies.[179] However, since 2017, contracts for difference have been available only for "less-established" technologies such as offshore wind power or tidal power, and not for "established technologies" including onshore wind power and large-scale solar power (the contract for difference framework refers to established and less-established technologies as 'Pot 1' and 'Pot 2' technologies respectively).[180] The Government has signalled its intention to continue this policy through the 2020s.[181]

Box 1: Contracts for Difference

Under the contract for difference mechanism, the Government signs contracts with renewable energy project developers (through the Low Carbon Contracts Company (LCCC), a Government-owned company) agreeing that for the duration of the contract, the LCCC will pay the developer the difference between the 'reference price' (a measure of the average market price) and the 'strike price' (the price negotiated at the beginning of the contract) for any electricity the developer sells into the grid. This guarantees the developer a stable price for the electricity it generates for the duration of the contract, usually 15 years. In the event that the wholesale price rises above the negotiated strike price, the developer instead pays the LCCC. The net cost of all payments made to contracted developers is funded through a levy on licensed electricity suppliers.

177 'Contracts for Difference', Department for Business, Energy and Industrial Strategy, accessed 3 June 2019

178 Department of Energy and Climate Change, 'Contracts for Difference (CFD) Allocation Round One Outcome' (2015) and Department for Business, Energy and Industrial Strategy, 'Contracts for Difference Second Allocation Round Results' (2017)

179 For example, see Drax Group plc (CGE0025), para 39

180 Department for Business, Energy and Industrial Strategy, 'Budget Notice for the Second CFD Allocation Round' (2017)

181 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), p99

Contracts for Difference are awarded through Allocation Rounds in which renewable power developers bid for contracts in a 'pay as clear' auction. The Government sets an overall budget cap for each auction as well as a maximum permissible strike price for each technology. Developers then make sealed bids of the capacity they are offering and the lowest strike price they would accept. The project with the lowest strike price is awarded a contract first. Each subsequent project wins a contract if its expected cost, when added to the cost of the previous winning projects in the auction, comes below an overall budget cap. Projects that have already won a contract have their strike price raised to that of the latest project being assessed and the revised overall cost of the auction is reassessed against the budget cap. The auction stops once a project's cost breaches the budget cap when added to the costs of projects that have already won.

The first Allocation Round in 2015 held separate auctions for different groups (or "pots") of technologies:

Pot 1—established technologies (such as onshore wind power and solar power); and

Pot 2—less established technologies (such as offshore wind power and wave power).

Sources: 'Contracts for Difference', Department for Business, Energy and Industrial Strategy, accessed 17 April 2019; 'CfD Overview', National Grid ESO, accessed 17 April 2019; National Audit Office, 'Investigation into the 2017 auction for low-carbon electricity generation contracts' (2018)

56. Numerous stakeholders contributing to our inquiry argued for the inclusion of established technologies in future contract for difference auctions.[182] In addition to the stakeholders that contributed to our inquiry, contract for difference auctions open to Pot 1 technologies have been recommended by independent organisations such as the Committee on Climate Change and the National Infrastructure Commission.[183] Alongside their low carbon intensity, the main argument for supporting the market for established renewable power generation technologies was their low cost. In particular, the cost of new wind power generation capacity in Europe has fallen continuously since at least 2015,[184] and the Government estimated in 2016 that onshore wind power would have the lowest deployment cost of any power generation technology—including those using fossil fuels—from 2020 onwards (the analysis included carbon pricing costs but not the wider system costs of different technologies).[185]

57. The Government therefore argued that "onshore wind and solar costs have already fallen significantly, and global market dynamics will continue to drive this, so it is right for us to have scaled back support in those areas".[186] However, RenewableUK has reported that new onshore wind installations fell by nearly 80% in 2018 to the lowest level since 2011, which it claimed was despite that fact that "there is currently 4,466MW [over seven times what was installed in 2018] of shovel-ready onshore wind that has gone through the local planning process".[187] The Solar Trade Association similarly reported a 95% drop in

182 For example, see: EDF Energy (CGE0020), para 8; Energy UK (CGE0024), paras 5–6; E.ON (CGE0036), para 17; RenewableUK (CGE0067), section 2; Qq65 and 262–263

183 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p54 and National Infrastructure Commission, 'National Infrastructure Assessment' (2018), pp40–42

184 Wind Europe, 'Financing and investment trends' (2019), p17

185 Department for Business, Energy and Industrial Strategy, 'Electricity Generation Costs' (2016), p29

186 Department for Business, Energy and Industrial Strategy (CGE0016), para 18

187 'New onshore wind installations plummet in 2018', RenewableUK, accessed 3 June 2019

deployment of new solar power in 2018 compared to 2015 and highlighted the UK's last-place ranking for anticipated growth in solar power out of 20 established global markets, as rated by Solar Power Europe.[188] Furthermore, planning permission applications for renewable generation fell in 2016 and 2017, from a total equivalent generation capacity of 2.5GW to 0.9GW.[189] Professor Keith Bell, co-Director of the UK Energy Research Centre, explained that it was not subsidy that Pot 1 technologies required from contracts for difference, but that instead "it is a question of the right contractual framework that allows the cost of capital to be reduced and allows the investment to be unlocked".[190] Dr Nina Skorupska, Chief Executive of the Renewable Energy Association, added that, with policies to support renewable technologies all ended or ending soon without replacement (other than for offshore wind power), "the general lack of a clear policy and framework beyond 2020 is stifling investment".[191]

58. Nevertheless, the costs of established renewable technologies are expected to continue falling. BVG Associates, a renewable energy consultancy firm, has estimated that the cost of onshore wind power could fall below the wholesale price of electricity in 2023, and therefore result in lower bills for consumers.[192] It projected that a series of five contract for difference auctions for onshore wind power, held at 18 month intervals between 2019 and 2025, could deliver a net benefit of £1.6bn to energy consumers over the total lifetime of the 15-year contract periods and an overall economic benefit of at least £8–12bn. Modelling commissioned by Citizens Advice in 2015 similarly found that the cost to consumers of excluding onshore wind power from the 2017 contract for difference auction would be £500m.[193] Additionally, a 2018 study from University College London argued that restoring Pot 1 auctions would help to improve the competitivity of UK heavy industry, by reducing its electricity costs to nearer the European average.[194] Lord Deben, Chairman of the Committee on Climate Change, told us that the Government "must either allow [onshore wind power] to be part of the structure […] or tell the public the extra cost that we are paying for our electricity because we do not do it".[195]

59. Despite these projected cost-savings, the 2017 Conservative manifesto stated that the party did "not believe that more large-scale onshore wind power is right for England".[196] The Minister for Energy and Clean Growth, Claire Perry MP, further explained that "people find these wind turbines to be very unsightly" and stated that the UK "could be generating all the wind power [it needs] offshore with concomitant industrial benefits".[197] The Government's own surveys have revealed, however, that 79% of the public support the use of onshore wind power and that 61% would be happy to have a large scale renewable

188 Solar Trade Association (CGE0053), para 3 and Solar Power Europe, 'Global Market Outlook for Solar Power 2018–2022' (2018), p20

189 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p61

190 Qq235–237; the Committee on Climate Change, of which Prof Bell was recently made a member, similarly said in 2017 that "with suitable long-term contracts [renewable power technologies] can be deployed without subsidy beyond the application of a carbon price to fossil fuel generation"—'Five reflections on Dieter Helm's Cost of Energy Review', Committee on Climate Change, accessed 7 June 2019

191 Q251

192 BVG Associates, 'The Power of Onshore Wind' (2018)—this report was commissioned by ScottishPower Renewables, Innogy, Statkraft and Vattenfall

193 Citizens Advice, 'Generating Value? A Consumer Friendly Electricity Generation Policy' (2016)

194 M. Grubb and P. Drummond, 'UK Industrial Electricity Prices: Competitiveness in a Low Carbon World' (2018)

195 Q21

196 Conservative and Unionist Party, 'Forward, Together: Our Plan for a Stronger Britain and a Prosperous Future' (2017), p22

197 Q443

energy development in their area.[198] Energy UK noted that "robust local planning rules" already ensured that new installations of these technologies would go ahead only where the local community supported them.[199] Indeed, there has been some criticism that changes to planning guidance in 2015 "place an effective moratorium on onshore wind projects without decisive and deliberate action from local councils or communities and increases the risk profile of the planning applications that are submitted".[200] It has also been argued that the UK's restrictive planning framework is responsible for the fact that the UK's new onshore wind farms have some of the smallest turbines in Europe,[201] despite the fact that larger turbines lead to greater power output, improved reliability and therefore cheaper costs.[202]

60. RenewableUK has argued that wind farms can provide job creation, inward investment and the provision of facilities for local communities, and estimated that for each installed megawatt of wind power capacity, around £100,000 stays in the community and surrounding areas during the lifetime of a project.[203] However, the British Academy has reported that "the UK has had a less stable environment" for supporting community energy projects than international leaders such as Denmark and Germany,[204] which have some of the highest rates of onshore wind power use in Europe as a result of "extensive local community ownership of onshore wind turbines".[205] Research suggests that increasing the public stake in projects by promoting community ownership and profit-sharing, and requiring meaningful public consultations (which provides an opportunity for participation) can build and maintain public support.[206] However, Community Energy England, a not-for-profit organisation representing community energy projects, reported that 2018 was "the toughest year yet for community energy, with new generation capacity falling steeply in comparison to previous years".[207] It blamed this principally on cuts to the feed-in tariff (see paragraphs 69 to 74) combined with a "restrictive planning environment".[208] An alliance of over twenty sustainable energy stakeholders, led by the Green Alliance, published a 'manifesto for community energy' in 2019, advocating:

- measures to ensure that the energy system values community energy, such as encouragement for public authorities to consider social impact in their energy supply or incentives for distribution system operators to support community energy projects;

- support for community energy innovation, for example by lowering the minimum levels of investment required from community energy initiatives in energy trials, ensuring trials are publicised and accessible to community groups, or providing central guidance and other support for community groups; and

198 Department for Business, Energy and Industrial Strategy, 'BEIS Public Attitudes Tracker: March 2019 (Wave 29)' (2019), pp25–26
199 Energy UK (CGE0024), para 6
200 Centre for Sustainable Energy 'Survey of local authority wind policies' (2017), p2; the policy guidance was changed by HCWS42, 18 June 2015
201 WindEurope, 'Wind energy in Europe in 2018' (2019), p20 and RenewableUK, 'Onshore Wind: the UK's Next Generation' (2019), p18
202 'Developments in Wind Power', POSTnote 602, Parliamentary Office of Science and Technology, May 2019
203 'Communities & Energy', RenewableUK, accessed 7 June 2019
204 British Academy, 'Cultures of Community Energy: International case studies' (2016), p3
205 WindEurope, 'Wind energy in Europe in 2018' (2019), p17 and International Energy Agency, '20 Renewable Energy Policy Recommendations' (2018), p14
206 'Developments in Wind Power', POSTnote 602, Parliamentary Office of Science and Technology, May 2019
207 Community Energy England, 'Community Energy State of the Sector 2019' (2019), p1
208 Community Energy England, 'Community Energy State of the Sector 2019' (2019), p3

- leadership, including requirements on commercial developers to offer shared ownership to community groups, consideration of community benefit in planning application decisions, or reinstating community energy projects into the Social Investment Tax Relief regime.[209]

61. In contrast to the UK Government's position, the Scottish Government stated in 2017 that "Scotland will continue to need more onshore wind development and capacity" and called on the UK Government to use its reserved powers and established market mechanisms to support onshore wind power projects.[210] The Welsh Government also called on the UK Government "to enable onshore wind and solar technologies to compete in the Contract for Difference mechanism to reduce overall costs and enable the continued renewable deployment needs to meet the UK's legally binding decarbonisation goals".[211] Giving evidence to the Business, Energy and Industrial Strategy Committee in November 2017, the Clean Growth Minister highlighted that "under the current contract for difference rules, it is impossible to bring forward geographically specific wind farms, much as we would like to".[212]

62. **Although onshore wind power and large-scale solar power are low-cost and low-carbon, the deployment of new installations of these technologies has fallen drastically since 2015. Onshore wind power in particular could lower costs to energy consumers as well as contributing to the UK's decarbonisation, and there is widespread support for increased Government support for such projects across Great Britain. *The Government must ensure that there is strong policy support for new onshore wind power and large-scale solar power projects for which there is local support and projected cost-savings for consumers over the long-term. The Government should actively encourage and support local authorities to adopt planning practices that promote local support for such renewable energy projects. The Government must additionally develop mechanisms to promote community ownership and profit-sharing of low-carbon projects, such as joint ventures, split ownership or shared revenue.***

63. Offshore wind power is set to be supported by the Offshore Wind Sector Deal as well as the Government's allocation of up to £557m for Pot 2 contract for difference auctions.[213] However, we heard of other less-established renewable power generation technologies that could also support clean growth in the UK during our inquiry, such as wave power, tidal power and geothermal power.[214] RenewableUK warned us that "as currently set up, the contract for difference [mechanism] is not a mechanism that will support marine renewables—or any new renewable technology—as they seek to secure the early-stage investment in smaller-scale projects" required to move these technologies from technology development to commercialisation.[215] RenewableUK consequently advocated the development of 'Innovation Power Purchase Agreements', which was supported by

209 Green Alliance, 'A manifesto for community energy' (2019)
210 Scottish Government, 'Onshore wind: policy statement' (2017)
211 Welsh Government, 'Public position on onshore wind and solar' (2017)
212 Oral evidence taken before the Business, Energy and Industrial Strategy Committee on 28 November 2017, HC 596/597, Q140
213 HM Government, 'Industrial Strategy: Offshore Wind Sector Deal' (2019) and Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), p99
214 For example, see: Renewable Energy Association (CGE0026), paras 7 and 9; Nova Innovation Ltd (CGE0044); Marine Energy Wales (CGE0047); The Geological Society (CGE0051), para 3; RenewableUK (CGE0067), section 3
215 RenewableUK (CGE0067), section 3

other marine energy stakeholders.[216] These agreements would be made between developers of certain renewable power technologies and large-scale energy consumers, with the Government providing tax rebates to the consumer covering the difference between the "emerging technology price" of the energy supplied by the developer and the market price, so that they would not incur a cost penalty for entering into such agreements.[217] The "emerging technology price" would be determined according to a pre-defined framework set by the Government, starting at an agreed value (proposed to be around £290/MWh) and decreasing as the total capacity deployed increases. Agreements would only be eligible for projects supplying up to 5MW of generation capacity. A cross-sector proposal for Innovation Power Purchase Agreements estimated that the maximum cost to the Government of such a scheme would average £141m per year over twenty years. Marine Energy Wales proposed that future Pot 2 contract for difference auctions additionally include a minimum allocation to be awarded to specific technologies, in order to support them through larger-scale commercialisation.[218]

64. **The marine energy sector has come together to propose market support mechanisms to support marine and other less-established renewable power technologies through technology development and commercialisation.** ***The Government should examine the case for supporting 'Innovation Power Purchase Agreements' and setting minimum allocations of future contract for difference auctions to specific technologies, to support the development and commercialisation of renewable power technologies that are less-established than offshore wind power.***

Repowering existing generation capacity

65. The Committee on Climate Change's estimate that 130–145TWh of additional low-carbon energy would be required by 2030 was based on the assumption that existing renewable power generation capacity that was scheduled to close during the 2020s would be replaced or have its life extended.[219] The average lifetimes of wind and solar farms—the two most common renewable power technologies in the UK—are around 20–25 years.[220] With the UK's first commercial renewable power projects installed through the 1990s, these installations are starting to near the end of their expected lifetimes.

66. The number of wind farms projected to reach the end of their lifetimes increases substantially from 2029 onwards.[221] This is notable given that RenewableUK, the trade association for the wind, wave and tidal energy industries, has estimated that it could take up to 10 years to start the planning process required to repower a wind farm.[222] The Government revised the National Planning Policy Framework in 2018 to exclude repowering projects from the stricter planning guidance for new wind farm projects,[223] but RenewableUK has warned that repowering projects are still threatened by a "lack of

216 See: Menter Mon (CGE0002); Sustainable Marine Energy (CGE0013), para 9; Marine Energy Wales (CGE0047), para 5.3; RenewableUK (CGE0067), section 3
217 Scottish Renewables, 'UK Marine Energy 2019' (2019), pp14–19
218 Marine Energy Wales (CGE0047), para 5.3
219 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p59
220 Department for Business, Energy and Industrial Strategy, 'Digest of United Kingdom Energy Statistics 2018' (2018), p159; RenewableUK, 'Onshore Wind: the UK's Next Generation' (2019), p2; and IHS Markit, 'Predictions for the PV industry in 2019' (2019), p5
221 RenewableUK, 'Onshore Wind: the UK's Next Generation' (2019), p4
222 RenewableUK, 'Onshore Wind: the UK's Next Generation' (2019), p9
223 Ministry of Housing, Communities and Local Government, 'National Planning Policy Framework' (2018), para 154

visibility surrounding the planning process".[224] It recommended that "UK Government, devolved governments and assemblies, local authorities and other key stakeholders should work in conjunction with the industry to create a supportive planning policy framework", including:

- clear criteria for the assessment of prospective repowering applications;
- a specific repowering framework for Environmental Impact Assessments and development plan policies that acknowledges the existing use of a site for wind power;
- promotion of the benefits of large turbines; and
- a presumption in favour of granting evergreen planning consent subject to the usual conditions dealing with decommissioning and restoration at the end of the life of the windfarm.[225]

67. RenewableUK also argued that the Government "should ensure that an appropriate market mechanism is in place to enable repowering".[226] Professor Keith Bell, co-Director of the UK Energy Research Centre, told us that although the risk attached to re-powering existing wind farms should in principle be lower than for building new farms due to the re-use of existing sites and connections to the power networks, there was a mixed degree of optimism in the wind power community regarding the ability for re-powering projects to go ahead without some form of contractual security.[227] Dr Nina Skorupska, Chief Executive of the Renewable Energy Association, indicated that the ability of existing onshore wind power sites to repower without market support would vary site-by-site.[228]

68. ***The Government should develop, by the end of 2020, a clear planning permission framework for re-powering existing onshore wind farms, and ensure that national planning policy facilitates re-powering with the most efficient technology and does not block proposals that attract local support. It must also monitor the proportion of onshore wind power sites that apply for permission to repower, and be ready to provide market support (for example through eligibility for contracts for difference) if this is not close to 100%.***

Small-scale renewable power

The Smart Export Guarantee scheme

69. Small-scale renewable power generation technologies include solar panels, small wind turbines and units that convert waste into biogas.[229] Until recently, these have been supported by a 'feed-in tariff' scheme, which paid owners of small-scale generation technologies according to the electricity they generated (the generation tariff) and the amount they provided to the grid instead of using themselves (the export tariff).[230] The

224 RenewableUK, 'Onshore Wind: the UK's Next Generation' (2019), p9
225 RenewableUK, 'Onshore Wind: the UK's Next Generation' (2019), p19
226 RenewableUK, 'Onshore Wind: the UK's Next Generation' (2019), p19
227 Q259
228 Q261
229 Department for Business, Energy and Industrial Strategy, 'The Future for Small-Scale Low-Carbon Generation' (2019), p24
230 'Feed-In Tariff (FIT) rates', Ofgem, accessed 7 June 2019

market regulator, Ofgem, split the costs of the scheme across energy suppliers, who ultimately passed it on to consumers through their energy bills.[231] However, the scheme was closed to new applications on 1 April 2019.[232] Announcing its decision to close the scheme, the Government argued that "growth in the small-scale low-carbon generation sector must be sustainable; driven by competition and innovation, not direct subsidies".[233] It also explained that the feed-in tariff scheme's "fixed and flat rate export tariff does not align with the wider government objectives to move towards market-based solutions, cost reflective pricing and the continued drive to minimise support costs on consumers".[234]

70. The Government has said that around 80% of the power generation capacity supported by the feed-in tariff was in the form of rooftop solar panels.[235] The Solar Trade Association told us that, due to the "the lack of appropriate regulatory scaffolding and lack of local flexibility markets", the smart energy market was "threatened" by the closure of the feed-in tariff.[236] It reported that domestic installations of solar panels had fallen each year since 2015,[237] which is when the Government first announced that it would start winding down parts of the feed-in tariff scheme.[238] Following a survey of its members in 2018, the Renewable Energy Association reported that over 40% of UK solar installers were considering leaving the industry in response to the closure of the feed-in tariff and that 78% were considering reducing staffing levels.[239] The Association also noted that previous changes in the feed-in tariff, to reduce the tariff offered, had led to an estimated 9,000 job losses in the solar panel industry.[240] The Solar Trade Association labelled the delay between the closure of the feed-in tariff scheme and details of any successor programme "a damaging policy hiatus".[241]

71. Since closing the feed-in tariff scheme, the Government has announced that a 'Smart Export Guarantee' scheme would be set up in its place, coming into force from the end of December 2019.[242] Under the scheme, large energy suppliers will be required to offer at least one export tariff scheme to small-scale generators, but would be free to set the form (within the accepted framework) and value of the tariff per kWh supplied (subject to it being always greater than zero).[243] The Government's hope is that such a scheme would foster innovation in the smart energy market, and create the conditions for small-scale

231 Ofgem, 'Feed-in Tariffs Annual Levelisation Process (2017–2018)' (2018)
232 Ofgem, 'Feed-in Tariffs: Essential Guide to Closure of the Scheme' (2019)
233 Department for Business, Energy and Industrial Strategy, 'The Feed-In Tariffs Scheme' (2018), para 4
234 Department for Business, Energy and Industrial Strategy, 'The Feed-In Tariffs Scheme' (2018), para 14
235 'Proposals to protect consumers whilst guaranteeing payments for households with solar by unlocking smarter energy system', Department for Business, Energy and Industrial Strategy, accessed 7 June 2019
236 Solar Trade Association (CGE0053), para 6
237 Solar Trade Association (CGE0053), para 3
238 Department for Business, Energy and Industrial Strategy, 'The Feed-In Tariffs Scheme' (2018), para 10
239 Renewable Energy Association, 'New data shows significant solar job losses if full Government proposals enacted' (2018)
240 Renewable Energy Association, 'New data shows significant solar job losses if full Government proposals enacted' (2018)
241 'MPs back solar industry call for fair market payment', Solar Trade Association, accessed 11 June 2019
242 Department for Business, Energy and Industrial Strategy, 'The Future for Small-Scale Low-Carbon Generation: Response to consultations on policy proposals for a Smart Export Guarantee, and on proposed amended licence conditions' (2019), p7
243 Department for Business, Energy and Industrial Strategy, 'The Future for Small-Scale Low-Carbon Generation: Response to consultations on policy proposals for a Smart Export Guarantee, and on proposed amended licence conditions' (2019), p7

generation to be rewarded according to its market value.[244] Notwithstanding its concern with the delay between the closure of the feed-in tariff and the start of the Smart Export Guarantee, the Renewable Energy Association said that it welcomed the new scheme overall as a "positive step towards a more decarbonised, local, and cheaper power system".[245]

72. Certain details of the announced Smart Export Guarantee scheme have, however, caused industry concern. In response to the consultation on the Smart Export Guarantee scheme, the Solar Trade Association highlighted the vulnerability of households operating small-scale generation or storage systems compared to large-scale operators, as well as the potentially limited number of households with smart meters capable of fulfilling the requirements of the Smart Export Guarantee scheme.[246] It argued that, in order to safeguard the small generation market, the Government should set a "fair minimum export floor price". Dr Nina Skorupska, Chief Executive of the Renewable Energy Association, similarly told us that her Association was advocating a "framework that makes sense from a market perspective but also makes sense for a consumer or developer", and indicated that this would require a "minimum index-linked safe tariff".[247] Professor Keith Bell, co-Director of the UK Energy Research Centre, also told us that "some kind of minimum export price would be extremely useful", but accepted that "there is a bit of work to do to define what that would be".[248] In addition to advocating a minimum export price, Dr Skorupska has also said that "minimum contract lengths should be required to give future generators certainty".[249] The Durham Energy Institute also told us that the new scheme should be "guaranteed over a sufficiently long time frame to ensure that continuity, consistency and clarity releases private investment".[250]

73. In its confirmation of the Smart Export Guarantee scheme in June 2019, the Government stated that Ofgem would report annually on the uptake and nature of tariffs offered and committed itself to "monitor[ing] whether the market is delivering an effective range of options for small exporters".[251] It also commented that "since the closure of the feed-in tariff scheme, there have been encouraging early signs that a nascent export market is developing":

> Some suppliers are offering or trialling export tariffs, either in line with the wholesale price or at levels comparable with the feed-in tariff export tariff

244 Department for Business, Energy and Industrial Strategy, 'The Future for Small-Scale Low-Carbon Generation: Response to consultations on policy proposals for a Smart Export Guarantee, and on proposed amended licence conditions' (2019), p8

245 'Government confirms details and timeline for a Smart Export Guarantee', Renewable Energy Association, accessed 11 June 2019

246 Solar Trade Association, 'The Future for Small-Scale Low Carbon Generation: A Consultation on a Smart Export Guarantee—Response on behalf of the Solar Trade Association' (2019)

247 Q282

248 Q282

249 'Government confirms details and timeline for a Smart Export Guarantee', Renewable Energy Association, accessed 11 June 2019

250 Durham Energy Institute (CGE0065), para 31

251 Department for Business, Energy and Industrial Strategy, 'The Future for Small-Scale Low-Carbon Generation: Response to consultations on policy proposals for a Smart Export Guarantee, and on proposed amended licence conditions' (2019), p7

> rate. We believe that these encouraging signals show that suppliers are keen to engage in this market and meaningful and competitive offerings will come through, without government taking the role of price setting.[252]

These are, however, only early signs. The Solar Trade Association is monitoring the emergence of supplier offers for small-scale generators and so far lists just two offers from one supplier, alongside small-scale trials from two other suppliers.[253]

74. **The delay between the end of the feed-in tariff scheme and the start of the Smart Export Guarantee scheme has caused unnecessary disruption to the smart energy and small-scale generation market. Nonetheless, the move towards a framework that facilitates greater flexibility and innovation in these markets is welcome, provided it offers a fair and sufficient means of compensation for owners of small-scale renewable generation capacity and a sufficient incentive for people to make the initial investment in such technologies. *The Government must ensure that it reviews the functioning of the Smart Export Guarantee scheme by the end of 2020, and should be ready to include a minimum price floor if there is evidence of a lack of market competitivity—for example, if uptake of tariffs is not significantly greater than the current number of tariffs or if the tariffs offered are significantly lower than wholesale electricity prices.***

Business rates

75. The Solar Trade Association additionally told us that its "industry has been further dismayed by the continuation of discriminatory business rate treatment of rooftop solar [power]".[254] In 2017, the Valuation Office Agency (an executive agency sponsored by HM Revenues and Customs) revised the methodology it applied to determine the rates applied to solar power, because the technology was more established than it had been at the previous valuation.[255] This led to a sharp increase in rates, from between threefold to eightfold, for some solar power generation owners including schools and hospitals.[256] The Solar Trade Association has since negotiated reduced business rates for companies that sell the majority of the solar power they generate, but this reduction does not apply to organisations that consume what they generate themselves (despite the potential for this to be more efficient, since no electricity transmission is required).[257] Consequently, the Association now provides guidance on how companies can establish 'special purpose vehicles' so that their panels are legally distinct entities from which they can then 'buy' their electricity.[258] A spokesman for the Association has reportedly said that "firms are circumnavigating the rates by doing this, but it is administratively expensive".[259] Additionally, an exemption from business rates for microgeneration sites (those producing no more than 50kW) ended

252 Department for Business, Energy and Industrial Strategy, 'The Future for Small-Scale Low-Carbon Generation: Response to consultations on policy proposals for a Smart Export Guarantee, and on proposed amended licence conditions' (2019), p15
253 'Smart Export Guarantee League Table', Solar Trade Association, accessed 11 June 2019
254 Solar Trade Association (CGE0053), para 4
255 Solar Trade Association, 'The 2017 business rates revaluation: impact on self-owned commercial rooftop solar PV' (2016)
256 Solar Trade Association, 'Briefing: Solar Business Rates Changes'
257 Solar Trade Association and Valuation Office Agency, 'Photovoltaic Memorandum of Agreement: Revaluation 2017' (2016)
258 Solar Trade Association, 'Minimising business rates impact for rooftop solar installations in England and Wales: SPV toolkit' (2017)
259 'Rates shock for green innovators', Lombard, accessed 11 June 2019

on 31 March 2017.[260] The Solar Trade Association has called for rooftop solar panels to be classed as "excepted plant and machinery" under the business rate regulations,[261] to match the exception already applied to combined heat and power units.[262]

76. **The Government must make sure that business rates incentivise embedded low-carbon generation and do not cause existing embedded generation to be disconnected.** ***The Government should reduce business rates for organisations that consume the majority of the power they generate to match the rates of organisations that sell the majority of their generation—and stop the administrative burden of loopholes that are being used to counter the discrepancy in rates. The Government should also reinstate the microgeneration exemption from business rates for renewable energy installations producing no more than 50kW. In its response to this Report, the Government should set out why combined heat and power units have been classed as excepted plant and machinery under the business rate regulations, but such a provision is not applied to solar panels and energy storage systems.***

Network charge reforms

77. Despite discussion of the closure of the feed-in tariff and the business rate rises, Dr Skorupska, Chief Executive of the Renewable Energy Association, told us that "the biggest challenge to small-scale renewables are the grid reforms".[263] This refers to Ofgem's proposals to change how the costs of electricity networks are recovered (see Box 2). This has been prompted by Ofgem's concern that "the current framework for residual charging may result in inefficient use of the networks":

> As a result of changes in technology and other factors, some network users are increasingly able to adjust the timing and volume of their production and/or consumption of electricity, reducing their exposure to charges. Therefore current residual charges will increasingly fall on those network users who are not able to do this. Those who are less likely to be able to adjust their consumption are likely to include residential and small business consumers in general and more vulnerable consumers in particular.[264]

Ofgem has therefore proposed introducing a fixed charge so that consumers pay only according to their 'customer segment' rather than the extent to which they use the network.[265] In addition to protecting vulnerable consumers, Ofgem has argued that this could save consumers £0.5–1.6bn by 2040.[266]

260 The Valuation for Rating (Plant and Machinery) (England) (Amendment) Regulations 2008 (SI 2008/2332)
261 Solar Trade Association, 'Budget Briefing' (2017)
262 The Valuation for Rating (Plant and Machinery) (England) (Amendment) Regulations 2001 (SI 2001/846)
263 Q282
264 Open letter from Ofgem, 4 August 2017
265 Ofgem, 'Targeted charging review: minded to decision and draft impact assessment' (2018)
266 Ofgem, 'Targeted charging review: minded to decision and draft impact assessment' (2018), pp5–6

Box 2: Network costs

The costs associated with building, maintaining and operating electricity networks are currently recovered through two main charges levied on electricity consumers (through their bills): 'forward-looking charges'; and 'residual charges'.

Forward-looking charges are based on projected use of the network whereas **residual charges** are applied retrospectively to recover any costs not recovered through forward-looking charges. The overall costs, incorporating both components, are determined through Ofgem's price controls, which set the total revenue the network companies are allowed to earn.

Ofgem has said that "residual charges are not intended to send signals or provide incentives to use networks in any particular way", which is instead the role of the forward-looking charges.

Source: Ofgem, 'Targeted charging review: minded to decision and draft impact assessment' (2018)

78. The Solar Trade Association has warned, however, that "a flat, fixed rate will dampen the price signal sent to consumers to encourage the uptake of technologies, products and behaviours that encourage flexibility".[267] Following the publication of Ofgem's proposals, six relevant trade associations, including the Renewable Energy Association and the Association for Decentralised Energy, issued a joint statement arguing that the proposals ran "contradictory to Government's ambition to decarbonise the energy system and create a market for flexibility".[268] Ofgem itself has estimated that the average domestic consumer using solar power with energy storage could see network charges increase from £25 per year to £64 per year, while small- to medium-sized enterprises using on-site generation and storage could see charges increase from £204 per year to £1,099 per year.[269]

79. **Ofgem must consider the interests of future consumers as well as current consumers in its decisions, including the need for decarbonisation. The projected increases in network costs for consumers and businesses that have installed on-site generation and flexibility technologies, arising from Ofgem's proposed network charging reforms, will act as a disincentive for further consumers or enterprises to install similar technologies. This is not conducive to the overall goal of decarbonisation. However, Ofgem is right to seek to avoid the costs of network usage falling increasingly on vulnerable consumers. *Ofgem must revise its proposed network charging reforms to ensure that they do not disincentivise the deployment of technologies that will contribute to the decarbonisation of the UK's energy system. The Government must ensure that vulnerable consumers do not pay an increasing proportion of network costs, and that all households have the ability to deploy technologies that will reduce their cost of energy and help to decarbonise the economy.***

267 Solar Trade Association, 'Press Release: United against the TCR', 6 February 2019

268 Letter from BEAMA, Association for Decentralised Energy, techUK, Renewable Energy Association, Solar Trade Association and RenewableUK to Rt Hon Greg Clark, 4 February 2019

269 Ofgem, 'Targeted charging review: minded to decision and draft impact assessment' (2018), p47

Nuclear power

Conventional nuclear power

80. The Intergovernmental Panel on Climate Change has estimated that the full lifecycle emissions associated with nuclear power are significantly lower than coal or gas power, less than solar power and comparable to wind power.[270] In 2017, nuclear power accounted for 21% of the UK's electricity generation.[271]

81. The UK currently has eight nuclear power plants, of which seven are planned to close by 2030.[272] These seven have a generation capacity of 7.7GW, or 87% of existing nuclear capacity.[273] One new plant, at Hinkley Point in Somerset, is currently under construction, which should provide 3.2GW of capacity by 2025.[274] There are proposals for new plants at Sizewell, in Suffolk, and at Bradwell, in Essex, which would be expected to provide a further 3.2GW and 2.3GW of generation capacity respectively.[275] However, plans for new reactors at Moorside, in Cumbria, Wylfa, in Anglesey, and Oldbury, in Gloucestershire, have reportedly been recently suspended.[276] The Minister for Energy and Clean Growth, Claire Perry MP, explained that:

> You have to spend taxpayers' money wisely. Given the precipitous decline [in costs], particularly in other renewable technologies, it became apparent that some of the financial proposals put forward for Wylfa in particular were just not good value for money, but those negotiations and conversations continue.[277]

The National Infrastructure Commission estimated in 2018 that the "average cost of the electricity system as a whole between 2030 and 2050 is broadly comparable between investing heavily in nuclear power stations or investing heavily in renewables".[278] However, it noted that whereas cost-reductions for renewable power technologies have had a track record of outperforming expectations, nuclear power costs have displayed "no discernible trend in construction costs over time". This appears to be substantiated by historic evidence.[279] Dr Robert Gross, co-Director of the UK Energy Research Centre, similarly told us that there was no evidence of cost reductions in nuclear power outside of East

270 Intergovernmental Panel on Climate Change, 'Climate Change 2014: Mitigation of Climate Change—Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change' (2014), p539
271 Department for Business, Energy and Industrial Strategy, 'Digest of United Kingdom Energy Statistics 2018' (2018), p117
272 'Country Nuclear Power Profiles: United Kingdom', International Atomic Energy Agency, accessed 12 June 2019
273 'Country Nuclear Power Profiles: United Kingdom', International Atomic Energy Agency, accessed 12 June 2019
274 'About Hinkley Point C', EDF Energy, accessed 12 June 2019
275 'Sizewell C proposals', EDF Energy and 'Bradwell B Project Website', CGN and EDF Energy, both accessed 12 June 2019
276 'Toshiba's UK withdrawal puts Cumbria nuclear plant in doubt', BBC News, 8 November 2018 and 'Nuclear plant in Anglesey suspended by Hitachi', BBC News, 17 January 2019
277 Q441
278 National Infrastructure Commission, 'National Infrastructure Assessment' (2018), p36
279 J. Lovering *et al.*, 'Historical construction costs of global nuclear power reactors', Energy Policy vol 91 (2016)

Asia.[280] Looking forward, however, the Energy Systems Catapult told us that "UK nuclear new build has very significant cost reduction potential",[281] provided that the Government could work with stakeholders to provide "schedule and budget certainty".[282]

82. Tom Greatrex, Chief Executive of the Nuclear Industry Association, told us that "it is the cost of capital that has the biggest single impact" on the cost of nuclear power, and said that the viability of future nuclear projects would be "determined largely by how much progress is made on adopting a more appropriate financing model".[283] In November 2018, the Secretary of State for Business, Energy and Industrial Strategy, Greg Clark MP, said that the Government was exploring alternative financing models for new nuclear plants.[284] In particular, he mentioned a 'Regulated Asset Base' model, which would provide a return to investors determined by an independent regulator (see Box 3). Professor Dieter Helm, of Oxford University, has said that such a model was "second best" behind direct Government procurement, but accepted that since direct procurement was essentially "ruled out by the Treasury imposed constraints", the Regulated Asset Base model was "both plausible and preferable to the Hinkley model" (the main alternative).[285] In contrast, the National Infrastructure Commission has cautioned that "there is limited experience of using the regulated asset base model for anything as complex and risky as nuclear [power]" and said that "it is not clear what the best model" for financing new nuclear power projects would be.[286] Dr Gross told us that a new nuclear power station "could be cheaper than Hinkley", but that in order to achieve this the Government would need to "take a public stake in the ownership" of the plant.[287]

Box 3: The Regulated Asset Base model

Under the Regulated Asset Base model, an independent regulator manages the return on investment that investors in the construction of an infrastructure asset receive. This return on investment is recovered from consumers. In the case of a nuclear power station, this would be through consumers' energy bills. Depending upon the details of the model used, investors can start to receive their return on investment during the construction of the power plant. This can increase the attractiveness to investors, who currently must invest many years before the plant will start generating power and therefore income. Different models either involve investors accepting all of the risks of the project not being completed (in return for a greater return on investment) or the risk being shared between investors and consumers. A Regulated Asset Base model has been used to fund construction of the Thames Tideway Tunnel project.

Sources: National Audit Office, 'Hinkley Point C' (2017), Appendix 4; Professor Helm, 'The Nuclear RAB Model', Energy Futures Network Paper 27 (2018); and National Audit Office, 'Review of the Thames Tideway Tunnel' (2017)

280 Qq275–276
281 Energy Systems Catapult (CGE0029), para 24
282 Energy Technologies Institute, 'The ETI Nuclear Cost Drivers Project: Summary Report' (2018)
283 Qq238 and 271
284 'After the trilemma—4 principles for the power sector', speech by Rt Hon Greg Clark MP, 15 November 2018
285 Professor Helm, 'The Nuclear RAB Model', Energy Futures Network Paper 27 (2018)—the "Hinkley model" refers to the financing used for Hinkley Point C, the main element of which was a contract for difference agreed directly between the Government and the NNB Generation Company that developed the power station, see: National Audit Office, 'Hinkley Point C' (2017), paras 1.2–1.5
286 National Infrastructure Commission, 'National Infrastructure Assessment' (2018), p38
287 Q281

83. The Secretary of State for Business, Energy and Industrial Strategy told Parliament in January 2019 that the Government intended to publish its assessment of the Regulated Asset Base model for new nuclear power projects "by the summer at the latest".[288] Tom Greatrex told us that there was "real urgency" in the need for a decision from the Government on future financing models for nuclear power,[289] and highlighted one timepoint in particular:

> There is a point at which you can, in a relatively straightforward way, transfer the supply chain [from Hinkley to Sizewell] and use the same equipment while the supply chain is in place. That means EDF needs to make a final investment decision, probably in 2021–22, so that needs a policy framework in the next year or so to be able to be in a sufficiently strong position to deliver that project, get the maximum cost reduction and make that contribution to help replace the fleet, most of which is going off by 2030.[290]

This aligns with the National Infrastructure Commission's recommended "one by one" approach to new nuclear plants, in which the UK seeks to maintain—but not grow—its nuclear industry and supply chains, by planning to be building no more than one new nuclear plant at a time.[291]

84. **Although it is not possible to directly compare the costs of different power generation technologies, the Government is right to support nuclear power subject to it representing value for money, because full lifecycle emissions from nuclear power will help the UK to achieve its emissions reduction targets.** ***The Government must make a decision on implementing a regulated asset base framework for nuclear power by the end of this year. Subject to value for money, the Government should seek to support new nuclear power generation so as to sustain, but not grow, the UK's nuclear power industry. It must anticipate any gap in future generation capacity such a policy would cause, and support sufficient renewable power alternatives to fill the gap.***

Small modular nuclear reactors

85. Small modular nuclear reactors (SMRs) are made of standardised factory-manufactured parts delivered ready for assembly,[292] although Tom Greatrex clarified that "SMRs are used as a catch-all term for a whole range of different technologies".[293] SMRs may offer nuclear power at lower cost than conventional nuclear power plants because of their amenability to mass manufacture, as a result of their size and standardisation. Rolls-Royce, a major developer of SMRs, told us that these reactors "offer a convincing alternative to the uncertainties of large nuclear new build in the UK" and said that it was "prepared to invest in [an SMR development] programme, if matched by Government support".[294]

288 Rt Hon Greg Clark MP, 'Statement on suspension of work on the Wylfa Newydd nuclear project', 17 January 2019
289 Q238
290 Q278
291 National Infrastructure Commission, 'National Infrastructure Assessment' (2018), p39
292 'Small Modular Nuclear Reactors', POSTnote 580, Parliamentary Office of Science and Technology, July 2018
293 Q273
294 Rolls-Royce Plc (CGE0039), Executive Summary and paras 1.4–1.6

86. The Government's 'Expert Finance Working Group on Small Nuclear Reactors' recently concluded that the UK "could be well placed to develop first-of-a-kind small reactors projects".[295] It made seven recommendations for Government action to support development of SMRs in the UK, including:

- providing resources for 'first of a kind' demonstrator projects, in exchange for intellectual property and other rights that "investors would expect";
- working with stakeholders from the energy, nuclear and finance sectors to develop a common understanding of the risks associated with SMR projects, to remove perceptions of risks that have so far acted as barriers to investment;
- establishing an advanced manufacturing supply chain initiative for SMRs, similar to the initiative launched for offshore wind; and
- developing nuclear regulations adapted to SMRs.[296]

87. One component of the Government's Nuclear Sector Deal was a new framework for SMRs, with the Government providing up to £56m to support the research and development of advanced nuclear technologies and stating its intention to "bring together vendors, utilities, energy intensive users and the finance sector to further develop credible commercial propositions that could be financed by the private sector" in response to the Expert Finance Working Group's recommendations for developing first-of-a-kind projects.[297] Tom Greatrex indicated that "the whole range" of recommendations from the Expert Finance Working Group "need to be implemented if [the UK wants] to try to have the opportunity of small modular reactors".[298]

88. **The Government's support for small modular nuclear reactors in the Nuclear Sector Deal is welcome.** ***The Government must ensure that it delivers on the recommendations from the Expert Finance Working Group on Small Nuclear Reactors, including on regulatory developments, without undue delay. The Government should set out, in its response to this Report, what steps it has taken since the publication of the Group's report and propose a pathway—with indicative dates for key milestones—for the deployment of a first-of-a-kind small modular nuclear reactor by 2030.***

Nuclear fusion

89. Conventional nuclear power and small modular nuclear reactors generate power from nuclear fission, which is the separation of heavy elements into lighter ones.[299] An alternative is to generate power from nuclear fusion, which is the production of heavier elements from light ones.[300] Tokamak Energy Ltd described the following benefits of nuclear fusion:

295 Expert Finance Working Group on Small Nuclear Reactors, 'Market framework for financing small nuclear' (2018), p4
296 Expert Finance Working Group on Small Nuclear Reactors, 'Market framework for financing small nuclear' (2018), p5
297 HM Government, 'Industrial Strategy: Nuclear Sector Deal' (2018), pp21–23
298 Q274
299 'New Nuclear Power Technologies', POSTnote 457, Parliamentary Office of Science and Technology, February 2014
300 'Nuclear Fusion', POSTnote 192, Parliamentary Office of Science and Technology, January 2003

> Fusion energy from tokamaks will be clean and safe. There is no emission of carbon from combustion, no long-lived radioactive waste and no risk of meltdown or proliferation. There is plentiful fuel for mankind's total needs for millennia.[301]

Professor Jim Skea, of Imperial College London, told us however that the "problem" with nuclear fusion was that "while fusion has stayed 30 or 40 years in the future, other things like nuclear fission and renewable energy have achieved that kind of goal in the shorter term".[302] The Engineering and Physical Sciences Research Council has said that although "the timeline for delivery is beyond the 2050 emission target, fusion is an attractive technology that needs to be developed".[303]

90. The UK has a national nuclear fusion programme at the Culham Centre for Fusion Energy, which also hosts the Joint European Torus (currently the most powerful magnetic fusion device in the world) on behalf of the EUROfusion consortium funded as part of EURATOM 2020.[304] Both programmes receive funding from the EU under the EURATOM treaty. The Government confirmed in 2017 its intention to leave EURATOM as it leaves the EU.[305] The Government signed an agreement with the European Commission in March 2019 to keep the Joint European Torus open until the end of 2020, securing at least €100m in additional inward investment from the EU.[306]

91. Tokamak Energy Ltd, which aims to accelerate the development and deployment of fusion energy, told us that it had now attracted over £50m of private investment but argued that the Government should "do more to encourage stronger private investment in fusion energy development", flagging recent developments in the USA:

> The US Nuclear Energy Innovation and Modernization Act (NEIMA) was passed in January 2019. It explicitly includes fusion in the definition of "advanced nuclear reactor" and provides for establishment of a regulatory framework for advanced nuclear power plants, including fusion, by December 2027.[307]

Acknowledging the UK Atomic Energy Authority's recently announced 'Spherical Tokamak for Energy Production' project that aims to design and build a compact fusion power station in the UK by 2040,[308] Tokamak Energy Ltd nevertheless argued that the Government should "do more to encourage stronger private investment in fusion energy development, for example by matching some of the legislative and policy measures used in the USA to encourage private ventures to develop fusion technology and future fusion power plants".[309]

301 Tokamak Energy Ltd (CGE0004), para 3
302 Q408
303 'Fusion', Engineering and Physical Sciences Research Council, accessed 9 July 2019
304 'Culham Centre for Fusion Energy', Culham Centre for Fusion Energy, accessed 9 July 2019
305 European Union (Notification of Withdrawal) Act 2017, section 1 and HM Government, 'Explanatory Notes: European Union (Notification of Withdrawal) Act 2017' (2017), chapter 9
306 'Future of JET secured with new European contract', Department for Business, Energy and Industrial Strategy, accessed 9 July 2019
307 Tokamak Energy Ltd (CGE0075), para 5
308 'Spherical Tokamak opportunities', Nuclear Advanced Manufacturing Research Centre, accessed 9 July 2019
309 Tokamak Energy Ltd (CGE0075), paras 6 and 9–11

92. **Nuclear fusion is unlikely to make a substantial contribution to the UK's net-zero target for 2050. Nevertheless, it could ultimately provide significant quantities of energy from abundant fuels and without radioactive waste.** ***The Government must ensure that, whatever the terms of the UK's departure from the European Union, the long-term future of nuclear fusion research in the UK is not disrupted. It should additionally review the case for providing support for the nuclear fusion industry similar to the measures introduced recently by the US Government.***

5 Decarbonising transport

93. Domestic transport (i.e. excluding international aviation and shipping originating or arriving in the UK) was responsible for around 27% of the UK's territorial greenhouse gas emissions in 2018.[310] It was the only major sector of the UK energy system to have increasing emissions over the course of the last carbon budget.[311] The Committee on Climate Change stated in 2018 that the transport sector was "significantly off-track from the cost-effective path" for meeting the UK's emissions targets.[312] In this Chapter we, focus on emissions from road transport, and the targets and policies the Government should adopt to help to decarbonise the UK's road transport system.

Internal combustion engine vehicles

Fiscal incentives

94. The Committee on Climate Change has suggested that the main reason for the recent increase in transport emissions has been growing demand for car and van travel combined with slowing efficiency gains.[313] This is borne out by statistics published by the Department for Transport in 2018, which showed that the distances driven in cars and vans, and overall emissions from cars and vans, have both been steadily growing since 2013.[314] This is despite the fact that, according to the Centre for Research into Energy Demand Solutions, there "remains substantial potential for improvement" in the efficiency of conventional cars and vans in the "short to medium term".[315] The Society of Motor Manufacturers and Traders told us that average new car emissions in the UK rose by 0.8% from 2016 to 2017, the first rise in emissions on record.[316] It estimated that 55% of this was attributable to consumers buying less efficient models and 45% to consumers switching from diesel to petrol cars. For example, registrations of superminis fell 14.3% from 2016 to 2017, while registrations of SUVs grew 5.1%.[317] In its 2018 progress report to Parliament, the Committee on Climate Change recommended that the Government implement stronger fiscal incentives to encourage consumers to buy lower emitting vehicles.[318]

95. Car owners must currently pay vehicle excise duty, which varies by carbon emissions and fuel type.[319] When the car is registered, the duty applied covers a spectrum from £0 to £2,135 according to fuel type and emissions. However, from the second year onwards the standard rate is £145, £135 or £0 for petrol and diesel cars, 'alternative fuel' cars, and fully electric cars respectively.[320] Although these rates favour vehicles with lower emissions,

310 Department for Business, Energy and Industrial Strategy, '2018 UK Greenhouse Gas Emissions, Provisional Figures' (2019), p6
311 Committee on Climate Change, '2018 Progress Report to Parliament', p16
312 Committee on Climate Change, '2018 Progress Report to Parliament', p147
313 Committee on Climate Change, '2018 Progress Report to Parliament', p147
314 Department for Transport, 'Transport Statistics: Great Britain 2018' (2018), pp4 and 8
315 Centre for Research into Energy Demand Solutions (CGE0070), para 15
316 Society of Motor Manufacturers and Traders (CGE0030), para 10
317 Society of Motor Manufacturers and Traders, 'New Car CO2 Report 2018' (2018), p5—the average new SUV emits 27.6% more carbon dioxide per km than the average new supermini
318 Committee on Climate Change, '2018 Progress Report to Parliament', p176
319 'Vehicle tax rates', HM Government, accessed 18 April 2019
320 'Vehicle tax rates', HM Government, accessed 18 April 2019—alternative fuel vehicles include hybrids and those that run on bioethanol and liquid petroleum gas

Andy Eastlake, Managing Director of the Low Carbon Vehicle Partnership, told us that he thought the Government had "undermined the use of vehicle excise duty as a tool in driving CO_2 behaviour":

> There is significant CO_2-related vehicle excise duty in the first year. Very few people see that because it is wrapped up in the price of their vehicle or their lease. Eighty-five per cent of vehicles are financed in some way; these days, not many people buy a vehicle with cash. The used car market is where vehicle excise duty potentially has more power and capability, and now there is a flat-rate vehicle excise duty for anything other than a zero-emission electric vehicle.[321]

96. **There is significant scope for emissions reductions in the transport sector as a result of the purchase of more efficient vehicle models, without requiring technological developments or alternative fuel sources. However, the current fiscal incentives for cars are not sufficient to encourage consumers to purchase lower-emissions vehicles, given that most of the increase in average new car emissions in 2017 was caused by consumers choosing more emitting models. *The Government must reconsider the fiscal incentives for consumers to purchase both new and used vehicle models with lower emissions, and develop a strategy by the time of the Spring Statement 2020 to use vehicle excise duty and other incentives to drive the purchase of vehicle models with lower average emissions. This must include consideration of post-sales vehicle excise duty and the second-hand market.***

Emissions regulations

97. Under EU law, the UK currently has legislation setting maximum average emissions standards for cars and vans.[322] This aims for average car emissions to drop to 95g of CO_2 per km by 2020 (compared to 161gCO_2/km in 2006). The EU has recently agreed new standards requiring a further reduction on 2021 levels of 15% by 2025 and 37.5% by 2030.[323] These will come into force on 1 January 2020. This is after the UK's scheduled departure from the EU, meaning that the standards would not automatically be incorporated into UK law on exit day.[324] The European Parliament has also approved the European Commission's proposals for new legislation regarding emissions from heavy-duty vehicles.[325] This would require a 15% reduction in average new truck emissions by 2025 and a 30% reduction by 2030 compared to 2019.[326] The Government informed us that since "new heavy duty vehicle CO2 regulation has yet to be finalised and adopted by the EU", its implementation in the UK "will depend on when this is achieved and the terms on which the UK leaves the EU".[327] Prior to the EU's new standards being agreed, the UK Government stated that, in

321 Q123—with tax rates of £145 applied to petrol and diesel cars and £135 applied to hybrid cars or those powered by bioethanol and liquid petroleum gas, there is not strictly speaking a "flat rate" duty for all cars other than a zero-emission vehicle

322 Council and Parliament Regulation (EU) No 333/2014 and Council and Parliament Regulation (EU) No 510/2011

323 Council and Parliament Regulation (EU) 2019/631—these standards will be weakened slightly for manufacturers whose new car sales are at least 35% zero- or low-emission by 2030

324 European Union (Withdrawal) Act 2018, section 3

325 European Parliament, 'Results of Plenary votes', 18 April 2019

326 European Parliament, 'CO2 emission standards for heavy-duty vehicles' (2019)

327 Department for Transport (CGE0088)

the context of Brexit, it "will pursue a future approach to vehicle emissions regulation that is at least as ambitious as the current arrangements",[328] but it is not clear whether or not this commitment applies to regulations that the EU has since agreed.

98. ***The Government must commit, prior to the UK's withdrawal from the European Union, to adopting transport emissions regulations that are, as a minimum, in line with current and future EU regulations on transport emissions. This should include legislation regarding emissions reductions requirements for heavy duty vehicles, regardless of the terms of the UK's departure from the EU.***

Ultra-low emissions vehicles

The Government's targets

99. The Government's stated long-term ambitions for decarbonising road transport are for:

- between 50% and 70% of new car sales and "up to 40%" of new van sales being ultra-low emission by 2030;[329]
- no sales of new conventional petrol and diesel cars and vans by 2040; and
- "almost every car and van" to be zero emission by 2050.[330]

The Government has said that "the 2040 ambition is consistent with [the UK's original overall decarbonisation] target" (to achieve 80% decarbonisation compared to 1990, by 2050).[331] However, Professor Jim Watson, Director of the UK Energy Research Centre, told us that "the 2040 target for phasing out fossil vehicles is just not ambitious enough".[332] Modelling undertaken by the UK Energy Research Centre projected that a 2040 ban "may neither hit the [original 2050 emissions reductions] target nor make the early gains needed for a 1.5°C trajectory".[333] Instead, it suggested that a 2040 ban would have to include hybrid as well as conventional cars in order to meet the UK's existing targets, and that this ban would have to be brought forward to 2030 in order to align with a pathway to 1.5°C global warming.[334] Lord Deben, Chairman of the Committee on Climate Change, similarly told us that if the Government did "not bring those dates forward, the contribution that is necessary from the electrification of motor vehicles will not be sufficient to meet the requirements of the budgets".[335] We heard from several other witnesses who also advocated an earlier ban.[336] The Committee on Climate Change has recommended that the Government's planned ban both be brought forward, to "2035

328 HM Government, 'Delivering Clean Growth: Progress Against Meeting Our Carbon Budgets—The Government Response to the Committee on Climate Change' (2018), p45

329 The Office for Low Emission Vehicles currently defines an 'ultra low emission vehicle' to be one that emits less than 75g of carbon dioxide from the tailpipe per kilometre driven measured against the European test cycle; the Government has said that it "expect[s]" to tighten this criterion to 50g from 2021—Department for Transport, 'Road to Zero' (2018), p24

330 Department for Transport, 'The Road to Zero' (2018), p2

331 Department for Transport (CGE0088)

332 Q79

333 UK Energy Research Centre, 'Review of Energy Policy: 2018' (2018), p8

334 C. Brand and J. Anable, ''Disruption' and 'continuity' in transport energy systems: the case of the ban on new conventional fossil fuel vehicles', ECEEE Summer Study Proceedings (2019)

335 Q23

336 For example, see: OVO Energy (CGE0007), para 6.6; E.ON (CGE0036), para 35; Qq116 and 118

at the latest", and cover "any car or van with petrol or diesel combustion engines" (*i.e.* including hybrid vehicles).[337] When we asked the Government for the basis on which it disagreed with the Committee on Climate Change and other stakeholders with regards to the date of the ban, it declined to explain.[338]

100. Conversely, the Society of Motor Manufacturers and Traders told us that is was "concerned about the significantly high ambition levels that have been set for the uptake of ultra-low and zero emission cars and vans […] by 2030".[339] However, Professor Watson countered that although "some car manufacturers say that it is terribly difficult […] that is what companies say when faced with something challenging".[340] Indeed, some manufacturers, such as Nissan and Volvo, appear to have set themselves more ambitious targets than the UK's current targets (both are aiming for electric vehicles to make up half of their sales in Japan and Europe by 2025).[341] Numerous countries, including Norway, India, China, Slovenia, Austria, Israel, the Netherlands, Ireland, Denmark and Scotland, also have more ambitious targets than the UK's current targets (with prospective bans starting between 2025 and 2035),[342] undermining the Government's statement to us that it seeks to "maintain the UK's leadership position".[343] Both the UK Energy Research Centre and the Committee on Climate Change have said that an earlier ban on conventional vehicle sales would deliver not only emissions reductions but also economic benefit to the UK.[344]

101. The Government's ultimate goal is for "almost every car and van" to be zero emission by 2050.[345] In order for this to be consistent with a 2040 target for banning the sales of conventional vehicles, this would require the scrappage of many cars at a maximum age of 10 years. In contrast, the Society of Motor Manufacturers and Traders reports that the current average age of scrappage is 14 years and that this has been rising since 2009.[346] This average age would suggest that a ban by at least 2036 would be required to meet the overall aim of a zero-emission vehicle fleet by 2050.

102. **The Government has said that a 2040 ban on the sale of conventional cars and vans is consistent with the UK's current emissions reductions targets for 2050, but this has been disputed by independent organisations such as the UK Energy Research Centre and the Committee on Climate Change. There is a strong case for bringing the date for a future ban forward, given that several manufacturers already have more ambitious commitments in place. *The Government should act on the advice of the Committee on Climate Change and bring forward the proposed ban on sales of new conventional cars and vans to 2035 at the latest. This ban should explicitly cover hybrid as well as internal combustion engines.***

337 Committee on Climate Change, 'Net Zero: The UK's contribution to stopping global warming' (2019), pp198–200
338 Department for Transport (CGE0088)
339 Society of Motor Manufacturers and Traders (CGE0030), para 5
340 Q80
341 'Nissan aims to sell 1 million electrified vehicles a year by FY2022', Nissan and 'Volvo Cars aims for 50 per cent of sales to be electric by 2025', Volvo, both accessed 10 June 2019
342 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p167 and 'Denmark embraces electric car revolution with petrol and diesel ban plan', Reuters, 2 October 2018
343 Department for Transport (CGE0088)
344 Q79 and Committee on Climate Change, 'Net Zero: The UK's contribution to stopping global warming' (2019), pp198–200
345 Department for Transport, 'The Road to Zero' (2018), p2
346 Society of Motor Manufacturers and Traders, '2018 UK Automotive Sustainability Report' (2018), p23

Ultra-low emissions vehicle uptake

103. The Committee on Climate Change has determined a pathway of annual electric vehicles sales that it estimates would be indicative of sufficient progress towards the UK's long-term emissions targets.[347] Sales of electric cars are currently falling behind these volumes, with the shortfall growing each year since 2014.[348] Andy Eastlake, Managing Director of the Low Carbon Vehicle Partnership, also warned us that electric vehicle uptake "is not increasing at the rate that we probably need to see to deliver the trajectory defined in the 'Road to Zero' [strategy]".[349] A 2018 survey of British consumers by Deloitte reported the following consumer concerns as barriers to increased uptake of electric vehicles:

- driving range (26% of consumers);
- cost (24%);
- lack of charging infrastructure (22%); and
- the time required to charge (13%).[350]

Other surveys have reported different proportions of consumers for each concern, but found the same concerns.[351] Over time, technological improvements in electric vehicles are expected to improve the range, costs and charging time characteristics.[352] Nevertheless, there is a role for the Government to play in addressing these consumer concerns.[353]

Charging infrastructure

104. Concerns regarding range, charging time and charging infrastructure are all related to the availability of chargepoints. Although the Government has said that the UK has "one of the largest, and most comprehensive rapid [chargepoint] networks in Europe",[354] and is spending £1.5bn on support for zero-emission vehicles,[355] PwC has noted that "public charging infrastructure in the UK […] has not [evolved] at the same rate as the electric vehicle stock".[356] Whereas the number of electric vehicles has grown at close to a 100% compound annual growth rate since 2012, the equivalent rate for the number of chargepoints available has been 44%. Several submissions to our inquiry, including from the Society of Motor Manufacturers and Traders and UK Research and Innovation, argued

347 Committee on Climate Change, '2009 Progress report to Parliament' (2009), p101 and Committee on Climate Change, '2018 Progress Report to Parliament' (2018), Supporting Data Table 5.13

348 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p166 and Supporting Data Table 5.13; Department for Transport, 'Vehicle Licensing Statistics: Annual 2018' (2019), p1; Committee analysis

349 Q99

350 Deloitte, 'New Market, New Entrants, New Challenges: Battery Electric Vehicles' (2018), p6

351 For example, see: Department for Transport, 'Public attitudes towards electric vehicles: 2016' (2016), p7; and National Franchised Dealers Association (CGE0073), para 23

352 Automotive Council UK, 'The Roadmap Report—Towards 2040: A Guide to Automotive Propulsion Technologies' (2018), p30

353 See, for example: Drax Group plc (CGE0025), paras 13–16; Society of Motor Manufacturers and Traders (CGE0030), para 20; Royal Academy of Engineering and allied institutions (CGE0055), para 6.2

354 Department for Transport, 'Road to Zero' (2018), p90

355 Q435

356 PwC, 'Charging ahead! The need to upscale UK electric vehicle charging infrastructure' (2018), p3

that better charging infrastructure was required to drive uptake of electric vehicles,[357] and the Government itself has stated that "it is clear that […] many more public chargepoints will be needed" and that "the consumer experience of public electric vehicle charging needs to be improved".[358]

105. National Grid identified five types of location that would require chargepoints:

- at home;
- on streets, for those without on-site parking at home;
- at common destinations such as places of work;
- at local fast-charging stations; and
- along the motorway network.[359]

National Grid advised that with just 54 charging stations in total, placed at appropriate points along the strategic road network, 99% of drivers in England and Wales would be within 50 miles of a chargepoint, regardless of the direction in which they were travelling.[360] It estimated that this could be delivered at a cost of £0.8bn, which it said equated to 65p per year, for all registered road vehicles, over the 40-year lifetime of the assets.[361] However, it warned that "investment will be needed by industry and enabled by government":

> Whilst the private sector has ambitions to invest in the 'connection to car' [the chargepoint itself], and we will support the wider grid reinforcement, there is a risk that the 'connection to the grid' [between the chargepoint and the existing grid infrastructure] may not take place until mass market electric vehicle adoption kicks in. Without some targeted intervention in this specific area, there is a risk that the roll-out will not happen fast enough, or with sufficient capacity to be able to meet the needs of the increasing number of cars that will require charging.[362]

National Grid has suggested that the costs for this infrastructure could be recovered either through the private sector charging more for motorway charging, through vehicle excise duty or car tax, from consumers' electricity bills or from general taxation.[363] Highways England has committed £15m to ensure that its users are within 20 miles of a rapid chargepoint along 95% of the strategic road network in England, but as of July 2018 it had only issued grants to two local authorities and received applications from a further four.[364]

357 For example, see: ABB (CGE0010), section 4.0; National Grid (CGE0019), paras 3.11–3.18; Drax Group plc (CGE0025), paras 14–16; Society of Motor Manufacturers and Traders (CGE0030), paras 23–24; Environmental Defense Fund Europe (CGE0042), para 6; ChargePoint (CGE0054), para 4.2; Royal Academy of Engineering and allied institutions (CGE0055), paras 6.2 and 50; UK Research and Innovation (CGE0058), para 9; Durham Energy Institute (CGE0065), para 8; National Franchised Dealers Association (CGE0073), paras 23–29

358 Department for Transport, 'Road to Zero' (2018), p82

359 National Grid (CGE0019), para 3.12

360 National Grid (CGE0019), para 3.13

361 National Grid (CGE0019), para 3.14

362 National Grid (CGE0019), paras 3.17–3.18

363 National Grid, 'Electric vehicle charging: Enabling the switch' (), p5

364 Department for Transport, 'Road to Zero' (2018), p97

106. Several submissions, including from the Royal Academy of Engineering and allied institutions, highlighted the importance of local charging.[365] The Government has set aside £4.5m grant funding for local authorities to deliver on-street charging.[366] The Royal Academy of Engineering and allied institutions told us that "ensuring local authorities take up government funding schemes" would be important to the acceleration of a chargepoint roll-out.[367] Another particular aspect that was commonly raised was the importance of interoperability between different chargepoint networks.[368] The National Franchised Dealers Association told us that of the fourteen major chargepoint networks in the UK, only three were interoperable, which meant that electric vehicle drivers "will likely need a subscription to multiple operators to ensure that they can recharge their cars when travelling longer distances".[369] It pointed to market solutions to this being developed in the USA, and to the 'Open Charge Point Protocol' being developed in the Netherlands, but warned that "there is little sign of a wide-ranging private sector interoperability agreement being implemented in the UK".[370]

107. In its latest review of potential future 'energy scenarios', National Grid stated that all of its possible scenarios "assume strong growth in electric vehicles".[371] Although it anticipated this placing up to 30% extra demand for total energy on the grid by 2050, it estimated that 'smart' charging (where electric vehicles respond to current electricity demand to shift their charging to periods of low demand) could reduce the corresponding increase in peak power demand to just 9%.[372] Ofgem argued that, managed correctly, electric vehicles' potential ability to "act as storage where they are able to export electricity to the grid" at times of peak demand could add flexibility to the UK energy system and assist in its management.[373] EDF Energy cautioned that, in order for this to be the case, it would be "critical to ensure that the majority of electric vehicles are charged smartly for the majority of the time":

> This is an achievable outcome that can be based on technology that is already available. The roll-out of smart meters and half hourly settlement in the domestic sector should facilitate a greater adoption of smart charging. However, while off-peak charging will be cheaper, the convenience of fast charging options, at any time of day, means that a smart outcome for the system as a whole is not guaranteed. Government and stakeholders should therefore continue to promote smart outcomes and technology and monitor progress in this area.[374]

365 For example, see: National Grid (CGE0019), para 3.12; Drax Group plc (CGE0025), para 15 and Royal Academy of Engineering and allied institutions (CGE0055), para 50
366 Department for Transport, 'Road to Zero' (2018), p85
367 Royal Academy of Engineering and allied institutions (CGE0055), para 50
368 For example, see: Society of Motor Manufacturers and Traders (CGE0030), para 24; Royal Academy of Engineering and allied institutions (CGE0055), para 50; National Franchised Dealers Association (CGE0073), paras 24–29
369 National Franchised Dealers Association (CGE0073), paras 24–25
370 National Franchised Dealers Association (CGE0073), paras 26–27
371 National Grid System Operator, 'Future Energy Scenarios' (2018), p72
372 National Grid System Operator, 'Future Energy Scenarios' (2018), p82
373 Ofgem (CGE0033), para 30—similar points were made by, among others: E.ON (CGE0036), para 20; Centre for Research into Energy Demand Solutions (CGE0070), para 21
374 EDF Energy (CGE0020), para 15

108. The Automated and Electric Vehicle Act 2018 introduced powers for the Government to regulate the provision of public electric vehicle charging points and hydrogen refuelling points in order to:

- standardise aspects of these points (such as the components used to connect vehicles to the points, or the payment methods used);
- require large fuel retailers or service area operators to provide refuelling points; and
- require operators of such points to publish and share information regarding the location and current status of those points.[375]

There were also provisions in the Act for the Government to regulate all charge points so that they were 'smart', meaning that they could receive, transmit, process and react to relevant information.[376] In addition to these powers, Tanya Sinclair, Policy Director UK and Ireland for ChargePoint, highlighted powers enabled by the Act to penalise companies whose charging points were unreliable.[377] However, the Government has not yet introduced any regulations permitted by the Act. Ms Sinclair told us that the Government now "need to switch on those powers".[378] The Government indicated to us that it intends to consult on its powers to regulate smart charging "in the coming months with a view to laying the regulations by early next year".[379]

109. **The availability of chargepoints is a significant factor in consumer uptake of electric vehicles. Although the extent of the UK's charging infrastructure is growing, it is not expanding at a pace to match the roll-out of electric vehicles. Interoperability of different chargepoint networks will be required to avoid the need for a roll-out of multiple extensive networks. Widespread adoption of electric vehicles will not necessarily require an unmanageable increase in power generation requirements, but in order for the electricity demand from widespread electric vehicles to be more comfortably met, and in order for electric vehicles to contribute to increased grid flexibility, smart charging will have to be commonplace.**

110. ***The Government must ensure sufficient roll-out of rapid chargepoints along the strategic road network, and smart chargepoints at domestic, destination (such as places of work or shopping centres) and local sites. It should work with public services and owners of public land, such as schools and hospitals, to accelerate the deployment of chargepoints. The Government's forthcoming consultation on the regulation of charging infrastructure must determine measures to deliver interoperability, compatibility with a smart energy system, public availability of real-time information on the current functionality of chargepoints, and enforcement powers to ensure that chargepoints are reliable.***

375 Automated and Electric Vehicles Act 2018, Part 2
376 Automated and Electric Vehicles Act 2018, section 15
377 Q129
378 Q129
379 Department for Transport (CGE0088)

Costs and other sales barriers

111. Electric cars typically have higher upfront costs but lower running costs compared to conventional cars. Deloitte has estimated that the overall cost of owning an electric vehicle would reach parity with conventional vehicles by around 2021–2024;[380] some studies, such as that from Palmer *et al.*, have suggested that the overall costs of electric vehicles can already be lower than conventional vehicles.[381] The Government offers a 'plug-in grant' of £3,500 for vehicles with emissions of less than 50g of carbon dioxide per km and a zero emission range of at least 70 miles.[382] The grant was previously £4,500 and a smaller grant was available for low-emission vehicles with less impressive emissions characteristics, but this was changed in October 2018.[383] The Government explained that this change would "focus our funding on the cleanest vehicles, and ensure that the grant remains sustainable as the UK market for ultra low emission vehicles develops". However, the Society of Motor Manufacturers and Traders told us that the plug-in grant had "been an essential lever" in encouraging the uptake of low-emissions vehicles and said the Government's decision was "a shock to the industry and risks damaging the market and further confusing consumers as to which technology to buy".[384] Since the changes to the Plug-In Grant, overall sales of low-emission cars have fallen for the first time in 26 months (although fully electric vehicles sales have continued to grow),[385] which Mike Hawes, Chief Executive of the Society for Motor Manufacturers and Traders, has described as a "grave concern":

> Manufacturers have invested billions to bring these vehicles to market but their efforts are now being undermined by confusing policies and the premature removal of purchase incentives. If we are to see widespread uptake of these vehicles, which are an essential part of a smooth transition to zero emission transport, we need world-class, long-term incentives and substantial investment in infrastructure.[386]

Prior to the cutback of the grant, the Green Alliance, a charitable environmental think tank, had said that although the Government should "plan to reduce the subsidy per electric vehicle as costs fall", international experience demonstrated that this should be done "according to a transparent formula" to avoid shocks to the market.[387]

112. **It is disappointing that the Government cut back the plug-in grant with electric vehicle sales below the indicative target set by the Committee on Climate Change. *The Government should set out, by the time of the Spring Statement 2020, how it intends to adjust the plug-in grant scheme in the future, using a transparent framework linked to ultra-low emissions vehicles sales.***

380 Deloitte, 'New Market, New Entrants, New Challenges: Battery Electric Vehicles' (2018), p8
381 K. Palmer *et al.*, 'Total cost of ownership and market share for hybrid and electric vehicles in the UK, US and Japan', Applied Energy vol 209 (2018)
382 'Changes to the Plug-in Car Grant', Office for Low Emissions Vehicle, accessed 13 June 2019
383 'Changes to the Plug-in Car Grant', Office for Low Emissions Vehicle, accessed 13 June 2019
384 Society of Motor Manufacturers and Traders (CGE0030), para 20
385 'Bump in the road to zero as low emission car demand reverses in June', Society of Motor Manufacturers and Traders, accessed 4 July 2019—see also monthly registration data published by the Society of Motor Manufacturers and Traders
386 'Bump in the road to zero as low emission car demand reverses in June', Society of Motor Manufacturers and Traders, accessed 4 July 2019
387 Green Alliance, 'How the UK can lead the electric vehicle revolution' (2018), p9

113. In an attempt to reduce the running costs of electric vehicles, the Scottish Government has developed a public network of chargepoints that are mostly free to use, subject to a one-off £20 registration fee.[388] Sales of electric vehicles in Scotland grew by 67% in 2017 compared to 24% in England, but a lower proportion of overall vehicles sales in Scotland were of electric cars than in England.[389] Scotland also has fewer ultra-low emissions vehicles per head than England overall.[390]

114. ***The Government should evaluate the impact of the free charging offered by the ChargePlace Scotland charging network as well as other potential incentive schemes for electric vehicle use.***

115. Almost half of new car registrations in the UK were fleet vehicles (purchased in bulk for uses such as rental cars, company cars or taxis) in 2018.[391] Andy Eastlake, Managing Director of the Low Carbon Vehicle Partnership, highlighted these as a particular target for fiscal incentives, arguing that "it is far more difficult to change an emotional purchase of an SUV for the school run than it is a company for a necessary vehicle for which there are potentially more tools in place that we could use to drive adoption".[392] However, he said that company car taxation had been "significantly disrupted" with recent decisions, noting that 'benefits in kind' tax on a fully electric vehicle would rise to 16% in 2019/20 before falling to 2% in 2020/21.[393] The Government explained this by saying that it wanted to provide long-term certainty by maintaining previously announced rates,[394] although this contrasts with its willingness to change the plug-in grant at short notice.[395]

116. The Green Alliance has also argued that the Government should target the fleet vehicle market—including the Government's own car fleet—given that this sector could more easily offset the high upfront costs of electric vehicles against their low running costs.[396] It specifically recommended that:

- the Government increase its electric vehicle commitment from 25% of the central Government fleet by 2022 to 100% of the central and local government fleets; and
- the Government commit to maintaining zero-rated vehicle excise duty for ultra-low emissions vehicles until 2022, and consider extending it to hybrid vehicles.[397]

The Government has since stated its intention for 100% of the central Government car fleet to be electric by 2030,[398] and announced that it had already reached almost 23%.[399] The European Parliament has approved the European Commission's proposals for new

388 'Electric Vehicles and ChargePlace Scotland', Energy Saving Trust, accessed 13 June 2019
389 Committee on Climate Change, 'Reducing emissions in Scotland: 2018 Progress Report to Parliament' (2018), p59
390 Department for Transport, 'Vehicle licensing statistics: 2018' (2019), Table 0131
391 'Car Registrations', Society of Motor Manufacturers and Traders, accessed 18 April 2019
392 Q127
393 Q125—see also Office for Low Emissions Vehicles, 'Tax benefits for ultra low emission vehicles' (2018), paras 4.1–4.7
394 Business, Energy and Industrial Strategy Committee, Fifteenth Special Report of Session 2017–2019, 'Electric vehicles: driving the transition: Government Response to the Committee's Fourteenth Report of Session 2017–19', HC 1881, p8
395 'Changes to the Plug-in Car Grant', Office for Low Emissions Vehicle, accessed 13 June 2019
396 Green Alliance, 'How the UK can lead the electric vehicle revolution' (2018), p7
397 Green Alliance, 'How the UK can lead the electric vehicle revolution' (2018), p8
398 Department for Transport, 'Road to Zero' (2018), p60
399 'Transport Secretary leads the way in transition to a zero-emission future', Department for Transport, accessed 17 June 2019

legislation regarding the proportion of low-emissions vehicles in publicly-procured fleets of vehicles.[400] This includes a range of measures to promote the public procurement of low-emissions vehicles including minimum proportions of vehicles procured to be low-emissions.[401] We asked the Government if it intended to adopt regulations at least as ambitious as any such regulations adopted by the EU post-Brexit, but it declined to comment.[402]

117. **Uptake of ultra-low emissions vehicles can potentially be driven in the fleet vehicle market more quickly than in the private consumer market. Options for supporting the uptake of ultra-low emissions vehicles in the fleet vehicle market include fiscal incentives and public procurement targets. *The Government should commit to adopting regulations on the public procurement of ultra-low emissions vehicles that are at least as ambitious as the EU's post-Brexit. It should further commit to having a 100% ultra-low emissions vehicle fleet by 2022 and to supporting local authorities in also having 100% ultra-low emissions fleets by 2030.***

118. Alongside cost as a barrier to consumer uptake, the Committee on Climate Change has reported "increasing evidence that production volumes [of electric vehicles] are insufficient, with demand outstripping supply for many models, resulting in long waiting times".[403] The European Federation for Transport and Environment, a sustainable transport advocacy group, has similarly argued that the low take-up of electric vehicles was partly due to manufacturers allocating insufficient resources to meeting demand as well as spending disproportionately little on marketing.[404] Evidence from elsewhere in Europe suggests that car dealers are also dismissive of electric vehicles, misinforming shoppers on vehicle specifications, omitting electric vehicles from the sales conversation and strongly orienting customers towards petrol and diesel vehicle options.[405] The Committee on Climate Change therefore recommended in 2018 that the Government reviewed the electric vehicle market, to "establish whether the willingness of manufacturers and dealers to sell electric vehicles is a barrier to uptake".[406]

119. The Environmental Defense Fund Europe, an environmental non-profit organisation, highlighted ultra-low emissions vehicles sales mandates in China and various US states and recommended that the UK adopt a similar approach.[407] The Green Alliance has also recommended that the UK adopt zero-emissions vehicle sales targets, using a tradeable credit scheme so that manufacturers could sell 'surplus' zero-emissions vehicle sales certificates to competitors.[408] Research in Canada suggested that a mandate on manufacturers to ensure that 30% of their sales were of ultra-low emissions models by 2030 would be achievable and reduce the cost to the Government compared to a consumer-

400 European Parliament, 'Results of Plenary votes', 18 April 2019
401 European Parliament, 'Review of the Clean Vehicles Directive' (2019)
402 Department for Transport (CGE0088)
403 Letter from Lord Deben to Rt Hon Chris Grayling MP and Rt Hon Greg Clark MP, 11 October 2018
404 European Federation for Transport and Environment, 'Carmakers still failing to hit their own goals for sales of electric cars' (2018)
405 G. Zarazua de Rubens *et al.*, 'Dismissive and deceptive car dealerships create barriers to electric vehicle adoption at the point of sale', Nature Energy vol 3 (2018)
406 Letter from Lord Deben to Rt Hon Chris Grayling MP and Rt Hon Greg Clark MP, 11 October 2018
407 Environmental Defense Fund Europe (CGE0042), para 4—see also Bloomberg, 'China Is About to Shake Up the World of Electric Cars', 14 November 2018 and Bloomberg, 'Colorado Joining California in Mandating Electric-Vehicle Sales', 17 January 2019
408 Green Alliance, 'How the UK can lead the electric vehicle revolution' (2018), p9

incentive driven strategy.[409] Although recently adopted EU regulations (see paragraph 97 of this Report) introduced ultra-low emissions sales targets on manufacturers, these targets are voluntary.[410]

120. **One current barrier to the uptake of ultra-low emissions vehicles in the UK is an insufficient supply to meet consumer demand, which has led to long waiting times. There is evidence in the UK and internationally suggesting that this could be partly due to inadequate support for the ultra-low emissions vehicle market from manufacturers and dealers.** ***The Government should review the functioning of the ultra-low emissions vehicles market annually, to determine if there are sufficient incentives for manufacturers and dealers to drive the adoption of ultra-low emissions vehicles, with the first review published by the time of the Spring Statement 2020. This should include consideration of the value of introducing minimum sales mandates on manufacturers, using tradeable sales certificate framework.***

Heavy goods vehicles

121. Heavy goods vehicles (HGVs) and buses are responsible for around 27% of all road transport emissions.[411] The Government has agreed a voluntary ambition with the HGV industry of reducing emissions across the sector by 15% by 2025, compared to 2015 levels.[412] This is intended to be achieved through a variety of measures such as driver training, the use of aerodynamic equipment and the adoption of more efficient tyres. The Government has not, however, set any longer-term targets for HGVs, in contrast to its targets for cars and vans. The National Infrastructure Commission has recommended that the Government should commit to decarbonising road freight by 2050, and announce plans by the end of 2021 to ban the sale of new diesel-powered HGVs no later than 2040.[413] It described this as a "challenging" but "possible" target, and indicated that a ban on sales of new diesel-powered HGVs by 2040 would be required in order for the whole fleet to be zero-emissions by 2050, in keeping with the Government's overall net-zero emissions targets.[414] This aligns with the average age of HGVs at scrappage, which has rarely fallen below 11 years since at least 2000.[415]

122. There are a variety of different potential technologies that could enable zero-emissions HGVs.[416] Whereas the Committee on Climate Change has said that "battery electric vehicles are now well placed to deliver the bulk of decarbonisation for cars and vans", it is less clear that electrification of HGVs is the optimal technological option.[417] The Royal Academy of Engineering and allied institutions explained that because "batteries have a relatively low power density and long charging time, battery electric heavy duty freight

409 J. Axsen and M. Wolinetz, 'Reaching 30% plug-in vehicle sales by 2030: Modeling incentive and sales mandate strategies in Canada', Transportation Research Part D vol 65 (2018)
410 Council and Parliament Regulation (EU) 2019/631—see also: European Parliament, 'CO2 standards for new cars and vans' (2019)
411 Department for Business, Energy and Industrial Strategy, '2017 UK greenhouse gas emissions: final figures–data tables' (2019)
412 Department for Transport, 'The Road to Zero' (2018), p62
413 National Infrastructure Commission, 'Better Delivery: The Challenge for Freight' (2019), pp29–36
414 National Infrastructure Commission, 'Better Delivery: The Challenge for Freight' (2019), p36
415 Society of Motor Manufacturers and Traders, '2018 UK Automotive Sustainability Report' (2018), p23
416 National Infrastructure Commission, 'Better Delivery: The Challenge for Freight' (2019), pp29–32
417 Committee on Climate Change, 'Hydrogen in a low-carbon economy' (2018), p8

is unlikely to be feasible".[418] However, Andy Eastlake, Managing Director of the Low Carbon Vehicle Partnership, told us that "we have not got to the point where we should be trying to pick a winner".[419]

123. In 2018, the Committee on Climate Change recommended that the Government develop a strategy for decarbonising heavy goods vehicles, which it said would "necessitate small-scale trial deployments of hydrogen HGVs in a variety of fleets prior to [the second half of the 2020s], in the UK or elsewhere".[420] The Government's 'Road to Zero' strategy said that the Government would conduct research into low-emissions technologies for HGVs "with a view to ultimately performing full-scale demonstrator trials on the UK road network if appropriate technologies are identified".[421] However, ULEMCo, a company that converts HGVs to run on hydrogen, told us that it "already supports a fleet of vehicles across a range of hydrogen hubs in the UK", suggesting that Government support could already go beyond early-stage research.[422] In addition to trials of different technologies, the National Infrastructure Commission has recommended that the Government should work with distribution and transmission network operators to "prepare detailed assessments of the infrastructure required to enable the uptake of battery electric or hydrogen HGVs, including the refuelling requirements at depots and key rest areas on major freight routes".[423]

124. **A ban on the sale of new diesel-powered heavy-goods vehicles will be needed by 2040 in order for the sector to achieve net-zero emissions by 2050. This will require policies now that will drive the development of alternative technologies and demonstrate the technical feasibility of such a ban.** ***The Government should introduce a ban on the sale of new diesel-powered heavy goods vehicles, for no later than 2040. It should additionally support trials of low-emissions HGV technologies on a timeframe that aligns with the proposed ban, and work with network operators and the delivery industry to plan for the potential charging infrastructure required for zero-emissions HGVs. Given that some HGVs are already being converted to run on hydrogen on a commercial basis, the Government should review the opportunity for market support mechanisms to drive higher rates of HGV conversion.***

The current and future transport system

125. Andy Eastlake, Managing Director of the Low Carbon Vehicle Partnership, noted that emissions were generated over the full lifecycle of a vehicle, not just as it travels.[424] Indeed, research for the European Parliament estimated that manufacturing accounts for around 23% of an internal combustion engine vehicle's lifetime emissions, and can account for as much as 80% of an electric vehicle's lifetime emissions depending upon the source of the electricity used to charge the vehicle.[425] In addition to the emissions associated with manufacturing, the availability of some of the materials required to make the batteries

418 Royal Academy of Engineering and allied institutions (CGE0055), para 53
419 Q151
420 Committee on Climate Change, 'Hydrogen in a low-carbon economy' (2018), p14
421 Department for Transport, 'The Road to Zero' (2018), p66
422 ULEMCo Ltd (CGE0005), paras 1.3 and 2.2
423 National Infrastructure Commission, 'Better Delivery: The Challenge for Freight' (2019), p36
424 Qq104–109
425 European Parliament, 'Research for TRAN Committee—Battery-powered electric vehicles: market development and lifecycle emissions' (2018), p43

used in electric vehicles has also raised concern (see also Box 4).[426] Mr Eastlake argued that in the long term, "we probably do not want 40 million very large electric cars circulating on our roads in the same way as we have 40 million vehicles currently":[427]

> Our objective is not to have a lot of zero-emission vehicles on the road, but to have zero-emission mobility. That can be delivered through a combination of buses, cars, small L-category vehicles—not the current type—rail and trams. We need to deliver a mobility system, not a fleet of vehicles.[428]

Box 4: Material resources required for electric batteries

Electric vehicle batteries typically require specific materials in their manufacturing, including lithium, cobalt, graphite and nickel. The United States Geological Survey reported in 2019 that, globally, there was an estimated 62m tonnes of lithium, 25m tonnes of cobalt, over 800m tonnes of graphite and at least 130m tonnes of nickel that could be economically extracted (continued resource exploration may well cause these figures to increase over time). Compared to the quantities of these materials used in an average electric vehicle battery, this would equate to the amounts needed for at least 2.3bn cars or around 30 years of the current global car production output. The European Commission has further noted that the recycling potential for electric vehicle batteries is "significant".

The Geological Society warned us, however, that "as it stands, there are no significant lithium or cobalt mines online anywhere in Europe", leaving "many long-term supply questions in the context of a booming industry, unanswered". The European Commission has said that "building up and strengthening EU activity in battery material supply is imperative to reduce the EU's future dependence on imported battery component materials for cell manufacturing".

Amnesty International has additionally noted that more than half of the world's cobalt sources are in the Democratic Republic of the Congo, where mining can be poorly regulated and dangerous, and is frequently carried out by children using hand tools. It has called for greater transparency in supply chains so that the origin of cobalt can be better traced.

Source: The Geological Society (CGE0051), para 6; European Commission, 'Report on Raw Materials for Battery Applications' (2018); United States Geological Survey, 'Mineral Commodity Summaries 2019' (2019); European Parliament, 'Research for TRAN Committee—Battery-powered electric vehicles: market development and lifecycle emissions' (2018), p23; Diekmann *et al.*, 'Ecological Recycling of Lithium-Ion Batteries from Electric Vehicles with Focus on Mechanical Processes', Journal of the Electrochemical Society vol 164 (2017); 'Estimated worldwide automobile production from 2000 to 2018', Statista, accessed 4 July 2019; Amnesty International, 'This Is What We Die For' (2016)

126. The Royal Automobile Club Foundation for Motoring has reported that the average car is parked 96.5% of the time and is in use only 3.5% of the time.[429] There is therefore significant scope to increase the proportion of the time that each vehicle is used, with consequent reductions in the total number of vehicles required and hence the emissions associated with their manufacture. This would require shared ownership or use of vehicles, which the Society of Motor Manufacturers and Traders told us was already how the automotive industry expected urban transport to develop:

426 The Geological Society (CGE0051), para 6
427 Q105
428 Q117
429 Royal Automobile Club Foundation for Motoring, 'Spaced Out: Perspectives on parking policy' (2012), p23

> In recent years, a clear shift from traditional vehicle ownership to usership has emerged. Individual access to vehicles is still generally the preferred option […] However, new technologies, linked to smart phones, etc. have led to a proliferation of pay-as-you-go schemes, such as car clubs or on-demand mobility services. Many automotive companies are recognising this shift and embracing the new opportunities offering their own services or partnering with other service providers.[430]

The Commission on Travel Demand, an independent working group funded by UK Research and Innovation, has also noted recent increases in car-sharing, but reported that this had "yet to lead to any transition away from personal car ownership".[431] Indeed, the number of vehicles per capita in Great Britain has increased by around 5% since the 2012 recession.[432] The Aldersgate Group, an alliance of multiple UK businesses across various sectors, has recommended that:

> The Government should update its procurement framework so that all departments, agencies, local authorities and public bodies investigate whether they can save money and reduce their transport emissions by replacing their fleets with membership of an existing car club scheme.[433]

It noted that Croydon Council had found that it could save on costs and emissions by doing this, with employees having exclusive use of cars in a shared fleet during working hours and the public able to use the cars as part of a car club outside of working hours.[434] The Minister of State for Transport, Michael Ellis MP, told us that reduced congestion through more efficient use of road space, including through ridesharing, was one of nine key principles identified by the Government's 'Future of Mobility Urban Strategy', and said that the Government was "considering whether setting shared mobility targets would be appropriate".[435]

127. One important factor in consumers' decisions to purchase a vehicle or not would be the availability, quality and cost of public transport, alternative options such as walking and cycling, and car share schemes. The Government's Clean Growth Strategy highlighted £37bn of investment in public transport between 2011 and 2016 and listed ambitions to make buses and trains more efficient, but did not specify any ambition or policies for encouraging greater use of public transport.[436] Campaign for Better Transport, a charitable transport campaign group, has noted that funding for supported bus services in England and Wales had fallen by around 45% since 2010.[437] The Government also published a 'Cycling and Walking Investment Strategy' in 2017,[438] and told us that "almost £2bn of investment is projected over this Spending Review period to 2020/21 to increase cycling and walking".[439] However, the Committee on Climate Change has argued that

430 Society of Motor Manufacturers and Traders (CGE0030), para 26
431 Commission on Travel Demand, 'All Change? The future of travel demand and the implications for policy and planning' (2018), p30
432 Department for Transport, 'Vehicle Licensing Statistics: 2013' (2014), p5 and Department for Transport, 'Vehicle Licensing Statistics: Annual 2018' (2019), p9
433 Aldersgate Group, 'Shifting Emissions into Reverse Gear: Priorities for Decarbonising Transport' (2019), pp19–21
434 See also: 'Croydon council cuts employee car usage in half with Zipcar', Zipcar, accessed 9 July 2019
435 Department for Transport (CGE0088)
436 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), pp83–92
437 'Buses in Crisis, 2018', Campaign for Better Transport, accessed 17 June 2019
438 Department for Transport, 'Cycling and Walking Investment Strategy' (2017)
439 Department for Transport (CGE0088)

"the continued rise in road transport emissions highlights the urgent need for stronger policies to reduce growth in demand for travel".[440] The Government admitted that the estimated impact of all sustainable travel interventions since 2009 was for a reduction in the number of car kilometres travelled per year of just 0.5% by 2021.[441]

128. With regards to influencing travel choices, the relative costs of private and public transport are important. On this front, Andy Eastlake told us that "fuel duty, which has been frozen for over 10 years, is another [policy] that sends a very strong message".[442] Whereas fuel duty has been frozen since 2009, rail prices and bus prices have risen every year over the same period.[443] Although the RAC has questioned whether or not increasing fuel duty would decrease demand given that some consumers might be unable to adapt their transport,[444] a 2014 evidence review found that there was a correlation between fuel duty and car use.[445] Together, the nine previous freezes in fuel duty are estimated to have increased traffic and carbon emissions by 4% (as well as costing the Treasury over £6bn per year).[446]

129. Andy Eastlake highlighted that because electric vehicles do not pay fuel duty, "there is no doubt that, if we deliver on our objectives, that will be a significant hole in Treasury finances", and said that the Government had not articulated how it would address this.[447] Fuel duties raised £27.9bn for the Government in 2017/18.[448] Policy Exchange, a think tank, has calculated that if the UK were to follow the Committee on Climate Change's recommended route to meeting its emissions reductions targets, fuel duty revenues in 2030 would be between £9bn and £23bn lower than the Office for Budget Responsibility has assumed.[449] Several stakeholders, such as the National Infrastructure Commission and the Aldersgate Group, have recommended the introduction of a 'road pricing' system that would use increased vehicle connectivity and other technological developments to monitor road users and charge them according to where and when they drove.[450] Both argued that such a system could help to reduce congestion, support a transition to car usership and incentivise more sustainable travel choices. The Centre for London has suggested that a similar system could be integrated with public transport such as buses and trains, and could promote as well as incentivise sustainable journey options.[451]

130. Tim Lord, Director of Clean Growth at the Department for Business, Energy and Industrial Strategy, told us that the Government understood that instead of replacing conventional cars with electric cars, it had to rethink "how we move around and mak[e]

440 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p153
441 Department for Transport (CGE0088)
442 Q99
443 Office of Rail and Road, 'Rail Fares Index (January 2019): Statistical Release' (2019), p1 and Department for Transport, 'Annual bus statistics: England 2017/18' (2019), p12
444 'RAC statement on 'The Unintended Consequences of Freezing Fuel Duty' report', RAC Media Centre, 1 June 2018
445 RAND Europe, 'Road traffic demand elasticities' (2014)
446 Greener Journeys, 'The Unintended Consequences of Freezing Fuel Duty' (2018), p7 and Institute for Fiscal Studies, 'Tax and benefit measures' (2017)
447 Q120
448 Office for Budget Responsibility, 'Economic and fiscal outlook: March 2019' (2019), p76
449 Policy Exchange, 'Driving Down Emissions' (2017), p85
450 National Infrastructure Commission, 'National Infrastructure Assessment' (2018), pp119–120 and Aldersgate Group, 'Shifting Emissions into Reverse Gear: Priorities for Decarbonising Transport' (2019), p35—see also Centre for London, 'Green Light: Next Generation Road User Charging for a Healthier, More Liveable, London' (2019)
451 Centre for London, 'Green Light: Next Generation Road User Charging for a Healthier, More Liveable, London' (2019)

sure that we are doing that much more efficiently",[452] highlighting the 'Future of Mobility' grand challenge in the Industrial Strategy.[453] However, the associated 'mission' addressed only the manufacturing and deployment of low-emissions vehicles, not wider changes to the transport system.[454] Furthermore, the Government's major targets for decarbonising transport—as set out in the 'Road to Zero' strategy—focus on tailpipe emissions and the sales of ultra-low emissions vehicles rather than lifecycle emissions or the emissions of the transport system as a whole.[455] Mr Eastlake therefore told us that the Government's "metrics certainly are not right for the very long term".[456]

131. **The Government's current long-term targets for decarbonising transport focus heavily on reducing exhaust emissions and increasing sales of low-emissions vehicles, rather than delivering a low-emissions transport system. In the long-term, widespread personal vehicle ownership does not appear to be compatible with significant decarbonisation.** ***The Government should not aim to achieve emissions reductions simply by replacing existing vehicles with lower-emission versions. Alongside the Government's existing targets and policies, it must develop a strategy to stimulate a low-emissions transport system, with the metrics and targets to match. This should aim to reduce the number of vehicles required, for example by: promoting and improving public transport; reducing its cost relative to private transport; encouraging vehicle usership in place of ownership; and encouraging and supporting increased levels of walking and cycling. The Government should commit to ensuring that the annual increase in fuel duty should never be lower than the average increase in rail or bus fares.***

132. ***Any move to electric vehicles must have an associated environmental impact assessment, including the potential for recycling lead, lithium, cobalt, nickel and graphite. Hydrogen technology may prove to be cheaper and less environmentally-damaging than battery-powered electric vehicles. The Government should not rely on a single technology.***

133. ***The Government should review the potential to reduce emissions and support shared car ownership by incorporating Government Department car fleets into car sharing schemes. It should encourage other public bodies and local authorities to do likewise.***

Last-mile deliveries

134. The growth in emissions from road transport has been driven by increases in miles travelled by vans as well as cars,[457] which has been attributed to the rise of online retail, economic growth in sectors that make most use of vans (such as construction, retail and food) and a shift from using heavy goods vehicles to vans instead.[458] The Aldersgate Group, an alliance of multiple UK businesses across various sectors, has highlighted the potential role for 'urban consolidation centres'—"warehouses located on the edge of urban areas where deliveries from a variety of retailers are consolidated by destination"—

452 Q490
453 HM Government, 'Industrial Strategy' (2017), pp48–51
454 'The Grand Challenge missions', Department for Business, Energy and Industrial Strategy, accessed 12 June 2019
455 Department for Transport, 'The Road to Zero' (2018), p2
456 Q104
457 Department for Transport, 'Transport Statistics: Great Britain 2018' (2018), p8
458 Committee on Climate Change, '2018 Progress Report to Parliament: Chapter 5 Annex—Growth in Van Demand' (2018)

in decarbonising freight, to improve the efficiency of 'last mile' freight deliveries.[459] The National Infrastructure Commission has also stated that "consolidation centres have shown that they can reduce freight trips into congested areas", but warned that "commercial viability and industry appetite remain challenges to roll out".[460] It recommended:

> Where the business case supports consolidation centres, authorities should use the planning system to make land available and consider the case for funding land and construction or subsidising operations in the short term. The case for consolidation centres can be made stronger by building incentives for operators to make use of them, through planning restrictions on new build properties and giving consolidated services preferential regulatory treatment such as reduced loading/unloading restrictions at the kerbside.[461]

We have also heard of the potential for electric-powered unmanned drones to provide last-mile deliveries, generating lower emissions than conventional land-based delivery modes.[462]

135. The Government has consulted on sustainable last-mile deliveries,[463] but its response focused heavily on low-carbon modes of transport such as e-cargo bikes and electric vans rather than approaches to adapt last-mile delivery systems, such as through the use of consolidation zones.[464] Nevertheless, in response to our enquiries, the Government told us that it would "seek to support the increased provision and availability of micro distribution hubs whilst recognising the importance of ensuring such facilities are supported by local bodies".[465] It referred to the National Planning Policy Framework, which stated that "planning policies and decisions should recognise and address the specific locational requirements of different sectors [including …] for storage and distribution operations at a variety of scales and in suitably accessible locations",[466] and said that it was exploring how the learning from two case studies in Southampton and Manchester could best be promoted.

136. **We commend the Government on its existing work to support the establishment and use of urban delivery consolidation zones. However, with just two major examples of completed projects to point to, there is clearly scope for a wider roll-out. *The Government should support the development of urban delivery consolidation centres, working with local authorities to assess the potential of such centres to reduce emissions and identify strategies to support their deployment and effective use.***

459 Aldersgate Group, 'Shifting Emissions into Reverse Gear: Priorities for Decarbonising Transport' (2019), pp13 and 15
460 National Infrastructure Commission, 'Better Delivery: The Challenge for Freight' (2019), p12
461 National Infrastructure Commission, 'Better Delivery: The Challenge for Freight' (2019), p13
462 Oral evidence taken before the Science and Technology Committee on 26 June 2019, HC 2021, Q281
463 Department for Transport, 'The Last Mile: A Call for Evidence on the opportunities available to deliver goods more sustainably' (2018)
464 Department for Transport, 'Government Response to Call for Evidence: The Last Mile—Delivering goods more sustainably' (2019)
465 Department for Transport (CGE0088)
466 Ministry of Housing, Communities and Local Government, 'National Planning Policy Framework' (2019), para 82

6 Decarbonising heating

137. Domestic, commercial and industrial heating is responsible for around a third of the UK's overall emissions,[467] which is unchanged from 2009.[468] Adjusting for environmental temperature, the UK's residential emissions have remained essentially unchanged since 2013.[469] There are two basic technical ways to reduce the carbon emissions associated with heating, either the reduction of demand through energy efficiency measures or the replacement of fossil fuel heating systems to less carbon-intensive versions. This Chapter examines what progress has been made so far, and what more could be done on each of those fronts.

A low-carbon heating strategy

138. There are a range of low-carbon heating technologies, including:

- heat pumps—these use electricity to transfer heat from the outside environment (either the air or the ground) into a building, using a similar process to a fridge in reverse. Heat pumps 'move' heat rather than generating it, offering high efficiencies in principle. Decarbonisation of electric power generation would then reduce the emissions associated with heating by heat pumps.[470]

- low-carbon gas—'biomethane' can be produced from waste, with emissions reductions compared to natural gas depending upon the waste used. Alternatively, hydrogen can be burned for heat, producing only water vapour (rather than carbon dioxide). However, it is not found naturally and therefore must be produced.[471]

- hybrid heat systems—which combine heat pumps, to be used for routine heating, with gas boilers to provide extra power at peak demand.[472]

- heat networks—which supply heat from a central source to consumers, via a network of underground pipes carrying hot water. The networks can span small clusters of buildings or whole cities. The heat can come from burning natural gas, use waste heat from industrial processes or use low-carbon generation technologies.[473]

Reviewing these different technological options, the Government said in its Clean Growth Strategy that "at present it is not certain which [low-carbon heat] approaches or combination of them will work best at scale and offers the most cost-effective long-term

467 Department for Business, Energy and Industrial Strategy, 'Clean Growth—Transforming Heating: Overview of Current Evidence' (2018), p3

468 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), p9 and Department of Energy and Climate Change, 'Emissions from Heat: Statistical Summary' (2012), p3

469 Department for Business, Energy and Industrial Strategy, 'Alternative Format 2018 UK greenhouse gas emissions: provisional figures—data tables' (2019), Table 4

470 For more information, see: 'Residential Heat Pumps', POSTnote 426, Parliamentary Office of Science and Technology, January 2013

471 For more information, see: 'Decarbonising the Gas Network', POSTnote 565, Parliamentary Office of Science and Technology, November 2017

472 For more information, see: National Grid System Operator, 'Future Energy Scenarios' (2018), pp70–71

473 For more information, see: Department for Business, Energy and Industrial Strategy, 'What is a heat network?' (2017)

answer".[474] Many submissions to our inquiry, such as those from Energy UK and the UK Energy Research Centre, agreed that it was not clear which low-carbon heating options would be most suitable in the longer-term, and several, including from National Grid, stressed that a balance of different technologies in different situations was likely to be the most effective solution.[475]

139. Amidst this technological uncertainty, Duncan Burt, Director of Operations, for National Grid System Operator, told us that the decarbonisation of heat was "the one big problem left to crack for the UK",[476] and said that there was a "need for a very clear pathway for decarbonised heat to be established".[477] He added that "the development of inter-seasonal storage [should be considered] alongside decarbonisation of the heat market" as "the two go intrinsically together".[478] Other witnesses agreed with the need for a heat decarbonisation strategy,[479] including Professor Tim Green of the Imperial College Energy Futures Lab, who emphasised that instead of "developing a strategy and then doing trial deployments […] the first plank of the strategy is that we have to try some of these things".[480] The Government has recognised this need for evidence-gathering, stating in its Clean Growth Strategy that it would "need to lay the groundwork this Parliament so we are ready to make decisions in the first half of the next decade about the long term future of how we heat our homes",[481] and stating in 2018 that its "initial next steps" for decarbonising heating in the UK would include:

- the development of "plans for a substantial new project to demonstrate modern electric heating solutions across a range of building types and consumers"; and
- collaboration with industry, academia and other key stakeholders to "progressively build up a comprehensive programme of work to demonstrate the technical and practical feasibility of using hydrogen in place of natural gas for heating".[482]

140. Despite these plans, the Committee on Climate Change argued in May 2019 that "over ten years after the Climate Change Act was passed, there is still no serious plan for decarbonising UK heating systems and no large-scale trials have begun for either heat pumps or hydrogen".[483] Reflecting the Committee on Climate Change's focus on large-scale trials, we heard repeatedly of the importance of trials at scale for potential low-carbon heating technologies.[484] Malcolm Brinded, representing the Royal Academy of Engineering and allied institutions, explained, for example, that "it is not about testing the technology but about testing a system":

474 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), p75
475 For example, see: National Grid (CGE0019), paras 3.5–3.6; Energy UK (CGE0024), para 9; Calor (CGE0027), para 11; SGN (CGE0040), para 1; UK Energy Research Centre (CGE0057), para 18—see also: National Infrastructure Commission, 'National Infrastructure Assessment' (2018), p44
476 Q336
477 Q312
478 Q312
479 Qq60 and 335–336—see also: Drax Group plc (CGE0025), para 7
480 Q336
481 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), p75
482 Department for Business, Energy and Industrial Strategy, 'Clean growth: transforming heating—overview of current evidence' (2018), pp 122–123
483 Committee on Climate Change 'Net Zero: The UK's contribution to stopping global warming' (2019), p175
484 For example, see: Greenpeace UK (CGE0022), para 7; Energy UK (CGE0024), para 9; Energy Systems Catapult (CGE0029), para 18; Royal Academy of Engineering and allied institutions (CGE0055), para 41; UK Energy Research Centre (CGE0057), para 18; and Qq209, 218 and 335–336

> The work to understand how those options would play out in the real world with consumer resistance, behaviour, price signals and all the other demand-side management measures that might go with it, has to be done in the period to 2025 to understand which trajectory we should be on. It is not an issue of saying that it will be about hydrogen, electrification or hybrid; it is about really understanding how those systems will work at scale, and the total system around that work.[485]

Professor Jim Watson, Director of the UK Energy Research Centre, similarly clarified that trials should involve "heating real homes in a real city".[486] Advocating greater Government willingness to support large-scale trials, the Aldersgate Group, an alliance of multiple UK businesses across various sectors, noted that the UK could install hybrid heat pumps in 1 million homes, heat networks in 1 million homes and hydrogen in 1 million homes and "there would still be 22m homes left to treat".[487]

141. Damitha Adikaari, Acting Director of Science and Innovation for Climate and Energy at the Department for Business, Energy and Industrial Strategy, conceded that the Government's trials so far had only involved up to around a hundred homes.[488] He acknowledged that large-scale demonstrations were "necessary" but said that they were "the most difficult" and explained that "the Government's push at the moment is to provide sufficient funds to de-risk some of those unknown technologies towards the demonstration phase".[489] The National Infrastructure Commission has commented, however, that "whilst there are incremental steps that can be taken to address some aspects of the challenge, an incremental approach on its own will not be enough".[490] Addressing hydrogen in particular, the Committee on Climate Change has similarly said that "continuation of an incremental approach that relies on isolated, piecemeal demonstration projects may lead to hydrogen continuing to remain forever an option 'for the future'".[491]

142. **Heating accounts for around a third of the UK's overall emissions, which has remained essentially unchanged since 2009. The decarbonisation of heating will be critical to the UK achieving its long-term emissions reductions targets, but there remains considerable uncertainty surrounding what mix of low-carbon heating technologies represents the best decarbonisation pathway for the UK, or what mix the Government will pursue. *The Government must urgently develop a clearer strategy for decarbonising heat. This will require large-scale trials of different heating technologies operating in homes and cities to build the evidence base required for long-term decisions. The Government must commit now to large-scale trials of low-carbon heating technologies, convening relevant stakeholders to determine what evidence must be gathered and to co-ordinate existing work.***

485 Qq51 and 60
486 Q50
487 Aldersgate Group, 'Zeroing In: Capturing the Opportunities from a UK Net Zero Emission Target' (2019), p19
488 Q449—see also: 'Smart Systems and Heat', Energy Systems Catapult, accessed 18 June 2019
489 Qq447–449
490 National Infrastructure Commission, 'National Infrastructure Assessment' (2018), p44
491 Committee on Climate Change, 'Hydrogen in a low-carbon economy' (2018), p123

Hydrogen trials

143. Professor Jim Watson, Director of the UK Energy Research Centre, noted that there was "an asymmetry of evidence about the heat pathway", with reasonable evidence gathered on electric heating but "hardly any real-world evidence of the hydrogen route".[492] He argued that this made trials of hydrogen a particular priority.[493] The Energy Systems Catapult told us that a large-scale trial of hydrogen "probably needs to take place by the early 2020s".[494] Malcolm Brinded and Duncan Burt similarly indicated that such trials would need to be complete by 2025,[495] while the National Infrastructure Commission has said that community-scale trials should be conducted by 2021 followed by trials involving at least 10,000 homes by 2023.[496]

144. The UK Hydrogen and Fuel Cell Association and Sam French, representing the Decarbonised Gas Alliance, noted that hydrogen could be used not only as a fuel for heating, but also for transport and industrial processing.[497] The Hydrogen Council, a coalition of over 50 international companies developing hydrogen technologies, has also highlighted that "hydrogen is exceptionally well suited to store large quantities of energy for long durations", which it said could aid in particular with the integration of increasing proportions of renewable power generation.[498] Anglo American, a company that mines platinum (a metal used in hydrogen generation and hydrogen-powered technologies), explained that 'surplus' renewable power generated at times of low demand could be used to generate hydrogen instead of going to waste.[499]

145. The UK Hydrogen and Fuel Cell Association acknowledged that there was growing recognition of the potential for hydrogen in the UK, and listed eight projects already underway.[500] One of these is the Hy4Heat project, which received £25m from the Government to "establish if it is technically possible, safe, and convenient to replace natural gas with hydrogen in residential and commercial buildings and gas appliances".[501] Sam French agreed that the Government had "at least five or six reasonably large programmes looking at all the key elements down the supply chain", and that "at this level, [the Government] does have a co-ordinated plan".[502] However, he said that it would be "the next step that will be critical", and argued that this would have to involve trials an order of magnitude larger than current projects.[503] The Energy Networks Association similarly told us that it "welcome[d] the approach being taken [by the Government] to build the evidence base around the options to decarbonise heat and transport, and would encourage increased activity in these areas".[504] Guy Newey, Director of Strategy and Performance at the Energy Systems Catapult, told us that although there were currently "dozens of projects going on", the key challenge would be how to "bring those together in

492 Q52
493 Q52
494 Energy Systems Catapult (CGE0029), para 18
495 Qq60 and 339
496 National Infrastructure Commission, 'National Infrastructure Assessment' (2018), p44
497 UK Hydrogen and Fuel Cell Association (CGE0034), paras 3 and 6; and Qq210–212 and 218
498 Hydrogen Council, 'Hydrogen Scaling Up: A sustainable pathway for the global energy transition' (2017), pp58–59
499 Anglo American (CGE0046), paras 4 and 7
500 UK Hydrogen and Fuel Cell Association (CGE0034), para 7
501 Department for Business, Energy and Industrial Strategy, 'Hy4Heat Progress Report' (2018)
502 Q218
503 Q218
504 Energy Networks Association (CGE0059), para 35

big demonstrations".[505] The Sustainable Gas Institute also stressed that "future projects should be coordinated to ensure findings from practical demonstrations inform modelling efforts, and vice versa".[506]

146. The Energy Systems Catapult told us that "it is unclear precisely what a comprehensive live trial(s) for the large-scale deployment of hydrogen might look like and what components are necessary or merely desirable", and argued that "consensus is needed to ensure a live trial(s) adequately provides sufficient information to enable Government to make a decision on hydrogen".[507] Professor Watson outlined a "number of aspects" that a trial of hydrogen would need to cover:

> One is the cost of producing the hydrogen […] There is the demonstration of converting your network to use hydrogen. Most networks can use some share of hydrogen, but another interesting question is how far you can go there. Then there is the demonstration of the end-user appliances, what you need to do in people's homes or businesses to be able to burn hydrogen rather than methane. Attached to that are questions about the financial model, consumer acceptability and whether, with that much change, it will still be as acceptable and whether the service will be as good.[508]

The Royal Society and EDF Energy listed similar areas for investigation, highlighting also the different potential methods for generating hydrogen as well as the storage and safety requirements that would need to be explored.[509] Given the different sectors in which hydrogen could be used as a fuel, the UK Hydrogen and Fuel Cell Association told us that the Government should take a "holistic approach" to developing hydrogen, with support for "whole system hydrogen energy demonstrations".[510]

147. Proposals for significant trials of hydrogen already exist. For example, Cadent, a gas distribution network operator, has proposed a 'Liverpool-Manchester hydrogen cluster' that would blend hydrogen at 10–20% into the gas supply and cost around £600m.[511] The H21 Leeds City Gate project has developed plans to incrementally convert the gas network in Leeds to 100% hydrogen over three years.[512] It said that this would use existing technologies and could support decarbonisation across heating, transport and power generation, with a total cost of around £2bn.[513] Both projects indicated that funding could potentially be secured through Ofgem's network price controls framework, depending upon the details of its next phase.[514] Sam French indicated that private investment could be pulled in to supplement public funding for hydrogen demonstration projects, with industry seeking "a provision for the next competition that is going to build some of these

505 Q52—Mr Newey was discussing demonstration projects for low-carbon heating, nuclear power and carbon capture and storage
506 Sustainable Gas Institute, 'A Greener Gas Grid: What Are the Options?' (2017), pix
507 Energy Systems Catapult (CGE0029), para 18
508 Q57
509 EDF Energy (CGE0020), para 24 and The Royal Society (CGE0056), paras 9–10—see also: The Geological Society (CGE0051), paras 11–12
510 UK Hydrogen and Fuel Cell Association (CGE0034), paras 9–10
511 Cadent, 'The Liverpool-Manchester Hydrogen Cluster: A Low Cost, Deliverable Project' (2017)
512 Northern Gas Networks, Wales and West Utilities, Kiwa and Amec Foster Wheeler, 'H21 Leeds City Gate' (2016)
513 Northern Gas Networks, Wales and West Utilities, Kiwa and Amec Foster Wheeler, 'H21 Leeds City Gate' (2016), pp6–8
514 Cadent, 'The Liverpool-Manchester Hydrogen Cluster: A Low Cost, Deliverable Project' (2017), p17 and Northern Gas Networks, Wales and West Utilities, Kiwa and Amec Foster Wheeler, 'H21 Leeds City Gate' (2016), p6

projects that are currently being designed".[515] Amanda Lyne, Chair of the UK Hydrogen and Fuel Cell Association, added that developing a hydrogen system at scale would help to make the costs more competitive.[516]

148. In a report examining potential options for decarbonising the UK's gas networks, the Sustainable Gas Institute noted that "choosing areas of the existing gas network to convert to hydrogen will be a significant policy consideration":

> Consumers in the area of conversion will not have the option to continue using natural gas. A number of policy considerations will arise as a result, including: who decides what areas are to be converted and how; who pays for appliance replacement; and what rights do consumers have if they do not want hydrogen?[517]

These are important considerations that must be included in any future trial of hydrogen. However, high levels of engagement and support from homeowners involved in the HyDeploy project near Stoke-on-Trent suggests that public support can be achieved.[518]

149. The Energy and Clean Growth Minister, Claire Perry MP, acknowledged that "there is a huge amount of enthusiasm for hydrogen heating", but warned that "there is a question about public perception and how much you can blend [hydrogen into the grid], and currently we do not have hydrogen-powered appliances".[519] Damitha Adikaari, Acting Director of Science and Innovation for Climate and Energy at the Department for Business, Energy and Industrial Strategy, correspondingly stated that the "Government's push at the moment is to provide sufficient funds to de-risk some of those unknown technologies towards the demonstration phase", focusing on the safety of hydrogen and the availability of appliances.[520] However, Sam French and the Energy and Utilities Alliance both told us that manufacturers were developing hydrogen boilers that were at the point of being ready for use.[521] The H21 Leeds City Gate project reported in 2016 that "there are already a few models [of appliances and equipment for domestic, commercial and industrial sectors] on the market, although sales are extremely low, due to an absence of piped hydrogen", but that "just with the knowledge of this study, several manufacturers are showing real enthusiasm for their development":

> A firm long-term plan and significant stimulus would be needed to provide the motivation to develop and produce the wide range of equipment required. This could potentially be in the form of a national heat policy.[522]

150. **The use of hydrogen as a fuel offers significant promise for low-carbon heating, transport and industrial processing, as well as for energy storage and to help manage intermittent renewable power generation. However, evidence from large-scale trials will be needed to allow the Government to make informed decisions on the UK's future energy system. Demonstrating the safety of hydrogen as a fuel is a critical first step,**

515 Q220
516 Q142
517 Sustainable Gas Institute, 'A Greener Gas Grid: What Are the Options?' (2017), p92
518 'HyDeploy: Safety', HyDeploy, accessed 20 June 2019
519 Q445
520 Q447
521 Energy and Utilities Alliance (CGE0031), para 20 and Q207
522 Northern Gas Networks, Wales and West Utilities, Kiwa and Amec Foster Wheeler, 'H21 Leeds City Gate' (2016), p4

and we commend the Government for its support of the Hy4Heat programme. ***The Government must complete the safety demonstration work for hydrogen as an urgent priority. The Government should also commit to completing at least one large-scale trial of hydrogen by 2025 conditional upon safety approval, and start developing now the terms for a competition to deliver such a trial. This should involve co-ordination of existing demonstration and modelling projects and should lead to the terms of a competition being announced no later than the end of 2020.***

151. The Committee on Climate Change has said that hydrogen faces a "chicken and egg" problem in the UK as it "does not currently produce significant amounts of low-carbon hydrogen, nor does it have technologies in place that would provide a market for that hydrogen".[523] As one solution to this challenge, the Decarbonised Gas Alliance told us that "simply allowing the hydrogen blend [in the gas grid] to be increased up to 2%, as a first step, would help to unlock [a new market in hydrogen]", suggesting for example that renewable energy produced at periods of surplus energy supply could be used to produce hydrogen if there were a market for it.[524] Currently, the concentration of hydrogen in the grid is limited to 0.1%,[525] although one trial project has received an exemption to demonstrate hydrogen concentrations of up to 20% on the Keele University campus.[526] Increasing proportions of hydrogen have been injected into some gas grids worldwide, reaching 10% concentration in Germany,[527] while Ofgem has stated that all gas appliances manufactured after 1993 have been required to operate with a hydrogen mix up to 23%.[528] Randolph Brazier, Head of Innovation and Development at the Energy Networks Association, told us that the Association believed that it could supply "up to 20% hydrogen into the gas networks without affecting consumer devices in the home".[529] The Minister indicated to us that "changing the regulations to allow us to introduce blended hydrogen into the system […] would be a really easy thing to do".[530]

152. The Sustainable Gas Institute indicated that, in addition to amendments to gas regulations, "there may also be a need for modifications to market arrangements to facilitate and encourage injection of biomethane or hydrogen".[531] The UK Hydrogen and Fuel Cell Association suggested that feed-in tariffs might be required to help build a market for hydrogen injection.[532] Alternative market support mechanisms could include a 'low-carbon gas obligation' similar to the Renewable Transport Fuel Obligation currently in place for suppliers of fuel used in transport.[533]

153. **Blending hydrogen into gas supplied via the gas grid could provide an initial market for early hydrogen production facilities.** ***Once clear evidence is obtained on the level at which it is safe to mix hydrogen into the existing gas grid, and which is compatible with existing appliances, the Government should amend regulations to raise the proportion of hydrogen permitted in the grid. With higher blends of hydrogen***

523 Committee on Climate Change, 'Hydrogen in a low-carbon economy' (2018), p123
524 Decarbonised Gas Alliance (CGE0032), para 19—see also: Qq207 and 339
525 Health and Safety Executive, 'A guide to the Gas Safety (Management) Regulations 1996' (2007), p49
526 'HyDeploy: Safety', HyDeploy, accessed 19 June 2019
527 Netherlands Enterprise Agency, 'The effects of hydrogen injection in natural gas networks for the Dutch underground storages: Final Report' (2017), p54
528 Ofgem, 'Project Summary: HyDeploy' (2016), p7
529 Q339
530 Q449
531 Sustainable Gas Institute, 'A Greener Gas Grid: What Are the Options?' (2017), p92
532 UK Hydrogen and Fuel Cell Association (CGE0034), para 11.2
533 Department for Transport, 'RTFO Guidance Part One: Process Guidance' (2019)

permitted, the Government should act to support the development of this as a market for hydrogen, perhaps through feed-in tariffs or low-carbon obligations analogous to the Renewable Transport Fuel Obligation.

Near-term measures for decarbonising heating

154. In addition to large-scale trials of different low-carbon heating options, David Weatherall, Head of Policy at the Energy Saving Trust, highlighted two actions that could be pursued immediately and which would be required whichever low-carbon heating technologies the Government pursued: improving energy efficiency in buildings; and raising public awareness of the need for decarbonising heat and what that might entail.[534] The Government listed a variety of measures that could improve energy efficiency in existing homes, including:

- changes to the 'fabric' of the building, such as loft, cavity wall and solid wall insulation, and double-glazing;
- upgrades to more efficient boiler or other heating systems; and
- systems for managing demand such as 'smart' heating controls.[535]

This section explores these options, as well as other measures that could contribute to the decarbonisation of heating in the UK in the near-term.

New buildings

155. Lord Deben, Chairman of the Committee on Climate Change, highlighted the inadequacy of energy standards for new homes currently being built as "the first and prime issue" for the UK's decarbonisation.[536] The Royal Academy of Engineering and allied institutions similarly told us that "building regulations (and their enforcement) should be strengthened", noting that "every home that is built to lower standards locks the occupants into excessive energy demands and costs that last for decades".[537] The Minister for Energy and Clean Growth argued that "in the past nine years the average energy performance standard for new homes has improved by 30%".[538] However, the Government's statistics on the average energy use of new homes demonstrates that almost all of this improvement occurred before 2014.[539] Jenny Holland, Senior Public Affairs and Policy Specialist for the UK Green Building Council, noted that "it is now six years since building regulations were last upgraded—the longest period without uplift since building regulations in their current form were introduced in 1984".[540]

534 Q215
535 Department for Business, Energy and Industrial Strategy, 'Call for Evidence: Building a Market for Energy Efficiency' (2017), p16
536 Q8
537 Royal Academy of Engineering and allied institutions (CGE0055), para 38
538 Q420
539 Ministry of Housing, Communities and Local Government, 'Live tables on Energy Performance of Buildings Certificates' (2019), Table NB7
540 Q169

156. Building regulations were due to be updated in 2016, through the introduction of the 'Zero Carbon Homes' policy.[541] This would have required all new homes to mitigate any carbon emissions produced on-site as a result of energy usage covered under building regulations (such as heating, cooling and lighting).[542] However, the 2015 Government decided not to pursue the zero carbon homes target in order to reduce regulations on homebuilders, arguing that regulations were one reason that the "UK has been incapable of building enough homes to keep up with growing demand".[543] This decision was criticised at the time in an open letter to the Chancellor with over 200 signatories, including major UK homebuilders.[544] The letter stated that:

> There was a broad consensus in support of the zero carbon policy, which was designed to give industry the confidence it needs to invest and innovate, in order to drive higher energy efficiency standards and low carbon energy solutions […] There is no evidence to suggest [ending the policy] will increase housing supply or boost productivity.[545]

Jenny Holland told us that the UK Green Building Council advocated a reinstatement of the Zero Carbon Homes Policy as a "modest start" for 2020, arguing that its "work with local authorities and developers up and down the country" suggested that this was "cost-effective and viable across a range of situations and geographical areas".[546] David Weatherall, Head of Policy at the Energy Saving Trust, told us that he supported this fully.[547] Lord Deben, Chairman of the Committee on Climate Change, argued that any costs involved with reaching higher standards would quickly fall due to economies of scale, and in any case be absorbed by reductions in land price.[548] Jenny Holland made the same argument.[549]

157. Graham Hazell, representing the Heat Pump Association, highlighted in particular the distorting impact of out-dated building regulations on homebuilders' actions to comply with current energy efficiency standards.[550] He explained that, as a result of failing to reflect significant recent reductions in the carbon intensity of the UK electricity supply, current building regulations were "more than doubling the carbon intensity of a heat pump completely artificially".[551] This erroneously incentivises homebuilders to meet building standards requirements through the installation of solar panels, which reduce electricity consumption, over heat pumps, which use electricity to efficiently move heat to inside a building.[552] Mr Hazell argued that rectifying the building regulations to better

541 HM Treasury, 'The Plan for Growth' (2011), paras 2.297–2.300
542 Zero Carbon Hub, 'Zero Carbon Homes and Nearly Zero Energy Buildings: UK Building Regulations and EU Directives' (2014)
543 HM Treasury, 'Fixing the foundations: Creating a more prosperous nation' (2015), paras 9.1 and 9.17
544 'Industry leaders urge chancellor to reconsider zero carbon homes 'U-turn'', Construction Manager, accessed 13 June 2019
545 'Industry leaders urge chancellor to reconsider zero carbon homes 'U-turn'', Construction Manager, accessed 13 June 2019
546 Qq169–170
547 Q170; reinstating the Zero Carbon Homes standard has been advocated by others too, such as the Energy Efficiency Infrastructure Group, a coalition of over twenty organisations—see Energy Efficiency Infrastructure Group, 'Affordable Warmth, Clean Growth: Action Plan for a Comprehensive Buildings Energy Infrastructure Programme' (2017)
548 Q8
549 Qq171–172
550 Qq166–169 and 206
551 Q167
552 Heat Pump Association (CGE0074)

reflect the actual carbon intensity of electricity would be "quite a small thing to do" but would represent a "massive step" for low-carbon heating systems.[553] The Heat Pump Association told us, however, that it did not expect changes to be made quickly "due to the process required which is a combination of the need to go to public consultation and the need to pass law within Parliament".[554]

158. In 2018, the Government said that it would consult on changes to Part L of the Building Regulations—the regulations that govern new building energy efficiency standards—in 2019, but no consultation has yet been launched.[555] The 2019 Spring Statement also announced a 'Future Homes Standard' to be developed by 2025, to "build on the Prime Minister's Industrial Strategy Grand Challenge mission to at least halve the energy use of new buildings by 2030" by "future-proofing new build homes with low carbon heating and world-leading levels of energy efficiency".[556] The Chancellor stated that this would include "mandating the end of fossil-fuel heating systems in all new houses from 2025".[557] The UK Green Building Council welcomed the announcement, but stressed that "it is vital that this is accompanied by truly world-leading energy efficiency standards".[558] Tim Lord, Director of Clean Growth at the Department for Business, Energy and Industrial Strategy, explained that the 2025 date was intended to give time for supply chains of technologies such as heat pumps to develop, but said that he expected homes to gradually meet the strengthened standards by 2025 rather than improving suddenly.[559]

159. The Energy Saving Trust has advocated moving towards a '2050-ready' set of standards so that homes built now are fit for a net-zero emissions future, and outlined what such standards should encompass.[560] It indicated that these could be based on the Zero Carbon Homes and London's current zero carbon homes policy, incorporating:

- energy and water efficiency standards;
- the installation of low-carbon energy generation technologies to account for the energy used to heat and light the home, and potentially the appliances run inside; and
- the offset of any 'surplus' emissions through investment in external emissions-saving measures.

Graham Hazell agreed that "we are building homes right now on a number of fronts that will either be very difficult or impossible to change in the future",[561] noting in particular the fact that new homes tended to use small-bore heating pipes and did not incorporate sufficient room for the installation of a hot water cylinder, both of which left them incompatible with the future installation of a heat pump system.[562] E.On argued that national adoption of tightened emissions standards modelled on London's zero carbon

553 Qq167 and 169
554 Heat Pump Association (CGE0074)
555 Department for Business, Energy and Industrial Strategy, 'Clean Growth—Transforming Heating: Overview of Current Evidence' (2018), p9
556 HM Treasury, 'Spring Statement 2019: Written Ministerial Statement' (2019), p4
557 Rt Hon Philip Hammond MP, Spring Statement 2019, 13 March 2019
558 'UKGBC responds to Spring Statement', UK Green Building Council, accessed 14 June 2019
559 Q471
560 Energy Saving Trust, 'The Clean Growth Plan: A "2050-ready" new-build homes policy' (2017)
561 Q205
562 Qq201–205

homes policy could "provide a stimulus, free from subsidy, for heat networks and heat pumps, providing scale and the ability of those technologies to be industrialised to realise cost reductions".[563]

160. **The Government's announced future homes standard is welcome. However, regulations requiring improvements to the efficiency of new buildings must be introduced before 2025.** ***The Government should re-introduce the zero-carbon homes standard as a matter of urgency, and no later than the end of 2019. It should additionally ensure that building regulations accurately reflect the current carbon intensity of electricity in Great Britain, and that this figure can be regularly updated (at least annually) in future.***

161. ***The Government should launch its consultation on Part L of the building regulations by the time of the Spring Statement 2020. Beyond that, it must ensure that homes built today are compatible with a net-zero emissions future and that the 'Future Homes Standard' reflects this.***

Existing buildings

162. The Royal Academy of Engineering and allied institutions noted that "most of the buildings that will exist in 2050 have already been built".[564] Lord Deben, Chairman of the Committee on Climate Change, told us that he focused on new buildings because that it "is the stupidest part of the whole situation", but agreed that "the biggest problem is all those houses that will still be there in 2050, when we are supposed to have reduced our emissions by 80%".[565]

Existing buildings—energy efficiency

163. The energy efficiency of a house is measured using the 'Standard Assessment Procedure', which assesses how much energy a building will consume when delivering a defined level of comfort and service provision, and awards the building a corresponding 'score' out of 100 determined by the associated energy costs per square metre.[566] Homes are awarded an Energy Performance Certificate on the basis of the score, which categorises them from Band A (least costly to run) to Band G (most costly to run).[567] The most recent breakdown of the proportion of homes in each EPC band is shown in Table 1.

Table 1: Proportion of English homes in each EPC Band

EPC Band	A/B	C	D	E	F	G
(%)	1.3	28.8	50.5	14.4	3.8	1.2

Source: Ministry of Housing, Communities and Local Government, 'English Housing Survey 2017 to 2018' (2019), Table AT2.7

563 E.ON (CGE0036), para 36
564 Royal Academy of Engineering and allied institutions (CGE0055), para 38
565 Q9
566 'Standard Assessment Procedure', Department for Business, Energy and Industrial Strategy, accessed 17 June 2019—see also Building Research Establishment, ' The Government's Standard Assessment Procedure for Energy Rating of Dwellings' (2014)
567 'Energy Performance Certificate', HM Government, accessed 8 February 2019

164. In its Clean Growth Strategy, the Government stated its ambition for:

- all fuel poor homes to be at least energy efficiency Band C by 2030; and
- as many homes as possible to reach Band C by 2035, where "practical, cost-effective and affordable".[568]

The Committee on Climate Change has concluded that achieving these goals would be compatible with the UK's emissions reductions targets, "provided that the limitations of 'practical' and 'affordable' do not significantly limit cost-effective uptake".[569] Tim Lord, Director of Clean Growth at the Department for Business, Energy and Industrial Strategy, told us that he "would not want to put a specific percentage number" on how many homes the Government's ambition would apply to, but indicated that he "would certainly expect to be able to improve cost-effectively a very significant majority of homes".[570]

165. ***The Government should set out, in its response to this Report, the criteria that will be used to determine 'practicality' and 'affordability' in its energy efficiency targets, and provide an indicative percentage of homes that it is intending to help reach Band C by 2035.***

166. David Weatherall, of the Energy Saving Trust, and Jenny Holland, of the UK Green Building Council, agreed with the Committee on Climate Change that the Government's targets were reasonable.[571] Instead, Ms Holland flagged that "it is the lack of policy rather than the targets being wrong".[572] Indeed, the most recent English Housing Survey reported a slowing in improvements in energy efficiency, with "no change in the average [energy efficiency] rating of homes between 2016 and 2017".[573] In its 2018 Progress Report to Parliament, the Committee on Climate Change noted that home insulation rates in 2017 were at just 5% of the peak rate achieved in 2012.[574]

167. David Weatherall told us that in the Energy Saving Trust's opinion, the Energy Company Obligation was "currently the only national funding scheme for energy efficiency in homes".[575] The Energy Company Obligation requires energy suppliers to deliver energy efficiency and heating measures to consumers' homes, typically by paying for part or all of the installation (although suppliers are allowed to trade achieved savings amongst themselves).[576] A national target of total home heating cost savings is periodically set in secondary legislation, and is allocated to be achieved by large energy suppliers through the installations they deliver, according to their market share. The most recent secondary legislation, made in 2018, set a target for 2018–2022 of £8.235bn.[577] Any supplier that has not accrued the necessary savings by the end of the required period can be fined

568 Department for Business, Energy and Industrial Strategy, 'Clean Growth Strategy' (2017), p77
569 Committee on Climate Change, 'An independent assessment of the UK's Clean Growth Strategy' (2018), p58
570 Qq469–470
571 Q173
572 Q173
573 Ministry of Housing, Communities and Local Government, 'English Housing Survey: Headline Report, 2017–18' (2019), para 2.24
574 Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p85
575 Q177
576 'About the ECO scheme', Ofgem, accessed 17 June 2019; Ofgem, 'Energy Companies Obligation (ECO) 2012–2015: Guidance for Suppliers' (2012); and Ofgem, 'Energy Company Obligation (ECO3) Guidance: Supplier Administration' (2018)
577 The Electricity and Gas (Energy Company Obligation) Order 2018 (SI 2018/1183)

by the regulator.[578] The Government amended the Energy Company Obligation in November 2018 so that the scheme targeted only low-income and vulnerable households.[579] It explained that this re-focus was introduced to "[help] to meet the Government's fuel poverty commitments", but acknowledged that the change would "result in lower carbon emissions reductions being achieved under the scheme".[580] This is because fuel poor households are likely to benefit from improved efficiency by increasing the extent to which the house can be heated, rather than by reducing the amount of heating required.[581]

168. Noting that the Energy Company Obligation is "increasingly being focused on those most in need of support", the Government opened a call for evidence on driving energy efficiency measures in the 'able to pay' market in 2017.[582] The consultation outlined several potential options for Government action, including:

- developing new methods for financing energy efficiency;
- strengthening price signals tied to the efficiency of properties;
- improving awareness and advice available to consumers regarding the benefits of energy efficiency;
- creating the conditions for other beneficiaries, such as distribution network operators, Clinical Commissioning Groups (who stand to gain from the improved health of those living in more efficient homes) and mortgage lenders, to support the implementation of energy efficiency improvements;
- supplementing the £10m thermal efficiency innovation challenge fund with other mechanisms to support innovation in energy efficiency;
- making use of increasing amounts of consumer and network data to gauge actual building thermal performances and impacts of improvements; and
- supporting designers and installers in local supply chains.[583]

However, the Government has still not responded to the consultation submissions.[584] Tim Lord, Director of Clean Growth at the Department for Business, Energy and Industrial Strategy, told us that the Government would be "bringing forward [its] plans in response to that call for evidence and consultation later in the year".[585]

578 Ofgem, 'Energy Company Obligation (ECO3) Guidance: Supplier Administration' (2018), p43
579 Department for Business, Energy and Industrial Strategy, 'Energy Company Obligation 2018–2022' (2019), p10—more specifically, the households covered are fuel-poor households, families receiving certain benefits or social housing with poor energy efficiency
580 Department for Business, Energy and Industrial Strategy, 'Energy Company Obligation: ECO3, 2018 to 2022' (2018), p1 and para 42
581 Qq31, 41and 175
582 Department for Business, Energy and Industrial Strategy, 'Call for Evidence: Building a Market for Energy Efficiency' (2017)
583 Department for Business, Energy and Industrial Strategy, 'Call for Evidence: Building a Market for Energy Efficiency' (2017), para 56
584 'Building a market for energy efficiency: call for evidence', Department for Business, Energy and Industrial Strategy, accessed 17 June 2019
585 Q428

169. The last significant policy framework intended to encourage homeowners to improve their homes' energy efficiency was the Green Deal.[586] This was a scheme under which loans were made available to homeowners to finance improvements to the energy performance of their properties. Loans were available for a specific set of energy efficiency and renewable generation technologies,[587] and individual properties had to be assessed and cost-saving opportunities identified for the property to be eligible for that improvement. The debt was taken on by the property rather than the owner and was paid back, with interest, through the property's electricity bill. The Green Deal scheme was launched by the then Government in 2011 but was closed in 2015 due to "low take-up and concerns about industry standards".[588] The Government has since acknowledged that the Green Deal only addressed the financial aspect of energy efficiency improvements, which was not enough to drive widespread uptake.[589] Jenny Holland, Senior Public Affairs and Policy Specialist for the UK Green Building Council, explained that the Green Deal falsely assumed that "thousands and thousands of householders out there were dying to make energy efficiency improvements to their homes and the only thing stopping them was a lack of available finance", but "the results speak for themselves" in showing this not to be the case.[590] The National Audit Office similarly reported in 2016 that initial concerns that the Green Deal would attract insufficient householder interest were well-founded, and found that "even where there has been some interest in Green Deal loans, the complex process meant many people did not complete the process of arranging a finance plan".[591]

170. Reflecting these previously identified problems with a lack of homeowner demand, Energy UK, a trade association covering the whole UK energy sector, recommended that the "Government should help kick-start a sustainable able-to-pay energy efficiency market via a combination of incentives and funding mechanisms to engage with different consumer groups".[592] The Energy Efficiency Infrastructure Group, a coalition of over twenty relevant organisations, has recommended a range of options to support this.[593] In particular, it suggested that the Government incentivise homeowners to make energy efficiency improvements by adjusting Stamp Duty so that it would vary according to the property's energy performance as well as its selling price.[594] Jenny Holland, Senior Public Affairs and Policy Specialist for the UK Green Building Council, told us that she would be "extremely supportive" of such an initiative.[595] A similar idea has been advocated by other stakeholders too, such as the Sustainable Energy Association.[596] The Energy Efficiency Infrastructure Group specified that under such a scheme, homebuyers should be given

586 'Green Deal: energy saving for your home', HM Government, accessed 17 June 2019
587 Department of Energy and Climate Change, 'Green Deal: Energy saving home improvements' (2013)
588 'Green Deal Finance Company funding to end', Department of Energy and Climate Change, and Ministry of Housing, Communities and Local Government, accessed 17 June 2019—A new Green Deal scheme has since been launched by a private company, see 'Newly Acquired Green Deal Finance Company Recommences Loan Origination', Green Deal Finance Company, accessed 17 June 2019
589 Department for Business, Energy and Industrial Strategy, 'Call for Evidence: Building a Market for Energy Efficiency' (2017), para 44
590 Q187
591 National Audit Office, 'Green Deal and Energy Company Obligation' (2016), paras 3.4–3.5
592 Energy UK (CGE0024), para 28
593 Energy Efficiency Infrastructure Group, 'Affordable Warmth, Clean Growth: Action Plan for a Comprehensive Buildings Energy Infrastructure Programme' (2017)
594 Energy Efficiency Infrastructure Group, 'Affordable Warmth, Clean Growth: Action Plan for a Comprehensive Buildings Energy Infrastructure Programme' (2017), pp11 and 53–56
595 Qq188 and 190—see also: E.ON (CGE0036), para 30
596 Sustainable Energy Association, 'Energy Efficiency—A Policy Pathway: Addressing the Able to Pay Sector' (2017), pp11–14—see also: Aldersgate Group, 'Increasing investment for domestic energy efficiency' (2018), p8

a year after purchase to complete any improvement works and claim a retrospective reduction in Stamp Duty, as this "would allow improvements to be undertaken at the same time as general renovations that often take place shortly after purchase".[597]

171. **Previous initiatives to encourage the installation of energy efficiency improvements in the 'able-to-pay' market have failed because they have focused too narrowly on providing financial support for specific interventions.** ***The Government's new energy efficiency policy must provide all homeowners with the incentive to make energy efficiency improvements to their property, with particular thought given to lower income households. By the time of the Spring Statement 2020, the Government should consider adjusting Stamp Duty so that it varies according to the energy performance of the home as well as the price paid for it. Homebuyers should then be able to make energy efficiency improvements within a defined time after purchasing the property, and claim back corresponding reductions in the Stamp Duty paid retrospectively. The adjustments made to Stamp Duty could be designed in order to be revenue-neutral to the Government. Robust certification of energy efficiency will need to be put in place to ensure that such a scheme is not open to exploitation and the Government should consider how best to incentivise upgrades in council, housing association and rented homes.***

172. The Government's realisation that an energy efficiency policy cannot focus on finance alone does not mean that finance is unimportant. Although energy efficiency improvements can often save costs in the long-term by reducing energy demand, homeowners still need to be able meet the upfront costs of making the improvement. The Green Deal offered loans to cover installation costs, which were repaid through the occupiers' electricity bill (even if the original homeowner had sold the property).[598] However, under the scheme's 'golden rule', loans were only awarded for energy efficiency improvements that would deliver greater cost savings over their lifetime than total loan repayments over the same period.[599] Jenny Holland advised that any future scheme should not adopt this rule, as it "limited the number and type of installations that you could put in".[600] Indeed, the National Audit Office found that, of seven common energy efficiency improvement measures, "only easy-to-treat cavity wall insulation would qualify on its own, while other measures would require some form of subsidy to be installed at zero net cost for the householder".[601]

173. The purpose of the Green Deal was to enable homeowners to pay for energy efficiency improvements in their homes, with the 'golden rule' intended to protect these homeowners from paying for energy efficiency improvements that would not deliver net cost-savings. The Energy Saving Trust has highlighted, however, that although some "home energy efficiency [improvements] may not be cost-effective for individual households, [they] may be highly cost-effective for the UK as a whole in reducing our overall energy demand and in meeting our 2050 carbon targets", pointing out that energy efficiency improvements can be more cost-effective than other measures subsidised by the Government, such as nuclear and some renewable power generation technologies.[602]

597 Energy Efficiency Infrastructure Group, 'Affordable Warmth, Clean Growth: Action Plan for a Comprehensive Buildings Energy Infrastructure Programme' (2017), pp53–54
598 'Getting a Green Deal: information for householders and landlords', HM Government, accessed 18 June 2019
599 Department of Energy and Climate Change, 'The Green Deal: A summary of the Government's proposals' (2010), pp11–12
600 Q191
601 National Audit Office, 'Green Deal and Energy Company Obligation' (2016), p43
602 Energy Saving Trust, 'The Clean Growth Plan: An offer to all householders' (2017), p2

174. The Energy Saving Trust has suggested various potential components of a future scheme for financing energy efficiency improvements in the 'able-to-pay' market, such as zero- or reduced-rate loans, grants, mortgage-linked cashback schemes and equity release schemes.[603] Bright Blue, an independent liberal conservative think tank, recommended the introduction of a 'Help to Improve' finance scheme for energy efficiency,[604] in reference to the 'Help to Buy' scheme in place for first-time homebuyers and for purchases of new homes.[605] This would comprise two main elements:

- 'Help to Improve' loans available to finance energy efficiency improvements, with Government funding used to reduce interest rates (potentially to zero), and made available through commercial banks; and
- 'Help to Improve' ISAs into which homeowners can invest and receive a bonus, funded by the Government, proportional to the sum invested by the homeowner and subject to a maximum cap, provided that the funds are used to pay for legitimate energy efficiency improvements.[606]

The Sustainable Energy Association has also recommended a 'Help to Improve' loan scheme, which it said was already used in other countries including Germany and France.[607] Evidence from Germany suggests that, as a result of the tax revenue from the economic activity associated with delivering energy efficiency improvements combined with reduced welfare spending due to improved housing and employment, the Government received a net income from the scheme.[608]

175. **The Green Deal's 'golden rule' heavily restricted the energy efficiency improvements that could be paid for by the scheme. Although some energy efficiency improvements may not deliver net cost-savings to homeowners, they may still represent cost-effective options for the UK to meet its emissions reductions targets. *The Government's new energy efficiency policy must enable homeowners to access the finance needed to cover the upfront costs of energy efficiency improvements that offer a cost-effective contribution to the UK's decarbonisation, not just net cost-savings to individual homeowners. In analogy to the existing 'Help to Buy' scheme, the Government should establish a 'Help to Improve' scheme by July 2020 that offers matched funding and interest-free loans to homeowners, to cover the costs of making energy efficiency improvements.***

176. Tim Lord, Director of Clean Growth at the Department for Business, Energy and Industrial Strategy, highlighted the fact that measures to improve energy efficiency could benefit from financial services innovation as well as technological innovation, noting in particular a potential role for 'green mortgages'.[609] The Minister explained that "people who are moving into energy-efficient homes are less likely to default on rental payments", providing an incentive for banks to offer lower mortgage rates.[610] However, the London School of Economics and Political Science has warned that the evidence base for this was

603 Energy Saving Trust, 'The Clean Growth Plan: An offer to all householders' (2017)
604 Bright Blue (CGE0049), paras 6–8
605 'Help to Buy', HM Government, accessed 18 June 2019
606 Bright Blue, 'Better Homes: Incentivising Home Energy Improvements' (2016), pp72–75
607 Sustainable Energy Association, 'Energy Efficiency—A Policy Pathway: Addressing the Able to Pay Sector' (2017), p25
608 KfW Bankengruppe, 'Impact on Public Budgets of KfW Promotional Programmes in the Field of "Energy-Efficient Building and Rehabilitation"' (2012)
609 Q428
610 Q429

limited, and that it was not clear whether more reliable payments were caused by energy efficiency or simply correlated.[611] Indeed, the Government itself has acknowledged that "it can be difficult to untangle the role of the property from the homeowner in these calculations".[612] Nevertheless, the LENDERS group, a coalition of organisations including the UK Green Building Council, the Energy Saving Trust and the Nationwide Building Society—supported by the Government—has also noted the correlation between energy efficiency and homeowners' capacity for mortgage repayments, and recommended that the mortgage industry reviews its current affordability calculations to take this into account.[613] Increasing potential purchasers' ability to secure a mortgage for homes with greater energy efficiency could help to drive demand for more energy efficient properties. The London School of Economics and Political Science has argued that this could apply to all mortgages, not just those intended to be 'green', and said that "this could be a safer and more flexible alternative to offering more favourable interest rates for green mortgages".[614] The LENDERS group indicated that the Government could support the mortgage industry in accessing "larger datasets in compatible formats to provide more accurate estimation for household expenditure".[615]

177. **We commend the Government for supporting research into, and the development of, 'green mortgages'.** ***The Government should consider the case for encouraging mortgage lenders to take energy efficiency into account for all mortgage applications, and should support the industry in capturing any potential in such a system for driving a market in energy efficiency improvements.***

178. The Minister for Energy and Clean Growth, Claire Perry MP, highlighted the fact that, in addition to the Energy Company Obligation, the Government had recently passed legislation targeting the "least energy-efficient part of the private rented sector".[616] This refers to amendments made to energy efficiency regulations under the Energy Act 2011.[617] The amended regulations forbid private landlords from granting new tenancies to new or existing tenants in properties with energy efficiencies beneath EPC Band E, and from April 2020 landlords will not be able to continue letting a property that is already let if it falls beneath these standards (with certain exclusions, especially in the social housing sector).[618] However, with the impact being restricted to privately-rented properties with efficiencies beneath Band E, these measures will only affect 2.5% of all English homes.[619] Suggesting policies that could affect a wider range of households, Bright Blue recommended that "the building code could be amended to mandate builders to improve the overall energy performance of homes whenever renovations take place":

611 'What are green mortgages and could they increase the energy efficiency of UK homes?', London School of Economics and Political Science, accessed 18 June 2019

612 Department for Business, Energy and Industrial Strategy, 'Call for Evidence: Building a Market for Energy Efficiency' (2017), para 86

613 LENDERS, 'Improving energy costs in mortgages, promoting energy efficiency in homes' (2017)

614 'What are green mortgages and could they increase the energy efficiency of UK homes?', London School of Economics and Political Science, accessed 18 June 2019

615 LENDERS, 'Improving energy costs in mortgages, promoting energy efficiency in homes' (2017), p19

616 Q420

617 The Energy Efficiency (Private Rented Property) (England and Wales) (Amendment) Regulations 2019 (SI 2019/595); The Energy Efficiency (Private Rented Property) (England and Wales) Regulations 2015 (SI 2015/962); and Energy Act 2011, section 52

618 Department for Business, Energy and Industrial Strategy, 'The Domestic Private Rented Property Minimum Standard' (2019)

619 Ministry of Housing, Communities and Local Government, 'English Housing Survey 2017 to 2018' (2019), Table AT2.7; Committee analysis

> The cost of the home energy improvements could be capped so they do not exceed a certain proportion of the overall cost of the building works. This regulation would be enforced in the same way that the building code, the regulations that govern building works, is currently enforced.[620]

This aligns with the UK Energy Research Centre's findings that households are much more likely to consider making energy efficiency improvements as part of wider renovations than for efficiency improvements alone.[621]

179. **We commend the Government for strengthening the requirements on landlords to improve the energy efficiency of the least efficient homes in England and Wales. However, these measures will affect only 2.5% of the housing stock.** ***The Government should amend building regulations so that renovations to buildings must always result in an overall improvement in energy efficiency.***

Existing buildings—low-carbon heating

180. The Renewable Heat Incentive (RHI) is a Government financial incentive aimed at promoting the use of renewable heat systems.[622] The National Audit Office has reported that, as of December 2017, the RHI had delivered just 78,000 of the 513,000 that it was projected to deliver between 2014 and 2020.[623] The RHI scheme is due to close to new applicants in 2021, with the Government saying it "is now considering how to transition support for [low-carbon heating] technologies away from direct subsidy".[624] Tim Lord, Director of Clean Growth at the Department for Business, Energy and Industrial Strategy, told us that he could not yet say "what the successor to or the future for that scheme will be".[625] **The Renewable Heat Incentive has significantly underperformed on the Government's expectations.** ***With the Renewable Heat Incentive due to close to new applications in 2021, the Government must ensure that it avoids a repeat of the disruption caused by the closure of the feed-in tariff, and announces its plans for the successor scheme to the Renewable Heat Incentive no later than the Spring Statement 2020. The successor scheme must be far more effective than the Renewable Heat Incentive scheme has proven to be.***

181. The Minister for Energy and Clean Growth, Claire Perry MP, told us that, following the Government's announced intention to mandate the end of fossil-fuel heating systems in all new houses from 2025,[626] "the hope is that through the regulatory changes we make we will kickstart a real cost reduction" in heat pumps and other existing technologies not yet deployed at scale.[627] This echoed what we heard from E.On, who argued that "if there was sufficient confidence within the supply chain that the market [for heat pumps] could be scaled, the cost of heat pump production and installation could be reduced significantly".[628]

620 Bright Blue (CGE0049), para 5
621 UK Energy Research Centre, 'Understanding Homeowners' Renovation Decisions: Findings of the VERD Project' (2013), p8
622 'About the Domestic RHI', Ofgem and 'About the Non-Domestic RHI', Ofgem, both accessed 18 June 2019
623 National Audit Office, 'Low-carbon heating of homes and businesses and the Renewable Heat Incentive' (2018)
624 Department for Business Energy and Industrial Strategy, 'A Future Framework for Heat in Buildings: Call for Evidence' (2018), paras 1.6–1.8
625 Q477
626 Rt Hon Philip Hammond MP, Spring Statement 2019, 13 March 2019
627 Q445
628 E.ON (CGE0036), paras 22–23

182. The Committee on Climate Change has commented that "switching to heat pumps is made more costly by the fact that the carbon costs of gas are not reflected in its price" and said that "there remain important questions to be resolved around the current balance of tax and regulatory costs across fuels, which currently weaken the private economic case for electrification".[629] Graham Hazell, representing the Heat Pump Association, similarly told us that "the driver [for low-carbon heating] has to be to put a cost on carbon" given that currently "the price of the fuel does not relate to the carbon content".[630] A 2013 report by the Centre for Climate Change Economics and Policy and the Institute for Fiscal Studies compared the variety of 'upstream' and 'downstream' policies on electricity with the fact that there were "no policies imposing a carbon price on gas use by households", and estimated that, in 2013/14 prices, households faced a carbon price of £27/tCO2e for electricity compared to a negative cost (taking into account the VAT 'subsidy') on household energy consumption) of £29/tCO2e for gas.[631] The authors of that report supported the introduction of a carbon tax on gas for domestic heating but highlighted that it would be regressive (because low-income households devote a larger portion of their spending to energy than richer households) and unpopular.[632] They recommended that such a move be accompanied by a compensation package to address these issues, and pointed out that the tax itself would raise a significant amount of money to enable this.

183. **The Government's announcement that fossil-fuel heating systems will not be permitted in new builds after 2025 may support the growth of supply chains for low-carbon heating technologies and deliver consequent cost-reductions as well.** ***The Government should further support the deployment of low-carbon heating technologies by setting out a clear roadmap by the time of the Spring Statement 2020 for rebalancing levies on electricity and gas, to better reflect the emissions intensities of each fuel.***

629 Committee on Climate Change, 'Next steps for UK heat policy' (2016), p74 and Committee on Climate Change, '2018 Progress Report to Parliament' (2018), p86

630 Qq198 and 214—see also: E.ON (CGE0036), para 22

631 Centre for Climate Change Economics and Policy, Institute for Fiscal Studies, Esmée Fairbairn Foundation and Economic and Social Research Council, 'Energy use policies and carbon pricing in the UK' (2013), p8

632 Centre for Climate Change Economics and Policy, Institute for Fiscal Studies, Esmée Fairbairn Foundation and Economic and Social Research Council, 'Energy use policies and carbon pricing in the UK' (2013), p10

7 The UK energy system

184. National Grid reported in 2018 that "the three drivers of decarbonisation, decentralisation and digitalisation are transforming the energy landscape".[633] Although this Report has focused on decarbonisation, decentralisation (the increasing use of smaller scale power generation, storage or management technologies, often situated close to consumers) and digitalisation (the increasing use of digital technologies to monitor and manage energy use) are important trends that will impact upon, and potentially facilitate, the decarbonisation of the UK's energy system. An additional trend highlighted during our inquiry was the increasing interdependence of previously distinct sectors such as power generation, transport and heat.[634] This Chapter examines some of these trends, as well as discussing the roles of different stakeholders in the UK energy system.

A smart energy system

185. The UK energy system has historically been 'centralised', with electricity being generated by a small number of large power stations and supplied to consumers via transmission and distribution networks.[635] These power stations have mostly used fossil fuels and have been able to vary their output to match demand.[636] As the power sector decarbonises, renewable technologies such as wind and solar power (which we discussed in Chapter 4) are increasingly being deployed. The output from these renewable sources is typically weather- and time-dependent, with far less scope for control. Furthermore, these new sources of power are being deployed in smaller units and closer to consumers than traditional power stations. This increases the complexity of power flows around the distribution networks.[637] Ofgem, the energy markets regulator, told us that the reduced control of power generation output combined with the decentralisation of power supply "poses new challenges in making sure the electricity system efficiently balances supply and demand and manages network constraints".[638]

186. In response to these trends, the Government and Ofgem together published a '*Smart Systems and Flexibility Plan*' in 2017.[639] The Plan set out 29 proposed actions, including:

- amending network usage costs and final consumption levies to apply more fairly to storage facilities;
- giving storage a legal definition in primary legislation, to provide regulatory clarity;
- strengthening regulation to avoid giving network operators an unfair advantage in the storage market;
- providing support for innovation in storage technologies;

633 National Grid System Operator, 'Future Energy Scenarios' (2018), p8
634 For example, see: Energy Systems Catapult (CGE0029); Ofgem (CGE0033), para 35; Dr Jonathan Radcliffe (CGE0041), para 19
635 'Flexible Electricity Systems', POSTnote 587, Parliamentary Office of Science and Technology, September 2018
636 The output from fossil fuel power plants can be controlled by varying the fuel input, subject to certain constraints. Nuclear power can in principle be controlled in the same manner, but in practice nuclear reactors tend to be run at a continuous rate.
637 Energy Networks Association (CGE0059), para 13
638 Ofgem (CGE0033), para 6
639 HM Government and Ofgem, 'Upgrading Our Energy System: Smart Systems and Flexibility Plan' (2017)

- supporting large non-domestic consumers to participate in demand-side response schemes;
- delivering the roll-out of smart meters and introducing half-hourly smart metering across the market, potentially mandated for all suppliers;
- consulting on seeking powers to set standards for smart appliances and electric vehicles;
- ensuring that storage and demand flexibility can compete in markets for network stability; and
- adapting network charges to an energy system less focused on central power generation.[640]

Duncan Burt, Director of Operations for National Grid System Operator, told us that the plan was "the right measure at the right time".[641] Randolph Brazier, Head of Innovation and Development at the Energy Networks Association, similarly told us that the Association "very much supports the smart systems and flexibility plan".[642]

187. In a 2018 'progress update', the Government listed 15 of the actions in the plan as "in progress" and 15 as "implemented" (one new action was added to the original 29).[643] Reviewing the progress of the plan in 2019, the National Infrastructure Commission reported that the Government "has been supportive of smart power and has made good progress in many areas".[644] Randolph Brazier, representing the Energy Networks Association, similarly told us that his organisation believed the plan was "making good progress".[645] Nevertheless, the National Infrastructure Commission report identified a few areas for further attention including three "priorities for 2019":

- a reduction of barriers to the creation of new "interconnectors" connecting the electricity networks in Great Britain to international networks, in particular in the context of Brexit negotiations;
- the establishment of a deadline for the transition currently being undertaken by energy distribution network operators as they start to more actively manage their networks, along with support from the Government and the regulator to facilitate the transition; and
- amendment to the Electricity Act 1989 to explicitly define electricity storage as a subset of generation.[646]

640 HM Government and Ofgem, 'Upgrading Our Energy System: Smart Systems and Flexibility Plan' (2017), pp21–30
641 Q334
642 Q334
643 HM Government and Ofgem, 'Upgrading Our Energy System: Smart Systems and Flexibility Plan—Progress Update' (2018), pp25–45
644 National Infrastructure Commission, 'Annual Monitoring Report 2019' (2019), p26
645 Q334
646 National Infrastructure Commission, 'Annual Monitoring Report 2019' (2019), p28

Storage

188. Dr Jonathan Radcliffe, of the University of Birmingham (and Specialist Adviser for this inquiry), noted that "the transition to a decarbonised economy presents challenges to energy systems by reducing their flexibility as an increased proportion of energy comes from variable renewable energy sources".[647] Many other submissions, including from National Grid and Ofgem, similarly highlighted the growing proportion of power provided by intermittent sources, and the consequential need for flexibility.[648] Dr Radcliffe told us that "energy storage technologies are one option for adding flexibility back into an energy system and analysis has shown that they have the potential to be part of a cost-effective transition to a low carbon and secure energy system", clarifying that different storage capabilities would be needed to manage:

- imbalances in transmission and distribution networks in 'real-time';
- peaks and troughs in energy demand through the day;
- days with low supplies of energy (for example with poor wind power generation); and
- seasonal variation in demand (for example increased heating in cold weather).[649]

Dr Radcliffe said that his team's "analysis of the energy system through the 2020s suggests that technologies that can store large quantities of energy […] will be important".[650] Randolph Brazier, Head of Innovation and Development at the Energy Networks Association, and Professor Nick Eyre, Director of the Centre for Research into Energy Demand Solutions, similarly said that deployment of sufficient long-term inter-seasonal energy storage would be the greatest challenge (see also paragraph 140).[651]

189. Several witnesses argued that the Government should aim to support the development of long-term energy storage technologies.[652] For example, the Durham Energy Institute told us that "significant intervention at the state level and investment is needed to reach the scale of storage required to make our energy system truly resilient and low-carbon".[653] The Institute said that this "could be achieved through direct investment in research and development, subsidies or by indirect market mechanisms such as requiring energy suppliers to implement a certain level of storage and tax breaks for companies who introduce storage".[654] Dr Jonathan Radcliffe similarly told us:

> Our review of international energy storage policies […] suggests that direct technology support for energy storage has been effective at increasing deployment in a number of markets. Such support has taken a number of forms including direct support for capital investment in energy storage

647 Dr Jonathan Radcliffe (CGE0041), para 4
648 For example, see: Cadent (CGE0015), para 15; National Grid (CGE0019), para 2.3; EDF Energy (CGE0020), para 9; Ofgem (CGE0033), para 6; Highview Power (CGE0050), section 1
649 Dr Jonathan Radcliffe (CGE0041), paras 4–5
650 Dr Jonathan Radcliffe (CGE0041), para 16
651 Qq307–309
652 For example, see: Greenpeace UK (CGE0022), para 7; Durham Energy Institute (CGE0065), paras 8 and 29–30; and Q310
653 Durham Energy Institute (CGE0065), para 29
654 Durham Energy Institute (CGE0065), para 30

> devices, mandated targets, and co-subsidies for renewables with energy storage; forms of which have been seen in Germany, Japan, and states in the US.[655]

He highlighted the ARPA-E GRIDS programme in the USA, which recently launched to support the development of "storage technologies that can store renewable energy for use at any location on the grid at an investment cost less than $100 per kilowatt hour".[656] Randolph Brazier clarified that long-term energy storage technologies existed, but that "they have not been tested at scale".[657]

190. Dr Radcliffe told us that although "large-scale energy storage of electricity and heat could be a key component of the future energy system […] policy/market signals that would encourage investment are lacking".[658] In keeping with the National Infrastructure Commission's recommendations, Eaton, a global power management company, told us that "there is currently no statutory definition for storage, which has significant detrimental impact on the technology's bankability":

> The Government's current plan to classify storage as a subset of generation provides short-term certainty, but is sub-optimal in the long term. In order to unlock the full potential value of storage, it needs to be defined in law as a separate asset class from generation systems which have completely different economics.[659]

191. The lack of a suitable legal definition for storage was also identified to us as a major barrier to the deployment of energy storage technologies by the Solar Trade Association and Highview Power.[660] The view that storage should not be defined as a subset of generation is reportedly widespread, given the additional roles it can play in the energy system.[661] Although the Government acknowledged the need for electricity storage to be defined in primary legislation in its '*Smart Systems and Flexibility Plan*',[662] Tim Lord, Director of Clean Growth at the Department for Business, Energy and Industrial Strategy, told us that the Government had "already taken a range of steps to enable storage to participate more fairly in the market" and that he was "not sure about any specifics on further legislation that people are seeking or require".[663]

192. **The development and deployment of energy storage technologies will be critical to the UK's transition towards a flexible, low-carbon energy system. It is disappointing that the Government has not made the Parliamentary time available to define energy storage in primary legislation. *The Government must ensure sufficient support for the development and deployment of energy storage technologies. Large-scale, inter-seasonal storage currently appears to pose the greatest technical challenges, and should be supported through demonstration projects, including in future large-scale trials of low-carbon heating. The Government should provide a dedicated legal definition of***

655 Dr Jonathan Radcliffe (CGE0041), para 17
656 Dr Jonathan Radcliffe (CGE0041), para 24–see also: ARPA-E, 'GRIDS Program Overview'
657 Q310
658 Dr Jonathan Radcliffe (CGE0041), para 2
659 Eaton (CGE0052)
660 Highview Power (CGE0050), section 4 and Solar Trade Association (CGE0053), para 14
661 'Brexit to blame for slow energy storage progress admits BEIS', Current +/-, 24 May 2018—see also: Qq322–323
662 HM Government and Ofgem, 'Upgrading Our Energy System: Smart Systems and Flexibility Plan' (2017), p21
663 Q496

energy storage in primary legislation as soon as possible. Such a commitment should be included in the next Queen's Speech, if Parliamentary time is not found for such legislation before then.

Smart meters

193. Energy storage is not the only option for increasing flexibility and managing increased levels of intermittent renewable power generation in the energy system.[664] One alternative is to better match demand to supply so that power is used when it is available and is not required when it is not available, an approach known as 'demand-side management'.[665] Duncan Burt, Director of Operations for National Grid System Operator, told us that one "fundamental" element of a smart energy system that could provide such demand-side management was the replacement of traditional electricity and gas meters with smart meters.[666] Smart meters measure a property's electricity or gas consumption (or electricity generation, where applicable) in real-time and can periodically relay this information to the energy supplier.[667] Although consumers are expected to benefit immediately from the installation of a smart meter on their property by:

- receiving automatic, accurate bills in place of manual metering or estimated bills; and
- being able to monitor their energy consumption in real-time, allowing for better management of home energy usage;[668]

the main benefits of smart meters are expected to accrue to consumers and to the wider system by enabling demand-side management.[669] In order for consumers to use electricity when it is most abundant, and to be rewarded for doing so (with lower energy costs, for example), their appliances must be able to respond to information about the current availability of electricity and suppliers need to know exactly when energy was consumed—this requires smart metering.

194. The improved information on, and control over, energy consumption might also allow for greater innovation in the energy system.[670] For example, companies may start offering 'heat as a service', where consumers pay for a pre-agreed level of comfort rather than for each unit of energy that they consume to heat their homes (such contracts would incentivise energy suppliers to provide the energy for heating as efficiently as possible).[671] By supporting energy supply contracts that encourage consumers to use energy when it is cheapest, smart meters may also help to reduce the peak demand for energy. This would reduce the need for power generation capacity and grid reinforcement. A 2016 study conducted by Imperial College London and the Carbon Trust estimated that flexibility could yield net savings for the UK energy system of £17–40bn by 2050.[672]

664 National Infrastructure Commission, 'Smart Power' (2016)
665 'Flexible Electricity Systems', POSTnote 587, Parliamentary Office of Science and Technology, September 2018
666 Q319
667 Smart Energy GB, 'Smart Meters'—smart meters can relay the information to suppliers every month, every day or every half-hour, but only provide the total consumption over half-hour periods
668 Smart Energy GB, 'Smart Meter FAQs'
669 Delta-EE, 'Smart Meter Benefits: Role of Smart Meters in Responding to Climate Change' (2019)
670 Delta-EE, 'Smart Meter Benefits: Role of Smart Meters in Responding to Climate Change' (2019)
671 Energy Systems Catapult, 'Smart Energy Services for Low Carbon Heat' (2019)
672 Imperial College London and Energy Saving Trust, 'An analysis of electricity system flexibility for Great Britain' (2016)—this study considered all flexibility options deployed together, not just smart meters

195. The Government has said that it is "committed to all homes and small businesses being offered smart meters by the end of 2020".[673] As part of their licence to operate, energy suppliers in Great Britain must "take all reasonable steps to have installed a smart meter" by the end of 2020.[674] However, as of December 2018, 12.7m smart meters were in operation in domestic properties across Great Britain, compared to 37.1m traditional meters.[675] The National Audit Office has said that "there is no realistic prospect of installing smart meters in all eligible premises covered by the rollout obligation by 2020".[676] Energy suppliers have said that they are aiming for 70–75% of households to have a smart meter by the end of 2020, which Claire Perry MP told the Business, Energy and Industrial Strategy Committee in January 2019 was "achievable".[677] However, in 2018, 4.9m smart meters were installed and if this rate were sustained, the roll-out would achieve around only 46% coverage by the end of 2020.[678] Further, installations rates have fallen since peaking at the end of 2017.[679]

196. Duncan Burt, Director of Operations for National Grid System Operator, told us that although the roll-out was "taking time", National Grid System Operator believed that the "strategy will deliver".[680] Professor Nick Eyre, Director of the Centre for Research into Energy Demand Solutions, told us that he thought it was "much more important to do the smart meter roll-out well than to do it quickly".[681] Dhara Vyas, Head of Future Energy Services at Citizens Advice, expressed a similar opinion in oral evidence to the Business, Energy and Industrial Strategy Committee in January 2019.[682]

197. Although energy suppliers should make all reasonable efforts to install a smart meter, households and businesses are not required to accept one.[683] Indeed, the National Audit Office has reported that "consumer behaviour has proven to be more of a barrier to mass uptake of smart meters than the [Government] anticipated".[684] Under half of households offered a smart meter reportedly accepted one in 2017,[685] although the Centre on Innovation and Energy Demand noted that there was "very little data available about acceptance rates".[686] It recommended that energy suppliers collect and publish data on acceptance rates and the reasons for consumer rejection, in order to identify options for increasing consumer acceptance. Professor Eyre told us that the smart meter roll-out should be treated "not just as a technology problem but recognising that people's trust in this technology and their ability to use it effectively to reduce their costs is absolutely

673 Department for Business, Energy and Industrial Strategy, 'Smart Meters: Unlocking the Future' (2018)
674 Ofgem, 'Supply licence guide: Smart metering' (2019)
675 Department for Business, Energy and Industrial Strategy, 'Smart Meter Statistics: Quarterly Report to end December 2018' (2019), p11
676 National Audit Office, 'Rolling out smart meters' (2018), para 1.36
677 Oral evidence taken before the Business, Energy and Industrial Strategy Committee on 9 January 2019, HC 1851, Q93
678 Department for Business, Energy and Industrial Strategy, 'Smart Meter Statistics: Quarterly Report to end December 2018' (2019), p10
679 Department for Business, Energy and Industrial Strategy, 'Smart Meter Statistics: Quarterly Report to end December 2018' (2019), p11
680 Q320
681 Q328
682 Oral evidence taken before the Business, Energy and Industrial Strategy Committee on 9 January 2019, HC 1851, Q70
683 'Smart meters: A guide to your rights', Ofgem, accessed 3 July 2019
684 National Audit Office, 'Rolling out smart meters' (2018), para 1.19
685 'Smart meter roll-out in question as only a fraction of households sign up', Daily Telegraph, 26 August 2017
686 Centre on Innovation and Energy Demand, 'The smart meter rollout: Social questions and challenges' (2018)

critical".[687] One problem has been the functionality of the smart meters, with the first models ceasing to operate smartly if the consumer changed energy suppliers.[688] A new generation of smart meters unaffected by this fault has now been developed, however, and the old meters are starting to be updated remotely to overcome the problem.[689]

198. In order for large numbers of consumers with smart meters to adjust their energy consumption to better match supply, it is likely that they will need to be financially rewarded for doing so. Although some energy suppliers currently offer tariffs that charge consumers according to when they consume energy, these are uncommon.[690] One barrier is the current settlement framework for network charges, under which consumers' consumption is typically estimated rather than measured. Since their suppliers pay the estimated charges, based on average consumer profiles rather than actual usage, the suppliers are then not exposed to the true network usage cost of supplying that consumer, which provides no incentive for the supplier to offer tariffs rewarding consumers for using electricity when it is abundant and cheap.[691] Ofgem told us that it was currently considering the case for market-wide 'half-hourly' settlement,[692] under which all suppliers would be charged according to the actual use of their consumers over every half-hour period. Ofgem said that it would be making its final decision on market-wide settlement reform in the second half of 2019, but warned that "the implementation of market-wide half-hourly settlement depends on the rollout of smart meters":

> A critical mass of smart meters will be needed to realise the full benefits of market-wide half-hourly settlement. To manage consumers without a smart meter when market-wide half-hourly settlement is implemented, a proportion of the energy market may need to continue to operate through some form of profiled data. In these circumstances, there may be costs to maintain the non-half hourly arrangements, which constrains the potential benefits of half-hourly settlement.[693]

199. **The roll-out of smart meters is one important enabling component of a flexible energy system that can match demand to supply, allowing increased deployment of intermittent renewable power generation. However, the Government's roll-out is severely behind schedule, in part because the original scheme had fundamental design faults, as highlighted by our predecessor Committee and the then Energy and Climate Change Committee.** ***The Government must ensure that it takes all reasonable steps to achieve a national roll-out of smart meters as soon as possible. In order to reduce consumer resistance to smart meters, the Government should run public engagement initiatives to raise public awareness that by having a smart meter installed, consumers can contribute to long-term reductions in the UK's greenhouse gas emissions. Ofgem should require energy suppliers to collect and publish data on consumer acceptance***

687 Q328
688 Department for Business, Energy and Industrial Strategy, 'Smart Metering Implementation Programme' (2018), p12
689 Department for Business, Energy and Industrial Strategy, 'Smart Metering Implementation Programme' (2018), pp12–13 and 'Way clear for second cohort of first-generation smart meters to be enrolled on central network', Data Communications Company, accessed 15 July 2019
690 Imperial College London Energy Futures Lab, 'Unlocking the potential of residential electricity consumer engagement with Demand Response' (2018), p10
691 Imperial College London Energy Futures Lab, 'Unlocking the potential of residential electricity consumer engagement with Demand Response' (2018), p10
692 Ofgem (CGE0033), paras 28–29
693 Ofgem, 'Market-wide Half-Hourly Settlement: Strategic Outline Case' (2018), para 2.41

rates for smart meter installation, and the reasons given by consumers for rejecting a smart meter. The Government should then be ready to act on this information to drive greater installation rates of smart meters, for example by introducing a consumer incentive mechanism. It should also require installation of a smart meter in properties without one whenever the owner or renter changes.

200. **Market-wide half-hourly settlement of energy consumption costs will incentivise energy suppliers to offer tariffs that reward consumers for using energy when it is abundant, helping to enable higher levels of intermittent renewable power generation. However, Ofgem has highlighted the dependence of market-wide half-hourly settlement on widespread smart meter deployment. Given the low current uptake of smart meters, this indicates that there could be very significant delays in the introduction of market-wide half-hourly settlement and the benefits of widespread 'smart' tariff adoption.** ***Ofgem should clarify what it determines to be the critical mass of smart meters required for market-wide half-hourly settlement. Since the introduction of market-wide half-hourly settlement will help to catalyse smart meter take-up, Ofgem should not set an overly stringent critical mass, and should be prepared to recover the costs of incomplete smart meter deployment from the suppliers of those consumers who do not have smart meters (in a way that protects vulnerable consumers).***

The Capacity Market

201. The Capacity Market was established by the then Government in 2013,[694] to address its concerns that falling power generation capacity combined with increasing levels of intermittent renewable generation could weaken the reliability of the electricity network.[695] Under the Capacity Market framework, National Grid estimates future peak electricity demand and determines a corresponding quantity of 'back-up' capacity required to ensure sufficient supply.[696] It then holds a lowest-cost auction for those willing to offer capacity. Successful bidders commit to provide electricity when needed in return for steady capacity payments. Two auctions are held each year, one to source capacity for four years' time (the T4 auction) and one to source additional capacity for one years' time (the T1 auction).[697] All T1 contracts last one year, but T4 contracts are available for up to 15 years for new facilities, for up to three years for refurbished facilities and for one year for existing facilities.[698] If contracted capacity providers cannot deliver electricity when required, they face financial penalties.[699] The cost of the Capacity Market is shared among electricity suppliers.[700]

202. Generation (*i.e.* back-up power generation plants) and non-generation (*e.g.* voluntary demand reduction schemes) approaches are eligible to apply to supply capacity in the Capacity Market.[701] However, non-generation suppliers may only apply for year-long

694 Energy Act 2013, sections 27–43
695 Department of Energy and Climate Change, 'Planning our electric future: A White Paper for secure, affordable and low-carbon electricity' (2011), p59
696 Department of Energy and Climate Change, 'Roles and responsibilities under the Capacity Market' (2015)—National Grid's forecasts are subject to independent scrutiny and approval by the Secretary of State
697 The Electricity Capacity Regulations 2014 (SI 2014/2043), section 2
698 Ofgem, 'Consolidated version of the Capacity Market Rules' (2018), pp25–26
699 The Electricity Capacity Regulations 2014 (SI 2014/2043), sections 39–41 and schedule 1
700 Department of Energy and Climate Change, 'Electricity Market Reform: policy overview' (2012), para 49
701 Department of Energy and Climate Change, 'Electricity Market Reform: policy overview' (2012), para 49

contracts.[702] The first T4 auction took place in 2014 for delivery in 2018/19.[703] Although the majority of capacity was contracted to existing gas-powered plants as expected,[704] the auction also supported a significant increase in small-scale diesel generators.[705] Highview Power, a 'liquid air' energy storage company, told us that this effective support for diesel generators does "not align with the decarbonisation agenda".[706] Tim Lord, Director of Clean Growth at the Department for Business, Energy and Industrial Strategy, highlighted however that capacity contracted through the Capacity Market might be used relatively infrequently—only at specific periods of low supply or high demand—and argued that the Capacity Market's support for fossil fuel technologies was therefore "not necessarily quite as problematic" as a scenario in which such technologies were being operated continuously.[707] Nevertheless, the results of the first T-4 auction will lead to around £1.2bn being provided to fossil-fuel generators over the course of the contracts agreed.[708]

203. Duncan Burt, Director of Operations for National Grid System Operator (which administers the Capacity Market), suggested that there was no technical reason why the Capacity Market could not make greater use of technologies such as batteries, interconnectors and demand-side response systems, without the need for diesel-powered generators.[709] Professor Nick Eyre, Director of the Centre for Research into Energy Demand Solutions, told us, however, that "it is clear that the Capacity Market has not been constructed to be a level playing field" for all technologies.[710] Although the Capacity Market is open to generation and non-generation technologies, non-generation suppliers may only apply for year-long contracts.[711] Professor Eyre argued that "it would be sensible for a demand-side response to be able to get the same contract lengths […] as supply-side technologies" and noted that "there is also no allowance for energy efficiency and energy demand reduction" even though "it is done in a number of American markets".[712] Highview Power advocated "the introduction of a carbon emissions intensity limit" to the Capacity Market, as well as longer contract durations.[713]

204. In 2014, Tempus, a company that manages voluntary demand reduction projects to provide capacity, took the European Commission to court, claiming that it did not sufficiently consider the compatibility of the Capacity Market with internal market and State Aid rules.[714] The General Court of the European Union ruled in November 2018 that the European Commission did not examine with sufficient thoroughness the compatibility of the Capacity Market with State Aid rules.[715] This has put the Capacity Market into a standstill, with no new auctions or payments under existing contracts permitted.[716] The European Commission must now re-evaluate the compliance of the Capacity Market with

702 Ofgem, 'Consolidated version of the Capacity Market Rules' (2018), pp25–26
703 Ofgem, 'Annual Report on the Operation of the Capacity Market' (2015)
704 Ofgem, 'Annual Report on the Operation of the Capacity Market' (2015), p19—see also: Dieter Helm, 'Cost of Energy Review' (2017), p93
705 Q303
706 Highview Power (CGE0050), section 4
707 Q494
708 Ofgem, 'Annual Report on the Operation of the Capacity Market' (2015), pp17 and 19
709 Qq303–304
710 Q305
711 Ofgem, 'Consolidated version of the Capacity Market Rules' (2018), pp25–26
712 Q305
713 Highview Power (CGE0050), section 4.1
714 'Tempus CEO—Why we challenged the UK Capacity Market', Tempus Energy, accessed 4 July 2019
715 General Court of the European Union, 'The General Court annuls the Commission's decision not to raise objections to the aid scheme establishing a capacity market in the UK', 15 November 2018
716 National Grid System Operator, 'Tempus state aid judgment' (2018), p4

State Aid rules, from which the Government has said it expects an Opening Decision "early this year", with the final decision "following later in the year" (neither decision has yet been made).[717] The Government has stated that "the General Court judgment ruled on procedural grounds and did not challenge the fundamental nature of the Capacity Market", and that the ruling "does not change the Government's view that the Capacity Market is the right mechanism to deliver secure electricity supply at least cost".[718] The Energy and Clean Growth Minister, Claire Perry MP, told the Business, Energy and Industrial Strategy Committee in January 2019 that the Government was "working closely with the European Commission to ensure that the Capacity Market can be reinstated swiftly".[719]

205. In line with requirements under the Energy Act 2013, the Minister has said separately that the Government would review the Capacity Market and its first five years of operation. It launched a consultation on this in August 2018 and published a summary of responses in March 2019.[720] The Government's summary of the responses concluded that "the Capacity Market was working as intended" although "there was scope to improve its design in some respects", in particular to ensure that the technology mix acquired through the market minimised costs and achieved "a range of energy objectives" rather than security of supply alone.[721] The summary did not provide detail on specific proposals, but noted that the Government's formal response would be published in summer 2019.[722] The Government's response to a separate consultation has also signalled its intention to allow certain renewable power generation technologies (solar and wind power) to compete in Capacity Market auctions from 2020 onwards.[723]

206. **Energy capacity secured through the Capacity Market supplies energy to the grid relatively infrequently throughout the year, and supports the co-deployment of increasing levels of intermittent renewable power generation. Nevertheless, contracts awarded through the Capacity Market provide funding for energy capacity technologies. So far, this has mostly supported technologies such as gas-fired and diesel generators, which are not in line with the UK's ambition to reach net-zero emissions. *In keeping with the UK's ambition to move towards net-zero emissions, the Government should ensure that the Capacity Market supports low-carbon technologies as far as possible without detriment to the wider deployment of renewable power generation. As it reviews the success of the Capacity Market to date, the Government should consider introducing a minimum proportion of Capacity Market funding that must be awarded to low-carbon technologies.***

207. ***Non-generation suppliers bidding for Capacity Market contracts should be eligible to bid for contracts of up to fifteen years, in line with new generation facilities.***

717 Letter from Rt Hon Claire Perry MP to Rachel Reeves MP, 3 January 2019
718 Department for Business, Energy and Industrial Strategy, 'Proposals for Further Amendments to the Capacity Market' (2019), p4
719 Letter from Rt Hon Claire Perry MP to Rachel Reeves MP, 3 January 2019
720 Department for Business, Energy and Industrial Strategy, 'Capacity Market and Emissions Performance Standard Review: Summary of call for evidence responses' (2019)
721 Department for Business, Energy and Industrial Strategy, 'Capacity Market and Emissions Performance Standard Review: Summary of call for evidence responses' (2019), p6
722 Department for Business, Energy and Industrial Strategy, 'Capacity Market and Emissions Performance Standard Review: Summary of call for evidence responses' (2019), p7
723 Department for Business, Energy and Industrial Strategy, 'Proposals for further amendments to the Capacity Market: Response to consultation' (2019), pp16–17

Price control framework

208. The market regulator, Ofgem, sets what costs energy network operators can recover from consumers' energy bills through its 'RIIO' ('Revenues using Incentives to deliver Innovation and Outputs') framework.[724] Ofgem explained to us that "the RIIO model of price regulation encourages innovation by incentivising network operators to behave in particular ways, for example reducing the number of times electricity consumers experience power cuts".[725] Ofgem is currently reviewing this framework, ready to operate RIIO-2 from 2021 for gas distribution and gas and electricity transmission networks, and from 2023 for electricity distribution networks.[726] It has said that it will "retain an innovation stimulus package, limited to innovation projects that might not otherwise be delivered under the core RIIO-2 framework".[727]

209. The Energy Networks Association told us that the first RIIO framework had had "significant success in encouraging network companies to bring forward innovative projects and embed a culture of innovation within their organisations".[728] It said that it was "vital, therefore, that innovation in networks continues to be strongly incentivised under future price controls, as the networks deliver their crucial role in developing the complex future energy system".[729] SGN, a gas distribution company, similarly told us that "sufficient funding for innovation […] as part of the [RIIO-2 gas distribution] network price control period […] will be crucial to enable timely future heat policy decisions from Government",[730] while Sam French, representing the Decarbonised Gas Alliance, agreed that "RIIO-2 is going to be really important" for the decarbonisation of gas.[731] However, following publication of Ofgem's proposals for RIIO-2,[732] Randolph Brazier, Head of Innovation and Development at the Energy Networks Association, told us that the Association advocated "more support for innovation in RIIO-2 [than what was in Ofgem's proposals], along the lines of what we have in RIIO-1".[733] SSE, a gas and electricity distribution network operator, has also warned that "the proposals put forward by Ofgem in developing the RIIO-2 model now put [the first price control framework's] success at risk".[734] It suggested a series of technical amendments to Ofgem's proposed framework, including the retainment of the Network Innovation Allowance and the Network Innovation Competition from the first framework.[735] These two elements were recently highlighted by a cross-sector strategy as having been "key to driving success forward".[736]

210. In addition to some witnesses expressing their hope for the new price control framework to continue the success of the first, we also heard from stakeholders advocating greater change. For example, Ovo Energy, an energy technology company and supplier, told us that "current incentive structures ought to do much more to accelerate change

724 Ofgem, 'RIIO-2 Framework Decision' (2018), p10
725 Ofgem (CGE0033), para 32
726 Ofgem, 'RIIO-2 Framework Decision' (2018)
727 Ofgem, 'RIIO-2 Framework Decision' (2018), p30
728 Energy Networks Association (CGE0059), para 9
729 Energy Networks Association (CGE0059), para 9
730 SGN (CGE0040), para 4
731 Q214
732 Ofgem, 'RIIO-2 Framework Decision' (2018)
733 Q333
734 SSE, 'Response to National Infrastructure Commission: Future of Regulation Study call for evidence' (2019)
735 SSE, 'Response to National Infrastructure Commission: Future of Regulation Study call for evidence' (2019)
736 Energy Networks Association, 'Gas Network Innovation Strategy' (2018), p3

in the energy system" and should encourage companies to incorporate innovation into business-as-usual, "rather than simply conduct pilot projects with no follow-on".[737] It made specific recommendations for the new framework, including:

- ensuring that network operators could make "genuine financial gains and losses based on their performance on whole-system outcomes", such as contributing to emissions reductions;
- making the cost and availability of new connections for renewable power generation a metric against which network operators were judged; and
- rewarding network operators for using existing infrastructure more efficiently, by making the ratio between maximum capacity and the average load on a network (the 'load factor') a primary metric for adjusting network company revenues.[738]

Ovo Energy has highlighted the last point in particular, arguing that the current price control framework "fail[s] to recognise and prioritise the procurement of flexibility services over alternative options such as investment in new network infrastructure",[739] and advocating with other stakeholders that network operators be "obligated to tackle network constraints by procuring flexibility services as a first measure, rather than by building expensive new network infrastructure".[740]

211. The Energy Networks Association, representing Great Britain's energy distribution network operators, said that it "welcome[d] the recognition [that Ovo Energy's campaign] gives to the important and exciting role that energy networks have to play in delivering a smarter, cleaner energy system", and argued that "energy networks are already delivering [flexibility services] across the country".[741] In 2018, the Association made a 'flexibility commitment', with the six distribution operators in Great Britain committing to:

- consider smart flexibility service markets when building significant new electricity network infrastructure;
- transparently compare relevant reinforcement and market flexibility solutions for all new projects of any significant value; and
- work with Ofgem and other stakeholders to ensure that the incentives under RIIO-2 do not favour the building of new infrastructure where flexibility services are more efficient.[742]

The Energy Networks Association has since published six principles that the network operators will adhere to in order to fulfil their commitment, and included case studies of how operators have acted upon this so far.[743]

737 Ovo Energy (CGE0007), paras 2.3 and 6.2
738 Ovo Energy (CGE0007), para 6.2
739 'Flexibility First: How the UK's network companies can facilitate clean, affordable energy for all', Ovo Energy, accessed 24 June 2019
740 'OVO leads the charge in calling for 'Flexibility First' revolution', Ovo Energy, accessed 24 June 2019
741 ''Flexibility First': Industry calls for networks to procure flexibility over network upgrades', Current +/-, 17 July 2018
742 Energy Networks Association, 'Energy Networks Association's Flexibility Commitment' (2018)
743 Energy Networks Association, 'Our six steps for delivering flexibility services' (2019)

212. **Regulation of UK energy markets will play a key part in the development of a smart and flexible energy system. The RIIO price control framework has helped to support innovation in the gas and electricity networks, but it is vital that the second price control framework promotes even greater levels of innovation as the energy networks undergo a period of significant change.** ***Ofgem must ensure that its second price control framework does not dilute its support for innovation and that the framework should further enable and incentivise network operators to innovate as part of their core business, rather than through standalone projects. Ofgem should work with network operators, energy suppliers and flexibility services providers to ensure that flexibility systems are always considered and deployed ahead of infrastructure construction, where possible and affordable.***

The roles for different stakeholders

The regulator

213. As discussed in the previous section (see paragraphs 208 to 212), the energy markets regulator has a key role to play in the decarbonisation of the UK energy system. The powers and duties of the regulator are provided for by a variety of UK and EU legislation,[744] but its "principal objective" is to "protect the interests of existing and future consumers in relation to gas conveyed through pipes and electricity conveyed by distribution or transmission systems".[745] These interests are defined to be "taken as a whole" and explicitly include consumers' interests in the reduction of gas- and electricity-supply emissions of targeted greenhouse gases.[746] Ofgem told us that its role was to "to design and regulate markets and networks which incentivise the lowest cost transition to a low carbon energy system whilst remaining technology neutral".[747]

214. Despite this responsibility to consider consumers' interests in the reduction of gas- and electricity-supply emissions of targeted greenhouse gases, we heard concerns expressed that Ofgem's focus lay too strongly on lowering costs for current consumers. For example, Zenobe Energy, a battery storage operator, noted that the impact assessment for Ofgem's proposed network charging reforms did not include criteria relevant to the UK's emissions reductions targets.[748] Indeed, Zenobe Energy told us that it thought that the proposed reforms would "undermine the UK's position as a global leader in the development and deployment of storage and renewable technologies".[749] SSE, a gas and electricity distribution network operator, has similarly argued that Ofgem's proposals for the next price framework "put too much emphasis […] on the short-term aspiration to exert downward pressure on customer bills" relative to the longer-term need for, and costs of, decarbonisation.[750] These concerns about Ofgem's proposed network charging reforms aligned with other evidence to our inquiry (see paragraphs 77 to 79).

744 In particular, the Gas Act 1986, the Electricity Act 1989, the Utilities Act 2000, the Competition Act 1998, the Enterprise Act 2002 and the Energy Acts of 2004, 2008, 2010 and 2011

745 'Powers and duties of GEMA', Ofgem, accessed 17 May 2019—for more detail, see: the Electricity Act 1989, section 3A and the Gas Act 1986, section 4AA

746 'Powers and duties of GEMA', Ofgem, accessed 17 May 2019—for more detail, see: the Electricity Act 1989, section 3A and the Gas Act 1986, section 4AA

747 Ofgem (CGE0033), para 2

748 Zenobe Energy (CGE0080), para 10

749 Zenobe Energy (CGE0080), para 9

750 SSE, 'Response to National Infrastructure Commission: Future of Regulation Study call for evidence' (2019)

215. At the request of the Government, the National Infrastructure Commission has launched an inquiry into the regulation of the energy, telecommunications and water markets, examining "what changes might be necessary to the existing regulatory framework to facilitate future investment needs […] while promoting competition and innovation and meeting the needs of both current and future consumers".[751] This is due to report in autumn 2019.

216. **The energy markets regulator has an explicit duty to protect consumers' interests in the reduction of gas- and electricity-supply emissions of targeted greenhouse gases, alongside other considerations such as minimising costs. However, there is no specific link between the regulator's objectives and the UK's emissions reduction targets. In addition, some have expressed concerns that the regulator focuses too heavily on reducing costs for current consumers, at the expense of contributing to the UK's decarbonisation. *When the Government reviews the upcoming recommendations from the National Infrastructure Commission on the future regulation of the energy market, it should consider the case for amending the energy market regulator's principal objective so that it explicitly includes ensuring that regulations align with the emissions reduction targets set out in the Climate Change Act 2008.***

Local authorities

217. Dr Jonathan Radcliffe, who leads the Energy Systems and Policy Analysis Group at the University of Birmingham and acted as a Specialist Adviser for our inquiry, told us that the trend for decentralisation in the energy system would "increase the importance of policy and regulation at a local level".[752] This is apparent from the range of issues relevant to local authorities discussed in this Report, including:

- planning support for low-carbon power generation technologies such as onshore wind farms (see paragraphs 59 to 62 and 65 to 68);
- the impact of urban planning on transport options, such as the quality of walking and cycling infrastructure and of public transport, and the establishment of urban delivery consolidation centres (see paragraphs 127 and 134);
- the provision of electric vehicle chargepoints (see paragraph 106);
- the development and enforcement of local building regulations (see paragraphs 155 to 161);
- the co-ordination between companies, households and infrastructure stakeholders required at a local level to deploy heat networks, which are so far mostly restricted to a few supportive local authority areas (see paragraph 138);[753]
- the strategic oversight required to plan local electricity and gas distribution networks ready for low-carbon transport and heating options such as electric vehicles and heat pumps (see paragraphs 106 and 138); and

751 National Infrastructure Commission, 'The Future of Regulation Study: Call for Evidence' (2019), p3
752 Dr Jonathan Radcliffe (CGE0041), para 18
753 Q54

- opportunities for local authorities to partner with local taxi services to promote the uptake of electric taxis.[754]

218. Dr Radcliffe told us that "a number of cities/regions are implementing their own energy innovation initiatives", pointing to examples in the West Midlands, Aberdeen and the Humber,[755] but argued that "there has been little consideration of the governance framework through which a more decentralised system can be coordinated".[756] Although Professor Nick Eyre, Director of the Centre for Research into Energy Demand Solutions, noted that there were "some excellent initiatives coming out of local government", he indicated that this was far from universal.[757] The Town and Country Planning Association concluded in 2016 that "local plans in England are not dealing with carbon dioxide emissions reduction effectively" and that "since 2012 climate change has been de-prioritised as a policy objective in the spatial planning system".[758]

219. Local authorities have a duty to include policies designed to mitigate climate change in local development plans,[759] with 2019 guidance from the Government for English local authorities stating that their planning systems must aim to support "moving to a low carbon economy" alongside achieving "economic" and "social" objectives.[760] However, this guidance was arguably weakened in 2018, with guidance requiring local authorities to "recognise the responsibility on all communities to contribute to energy generation from renewable or low carbon sources" removed and guidance on "building a strong, competitive economy" no longer referencing decarbonisation.[761] Regen, a not-for-profit sustainable energy consultant, summarised:

> Overall, there are suggestions that local planning authorities should have positive strategies in place and consider energy in relation to new developments, but there is little to require a more proactive approach. As a result, only authorities with the capacity and political drive to plan positively for low carbon will do so.[762]

220. The Energy Systems Catapult has further argued that the new requirements were "primarily focused on enabling low carbon energy-related developments in spatial planning in which the focus is to balance demands for land use", which it said was "conceptually different from local area energy planning, in which the focus is on achieving a balanced energy system while meeting social, economic and environmental objectives".[763] In contrast, Scottish local authorities are explicitly required to act "in the way best calculated to contribute to delivery of the [emissions reductions] targets" set by Scotland's 2009

754 'Electric taxis could be about to hit the streets of Bristol', Bristol Live, 13 May 2019
755 '21st Century Energy', Energy Capital; 'H2 Aberdeen', Aberdeen City Council; and 'Energy Estuary' Humber Local Enterprise Partnership—all accessed 4 July 2019
756 Dr Jonathan Radcliffe (CGE0041), paras 18–19
757 Q345
758 Town and Country Planning Association, 'Planning for the climate challenge?' (2016), p2
759 Planning and Compulsory Purchase Act 2004, section 19
760 Ministry of Housing, Communities and Local Government, 'National Planning Policy Framework' (2019), para 8
761 Ministry of Housing, Communities and Local Government, 'National Planning Policy Framework' (2018) and Department for Communities and Local Government, 'National Planning Policy Framework' (2012), paras 18 and 97
762 'Revised National Planning Policy Framework published', Regen, accessed 21 June 2019—Regen was commenting on the changes to the National Planning Policy Framework made in 2018; although the framework has since been updated again, the relevant sections have not been changed
763 Energy Systems Catapult, 'Local Area Energy Planning: Supporting clean growth and low carbon transition' (2018), p52

Climate Change Act.[764] Randolph Brazier, Head of Innovation and Development at the Energy Networks Association, noted that Scottish local authorities have started to consider local whole energy system plans more than most English authorities.[765] Highlighting the "vaguer" obligations placed on English local authorities compared to Scottish authorities, Professor Nick Eyre argued that "the role of local authorities in the energy system in England" ought to be made more specific.[766]

221. With 115 councils in the UK, as well as the Local Government Association, having declared a 'climate emergency',[767] it is, however, clear that limited local action on decarbonisation is not purely the result of weak obligations dampening ambition. Professor Eyre explained that there was "in many cases, very limited capacity for local government to respond clearly".[768] UK100, a network of local government leaders who have pledged to work towards "100% clean energy by 2050", has similarly said that the ambition of local authorities is "stymied by a lack of capacity and capability when it comes to turning that ambition into reality".[769] With regards to local authorities' access to finance for developments intended to reduce emissions, the Minister of State for Energy and Clean Growth, Claire Perry MP, highlighted Salix Finance, which offers interest-free loans to local authorities to make energy efficiency improvements, and told us that the Government had committed £10m to local energy hubs.[770] Professor Jim Watson, Director of the UK Energy Research Council, told us, however, that "one problem with many local authorities, even those that are doing quite a lot, is that they are very dependent on specific income streams via specific programmes":

> We had a conversation with the Treasury about the mechanism that allows [local authorities] to build up a general capability in this area, whether it is about giving them obligations, or whatever, and the budget to match. When you talk to local authorities, you find that that is often the struggle—they get offices in place on the back of particular projects and programmes, but that does not necessarily mean that over a long term they will get the capability that enables them to make those sorts of planning decisions, unless they are very entrepreneurial and successful.[771]

The Local Government Association has similarly reported, from a survey of local authorities, that the main barriers to local authorities' investment in sustainable transport were a lack of revenue and capital funding and a lack of certainty over continued levels of funding.[772]

222. The Energy Systems Catapult told us that, beyond access to finance, "the problem [local authorities] face is how to decide which options are most appropriate for their local area and in what order they should be prioritised".[773] Tanya Sinclair, Policy Director

764 Climate Change (Scotland) Act 2009, section 44
765 Q355
766 Q356
767 'Declare a Climate Emergency', Climate Emergency, accessed 9 July 2019 and Local Government Association, 'Debate on tackling climate change, protecting the environment and securing global development: Briefing' (2019)
768 Q345
769 UK100, 'Financing the Transition: Harnessing UK Cities' Ambition for Clean Energy' (2019), p1
770 Q452
771 Q55
772 Local Government Association, 'Sustainable Travel: Survey Results' (2018), p9
773 Energy Systems Catapult (CGE0029), para 4

at ChargePoint, told us that many of the strategies adopted by local authorities were transferable and that there was "a need for greater sharing of information between them".[774] Identifying similar problems, the UK Energy Research Centre recommended in 2017 that the Government should "consider further the need for support agencies and shared services for local authority energy developments including national or regional energy agencies and specialist procurement organisations".[775] In an attempt to address both capacity and funding challenges, UK100 recently recommended that the Government launch a 'Clean Energy Action Partnership' programme under which local authorities would be invited to apply for competitive funding to support clean energy projects, with successful authorities provided with access to a new, central team of experts in addition to receiving the funding.[776] UK100 said that, if the programme focused on proposals that could later be transferred to other local authorities, the Government could subsequently "ensure that successful approaches are applied at the national scale and supported into export markets where applicable".[777] This multi-stage approach ties in with the "evolutionary approach" to local area energy planning recommended by the Energy Systems Catapult, which suggested that the Government pursue an "initial emphasis on encouragement, facilitation and supporting funding", moving towards "an obligatory approach in the mid-2020s" if this works well.[778]

223. **Local authorities have a vital role to play in the UK's decarbonisation. Many local authorities are pursuing emissions reductions projects, but the capacity and capability for decarbonisation at the local level varies. *The Government should introduce a statutory duty on local authorities in England and Wales, by Green Week 2020, to develop emissions reduction plans in line with the national targets set by the Climate Change Act 2008, and to report periodically on progress made against these plans. In preparation for this new obligation, the Government should establish centralised support to help local authorities develop decarbonisation strategies and deliver initiatives aimed at reducing greenhouse gas emissions. It should also support local authorities' access to low-cost, long-term finance in order to enable the delivery of such strategies. The Government should adopt UK100's proposals for 'Clean Energy Action Partnerships'.***

Consumers

224. Greenpeace UK pointed out that, so far, "most UK carbon emission reduction has happened in the power sector whilst having little impact on most peoples' day to day lives", but that the future impact on consumers would be greater as more consumer-facing sectors such as transport and heating started to decarbonise.[779] The Association for Decentralised Energy has argued that "it is simply not possible to decarbonise the energy system without the customer being central to the transition, because customers own so much of the equipment that causes emissions".[780] Indeed, the Committee on Climate Change has estimated that while 38% of the emissions reductions required for net-zero

774 Q127
775 UK Energy Research Centre, 'What We Know about Local Authority Engagement in UK Energy Systems' (2017), p3
776 UK100, 'Financing the Transition: Harnessing UK Cities' Ambition for Clean Energy' (2019), pp43–53
777 UK100, 'Financing the Transition: Harnessing UK Cities' Ambition for Clean Energy' (2019), p50
778 Energy Systems Catapult, 'Local Area Energy Planning: Supporting clean growth and low carbon transition' (2018), p13
779 Greenpeace UK (CGE0022), para 5
780 Association for Decentralised Energy, 'Solving the energy policy puzzle for users' (2019), p11

emissions by 2050 would likely be purely technological, 53% would require a combination of technological and societal change and 9% would largely entail societal or behavioural changes alone.[781] Many submissions to our inquiry made similar arguments.[782]

225. The most recent of the Government's periodic surveys on public opinion towards climate change reported that 80% of the population were either "fairly concerned" or "very concerned" about climate change.[783] The Government said that this was "the highest proportion of overall concern since the survey started and is driven by an increase in the proportion very concerned about climate change".[784] However, public awareness of how to take measures to support the UK's decarbonisation is not always as great as its apparent concern on the issue. For example, the same Government survey found that 48% of the public had "never heard" of renewable heating systems, with just 6% claiming to "know a lot".[785] UK Research and Innovation similarly told us that although there was "a relatively high level of public awareness of the need to transition to low carbon alternatives" in some areas, for example regarding the uptake of low-emissions vehicles, "in others such as domestic heat, there is very low awareness and insufficient societal acceptance of the degree of disruption that such a transition will entail".[786] It told us that it was working with the UK Energy Research Centre and other sector stakeholders to design a programme, called 'C3T', that would "help improve public awareness of these challenges", but stated that the programme:

> does not yet have the sufficient momentum or Government awareness to give any certainty that it will make a meaningful difference in addressing current low levels of public awareness, or in ensuring the necessary behavioural changes to deliver this transition to a low-carbon economy.[787]

226. With regard to raising consumer awareness, Graham Hazell, representing the Heat Pump Association, told us that "people would like to see an independent route for advice".[788] Many sources of information on emissions-reducing actions exist, from publicly-funded as well as private and third-sector organisations.[789] However, David Weatherall, Head of Policy at the Energy Saving Trust, told us that "one of the areas where there have been cuts in England is in that provision of advice and support".[790] He said that in Scotland, "you can call the Energy Saving Trust acting on behalf of the Scottish Government", who "would send an expert adviser to look at your home and help you to identify what you can do to take action", which nearly 4,000 consumers chose to do in Scotland in 2018, of which 85% went on to take some action.[791] These advisers are trained to deliver bespoke and locally-tailored advice on a range of low-carbon measures including energy efficiency,

781 Committee on Climate Change, 'Net Zero: The UK's contribution to stopping global warming' (2019), p155
782 For example, see: National Grid (CGE0019), para 3.4; Greenpeace UK (CGE0022), para 5; Energy UK (CGE0024), paras 17 and 27–28; Energy Systems Catapult (CGE0029); Royal Academy of Engineering and allied institutions (CGE0055), paras 5.1, 6.1, 25 and 46–48; UK Research and Innovation (CGE0058), para 23; Imperial College London (CGE0071), para 8
783 Department for Business, Energy and Industrial Strategy, 'BEIS Public Attitudes Tracker—Wave 29' (2019), p11
784 Department for Business, Energy and Industrial Strategy, 'BEIS Public Attitudes Tracker—Wave 29' (2019), p6
785 Department for Business, Energy and Industrial Strategy, 'BEIS Public Attitudes Tracker—Wave 28' (2019), p20
786 UK Research and Innovation (CGE0058), para 23
787 UK Research and Innovation (CGE0058), para 23
788 Q214
789 For example, see: 'Save energy at home', Energy Saving Trust; '120 Ways to save and conserve energy', Ovo Energy; 'How to save energy at home', Greener Scotland, all accessed 21 June 2019, and Energy Systems Catapult, 'Living Carbon Free' (2019)
790 Q189
791 Q189

renewable power generation and electric vehicle use, and can act as the initial point of contact for applying for financial support from the Scottish Government for adopting such measures.[792] In contrast, in England, the Government closed the energy saving advice service so that now there is only a website, which offers only generic advice.[793]

227. **Emissions reductions in the transport and heating sectors will involve greater impact on, and require greater involvement of, consumers than the decarbonisation of the power generation sector, which is where the UK has achieved the bulk of its emissions reductions so far. Although public support for measures to reduce emissions appears high, this is not always matched with awareness of what actions consumers can take to support decarbonisation. *In co-ordination with existing organisations, such as the Energy Saving Trust, who work to raise consumer awareness of available emissions-reduction measures, the Government should publish an easily-accessible, central guide for members of the public explaining what measures individuals and households can take to support the UK's decarbonisation.***

228. ***The Government should re-introduce a telephone and visiting advice service in England which offers bespoke advice on measures such as residential energy efficiency and low-carbon heating and transport.***

229. Researchers from Imperial College London noted that some consumers already used their "spending power" to support 'ethical' goods such as organic or fair trade products, and argued that if consumer goods were labelled with clear information regarding the emissions involved in their manufacturing and transport, the market could reward and incentivise lower-emissions products.[794] Addressing the complexity of modern supply chains and hence the potential difficulty of tracking emissions, the research group further added that it had "devised a method to calculate the carbon footprints of all consumer goods" using machine-learning.[795]

230. **Product labelling already helps consumers choose products based on qualities such as healthiness, environmental impact and employee or animal welfare. *The Government should explore the feasibility and potential benefits of establishing a standard for the emissions associated with the manufacturing and transportation of consumer goods, to enable retailers to label their products with emissions information and to enable consumers to factor this into their purchasing decisions.***

Equity

231. The Committee on Climate Change has estimated that achieving net-zero emissions could cost around 1–2% of GDP by 2050.[796] Professor Jim Watson, Director of the UK Energy Research Centre, highlighted "the need to implement this [lower-emissions] transition in a way that pays attention to equity, particularly to the fuel poor", and to "address some of the arguments sometimes made that we are spending too much money and that there is a disproportionate burden on poorer consumers and citizens".[797] He suggested that this could involve "thinking about things like implementing upgrades to

792 'Grants and Loans', Energy Saving Trust, accessed 9 July 2019
793 Q189—see also: 'Simple Energy Advice', accessed 9 July 2019
794 Imperial College London (CGE0071)
795 Imperial College London (CGE0071), para 2
796 Committee on Climate Change, 'Net Zero: The UK's contribution to stopping global warming' (2019), pp212–255
797 Q41—see also: Durham Energy Institute (CGE0065), paras 15–18

homes and targeting [the fuel poor] first".[798] Several stakeholders have pointed out that policies that ultimately derived funding from energy bills were more regressive than using general taxation.[799] For example, Energy UK told us that supplier obligations like the Energy Company Obligation were "financially regressive as the costs are distributed among energy consumers regardless of their ability to pay" and said that it "strongly believes that the fairest and most progressive method of funding energy efficiency programmes is through general taxation".[800]

232. Professor Watson added that the Government should also consider "the industrial strategy benefits and jobs benefits [of decarbonisation], thinking about the regional economies and spread of those benefits in the way we implement those strategies", adding that he did not think the Government was doing enough on this front.[801] Menter Môn, a marine energy developer, similarly argued that "supply chain improvements and bringing jobs to the extremities of the UK, where unemployment is higher, and prospects are lower, should be a result of investment in clean growth".[802] Several submissions highlighted technological opportunities for low-carbon growth that would align with economic regeneration in disadvantaged communities, for example:

- the Durham Energy Institute told us that geothermal heating could make use of water in flooded coal mines, potentially bringing "employment and inward investment" to regions with disused coal mines;[803]
- Johnson Matthey highlighted that "brown field sites in the North East and North West, South Wales, Grangemouth, Humber and Aberdeen" would be "obvious locations for hydrogen production at large scale";[804] and
- Marine Energy Wales told us that "50–60% of the economic benefit of both gross value added and jobs expected to be generated" by marine energy would be "in coastal areas in need of economic regeneration".[805]

The Renewable Energy Association also flagged the "regional nature of both marine and geothermal technologies, which include Cornwall, Wales and Scotland", and said that this "means they could be essential components of regional sector deals, crucial to growth in these areas".[806]

798 Q41—see also: 'About the ECO scheme', Ofgem, accessed 17 June 2019
799 For example, see: Energy UK (CGE0024), para 25; UK Energy Research Centre, 'Review of Energy Policy: 2018' (2018), p7; 'How can we make sure the low carbon energy transition is fair?', Green Alliance, accessed 4 July 2019
800 Energy UK (CGE0024), para 25
801 Q41
802 Menter Môn (CGE0002)
803 Durham Energy Institute (CGE0065), para 28
804 Johnson Matthey (CGE0066), para 13
805 Marine Energy Wales (CGE0047), para 1.6
806 Renewable Energy Association (CGE0026), para 16

233. **The decarbonisation of the UK's economy is critical for the environment and is a legally-binding target for the Government. Although decarbonisation offers opportunity for economic growth, it will inevitably also entail costs. The Committee on Climate Change has estimated that achieving net-zero emissions could cost around 1–2% of GDP by 2050. It is important that these costs are shared fairly among citizens.** ***The Government must ensure that its policies for achieving net-zero emissions consider the economic impacts on individuals. The Government should aim to cover the costs of measures through progressive means rather than through energy bills.***

234. ***In line with the Government's focus on 'place' in its Industrial Strategy, the Government should include the potential for supporting economic growth in disadvantaged regions in its determination of where to locate demonstration projects and other initiatives.***

8 Carbon capture and storage

235. In addition to minimising the extent of global warming by reducing greenhouse gas emissions—by reducing demand for carbon-intensive processes or by making those processes less carbon intensive—technologies can also be used to directly capture carbon dioxide, either at the point of emission from an industrial process or from the ambient atmosphere. Depending upon the technique used, this can significantly reduce overall emissions or even deliver a net reduction in the quantity of carbon dioxide in the Earth's atmosphere. This Chapter examines some of these techniques and what the Government should be doing to provide the appropriate level of support for their development and deployment.

Carbon capture, usage and storage

236. Carbon capture and storage (CCS) entails collecting the carbon dioxide released during a process and storing it so that it is not released into the atmosphere. CCS could, for example, significantly reduce or potentially eliminate emissions from a range of processes including power generation, hydrogen production or industrial processing.[807] Carbon capture, usage and storage (CCUS) is a related term incorporating the possible use of captured carbon dioxide, for example as an ingredient for construction materials or to produce biofuels.[808] The Carbon Capture and Storage Association warned us, however, that carbon usage has "limited potential for climate mitigation due to the limited overall volumes of CO_2 that can be utilised".[809]

237. The Committee on Climate Change has stressed "the importance of carbon capture and storage to achieving the current 2050 target at lowest cost and being an enabler of deeper reductions beyond that".[810] In 2014 (prior to the UK strengthening its 2050 emissions reduction targets), the Energy Technologies Institute estimated that the cost of meeting the UK's then target for 2050 would be around £30bn greater without the use of carbon capture and storage.[811] Malcolm Brinded, representing the Royal Academy of Engineering and allied institutions, told us that "CCS is going to be an essential component of any negative emissions strategy for the world to get to 2°C and certainly to 1.5°C", and that large-scale demonstrations of CCS would provide "an opportunity for the UK to be at the front of that".[812] Several other submissions to our inquiry, including from Energy UK and the Energy Systems Catapult, also described CCS as a key technology for the decarbonisation of multiple sectors, and emphasised the importance of Government support for further development.[813]

238. In 2018, the Government published an "action plan" for CCUS, stating an overall ambition for the UK to deploy a first CCUS facility in the 2020s and to "have the option to deploy CCUS at scale during the 2030s, subject to the costs coming down sufficiently".[814]

807 Scottish Carbon Capture and Storage (CGE0021), section 3
808 Global CCS Institute, 'The Global Status of CCS: 2017' (2017), p9
809 Carbon Capture and Storage Association (CGE0023), para 6
810 Committee on Climate Change, 'Reducing UK emissions: 2018 Progress Report to Parliament' (2018), pp44–45
811 Energy Technologies Institute, 'Carbon Capture and Storage: Potential for CCS in the UK' (2014), p23
812 Q49
813 For example, see: Cadent (CGE0015), para 3; Energy UK (CGE0024), paras 19–22; Drax Group plc (CGE0025), paras 36–38; Energy Systems Catapult (CGE0029), para 5; Decarbonised Gas Alliance (CGE0032), para 25; The Geological Society (CGE0051), paras 7–9
814 HM Government, 'The UK Carbon Capture Usage and Storage deployment pathway: An Action Plan' (2018)

The action plan highlighted the £315m 'Industrial Energy Transformation Fund' as a potential source of funding for CCUS projects,[815] and stated the Government's intention to:

- provide £40m for innovation programmes focused on CCUS and collaborate with industry and academia on further innovation;
- work with industry to identify investable commercial models and establish market-based frameworks for bringing forward CCUS;
- review barriers to deployment and consult on findings;
- identify opportunities to re-use existing infrastructure and share existing or new infrastructure;
- assess delivery capability required for projects during the 2020s; and
- work with international partners to accelerate the global deployment of CCUS and support global cost reductions.[816]

The Government has since allocated £170m to support the development of the world's first 'net-zero carbon' industrial cluster by 2040, with carbon capture and storage expected to play a prominent role.[817]

239. Professor Gibbins told us that "if it is carried through", the Government's CCUS plan made the large-scale deployment of carbon capture and storage "eminently viable",[818] adding that the Minister had "done an awful lot to accelerate [the deployment of CCS] and make it clear that things need to happen".[819] The Committee on Climate Change welcomed the action plan as a sign of the Government's "recommitment" to carbon capture and storage, but cautioned that "the Government has not yet proposed concrete approaches to tackle the challenges in deploying CCS in the UK", noting that "many of these have been well understood for some time and should progress more quickly than proposed in the action plan".[820] The Carbon Capture and Storage Association, representing a variety of companies working on CCS, similarly told us that the "Government's recognition of the need to develop the first project by the mid-2020s as an enabler towards having the ability to deploy CCUS at scale in the 2030s" was "an important element" of the plan, but highlighted several "limitations and missing aspects" in the plan:

- it said that the plan lacked a "clear framework", which left industry unsure of "how and on what terms it can invest in CCUS", and that it also lacked clarity in the Government's definition of deployment "at scale", its criteria for sufficient cost-reduction and its proposed balance of cost-sharing with industry;

815 HM Government, 'The UK Carbon Capture Usage and Storage deployment pathway: An Action Plan' (2018), p33—see also: Department for Business, Energy and Industrial Strategy, 'Designing the Industrial Energy Transformational Fund' (2019)

816 HM Government, 'The UK Carbon Capture Usage and Storage deployment pathway: An Action Plan' (2018), pp6–11

817 'World-first carbon 'net-zero' hub of heavy industry to help UK seize global economic opportunities of clean growth', Department for Business, Energy and Industrial Strategy, accessed 4 July 2019

818 Q403

819 Q404

820 'CCC welcomes Government's recommitment to Carbon Capture and Storage technology', Committee on Climate Change, accessed 4 July 2019

- it contrasted the Government's ambition to have the option to deploy CCUS in the 2030s, subject to cost-reductions, with the importance of CCUS to the UK's future decarbonisation as described by the Committee on Climate Change; and
- it argued that the Government should aim to develop at least two to three CCUS clusters during the 2020s, rather than just one individual facility.[821]

The Carbon Capture and Storage Association consequently told us that "further commitments and early actions from both Government and industry are required to ensure the progression of a pipeline of multiple projects in the near-term".[822]

240. The UK Government has already twice run competitions to develop CCS plants, both without success. The first was launched in 2007 and closed in 2011,[823] while the second was launched in 2012 and ended in 2015.[824] The National Audit Office estimated that the first and second CCS projects cost the Government £64m and £100m respectively prior to their cancellation.[825] Professor Gibbins explained that these projects combined carbon capture and storage with coal or gas-fired electricity generation, and failed due to a combination of the recession dampening demand for electricity, shale gas and renewable power developments competing with coal and gas-fired power generation, and insufficient scale.[826] He told us that, learning from these previous projects, it was now "important that the Government aim to develop a number of these clusters […] because if you aim to do one it is very easy to end up doing nothing", whereas "if you get ready to do several, at least one will happen first and, since we need the others anyway, they will follow on".[827] He also highlighted the importance of "open access development" of Government-supported demonstration projects, arguing that learning generated through such projects should be made public rather than commercially protected, so that "commercial readiness and expertise [builds up] more quickly than would normally happen".[828]

241. **Carbon capture and storage has been widely identified as a key technology for decarbonisation in several sectors. The Energy Technologies Institute estimated, prior to the UK's net-zero emissions ambition, that meeting the UK's original 2050 emissions targets without the use of carbon capture and storage would incur an additional £30bn in costs. This puts the Government's desire for value-for-money in context. We commend the Government for recapturing lost momentum in the development of carbon capture and storage. However, there are concerns that its action plan lacks clarity and ambition.**

242. ***Industry must have clarity on the framework through which it can invest in carbon capture, usage and storage (CCUS), as well as the timetable for the Government's CCUS Action Plan. The Government must provide greater clarity on the details of its action plan, and should set out in its response to this Report: what it considers to be deployment at scale; what constitutes cost-effectiveness or sufficient cost-reduction; how it expects***

821 Carbon Capture and Storage Association (CGE0079), paras 4–9
822 Carbon Capture and Storage Association (CGE0079), para 8
823 'Longannet carbon capture scheme scrapped', BBC News, 19 October 2011
824 'UK government carbon capture £1bn grant dropped', BBC News, 25 November 2015
825 National Audit Office, 'Carbon capture and storage: lessons from the competition for the first UK demonstration' (2012), p4 and National Audit Office, 'Carbon capture and storage: the second competition for government support' (2017), p4
826 Q396
827 Q403
828 Q393

to share costs with industry; and what the major milestones for the plan are, as well as when they are expected to be achieved. The Government should learn from previous carbon capture and storage projects and ensure that a sufficient number of projects, of sufficient scale, are undertaken to optimise the chance of successful deployment, and that the knowledge gained from publicly-funded work is publicly accessible.

A greenhouse gas removal strategy

243. A variety of techniques exist whose overall effect is to reduce the level of greenhouse gases in the atmosphere.[829] The Royal Society and the Royal Academy of Engineering have set out the major examples of these greenhouse gas removal technologies, as well as the maximum quantity of greenhouse gases they estimated these technologies could plausibly remove in 2050 (reproduced in Table 2).

Table 2: Major greenhouse gas removal techniques

Technique	Maximum 2050 greenhouse gas removal capacity (MtCO2)	Description
Bioenergy with carbon capture and storage (BECCS)	50	Capturing and storing the emissions produced as sustainably sourced biomass (e.g. wood) is burnt to produce energy, to remove the carbon extracted from the atmosphere by the biomass as it grew
Direct air carbon capture and storage (DACCS)	25	Deploying technologies that extract carbon dioxide directly from the air, for example through chemical reactions that convert carbon dioxide into a different chemical
Forestation	15	Growing new forests, whose trees absorb carbon dioxide as they grow
Enhanced terrestrial weathering	15	Accelerating the natural decomposition processes of certain minerals that extract carbon dioxide from the air as they decompose, for example by milling the minerals into a fine powder that can be spread over crops
Soil carbon sequestration	10	Changing land management practices to promote the capture and retention of carbon by soil, for example by using certain crops or fertilisers

829 'Negative Emissions Technologies', POSTnote 447, Parliamentary Office of Science and Technology, October 2013

Technique	Maximum 2050 greenhouse gas removal capacity (MtCO2)	Description
Biochar production and use	5	Converting biomass into 'biochar' products such as charcoal can significantly slow the rate at which carbon dioxide is released as it decomposes, as well as improving the fertility of soil it is spread on (which can further enhance carbon dioxide capture)
Habitat restoration	5	Restoring ecosystems that absorb high quantities of carbon dioxide, such as wetland, peatland or certain coastal habitats
Low-carbon building methods	5	Using sustainable wood or low-carbon concrete increases the carbon dioxide stored in building materials

Source: Royal Society and Royal Academy of Engineering, 'Greenhouse Gas Removal' (2018), pp25–65 and 95–103

Greenhouse gas removal projections

244. The Committee on Climate Change has stated that, even with the deployment of emissions reductions options "towards the maximum limits that are likely to be feasible, acceptable and sustainable", it expects the UK to emit greenhouse gases with the equivalent warming impact of around 130 million tonnes of carbon dioxide ($130MtCO_2e$) in 2050.[830] In order to meet the Government's target of net-zero emissions by 2050, this will therefore require the annual removal of $130MtCO_2e$ by 2050. Comparing this quantity with the total estimated greenhouse gas removal capacity of all plausible technologies combined (see Table 2), the Royal Society and the Royal Academy of Engineering concluded that the Committee on Climate Change's estimated removal requirement was "possible, but very challenging", and would involve "many methods [of greenhouse gas removal] deployed at the limit of their maximum deployment".[831]

245. In contrast to these projections, none of the Government's three "illustrative" pathways to meeting the UK's existing 2050 emissions reduction target involves any more than $20MtCO_2$ removal (despite one being labelled the "emissions removal" pathway).[832] Dr Naomi Vaughan, of the Tyndall Centre for Climate Change Research, highlighted that the Government's new target of net-zero emissions by 2050 would make greenhouse gas removal "even more necessary" given the difficulty of eliminating emissions from certain processes in aviation, agriculture and industry.[833]

246. Reviewing the technological readiness of greenhouse gas removal technologies, the Royal Society and Royal Academy of Engineering reported that "some greenhouse gas removal methods are already in use today, while others require significant development and demonstration before they can remove emissions at scale", but qualified that "when

830 Committee on Climate Change, 'UK Climate Action following the Paris Agreement' (2016), pp35–39
831 Royal Society and Royal Academy of Engineering, 'Greenhouse Gas Removal' (2018), p9
832 HM Government, 'The Clean Growth Strategy' (2017), pp151–152
833 Q362

considered at the scale required, none of the methods have been fully evaluated across their life cycle".[834] In order to meet the scale of removal necessary for 2050, Dr Naomi Vaughan, of the Tyndall Centre for Climate Change Research, told us that most of these technologies would need to start being deployed during the 2030s in order to contribute fully to the greenhouse gas removal required by 2050.[835] Professor Gideon Henderson, representing the Royal Society, said that the technologies could be broadly broken down into three categories of readiness:

- those that can be rolled out now, including forestation, habitat restoration, soil carbon sequestration and low-carbon building methods;
- those that still require substantial research and development, including biochar production and use, and enhanced terrestrial weathering; and
- technologies that will need to be deployed in conjunction with carbon storage, namely bioenergy and carbon capture and storage and direct air carbon capture and storage.[836]

He warned that there was an "urgent need to do research and development" on the second category of technologies, because it "would take some time, in order for us then to be able to roll them out to achieve net zero in 2050", while Professor Jonathan Gibbins, Director of the UK Carbon Capture and Storage Research Centre, told us that technologies requiring carbon capture and storage needed to start being deployed at scale "very quickly".[837]

Frameworks for the deployment of greenhouse gas removal technologies

247. Professor Henderson flagged that technological readiness would not be the only consideration relevant to the deployment of greenhouse gas removal technologies.[838] For example, Professor Jim Skea, of Imperial College London, highlighted that "transmitting a carbon price in some form is absolutely essential" because "people need to be rewarded" if they are to deploy greenhouse gas removal technologies.[839] Professor Henderson told us that there were a range of ways to incentivise the deployment of greenhouse gas removal technologies, including direct payments, tax credits or obligations on certain stakeholders.[840] In addition to requiring a system for incentivising or mandating greenhouse gas removal, he indicated that it would also probably be necessary to determine a price associated with emissions:

> Normally, the way in which we judge whether [greenhouse gas removal technologies] are worthwhile is to look at what you might call the social cost of carbon. You work out how much you think a tonne of CO_2 in the atmosphere is doing damage to the planet and societies, value that and then work out whether the cost of your technologies to remove the carbon dioxide is lower than that social cost of carbon. The Stern-Stiglitz report, for

834 Royal Society and Royal Academy of Engineering, 'Greenhouse Gas Removal' (2018), p8
835 Q366
836 Q367
837 Q367
838 Q372
839 Q376
840 Q380

> instance, values the social cost of carbon currently at something like US$30 per tonne of CO_2, with that escalating into the future. It rapidly gets to $50 and $100.[841]

Professor Gibbins argued that "a better measure of cost is what it would cost to get carbon neutrality by other means", saying that net-zero emissions would have to be achieved one way or another.[842]

248. As well as a framework for determining a suitable incentive or requirement for greenhouse gas removal, Professor Skea said that "one of the prerequisites would be better measurement and estimate of emissions [removals]" achieved by deployments of such technologies, explaining that "you need to be able to measure it, so that you can reward it properly".[843] Professor Henderson noted that a framework for greenhouse gas removal would require systems for reporting and verification as well as measuring and monitoring.[844] Dr Vaughan further noted that different frameworks would probably be required for technologies related to land management, which typically involve large numbers of landowners and farmers, compared to those that require significant infrastructure, which might involve networks of industries.[845]

249. Dr Vaughan also highlighted the wider environmental impacts of different greenhouse gas removal technologies.[846] In particular, she emphasised that "it is essential that […] bioenergy is sustainably sourced":

> You could have biomass energy with carbon capture with storage of a megaton of CO_2 underground, but the net effect is not to remove anything if you get wrong how you get that bioenergy. If you deforest a primary rain forest or interfere with a high-carbon ecosystem, you can make all that effort but the planet will see no benefit.[847]

Dr Vaughan said that the governance and regulation of bioenergy was therefore critical, and would have to be assured for international imports as well as domestic produce. Beyond the importance of ensuring that bioenergy with carbon capture and storage yields net greenhouse gas removal, Professor Henderson told us that "in many cases we do not really know the environmental impact" of greenhouse gas removal technologies, which could relate to impacts on biodiversity, environmental toxicity or food security, and that this was "another reason why doing things at field scale and demonstrating them is really important to see how the impact plays out".[848]

841 Q383
842 Q385
843 Q376
844 Q390
845 Q390
846 Q397
847 Q397
848 Q401

The Government's support for greenhouse gas removal

250. In its Clean Growth Strategy, the Government stated that its "strategic approach to greenhouse gas removal" had two main elements:

- a research and development programme, to "help overcome the uncertainties around their costs, deployment potential, and impacts on the environment"; and
- consideration of "the scope for removing barriers and strengthening incentives to support the deployment of greenhouse gas removal".[849]

The research and development programme received £8.6m of funding over four years until 2021.[850] Professor Henderson told us that although the UK's greenhouse gas removal research programme was "the first of its type internationally", "there is an urgent need for more", in particular for demonstration trials and lifecycle assessment.[851] Professor Skea agreed that "what is needed is a real demonstration to the commercial sector".[852] Discussing direct air carbon capture and storage and bioenergy with carbon capture and storage specifically, UK Research and Innovation—the body responsible for overseeing the Government's research and innovation programme—told us that "with some notable exceptions […] more needs to be done to demonstrate the potential of these technologies".[853]

251. Regarding the Government's consideration of the barriers and incentives for greenhouse gas removal technologies, the Government recently said that it "has no current policies to deploy specific greenhouse gas removal technologies beyond existing commitments made in the Clean Growth Strategy to plant 11 million trees in England, to restore peatland, and to increase the amount of UK timber used in construction".[854] Professor Henderson told us, however, that as far as he knew, "currently there are very few, if any, approaches in the UK that financially incentivise removal of CO_2":

> In fact, many of the greenhouse gas removal technologies are not formally factored into global carbon accounting at the moment. Forestation is an exception. Most other technologies are not factored in.[855]

Dr Vaughan highlighted that the Government was not meeting its targets for forestation, and that there was "a basket of things that we can do now", including coastal habitat restoration as well as a greater level of forestation and peatland restoration.[856] Professor Skea added that land management practices could also contribute to greenhouse gas removal already, and noted that he had had "many complaints from the National Farmers Union that farmers are punished for their livestock emissions, but not rewarded for the way in which they manage the land and the soil".[857] Professor Henderson flagged that the Government had recognised the potential for an improved incentives framework for land use management in its 25-year environment plan, and that this would "probably be

849 HM Government, 'The Clean Growth Strategy' (2017), p57
850 '£8.6 million UK research programme on greenhouse gas removal', Natural Environment Research Council, accessed 20 June 2019 and PQ HL15075, 16 April 2019
851 Q390
852 Q390
853 UK Research and Innovation (CGE0058), para 7
854 Department for Business, Energy and Industrial Strategy, 'The UK Government's View on Greenhouse Gas Removal Technologies and Solar Radiation Management ("Geoengineering")' (201)
855 Q388
856 Qq383–384 and 390
857 Qq376 and 387

recognised in the Environment Bill".[858] The '25 Year Plan' did state the Government's intention to work with stakeholders to design a new woodland creation grant scheme to "incentivise larger scale afforestation to meet carbon goals and wider environmental benefits at a landscape scale".[859] However, the draft Environment Bill does not reference forestation, and the draft Agriculture Bill includes powers for the Secretary of State to "give financial assistance for or in connection with the purpose of starting, or improving the productivity of, an agricultural, horticultural or forestry activity" but only in the context of improving the quality of forestry products or the resource efficiency of these activities.[860]

252. **The Government's new ambition, to reach net-zero emissions by 2050, will probably require the active removal of at least 130 million tonnes of carbon dioxide from the atmosphere annually by 2050. This is significantly greater than the extent of greenhouse gas removal envisioned in any of the Government's previous 'illustrative pathways' to meeting its original 2050 target, and is also at the limit of what is expected to be reasonably deliverable.** ***The Government should plan for the deployment of greenhouse gas removal technologies capable of removing around 130 million tonnes of carbon dioxide by 2050. It should develop and publish, within six months of this Report's publication, an illustrative pathway detailing the full extent of greenhouse gas removal that it projects to be possible from each major technology option by 2050, as well as a strategy for ensuring this pathway is feasible, including any policy decisions required now.***

253. ***The Government should launch a consultation to inform the development of a future framework for managing and incentivising greenhouse gas removal, and to provide greater certainty to encourage private investment in the development of these technologies. The consultation should examine potential frameworks for valuing, incentivising, measuring, reporting and validating greenhouse gas removal by different technologies.***

254. **The step-change in greenhouse gas removal required by the Government's new ambition to reach net-zero emissions by 2050 will require a significant increase in current support for greenhouse gas removal technologies. Some urgently require research and development, whereas others could be deployed at scale now with the correct support.** ***In line with its future strategy for greenhouse gas removal, the Government should be ready to increase funding for research, development and demonstration of greenhouse gas removal technologies. It must also ensure that it is seizing currently available opportunities for greenhouse gas removal, and should develop an effective framework for managing and incentivising forestation and land use management to achieve net emissions removals.***

Geoengineering

255. In addition to technologies for removing carbon dioxide from the atmosphere, there are some proposed technologies that could potentially control global warming in other ways. The main technologies aim to do this by managing the solar radiation entering the Earth's atmosphere and striking its surface, for example by:

858 Q377
859 HM Government, 'A Green Future: Our 25 Year Plan to Improve the Environment' (2018), pp49–50
860 Draft Environment (Principles and Governance) Bill and Draft Agriculture Bill, section 1

- releasing reflective aerosol particles high in the Earth's atmosphere;
- spraying saltwater into the sky above seas, to precipitate increased, brighter cloud cover;
- using ships to churn up microbubbles on the ocean surface, increasing the reflectivity;
- distributing particles via aircraft or drones to dissipate high-altitude cirrus clouds, which absorb heat from the Sun; or
- putting a fleet of mirrors into orbit.[861]

256. Dr Naomi Vaughan, of the Tyndall Centre for Climate Change Research, told us that "modelling studies have shown that some [solar radiation management] technologies could lower the temperature", but said that this would only last as long as the intervention was maintained, and would not address the underlying problem of excess greenhouse gases in the atmosphere.[862] Professor Gideon Henderson, representing the Royal Society, further warned that "the cooling is also not uniform, so radiation management would not lead to the same cooling level across the world; you would get patchiness and, therefore, different countries would benefit differently".[863]

257. Professor Gibbins agreed that "solar radiation management is a very dangerous thing to do", but noted that "globally there would be a strong incentive to do it if it seemed like the alternatives were worse—for example, destabilisation of the Greenland ice cap or uncontrolled release of methane from thawing permafrost".[864] He argued that it was "very much in the UK's interest to research solar radiation management to show how dangerous it is and all the effects you will get:

> It does not reverse CO_2 emissions, but, bearing in mind that we may face suggestions to use it even within our lifetime, we need to be prepared. Wilfully closing our eyes to studying it because it is very unattractive and dangerous is not a responsible attitude.[865]

Professor Jim Skea, of Imperial College London, told us that his personal opinion was that "it would be worthwhile doing desk studies of solar radiation management", but that he would be "far less convinced of the case for doing demonstration".[866] Professor Henderson similarly told us that he thought that the "dominant research spending should be on greenhouse gas removal" compared to solar radiation management.[867]

258. **Solar radiation management does not address the fundamental problem of excess concentrations of greenhouse gases in the Earth's atmosphere, and does not appear to be a long-term solution to global warming. Nevertheless, it may be considered as a short-term solution if global greenhouse gas emissions are not reduced quickly enough to avoid significant global warming. In this scenario, detailed understanding of the wider effects of solar radiation management will be vital. *UK Research and Innovation***

861 'Explainer: Six ideas to limit global warming with solar geoengineering', Carbon Brief, accessed 4 July 2019
862 Q409
863 Q409
864 Q409
865 Q409
866 Q412
867 Q411

should review the current state of research into solar radiation management, the likely timeframes that would be required for detailed research and potential testing of such technologies, and the case for any increased research now. It should ensure that research into solar radiation management is sufficient to allow for any potential future decisions to be made on the deployment of such technology to be sufficiently well-informed.

Conclusions and recommendations

UK Greenhouse Gas Emissions

1. The UK has achieved world-leading emissions reductions for over two decades. However, this has not been exclusively the result of Government policies. The Government has decided to carry forward the equivalent of 88 million tonnes of carbon dioxide from the second carbon budget to the third, as permitted by the Climate Change Act 2008, pending advice from the Committee on Climate Change on technical changes to how the UK calculates and reports its emissions. *The Government must not use outperformance of the second carbon budget to weaken its targets for subsequent carbon budgets. As soon as possible after the Committee on Climate Change's advice on technical changes to the UK's emissions baseline, the Government should unambiguously declare its commitment to follow that advice.* (Paragraph 12)

2. Progress against the UK's emissions reductions targets must not be achieved by 'offshoring' UK industry and displacing the UK's territorial emissions to be counted instead in its consumption emissions. The Government should do more to meet its commitment to increase the prominence of consumption emissions statistics in its publications. *The Government should include consumption emissions alongside territorial emissions in all future publications on UK emissions. It should consider the impact of all policies on consumption emissions as well as territorial emissions, and ensure that progress is not achieved by 'offshoring' emissions to other countries to the detriment of the global environment. We do not accept that territorial emissions should be the sole basis for international negotiations. The United Kingdom's decarbonisation targets should also include consumption emissions.* (Paragraph 16)

3. We commend the Government for adopting a net-zero emissions target, in line with the 2015 Paris Agreement. It is vital now that this ambition is backed up with policies to ensure that the UK meets its targets. *The Government must develop and act on policies to ensure that the UK is on track to meet a 2050 net-zero emissions target. It must seek to achieve this through, wherever possible, domestic emissions reductions. However, it should also work to develop robust international frameworks for carbon units trading, to ensure that effective and efficient methods for reducing global emissions are supported where available.* (Paragraph 19)

4. We commend the Government on responding promptly to the Intergovernmental Panel on Climate Change's 2018 report on 1.5˚C global warming, by asking the Committee on Climate Change (CCC) for advice on net-zero emissions. However, it is disappointing that the Government excluded existing carbon budgets from the scope of this advice. *The Government should explicitly state, in advance of the CCC's advice on the sixth carbon budget, its willingness to amend the fourth and fifth carbon budgets in line with the CCC's cost-effective path to net-zero emissions by 2050 if recommended to do so.* (Paragraph 21)

5. Lord Deben, the Chairman of the Committee on Climate Change, gave evidence to our Committee. He did not declare his interest as the Chair of Sancroft International. This company has had amongst its clients Drax, the largest recipient of renewable

energy subsidies in the country, and Johnson Matthey, who are about to make a huge investment in electric vehicles. These should have been declared to the Science and Technology Committee. (Paragraph 23)

The Clean Growth Strategy

6. The Government's own projections suggest that the UK is not currently on track to meet its existing emission targets, although we note that there are several significant policies and ambitions that have not yet been included in these calculations. Nevertheless, the rate of deployment of several key low-carbon technologies is significantly lower than what is required to meet the Government's ambitions, and various stakeholders—including the Committee on Climate Change—have expressed concern at the current and projected rate of progress of the UK's decarbonisation. In order to meet the fourth and fifth carbon budgets, emissions reductions cannot continue only in sectors that have decarbonised successfully so far, and must be significantly accelerated in sectors such as transport, heating and agriculture that have made little progress. The step-change in decarbonisation required will need policies to support the deployment and roll-out of existing technologies alongside, and co-ordinated with, significant research, development and demonstration of less mature technologies. (Paragraph 36)

7. The UK can simultaneously achieve economic growth and global emissions reductions through the export of low-carbon technologies to other countries. This potentially offers global emissions reduction at lower cost than the same level of reduction in the UK. However, opportunities for delivering emissions reductions outside of the UK were not included in the 50 key policies and proposals of the Government's Clean Growth Strategy. When it laid legislation strengthening the UK's long-term emissions reduction targets, the Government said that it would review the net-zero target within five years, to review the extent to which other countries had followed the UK's lead in setting and acting upon decarbonisation targets. (Paragraph 40)

8. *Ahead of its review of international reaction to the UK's net-zero target, the Government should actively encourage other countries to take similarly ambitious action. It should develop a strategy by the end of 2020, identifying opportunities for the UK to encourage and support decarbonisation in other countries, and prioritising action that will achieve the greatest global emissions reduction. This should include cross-Government action to support British companies exporting technologies that can deliver emission reductions abroad.* (Paragraph 41)

9. *The Government should increase the number of Ministers across Government Departments working on climate change, including a new Ministerial role at the Foreign and Commonwealth Office with explicit responsibility for delivering multi-lateral action internationally on climate change. Reflecting the critical importance of mitigating climate change, and to improve cross-Government co-ordination, the Minister charged with co-ordinating the UK's action on national and international decarbonisation should be a full Cabinet Minister.* (Paragraph 43)

Decarbonising power generation

10. We commend National Grid Electricity System Operator for its ambition to be able to manage a 'zero carbon' electricity grid by 2025. This goes significantly beyond the Government's projections for possible renewable power deployment by 2032, and indicates that any 'over-delivery' on the deployment of low-carbon power generation in the 2020s will not be incompatible with the electricity transmission system. *We urge distribution network operators to adopt a similar ambition to National Grid System Operator, of operating a zero carbon grid by 2025. Ofgem should work with distribution network operators to ensure that the regulatory framework required to allow this is in place. If sufficient progress is not made we urge the Government to consider strengthening Ofgem's mandate to require the distribution network operators to speed up the investment and upgrading of the distribution networks required.* (Paragraph 53)

11. The Government has indicated that it expects requirements for new power generation capacity to be met through offshore wind power, nuclear power and gas-fired power with carbon capture and storage. There is considerable risk that these technologies may not provide the generation capacity required. *The Government must set out in its response to this Report how it intends to monitor and address any potential shortfall in power generation capacity, and ensure that this can be achieved with low emissions and costs.* (Paragraph 54)

12. Although onshore wind power and large-scale solar power are low-cost and low-carbon, the deployment of new installations of these technologies has fallen drastically since 2015. Onshore wind power in particular could lower costs to energy consumers as well as contributing to the UK's decarbonisation, and there is widespread support for increased Government support for such projects across Great Britain. *The Government must ensure that there is strong policy support for new onshore wind power and large-scale solar power projects for which there is local support and projected cost-savings for consumers over the long-term. The Government should actively encourage and support local authorities to adopt planning practices that promote local support for such renewable energy projects. The Government must additionally develop mechanisms to promote community ownership and profit-sharing of low-carbon projects, such as joint ventures, split ownership or shared revenue.* (Paragraph 62)

13. The marine energy sector has come together to propose market support mechanisms to support marine and other less-established renewable power technologies through technology development and commercialisation. *The Government should examine the case for supporting 'Innovation Power Purchase Agreements' and setting minimum allocations of future contract for difference auctions to specific technologies, to support the development and commercialisation of renewable power technologies that are less-established than offshore wind power.* (Paragraph 64)

14. *The Government should develop, by the end of 2020, a clear planning permission framework for re-powering existing onshore wind farms, and ensure that national planning policy facilitates re-powering with the most efficient technology and does not block proposals that attract local support. It must also monitor the proportion*

of onshore wind power sites that apply for permission to repower, and be ready to provide market support (for example through eligibility for contracts for difference) if this is not close to 100%. (Paragraph 68)

15. The delay between the end of the feed-in tariff scheme and the start of the Smart Export Guarantee scheme has caused unnecessary disruption to the smart energy and small-scale generation market. Nonetheless, the move towards a framework that facilitates greater flexibility and innovation in these markets is welcome, provided it offers a fair and sufficient means of compensation for owners of small-scale renewable generation capacity and a sufficient incentive for people to make the initial investment in such technologies. *The Government must ensure that it reviews the functioning of the Smart Export Guarantee scheme by the end of 2020, and should be ready to include a minimum price floor if there is evidence of a lack of market competitivity—for example, if uptake of tariffs is not significantly greater than the current number of tariffs or if the tariffs offered are significantly lower than wholesale electricity prices.* (Paragraph 74)

16. The Government must make sure that business rates incentivise embedded low-carbon generation and do not cause existing embedded generation to be disconnected. *The Government should reduce business rates for organisations that consume the majority of the power they generate to match the rates of organisations that sell the majority of their generation—and stop the administrative burden of loopholes that are being used to counter the discrepancy in rates. The Government should also reinstate the microgeneration exemption from business rates for renewable energy installations producing no more than 50kW. In its response to this Report, the Government should set out why combined heat and power units have been classed as excepted plant and machinery under the business rate regulations, but such a provision is not applied to solar panels and energy storage systems.* (Paragraph 76)

17. Ofgem must consider the interests of future consumers as well as current consumers in its decisions, including the need for decarbonisation. The projected increases in network costs for consumers and businesses that have installed on-site generation and flexibility technologies, arising from Ofgem's proposed network charging reforms, will act as a disincentive for further consumers or enterprises to install similar technologies. This is not conducive to the overall goal of decarbonisation. However, Ofgem is right to seek to avoid the costs of network usage falling increasingly on vulnerable consumers. *Ofgem must revise its proposed network charging reforms to ensure that they do not disincentivise the deployment of technologies that will contribute to the decarbonisation of the UK's energy system. The Government must ensure that vulnerable consumers do not pay an increasing proportion of network costs, and that all households have the ability to deploy technologies that will reduce their cost of energy and help to decarbonise the economy.* (Paragraph 79)

18. Although it is not possible to directly compare the costs of different power generation technologies, the Government is right to support nuclear power subject to it representing value for money, because full lifecycle emissions from nuclear power will help the UK to achieve its emissions reduction targets. *The Government must make a decision on implementing a regulated asset base framework for nuclear power by the end of this year. Subject to value for money, the Government should seek to support new nuclear power generation so as to sustain, but not grow, the UK's*

nuclear power industry. It must anticipate any gap in future generation capacity such a policy would cause, and support sufficient renewable power alternatives to fill the gap. (Paragraph 84)

19. The Government's support for small modular nuclear reactors in the Nuclear Sector Deal is welcome. *The Government must ensure that it delivers on the recommendations from the Expert Finance Working Group on Small Nuclear Reactors, including on regulatory developments, without undue delay. The Government should set out, in its response to this Report, what steps it has taken since the publication of the Group's report and propose a pathway—with indicative dates for key milestones—for the deployment of a first-of-a-kind small modular nuclear reactor by 203*0. (Paragraph 88)

20. Nuclear fusion is unlikely to make a substantial contribution to the UK's net-zero target for 2050. Nevertheless, it could ultimately provide significant quantities of energy from abundant fuels and without radioactive waste. *The Government must ensure that, whatever the terms of the UK's departure from the European Union, the long-term future of nuclear fusion research in the UK is not disrupted. It should additionally review the case for providing support for the nuclear fusion industry similar to the measures introduced recently by the US Government*. (Paragraph 92)

Decarbonising transport

21. There is significant scope for emissions reductions in the transport sector as a result of the purchase of more efficient vehicle models, without requiring technological developments or alternative fuel sources. However, the current fiscal incentives for cars are not sufficient to encourage consumers to purchase lower-emissions vehicles, given that most of the increase in average new car emissions in 2017 was caused by consumers choosing more emitting models. *The Government must reconsider the fiscal incentives for consumers to purchase both new and used vehicle models with lower emissions, and develop a strategy by the time of the Spring Statement 2020 to use vehicle excise duty and other incentives to drive the purchase of vehicle models with lower average emissions. This must include consideration of post-sales vehicle excise duty and the second-hand market*. (Paragraph 96)

22. *The Government must commit, prior to the UK's withdrawal from the European Union, to adopting transport emissions regulations that are, as a minimum, in line with current and future EU regulations on transport emissions. This should include legislation regarding emissions reductions requirements for heavy duty vehicles, regardless of the terms of the UK's departure from the EU.* (Paragraph 98)

23. The Government has said that a 2040 ban on the sale of conventional cars and vans is consistent with the UK's current emissions reductions targets for 2050, but this has been disputed by independent organisations such as the UK Energy Research Centre and the Committee on Climate Change. There is a strong case for bringing the date for a future ban forward, given that several manufacturers already have more ambitious commitments in place. *The Government should act on the advice of the Committee on Climate Change and bring forward the proposed ban on sales of new conventional cars and vans to 2035 at the latest. This ban should explicitly cover hybrid as well as internal combustion engines.* (Paragraph 102)

24. The availability of chargepoints is a significant factor in consumer uptake of electric vehicles. Although the extent of the UK's charging infrastructure is growing, it is not expanding at a pace to match the roll-out of electric vehicles. Interoperability of different chargepoint networks will be required to avoid the need for a roll-out of multiple extensive networks. Widespread adoption of electric vehicles will not necessarily require an unmanageable increase in power generation requirements, but in order for the electricity demand from widespread electric vehicles to be more comfortably met, and in order for electric vehicles to contribute to increased grid flexibility, smart charging will have to be commonplace. (Paragraph 109)

25. *The Government must ensure sufficient roll-out of rapid chargepoints along the strategic road network, and smart chargepoints at domestic, destination (such as places of work or shopping centres) and local sites. It should work with public services and owners of public land, such as schools and hospitals, to accelerate the deployment of chargepoints. The Government's forthcoming consultation on the regulation of charging infrastructure must determine measures to deliver interoperability, compatibility with a smart energy system, public availability of real-time information on the current functionality of chargepoints, and enforcement powers to ensure that chargepoints are reliable.* (Paragraph 110)

26. It is disappointing that the Government cut back the plug-in grant with electric vehicle sales below the indicative target set by the Committee on Climate Change. *The Government should set out, by the time of the Spring Statement 2020, how it intends to adjust the plug-in grant scheme in the future, using a transparent framework linked to ultra-low emissions vehicles sales.* (Paragraph 112)

27. *The Government should evaluate the impact of the free charging offered by the ChargePlace Scotland charging network as well as other potential incentive schemes for electric vehicle use.* (Paragraph 114)

28. Uptake of ultra-low emissions vehicles can potentially be driven in the fleet vehicle market more quickly than in the private consumer market. Options for supporting the uptake of ultra-low emissions vehicles in the fleet vehicle market include fiscal incentives and public procurement targets. *The Government should commit to adopting regulations on the public procurement of ultra-low emissions vehicles that are at least as ambitious as the EU's post-Brexit. It should further commit to having a 100% ultra-low emissions vehicle fleet by 2022 and to supporting local authorities in also having 100% ultra-low emissions fleets by 2030.* (Paragraph 117)

29. One current barrier to the uptake of ultra-low emissions vehicles in the UK is an insufficient supply to meet consumer demand, which has led to long waiting times. There is evidence in the UK and internationally suggesting that this could be partly due to inadequate support for the ultra-low emissions vehicle market from manufacturers and dealers. *The Government should review the functioning of the ultra-low emissions vehicles market annually, to determine if there are sufficient incentives for manufacturers and dealers to drive the adoption of ultra-low emissions vehicles, with the first review published by the time of the Spring Statement 2020. This should include consideration of the value of introducing minimum sales mandates on manufacturers, using tradeable sales certificate framework.* (Paragraph 120)

30. A ban on the sale of new diesel-powered heavy-goods vehicles will be needed by 2040 in order for the sector to achieve net-zero emissions by 2050. This will require policies now that will drive the development of alternative technologies and demonstrate the technical feasibility of such a ban. *The Government should introduce a ban on the sale of new diesel-powered heavy goods vehicles, for no later than 2040. It should additionally support trials of low-emissions HGV technologies on a timeframe that aligns with the proposed ban, and work with network operators and the delivery industry to plan for the potential charging infrastructure required for zero-emissions HGVs. Given that some HGVs are already being converted to run on hydrogen on a commercial basis, the Government should review the opportunity for market support mechanisms to drive higher rates of HGV conversion.* (Paragraph 124)

31. The Government's current long-term targets for decarbonising transport focus heavily on reducing exhaust emissions and increasing sales of low-emissions vehicles, rather than delivering a low-emissions transport system. In the long-term, widespread personal vehicle ownership does not appear to be compatible with significant decarbonisation. The Government should not aim to achieve emissions reductions simply by replacing existing vehicles with lower-emission versions. *The Government should not aim to achieve emissions reductions simply by replacing existing vehicles with lower-emissions versions. Alongside the Government's existing targets and policies, it must develop a strategy to stimulate a low-emissions transport system, with the metrics and targets to match. This should aim to reduce the number of vehicles required, for example by: promoting and improving public transport; reducing its cost relative to private transport; encouraging vehicle usership in place of ownership; and encouraging and supporting increased levels of walking and cycling. The Government should commit to ensuring that the annual increase in fuel duty should never be lower than the average increase in rail or bus fares.* (Paragraph 131)

32. *Any move to electric vehicles must have an associated environmental impact assessment, including the potential for recycling lead, lithium, cobalt, nickel and graphite. Hydrogen technology may prove to be cheaper and less environmentally-damaging than battery-powered electric vehicles. The Government should not rely on a single technology.* (Paragraph 132)

33. *The Government should review the potential to reduce emissions and support shared car ownership by incorporating Government Department car fleets into car sharing schemes. It should encourage other public bodies and local authorities to do likewise.* (Paragraph 133)

34. We commend the Government on its existing work to support the establishment and use of urban delivery consolidation zones. However, with just two major examples of completed projects to point to, there is clearly scope for a wider roll-out. *The Government should support the development of urban delivery consolidation centres, working with local authorities to assess the potential of such centres to reduce emissions and identify strategies to support their deployment and effective use.* (Paragraph 136)

Decarbonising heating

35. Heating accounts for around a third of the UK's overall emissions, which has remained essentially unchanged since 2009. The decarbonisation of heating will be

critical to the UK achieving its long-term emissions reductions targets, but there remains considerable uncertainty surrounding what mix of low-carbon heating technologies represents the best decarbonisation pathway for the UK, or what mix the Government will pursue. *The Government must urgently develop a clearer strategy for decarbonising heat. This will require large-scale trials of different heating technologies operating in homes and cities to build the evidence base required for long-term decisions. The Government must commit now to large-scale trials of low-carbon heating technologies, convening relevant stakeholders to determine what evidence must be gathered and to co-ordinate existing work.* (Paragraph 142)

36. The use of hydrogen as a fuel offers significant promise for low-carbon heating, transport and industrial processing, as well as for energy storage and to help manage intermittent renewable power generation. However, evidence from large-scale trials will be needed to allow the Government to make informed decisions on the UK's future energy system. Demonstrating the safety of hydrogen as a fuel is a critical first step, and we commend the Government for its support of the Hy4Heat programme. *The Government must complete the safety demonstration work for hydrogen as an urgent priority. The Government should also commit to completing at least one large-scale trial of hydrogen by 2025 conditional upon safety approval, and start developing now the terms for a competition to deliver such a trial. This should involve co-ordination of existing demonstration and modelling projects and should lead to the terms of a competition being announced no later than the end of 2020. (Paragraph 150)*

37. Blending hydrogen into gas supplied via the gas grid could provide an initial market for early hydrogen production facilities. *Once clear evidence is obtained on the level at which it is safe to mix hydrogen into the existing gas grid, and which is compatible with existing appliances, the Government should amend regulations to raise the proportion of hydrogen permitted in the grid. With higher blends of hydrogen permitted, the Government should act to support the development of this as a market for hydrogen, perhaps through feed-in tariffs or low-carbon obligations analogous to the Renewable Transport Fuel Obligation.* (Paragraph 153)

38. The Government's announced future homes standard is welcome. However, regulations requiring improvements to the efficiency of new buildings must be introduced before 2025. *The Government should re-introduce the zero-carbon homes standard as a matter of urgency, and no later than the end of 2019. It should additionally ensure that building regulations accurately reflect the current carbon intensity of electricity in Great Britain, and that this figure can be regularly updated (at least annually) in future.* (Paragraph 160)

39. *The Government should launch its consultation on Part L of the building regulations by the time of the Spring Statement 2020. Beyond that, it must ensure that homes built today are compatible with a net-zero emissions future and that the 'Future Homes Standard' reflects this.* (Paragraph 161)

40. *The Government should set out, in its response to this Report, the criteria that will be used to determine 'practicality' and 'affordability' in its energy efficiency targets, and provide an indicative percentage of homes that it is intending to help reach Band C by 2035.* (Paragraph 165)

41. Previous initiatives to encourage the installation of energy efficiency improvements in the 'able-to-pay' market have failed because they have focused too narrowly on providing financial support for specific interventions. *The Government's new energy efficiency policy must provide all homeowners with the incentive to make energy efficiency improvements to their property, with particular thought given to lower income households. By the time of the Spring Statement 2020, the Government should consider adjusting Stamp Duty so that it varies according to the energy performance of the home as well as the price paid for it. Homebuyers should then be able to make energy efficiency improvements within a defined time after purchasing the property, and claim back corresponding reductions in the Stamp Duty paid retrospectively. The adjustments made to Stamp Duty could be designed in order to be revenue-neutral to the Government. Robust certification of energy efficiency will need to be put in place to ensure that such a scheme is not open to exploitation and the Government should consider how best to incentivise upgrades in council, housing association and rented homes.* (Paragraph 171)

42. The Green Deal's 'golden rule' heavily restricted the energy efficiency improvements that could be paid for by the scheme. Although some energy efficiency improvements may not deliver net cost-savings to homeowners, they may still represent cost-effective options for the UK to meet its emissions reductions targets. *The Government's new energy efficiency policy must enable homeowners to access the finance needed to cover the upfront costs of energy efficiency improvements that offer a cost-effective contribution to the UK's decarbonisation, not just net cost-savings to individual homeowners. In analogy to the existing 'Help to Buy' scheme, the Government should establish a 'Help to Improve' scheme by July 2020 that offers matched funding and interest-free loans to homeowners, to cover the costs of making energy efficiency improvements.* (Paragraph 175)

43. We commend the Government for supporting research into, and the development of, 'green mortgages'. *The Government should consider the case for encouraging mortgage lenders to take energy efficiency into account for all mortgage applications, and should support the industry in capturing any potential in such a system for driving a market in energy efficiency improvements.* (Paragraph 177)

44. We commend the Government for strengthening the requirements on landlords to improve the energy efficiency of the least efficient homes in England and Wales. However, these measures will affect only 2.5% of the housing stock. *The Government should amend building regulations so that renovations to buildings must always result in an overall improvement in energy efficiency.* (Paragraph 179)

45. The Renewable Heat Incentive has significantly underperformed on the Government's expectations. *With the Renewable Heat Incentive due to close to new applications in 2021, the Government must ensure that it avoids a repeat of the disruption caused by the closure of the feed-in tariff, and announces its plans for the successor scheme to the Renewable Heat Incentive no later than the Spring Statement 2020. The successor scheme must be far more effective than the Renewable Heat Incentive scheme has proven to be.* (Paragraph 180)

46. The Government's announcement that fossil-fuel heating systems will not be permitted in new builds after 2025 may support the growth of supply chains for

low-carbon heating technologies and deliver consequent cost-reductions as well. *The Government should further support the deployment of low-carbon heating technologies by setting out a clear roadmap by the time of the Spring Statement 2020 for rebalancing levies on electricity and gas, to better reflect the emissions intensities of each fuel.* (Paragraph 183)

The UK energy system

47. The development and deployment of energy storage technologies will be critical to the UK's transition towards a flexible, low-carbon energy system. It is disappointing that the Government has not made the Parliamentary time available to define energy storage in primary legislation. *The Government must ensure sufficient support for the development and deployment of energy storage technologies. Large-scale, inter-seasonal storage currently appears to pose the greatest technical challenges, and should be supported through demonstration projects, including in future large-scale trials of low-carbon heating. The Government should provide a dedicated legal definition of energy storage in primary legislation as soon as possible. Such a commitment should be included in the next Queen's Speech, if Parliamentary time is not found for such legislation before then.* (Paragraph 192)

48. The roll-out of smart meters is one important enabling component of a flexible energy system that can match demand to supply, allowing increased deployment of intermittent renewable power generation. However, the Government's roll-out is severely behind schedule, in part because the original scheme had fundamental design faults, as highlighted by our predecessor Committee and the then Energy and Climate Change Committee. *The Government must ensure that it takes all reasonable steps to achieve a national roll-out of smart meters as soon as possible. In order to reduce consumer resistance to smart meters, the Government should run public engagement initiatives to raise public awareness that by having a smart meter installed, consumers can contribute to long-term reductions in the UK's greenhouse gas emissions. Ofgem should require energy suppliers to collect and publish data on consumer acceptance rates for smart meter installation, and the reasons given by consumers for rejecting a smart meter. The Government should then be ready to act on this information to drive greater installation rates of smart meters, for example by introducing a consumer incentive mechanism. It should also require installation of a smart meter in properties without one whenever the owner or renter changes.* (Paragraph 199)

49. Market-wide half-hourly settlement of energy consumption costs will incentivise energy suppliers to offer tariffs that reward consumers for using energy when it is abundant, helping to enable higher levels of intermittent renewable power generation. However, Ofgem has highlighted the dependence of market-wide half-hourly settlement on widespread smart meter deployment. Given the low current uptake of smart meters, this indicates that there could be very significant delays in the introduction of market-wide half-hourly settlement and the benefits of widespread 'smart' tariff adoption. *Ofgem should clarify what it determines to be the critical mass of smart meters required for market-wide half-hourly settlement. Since the introduction of market-wide half-hourly settlement will help to catalyse smart meter take-up, Ofgem should not set an overly stringent critical mass, and should be*

prepared to recover the costs of incomplete smart meter deployment from the suppliers of those consumers who do not have smart meters (in a way that protects vulnerable consumers). (Paragraph 200)

50. Energy capacity secured through the Capacity Market supplies energy to the grid relatively infrequently throughout the year, and supports the co-deployment of increasing levels of intermittent renewable power generation. Nevertheless, contracts awarded through the Capacity Market provide funding for energy capacity technologies. So far, this has mostly supported technologies such as gas-fired and diesel generators, which are not in line with the UK's ambition to reach net-zero emissions. *In keeping with the UK's ambition to move towards net-zero emissions, the Government should ensure that the Capacity Market supports low-carbon technologies as far as possible without detriment to the wider deployment of renewable power generation. As it reviews the success of the Capacity Market to date, the Government should consider introducing a minimum proportion of Capacity Market funding that must be awarded to low-carbon technologies.* (Paragraph 206)

51. *Non-generation suppliers bidding for Capacity Market contracts should be eligible to bid for contracts of up to fifteen years, in line with new generation facilities.* (Paragraph 207)

52. Regulation of UK energy markets will play a key part in the development of a smart and flexible energy system. The RIIO price control framework has helped to support innovation in the gas and electricity networks, but it is vital that the second price control framework promotes even greater levels of innovation as the energy networks undergo a period of significant change. *Ofgem must ensure that its second price control framework does not dilute its support for innovation and that the framework should further enable and incentivise network operators to innovate as part of their core business, rather than through standalone projects. Ofgem should work with network operators, energy suppliers and flexibility services providers to ensure that flexibility systems are always considered and deployed ahead of infrastructure construction, where possible and affordable.* (Paragraph 212)

53. The energy markets regulator has an explicit duty to protect consumers' interests in the reduction of gas- and electricity-supply emissions of targeted greenhouse gases, alongside other considerations such as minimising costs. However, there is no specific link between the regulator's objectives and the UK's emissions reduction targets. In addition, some have expressed concerns that the regulator focuses too heavily on reducing costs for current consumers, at the expense of contributing to the UK's decarbonisation. *When the Government reviews the upcoming recommendations from the National Infrastructure Commission on the future regulation of the energy market, it should consider the case for amending the energy market regulator's principal objective so that it explicitly includes ensuring that regulations align with the emissions reduction targets set out in the Climate Change Act 2008.* (Paragraph 216)

54. Local authorities have a vital role to play in the UK's decarbonisation. Many local authorities are pursuing emissions reductions projects, but the capacity and capability for decarbonisation at the local level varies. *The Government should introduce a statutory duty on local authorities in England and Wales, by Green Week 2020, to develop emissions reduction plans in line with the national targets set by*

the Climate Change Act 2008, and to report periodically on progress made against these plans. In preparation for this new obligation, the Government should establish centralised support to help local authorities develop decarbonisation strategies and deliver initiatives aimed at reducing greenhouse gas emissions. It should also support local authorities' access to low-cost, long-term finance in order to enable the delivery of such strategies. The Government should adopt UK100's proposals for 'Clean Energy Action Partnerships'. (Paragraph 223)

55. Emissions reductions in the transport and heating sectors will involve greater impact on, and require greater involvement of, consumers than the decarbonisation of the power generation sector, which is where the UK has achieved the bulk of its emissions reductions so far. Although public support for measures to reduce emissions appears high, this is not always matched with awareness of what actions consumers can take to support decarbonisation. *In co-ordination with existing organisations, such as the Energy Saving Trust, who work to raise consumer awareness of available emissions-reduction measures, the Government should publish an easily-accessible, central guide for members of the public explaining what measures individuals and households can take to support the UK's decarbonisation.* (Paragraph 227)

56. *The Government should re-introduce a telephone and visiting advice service in England which offers bespoke advice on measures such as residential energy efficiency and low-carbon heating and transport.* (Paragraph 228)

57. Product labelling already helps consumers choose products based on qualities such as healthiness, environmental impact and employee or animal welfare. *The Government should explore the feasibility and potential benefits of establishing a standard for the emissions associated with the manufacturing and transportation of consumer goods, to enable retailers to label their products with emissions information and to enable consumers to factor this into their purchasing decisions.* (Paragraph 230)

58. The decarbonisation of the UK's economy is critical for the environment and is a legally-binding target for the Government. Although decarbonisation offers opportunity for economic growth, it will inevitably also entail costs. The Committee on Climate Change has estimated that achieving net-zero emissions could cost around 1–2% of GDP by 2050. It is important that these costs are shared fairly among citizens. *The Government must ensure that its policies for achieving net-zero emissions consider the economic impacts on individuals. The Government should aim to cover the costs of measures through progressive means rather than through energy bills.* (Paragraph 233)

59. *In line with the Government's focus on 'place' in its Industrial Strategy, the Government should include the potential for supporting economic growth in disadvantaged regions in its determination of where to locate demonstration projects and other initiatives.* (Paragraph 234)

Carbon capture and storage

60. Carbon capture and storage has been widely identified as a key technology for decarbonisation in several sectors. The Energy Technologies Institute estimated, prior to the UK's net-zero emissions ambition, that meeting the UK's original 2050

emissions targets without the use of carbon capture and storage would incur an additional £30bn in costs. This puts the Government's desire for value-for-money in context. We commend the Government for recapturing lost momentum in the development of carbon capture and storage. However, there are concerns that its action plan lacks clarity and ambition. (Paragraph 241)

61. *Industry must have clarity on the framework through which it can invest in carbon capture, usage and storage (CCUS), as well as the timetable for the Government's CCUS Action Plan. The Government must provide greater clarity on the details of its action plan, and should set out in its response to this Report: what it considers to be deployment at scale; what constitutes cost-effectiveness or sufficient cost-reduction; how it expects to share costs with industry; and what the major milestones for the plan are, as well as when they are expected to be achieved. The Government should learn from previous carbon capture and storage projects and ensure that a sufficient number of projects, of sufficient scale, are undertaken to optimise the chance of successful deployment, and that the knowledge gained from publicly-funded work is publicly accessible.* (Paragraph 242)

62. The Government's new ambition, to reach net-zero emissions by 2050, will probably require the active removal of at least 130 million tonnes of carbon dioxide from the atmosphere annually by 2050. This is significantly greater than the extent of greenhouse gas removal envisioned in any of the Government's previous 'illustrative pathways' to meeting its original 2050 target, and is also at the limit of what is expected to be reasonably deliverable. *The Government should plan for the deployment of greenhouse gas removal technologies capable of removing around 130 million tonnes of carbon dioxide by 2050. It should develop and publish, within six months of this Report's publication, an illustrative pathway detailing the full extent of greenhouse gas removal that it projects to be possible from each major technology option by 2050, as well as a strategy for ensuring this pathway is feasible, including any policy decisions required now.* (Paragraph 252)

63. *The Government should launch a consultation to inform the development of a future framework for managing and incentivising greenhouse gas removal, and to provide greater certainty to encourage private investment in the development of these technologies. The consultation should examine potential frameworks for valuing, incentivising, measuring, reporting and validating greenhouse gas removal by different technologies.* (Paragraph 253)

64. The step-change in greenhouse gas removal required by the Government's new ambition to reach net-zero emissions by 2050 will require a significant increase in current support for greenhouse gas removal technologies. Some urgently require research and development, whereas others could be deployed at scale now with the correct support. *In line with its future strategy for greenhouse gas removal, the Government should be ready to increase funding for research, development and demonstration of greenhouse gas removal technologies. It must also ensure that it is seizing currently available opportunities for greenhouse gas removal, and should develop an effective framework for managing and incentivising forestation and land use management to achieve net emissions removals.* (Paragraph 254)

65. Solar radiation management does not address the fundamental problem of excess concentrations of greenhouse gases in the Earth's atmosphere, and does not appear to be a long-term solution to global warming. Nevertheless, it may be considered as a short-term solution if global greenhouse gas emissions are not reduced quickly enough to avoid significant global warming. In this scenario, detailed understanding of the wider effects of solar radiation management will be vital. *UK Research and Innovation should review the current state of research into solar radiation management, the likely timeframes that would be required for detailed research and potential testing of such technologies, and the case for any increased research now. It should ensure that research into solar radiation management is sufficient to allow for any potential future decisions to be made on the deployment of such technology to be sufficiently well-informed.* (Paragraph 258)

Annex 1: Units used in the Report

tCO_2e, $MtCO_2e$: The greenhouse effect varies according to the quantity of greenhouse gases in the Earth's atmosphere. One tonne of CO_2-equivalent (tCO_2e) refers to one tonne of carbon dioxide, or a quantity of another greenhouse gas that would contribute to global warming to an equivalent degree as one tonne of carbon dioxide. One megatonne of CO_2-equivalent (M tCO_2e) is equal to one million tonnes of CO_2-equivalent.

W, MW, GW: A Watt (W) is a unit of *power*, that is the rate of energy produced or consumed at a certain point in time. One Megawatt (MW) is equal to a million Watts and one Gigawatt (GW) is equal to a billion Watts. Power generation capacity can also be measured in Watts, in which case it represents the average or maximum power output that the generation plant can provide. A typical rooftop solar panel might generate a few thousand Watts in the middle of a sunny day, while a nuclear power station might generate a few billion Watts.

Wh, kWh, MWh: One watt-hour (Wh) is a unit of *energy*, equivalent to the total energy generated or consumed by a 1W device over the course of an hour. One kilowatt-hour (kWh) is equal to one thousand watt-hours and one megawatt-hour (MWh) is equal to one million watt-hours. Since there are 8,760 hours in a year, a 1MW power station would generate 8,760MWh of energy in a year. The average UK household uses around 10kWh of electricity a day, or around 4MWh of electricity each year.

Formal minutes

Wednesday 17 July 2019

Members present:

Norman Lamb in the Chair

Vicky Ford	Carol Monaghan
Bill Grant	Graham Stringer
Darren Jones	Martin Whitfield
Stephen Metcalfe	

Draft Report (*Clean Growth: Technologies for meeting the UK's emissions reduction targets*), proposed by the Chair, brought up and read.

Ordered, That the draft Report be read a second time, paragraph by paragraph.

Paragraphs 1 to 18 read and agreed to.

Paragraph 19 read.

Motion made, to leave out paragraph 19 and insert the following new paragraphs:

Professor Dieter Helm's October 2017 Cost of Energy Review: Independent Report was highly critical of the Government's response to the Climate Change Act:

1. This review has two main findings. The first is that the cost of energy is significantly higher than it needs to be to meet the government's objectives and, in particular, to be consistent with the Climate Change Act (CCA) and to ensure security of supply. The second is that energy policy, regulation and market design are not fit for the purposes of the emerging low-carbon energy market, as it undergoes profound technical change.

2. Since late-2014, the prices of oil, gas and coal have fallen significantly, contrary to the modelling and forecasting of both the Department of Energy & Climate Change (DECC) and the Committee on Climate Change (CCC). Since then, the price of renewables has been coming down fast too, as have the costs of addressing intermittency, as a host of new battery and other storage and demand-side options become available. Productivity increases should have been putting further downward pressure on the costs of transmission, distribution and supply. New technologies should mean lower, not higher, costs and much greater scope for energy efficiency. Margins should be falling as competition should be increasing. Yet in this period, households and industry have seen limited benefits from these cost reductions. Prices have gone up, not down, for many customers.

3. These excessive costs are not only an unnecessary burden on households and businesses, they also risk undermining the broader democratic support for decarbonisation. In electricity, the costs of decarbonisation are already estimated

by the CCC to be around 20% of typical electricity bills. These legacy costs will amount to well over £100 billion by 2030. Much more decarbonisation could have been achieved for less; costs should be lower, and they should be falling further.

4. Many of these excessive costs are locked in for a decade or more, given the contractual and other legal commitments governments have made. These include Renewables Obligation Certificates (ROCs), feed-in tariffs (FiTs), and low-carbon contracts for difference (CfDs) granted to early-stage wind and solar, larger-scale nuclear, biomass, and offshore wind. Since the ROCs, FiTs and low-carbon CfDs are formal contracts, they are taken as given in this review. The task is to find ways of minimising the burden these impose, and making them transparent, ring-fenced, and separated out from the market, where costs should be coming down.

5. The burden on households and businesses would have been even greater had there not been a financial crisis in 2007/08 which held down demand, and a parallel continued decline of the energy-intensive industries. Had the crash not happened, GDP would be perhaps 20–25% higher in 2017 (assuming no sharp fall in GDP in the immediate aftermath of the crash and 2–3% GDP growth since then). There would then have been a serious capacity crunch and much higher prices. As it is, the UK has flirted with dangerously low capacity margins despite the GDP effect, and this drives up prices as the more expensive marginal plant is drawn onto the system to match demand.

6. In the current decade, the government has moved from mainly market-determined investments to a new context in which almost all new electricity investments are determined by the state through direct and often technology-specific contracts. Government has got into the business of 'picking winners'. Unfortunately, losers are good at picking governments, and inevitably – as in most such picking-winners strategies – the results end up being vulnerable to lobbying, to the general detriment of household and industrial customers.

7.As a consequence of Electricity Market Reform (EMR), the government now determines the level and mix of generation to a degree not witnessed since these were determined by the nationalised industries – notably the Central Electricity Generating Board (CEGB). Investment decision-making has been effectively quasi-renationalised. This is a direct consequence of EMR. The government, not the customer, has become the client.

8. In determining not just the level of new capacity, but also the composition of the low-carbon portfolio, the government started out with some of the most expensive technologies first, and it could be argued that since then it has at times been exploring even more expensive options. The result is that British households and businesses are locked into higher renewables and other low-carbon generation costs than they need be to achieve the decarbonisation objectives for decades to come.

9. These state-backed contracts have been supported by the return to formal modelling and forecasting by DECC (now BEIS, the Department for Business, Energy & Industrial Strategy) and the CCC. In the case of DECC, the results have at times been spectacularly bad. In particular, in the first half of this decade, DECC

focused on its forecasts of high, rising and volatile gas prices, and therefore it could conclude that the wholesale price of electricity would rise to over £92/MWh by the early 2020s. It was confident that because fossil fuel prices (and particularly gas) were going up, households would be relatively better off as a result of its policies by around 7% by 2020.

10. The EU Renewables Directive and its particular definition of renewables has been a major contributor to raising the costs above those necessary to reduce carbon emissions to meet the CCA. A further contributor is the inefficient way in which the carbon budgets have been addressed, notably by not moving against coal earlier.

11. The overwhelming focus on electricity rather than agriculture, buildings and transport has added to the cost. Agriculture in particular contributes 10% greenhouse gas (GHG) emissions, and the costs of reducing these emissions are much lower than many of the chosen options because the economic consequences of a loss of output in agriculture are small. Agriculture comprises just 0.7% GDP and at least half its output is uneconomic in the absence of subsidies. With the development of electric vehicles (EVs) it is apparent that transport can contribute more. The CCC could have paid more attention to the lower marginal cost of abatement in these sectors.

12. Keeping costs down is all the more important as the electricity system faces a series of major challenges over the next decade. Not only does it need to meet the carbon budgets, it needs to do this in the context of major retirement of existing capacity, the investment requirements to handle the intermittent renewables, the coming of electric transport, and the wider demands of a digitalising economy. These challenges are on a scale and magnitude not witnessed since the reconstruction of the electricity industry immediately after the Second World War.

13. The energy sector is going through a technological transformation as electricity becomes an increasingly dominant form of energy. Previous structural breaks have come from single technologies, like the coal-fired power station, the gas turbine, and the civil nuclear power stations. This time there are structural breaks which span the whole economy as it digitalises, the transport sector as it electrifies, and the generation, transmission, distribution, supply and the demand for electricity. We are moving towards a decarbonised, digital, smart electric energy world, offering the prospect of ever-lower costs from cleaner energy.

14. The CCC neglects some of the opportunities of these technology impacts in its time horizon to 2050, arguing that any new technologies will have to be deployed before 2030 if they are to make much impact before 2050. This, together with the assumption that gas prices will rise by 30% by 2030, is a key rationale for the roughly linear profile of emissions reductions from now through to 2030. If the objective is limited to the CCA 2050 target, then the carbon budgets overegg the early stages, and make the trajectory between now and 2050 more expensive than it needs to be. Indeed, with such early action in the linear trajectory, it may turn out that decarbonisation is achieved much faster.

15. Tempting though it is to many observers to predict how this transformation is going to take place, and profitable to many lobbyists to persuade government that their specific technologies and projects are the right answers, the design of energy policy and the interventions to achieve the objectives should be driven by the uncertainty about the detailed shape of the decarbonisation path. In order to achieve the prize, it is important not to try to pick winners, and to focus on the framework within which the private sector brings new ideas, new technologies and new products to the end-user. Avoiding detailed intervention is a key to keeping down the cost of energy.

16. Since 2015, a number of reforms have begun to reverse some of the more grossly inefficient dimensions of current policies. The greater use of auctions has begun to bear down on excessive costs, but there is a long way to go. The decision to exit coal by 2025 is a belated but welcome step to recognise that switching away from coal is the cheapest way to decarbonise. It should have been the first option.

17. Notwithstanding the significant cost reductions from the auctions so far, existing energy policy is not fit for these new purposes. It remains complex and expensive, and it is slowing down the transition to a decarbonised economy.

18. The measures necessary to reduce the costs include: the unification of the capacity and FiTs and CfDs auctions on the basis of equivalent firm power (EFP); the gradual reforms of the structure of FiTs and CfDs in the transition to their eventual abolition; and further enhancements to competition in the wholesale and balancing markets. There should be significant reforms of the regulation of transmission and distribution focused on the role of system operators at the national and local levels, and the replacement of the specific licences for distribution, supply and decentralised generation with a general licence. A default supply tariff should be required and the margins published. Finally, carbon prices and energy taxes should be harmonised.

19. This package of measures is a major shift from the original market design and regulation model at privatisation, and moves on from EMR. It would create a simpler, more competitive structure fit for the new purposes. Instead of low-carbon technologies being grafted onto the fossil fuel-based system, the new world is radically different, backed up by new smart technologies, data and smart energy networks and services. A common carbon price would significantly lower the cost of decarbonisation and greatly enhance incentives.

20. As the fixed system costs gain an increased share of total costs, it will be government that ultimately decides the allocation between customer classes of these fixed costs. The legacy costs are also fixed. The scope for protecting the poorest customers will be increased, and the government should consider a universal basic allocation of fixed costs.

21. The fixed costs also permit a more efficient allocation to the industrial sector, and particularly to those companies facing international competition. In addition to exemptions from the legacy costs, consideration should be given to the relative burdens on industry and households from the rising proportion of fixed costs. However, neither should be exempt from the carbon price.

22. These measures require significant institutional reform. The system operator model should be further developed, with an independent national system operator (NSO) and a series of regional system operators (RSOs) playing a bigger part.

23. Ofgem's role in regulation should be significantly reduced as the NSO and RSOs assume some of the duties currently placed on distribution network operators (DNOs) and Ofgem, with much greater use being made of competitive tenders and auctions. The licensing regime at the local level should be simplified, abolishing the increasingly anachronistic distinctions between generation, supply and distribution, which are being overtaken by the new technologies that are emerging.

24. The comprehensive long-term framework set out in this review is a practical and evolutionary package, and will deliver benefits not only over the coming decades, but in the immediate future too. Immediate benefits would come from revisiting the transmission and distribution price reviews, introducing a default tariff for supply focused on the margins, and reforms to the FiTs to capture the refinancing gains after existing commitments have been fully met.

25. This long-term framework, coupled with these immediate measures, is the least-cost way of achieving the objectives, with the prospect that the 2050 carbon target could be met at lower cost, and could even be met early, to the benefit of households and industry.

26. Not to implement these recommendations is likely to perpetuate the crisis mentality of the industry, and these crises are likely to get worse, challenging the security of supply, undermining the transition to electric transport, and weakening the delivery of the carbon budgets. It will continue the unnecessary high costs of the British energy system, and as a result perpetuate fuel poverty, weaken industrial competitiveness, and undermine public support for decarbonisation. We can, and should, do much better, and open up a period of falling prices as households and industry benefit from the great technological opportunities over the coming decades.

The Government must change its response to the Climate Change Act so that the burden of implementation does not fall unfairly on the poorest members of society. There can be little confidence in this as when the government introduced its target of net zero emissions by 2050 it failed to produce an impact assessment.—(*Graham Stringer.*)

The Committee divided.

Ayes, 1	Noes, 5
Graham Stringer	Vicky Ford
	Darren Jones
	Stephen Metcalfe
	Carol Monaghan
	Martin Whitfield

Question accordingly negatived.

Paragraph 19 agreed to.

Paragraph 20 read and agreed to.

Paragraphs—(*Graham Stringer*)—brought up and read, as follows:

> Climate models are an imperfect way of understanding global warming. A number of academic reports have questioned their accuracy. The IPCC Synthesis Report 2012, page 43, found 111 of 114 climate models predicted higher temperatures than were observed between 1998 and 2012. Warming in the troposphere was found to be less than half that predicted in the Asia-Pacific Atmospheric Journal, reference 53/4 2017.
>
> With only partial information the Government has moved to a zero emissions policy for 2050. It does not know the cost of this policy and there is no evidence that the major emitters of carbon dioxide are following. In fact, India has cancelled its nuclear programme and China is building 700 coal fired power stations. On its own, if successful, the UK's greenhouse gas reduction policy would delay global warming by 8 months. Unilateralism is an expensive and ineffective policy for tackling climate change.

Question put, That the paragraphs be read a second time.

The Committee divided.

Ayes, 1	Noes, 5
Graham Stringer	Vicky Ford
	Darren Jones
	Stephen Metcalfe
	Carol Monaghan
	Martin Whitfield

Question accordingly negatived.

Paragraphs 21 and 22 read and agreed to.

Paragraph 23 read.

Amendment proposed, in line 18, after "Science and Technology Committee.", to insert "It also creates a major conflict of interest for Lord Deben as the Chair of the Climate Change Committee. He should not continue as Chair of that committee."—(*Graham Stringer.*)

The Committee divided.

Ayes, 1	Noes, 5
Graham Stringer	Vicky Ford
	Darren Jones
	Stephen Metcalfe
	Carol Monaghan
	Martin Whitfield

Question accordingly negatived.

Paragraph 23 agreed to.

Paragraphs 24 to 258 read and agreed to.

Annex and Summary agreed to.

Resolved, That the Report be the Twentieth Report of the Committee to the House.

Ordered, That the Chair make the Report to the House.

Ordered, That embargoed copies of the Report be made available (Standing Order No. 134).

[Adjourned till Wednesday 4 September at 9.00am

Witnesses

The following witnesses gave evidence. Transcripts can be viewed on the inquiry publications page of the Committee's website.

Tuesday 15 January 2019

Lord Deben, Chairman, and **Chris Stark**, Chief Executive, Committee on Climate Change	Q1–38
Malcolm Brinded, Fellow, Royal Academy of Engineering and allied institutions, **Guy Newey**, Director of Strategy and Performance, Energy Systems Catapult, and **Professor Jim Watson**, Director, UK Energy Research Centre	Q39–91

Tuesday 26 February 2019

Amanda Lyne, Chair, UK Hydrogen and Fuel Cell Association, **Andy Eastlake**, Managing Director, Low Carbon Vehicle Partnership, and **Tanya Sinclair**, Policy Director UK & Ireland, ChargePoint	Q92–164
David Weatherall, Head of Policy, Energy Saving Trust, **Jenny Holland**, Senior Public Affairs & Policy Specialist, UK Green Building Council, **Sam French**, Decarbonised Gas Alliance, and **Graham Hazell**, Consultant, Heat Pump Association	Q165–229

Tuesday 2 April 2019

Professor Keith Bell, University of Strathclyde, **Dr Robert Gross**, Imperial College London, **Dr Nina Skorupska**, Chief Executive, Renewable Energy Association, and **Tom Greatrex**, Chief Executive, Nuclear Industry Association	Q230–294
Professor Nick Eyre, Director, Centre for Research into Energy Demand Solutions, **Professor Tim Green**, Co-Director, Imperial College Energy Futures Lab, **Randolph Brazier**, Head of Innovation and Development, Energy Networks Association, and **Duncan Burt**, Director of Operations, National Grid System Operator	Q295–356

Tuesday 23 April 2019

Professor Jim Skea, Imperial College London, **Professor Gideon Henderson**, Royal Society, **Professor Jon Gibbins**, Centre Director, UK Carbon Capture and Storage Research Centre, and **Dr Naomi Vaughan**, Tyndall Centre for Climate Change Research	Q357–413
Rt Hon Claire Perry MP, Minster of State for Energy and Clean Growth, **Tim Lord**, Director, Clean Growth, and **Damitha Adikaari**, Acting Director, Science and Innovation for Climate and Energy, Department for Business, Energy and Industrial Strategy	Q414–504

Published written evidence

The following written evidence was received and can be viewed on the inquiry publications page of the Committee's website.

CGE numbers are generated by the evidence processing system and so may not be complete.

1 ABB (CGE0010)
2 Amir Eilon (CGE0078)
3 Anglian Water Services (CGE0017)
4 Anglo American (CGE0046)
5 Bright Blue (CGE0049)
6 Cadent (CGE0015)
7 Calor (CGE0027)
8 Carbon Capture and Storage Association (CGE0023), (CGE0079)
9 CBMNet (CGE0003)
10 Centre for Research into Energy Demand Solutions (CGE0070)
11 ChargePoint (CGE0054)
12 Decarbonised Gas Alliance (CGE0032)
13 Department for Business, Energy and Industrial Strategy (CGE0016), (CGE0089)
14 Department for Transport (CGE0088)
15 Dolphin N2 (CGE0069)
16 Dr Duncan Connors (CGE0060)
17 Dr Jonathan Radcliffe (CGE0041)
18 Drax Group plc (CGE0025)
19 Durham Energy Institute (CGE0065)
20 E.ON (CGE0036)
21 Eaton (CGE0052)
22 EDF Energy (CGE0020)
23 Energy and Utilities Alliance (CGE0031)
24 Energy Networks Association (CGE0059)
25 Energy Systems Catapult (CGE0029)
26 Energy Technologies Institute (CGE0061)
27 Energy UK (CGE0024)
28 Enertek International Ltd (CGE0063)
29 Environmental Defense Fund Europe (CGE0042)
30 Federation of Petroleum Suppliers (CGE0028)
31 Greenpeace UK (CGE0022)
32 Heat Pump Association (CGE0074)
33 Highview Power (CGE0050)

34 Imperial College London (CGE0071)
35 Johnson Matthey (CGE0066)
36 Marine Energy Wales (CGE0047)
37 Menter Mon (CGE0002)
38 Michael Pilling (CGE0087)
39 Mr Andrew Lewis (CGE0008)
40 Mr Colin Megson (CGE0082)
41 Mr George Busby (CGE0072)
42 Mr Timothy Kingham (CGE0064)
43 National Franchised Dealers Association (CGE0073)
44 National Grid (CGE0019)
45 National Physical Laboratory (CGE0014)
46 Network/Utility Week (CGE0086)
47 Nova Innovation Ltd (CGE0044)
48 Nuclear Industry Association (CGE0018)
49 Offshore Renewable Energy Catapult (CGE0081)
50 Ofgem (CGE0033)
51 OVO Energy (CGE0007)
52 Policy Connect (CGE0011)
53 Professor Jonathan Gibbins (CGE0045)
54 Pupils 2 Parliament (CGE0012)
55 Renewable Energy Association (CGE0026)
56 Renewable Thermal Systems Limited (CGE0077)
57 RenewableUK (CGE0067)
58 Rolls-Royce Plc (CGE0039)
59 Royal Academy of Engineering (cross-engineering sector response) (CGE0055)
60 Scottish Carbon Capture and Storage (CGE0021)
61 SGN (CGE0040)
62 Society of Motor Manufacturers and Traders (CGE0030)
63 Solar Trade Association (CGE0053)
64 Sustainable Marine Energy (CGE0013)
65 The Geological Society (CGE0051)
66 The Royal Society (CGE0056)
67 Tokamak Energy Ltd (CGE0004), (CGE0075)
68 UCL Green Innovation Policy Commission (CGE0009)
69 UK Energy Research Centre (CGE0057)
70 UK Hydrogen and Fuel Cell Association (CGE0034)
71 UK Research and Innovation (CGE0058)

72 UKLPG (CGE0062)

73 ULEMCo Ltd (CGE0005)

74 Victor Harman (CGE0068)

75 Zenobe Energy (CGE0080)

List of Reports from the Committee during the current Parliament

All publications from the Committee are available on the publications page of the Committee's website. The reference number of the Government's response to each Report is printed in brackets after the HC printing number.

Session 2017–19

First Report	Pre-appointment hearing: chair of UK Research & Innovation and executive chair of the Medical Research Council	HC 747
Second Report	Brexit, science and innovation	HC 705
Third Report	Genomics and genome editing in the NHS	HC 349
Fourth Report	Algorithms in decision-making	HC 351
Fifth Report	Biometrics strategy and forensic services	HC 800
Sixth Report	Research integrity	HC 350
Seventh Report	E-cigarettes	HC 505
Eighth Report	An immigration system that works for science and innovation	HC 1061
Ninth Report	Flu vaccination programme in England	HC 853
Tenth Report	Research integrity: clinical trials transparency	HC 1480
Eleventh Report	Evidence-based early years intervention	HC 506
Twelfth Report	Quantum technologies	HC 820
Thirteenth Report	Energy drinks and children	HC 821
Fourteenth Report	Impact of social media and screen-use on young people's health	HC 822
Fifteenth Report	Evidence-based early years intervention: Government's Response to the Committee's Eleventh Report of Session 2017–19	HC 1898
Sixteenth Report	'My Science Inquiry'	HC 1716
Seventeenth Report	Japanese knotweed and the built environment	HC 1702
Eighteenth Report	Digital Government	HC 1455
Nineteenth Report	The work of the Biometrics Commissioner and the Forensic Science Regulator	HC 1970
First Special Report	Science communication and engagement: Government Response to the Committee's Eleventh Report of Session 2016–17	HC 319
Second Special Report	Managing intellectual property and technology transfer: Government Response to the Committee's Tenth Report of Session 2016–17	HC 318
Third Special Report	Industrial Strategy: science and STEM skills: Government Response to the Committee's Thirteenth Report of Session 2016–17	HC 335

Fourth Special Report	Science in emergencies: chemical, biological, radiological or nuclear incidents: Government Response to the Committee's Twelfth Report of Session 2016–17	HC 561
Fifth Special Report	Brexit, science and innovation: Government Response to the Committee's Second Report	HC 1008
Sixth Special Report	Algorithms in decision-making: Government Response to the Committee's Fourth Report	HC 1544
Seventh Special Report	Research integrity: Government and UK Research and Innovation Responses to the Committee's Sixth Report	HC 1562
Eighth Special Report	Biometrics strategy and forensic services: Government's Response to the Committee's Fifth Report	HC 1613
Ninth Special Report	An immigration system that works for science and innovation: Government's Response to the Committee's Eighth Report	HC 1661
Tenth Special Report	Research integrity: clinical trials transparency: Health Research Authority Response to the Committee's Tenth Report	HC 1961
Eleventh Special Report	Quantum technologies: Government Response to the Committee's Twelfth Report	HC 2030
Twelfth Special Report	Impact of social media and screen-use on young people's health: Government Response to the Committee's Fourteenth Report	HC 2120

CREDS

Shifting the focus: energy demand in a net-zero carbon UK

July 2019

Editors: Nick Eyre & Gavin Killip

About this report

Reviewers

Sections of the report have been reviewed internally, by chapter authors and the following colleagues in the CREDS consortium: Stanley Blue, Phil Coker, Clare Downing, Mike Fell, Sarah Higginson, Kay Jenkinson, Bob Lowe, Greg Marsden, Elizabeth Shove, Stefan Smith, Steve Sorrell, Peter Taylor and Marina Topouzi.

We are also grateful for comments by external reviewers from Green Alliance: Dustin Benton and Libby Peake; and from the Committee on Climate Change: Ellie Davies, Adrian Gault, Aaron Goater, Jenny Hill and Sarah Livermore.

This report should be referenced as:

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ISBN: 978-1-913299-00-2

Frequently used acronyms

BEIS	Department for Business, Energy & Industrial Strategy
CCC	Committee on Climate Change
DCLG	Department for Communities and Local Government, now Ministry of Housing, Communities & Local Government
DECC	Department for Energy and Climate Change, now incorporated into BEIS
Defra	Department for Environment, Food & Rural Affairs
DfID	Department for International Development
DfT	Department for Transport
DIT	Department for International Trade
FCO	Foreign and Commonwealth Office
HMT	HM Treasury
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
MHCLG	Ministry of Housing, Communities & Local Government

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Introduction to CREDS

The Centre for Research in Energy Demand Solutions (CREDS) was established as part of the UK Research and Innovation's Energy Programme in April 2018, with funding of £19.5M over 5 years. Its mission is to make the UK a leader in understanding the changes in energy demand needed for the transition to a secure and affordable, low carbon energy system. CREDS has a team of over 90 people based at 13 UK universities.

The aims of the Centre are:

- to develop and deliver internationally leading research, focusing on energy demand;
- to secure impact for UK energy demand research in businesses and policymaking; and
- to champion the importance of energy demand, as part of the strategy for transition to a secure and affordable low carbon energy system.

This report

Shifting the focus: energy demand in a net-zero carbon UK is CREDS' first major publication. It builds on research undertaken by members of the CREDS consortium over many years to address the question "What can changes in energy demand contribute to the transition to a secure and affordable UK energy system that is compatible with net-zero carbon emissions?". It examines the most recent comprehensive statement of UK Government Energy policy – the Clean Growth Strategy. Drawing on expertise in the CREDS consortium across the buildings, transport, industry and electricity sectors, the report sets out a vision for the role of energy demand changes and develops detailed recommendations for action.

Shifting the focus: energy demand in a net-zero carbon UK

Foreword by Chris Stark, Chief Executive, Committee on Climate Change

Delivering net-zero greenhouse gas emissions depends critically on changing energy systems. Every analysis, globally and in the UK, shows that there will need to be rapid and extensive change to energy supply and energy demand. The UK has achieved major changes in complex systems before, but not at the scale that the Committee on Climate Change has now recommended to reach net-zero in the UK.

For most people, their main interaction with the energy system is through using energy, at home, at work and in transport. We've become accustomed to these interactions being simple – rarely something that we consider actively – even as the UK has achieved substantial reductions in emissions from electricity supply. As we look forward to a zero carbon future, the technologies that manage and consume energy will change, affecting people's experience and even their behaviour. This makes changing energy demand a controversial topic, but an important one. Consumers must become more engaged in the next stage of the energy transition.

Public support for changing the way energy is used is essential. Reducing energy demand saves money for households and businesses, of course, as well as reducing emissions. And importantly, it can have other benefits – improving air quality, improving our homes and public spaces, and creating employment across the UK.

Over the last 15 years, reduction in demand for energy has been an important contributor to lowering UK carbon emissions. However, in recent years, the downward trend in demand has begun to falter, largely due to weakening of Government policy. Our analysis at the Committee on Climate Change is that stronger policy to reduce demand is urgently needed. And we know that the policies that might influence energy demand are very different to those for supply – policies that are often made outside of Westminster, making this a fascinating public policy challenge overall.

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I therefore welcome this report from the Centre for Research into Energy Demand Solutions (CREDS). As a major research consortium focusing on energy demand, CREDS brings together many researchers who have individually contributed to the work of the Committee over several years. We look forward to working closely with them over the coming years to better understand the challenges of changing energy demand.

The report draws on CREDS researchers' expertise. It sets out the key changes in energy demand that can contribute to carbon emissions reduction and the other energy policy challenges of the UK. Taking the Government's Clean Growth Strategy as its starting point, it highlights where more specific policies are needed to deliver the Government's ambitions and where ambitions can be increased. It is a welcome contribution to the net-zero debate.

Chris Stark

Chief Executive, Committee on Climate Change

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Report Editors: Nick Eyre, Gavin Killip

Summary of recommendations

The complexity of energy demand means there is no 'silver bullet' solution or policy: a range of policy instruments is required to meet energy policy goals. These involve many sectors, institutions and stakeholders, with a range of different timescales for action. We list a large number of recommendations in this report, and bring them together in Chapter 9. They can be considered under the following six broad headings.

1. Prioritise energy demand solutions

Energy demand change can support all the key goals of energy policy – security, affordability and sustainability – with more synergies and fewer trade-offs than supply-side solutions. For this reason, treating demand reduction as 'the first fuel' is already the policy of the International Energy Agency (IEA) and the European Union. Demand-side solutions also form a key part of implementing zero carbon sustainable supply, through using zero carbon fuels and enabling greater use of variable renewables. In UK energy policy, there has been a tendency to focus on energy supply options rather than a systemic approach. We recommend that this is reversed, and that demand-side solutions are given at least equal weight.

2. Consider and promote all the benefits of demand-side solutions

UK policy with respect to energy demand tends to focus on the benefits of lower carbon emissions and lower bills for energy users, often using the latter as an argument for minimal intervention. Reduced demand, improved energy efficiency, greater flexibility and decarbonised fuels have a much wider range of benefits, notably for health and employment. Addressing energy demand is generally more likely to promote sustainable development than increasing energy supply. As importantly, recognising all the benefits is more likely to motivate action. We recommend that all the benefits of demand-side solutions are considered in developing and promoting policy.

3. Scale up policies that work

UK energy demand policy has featured numerous policy changes in the last decade. In some cases, such as Carbon Emissions Reduction Target, the Carbon Reduction Commitment and the proposed Zero Carbon Homes standard, policy instruments that were well-designed and effective have been modified, or much reduced in scale. This has significantly reduced the effectiveness of UK energy policy. We recommend greater consistency in demand side policymaking and, in particular, scaling up policies that have been shown to work.

4. Develop long term plans for demand-side innovation

There has been a tendency in policymaking to see the demand side as having the potential to provide quick wins, but not to have a fundamental role in the transition. Our analysis indicates that this is unhelpful. Energy demand reduction, flexibility and decarbonisation will need to play a critical role and this should be recognised in energy innovation policy. We recommend that Government should develop long-term plans for demand-side innovation.

5. Build effective institutions for delivery of demand-side solutions

Energy using activities are diverse, and therefore the policy agenda set out above involves influencing a wide range of stakeholders, including both specialists and the general public. Doing this effectively will require a major increase in activity in demand-side policy delivery in Government at a range of levels. This will require better coordination across departments, with more capacity and clearer responsibilities for specialist agencies, devolved governments and local government departments. We recommend that Government should reform the existing delivery structures and develop an institutional framework designed for delivering the energy transition.

6. Involve a wider range of stakeholders to build capacity across society

A transformation in the way that energy is used needs to be led by Government, but cannot be delivered by Government alone. There is some good practice on which to build, but there needs to be a concerted effort to engage, enthuse and empower stakeholders across business and civil society. We recommend that Government should develop a strategy for involving a wider range of stakeholders to build capacity across society.

1. Introduction: why energy demand is important to a low carbon transition

Nick Eyre (University of Oxford), Tim Foxon (University of Sussex) and Gavin Killip (University of Oxford)

The aims of this report

This report sets out the critical role that needs to be played by changes to energy demand in delivering the ambitious goals of UK energy policy – a secure and affordable, low carbon energy system. Our analysis draws on current knowledge from the UK energy demand research community. We take as our starting point the ambitious goals of UK Government policy set out in the Clean Growth Strategy (BEIS, 2017), the Government's most recent statement on the energy transition. In particular, this report considers the aim to accelerate the pace of clean growth, and we seek to build on the comprehensive, quantitative analysis of the Strategy done by the Committee on Climate Change (CCC, 2018). We agree with the Strategy that major improvements in energy productivity in businesses, transport and homes are crucial to achieving this goal. We set out a broad vision for how this might be achieved, and show that this requires attention to technical, social and institutional factors that drive energy demand. We argue that a stronger focus on demand will be required to address the greater action implied by a net-zero carbon target (CCC, 2019). We set out recommendations on the changes in policy required to deliver the goals of the Clean Growth Strategy, in relation to energy use.

The key role of energy demand

Energy use has been a key driver of economic and social development, by enabling production and consumption of goods and services and allowing people to lead comfortable and enjoyable lives. The industrial revolution began in Britain in the late eighteenth century, by harnessing first water power and then fossil fuels to provide heat and power. Energy use has driven the development of modern societies, and is critical to most aspects of our lives in homes, businesses and transport. Figure 1 shows the breakdown of energy use in the UK – broadly an even split between households, workplaces (industry and other) and transport.

Photo by Christopher Burns on Unsplash

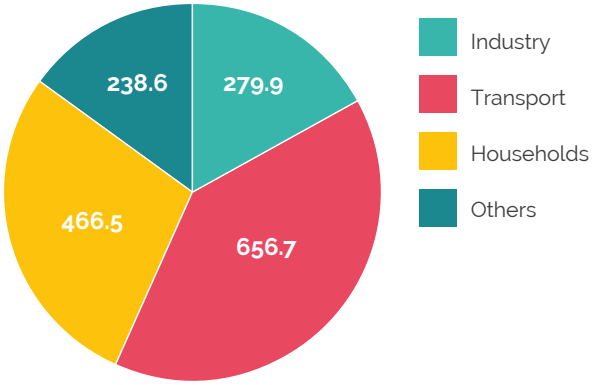

Figure 1: Energy use in the UK by sector in 2017 (TWh). CREDS calculations based on BEIS (2018)

However, the widespread use of fossil fuels has also driven major environmental problems, which has required action to mitigate by households, industry and Government. Although the worst excesses of urban air pollution have been addressed in industrialised countries, energy related pollution remains a major cause of ill health, even in the UK. In addition, a range of evidence has shown that stabilising the global climate will require the elimination of fossil fuel use within a few decades (IPCC, 2014, 2018). The UK has led the world in adopting a strategic approach to doing this through the 2008 Climate Change Act. This sets progressively tighter carbon budgets for national emissions for successive five-year periods, at least 15 years in advance. Good progress has been made to date, with a 43% reduction in emissions since 1990 by 2017. However, the Clean Growth Strategy provides a clear warning that more needs to be done: "In order to meet the fourth and fifth carbon budgets (covering the periods 2023–2027 and 2028–2032) we will need to drive a significant acceleration in the pace of decarbonisation and in this Strategy we have set out stretching domestic policies that keep us on track to meet our carbon budgets" (BEIS, 2017, page 9). At the UK Government's request, the Committee on Climate Change has recently concluded that even more stringent budgets will be needed as 2050 is approached, for the UK to reach net-zero greenhouse gas emissions and make its fair contribution to the goals of the Paris Agreement (CCC, 2019).

Addressing this challenge of achieving further and faster carbon reductions will require both widespread deployment of clean energy sources to replace fossil fuels, and reducing total energy demand, whilst continuing to deliver the services that people and businesses need. This requires much better understanding of the role of demand-side solutions in mitigating climate change (Creutzig *et al*, 2018).

Changes to the way that energy is used are critical to the development of a secure, affordable and sustainable energy system. In recent decades, more than 90% of the progress in breaking the relationship between carbon emissions and economic growth globally has come from reducing the energy intensity of the economy (IPCC, 2014). By comparison, reducing the carbon emissions per unit of energy has, to date, been a relatively minor effect. Similarly, in relation to energy security, the International Energy Agency (IEA, 2016) showed that, in leading energy-importing countries, energy efficiency improvements have played a major role in reducing dependence on imported fuel.

These trends have been seen strongly across northern Europe, including the UK, where the decoupling of energy use and economic activity has been reflected in absolute reductions in energy demand. Primary energy demand in the UK has fallen by 20% since 2003. This has confounded official projections made at the beginning of this period, which projected slow but steady energy demand growth (McDowall *et al*, 2014). This decoupling has a longer history, with an annual improvement of the GDP/energy ratio averaging 2.5% since 1970, reducing current energy demand to one third of what it would have been with no improvement.

These changes in energy demand have been driven by a combination of three factors:

- economic restructuring (away from energy intensive manufacturing and towards services)
- technical energy efficiency improvements, and
- a slowing in the growth of demand for many of the services provided by energy.

To some extent, the first of these factors is linked to the movement of manufacturing activity out of the UK, in particular to East Asia. This offshoring of economic activity has reduced UK industrial energy demand; its effect has been broadly similar in scale to that of technical improvements in industrial energy efficiency (Hardt *et al*, 2018). The Clean Growth Strategy aims to halt this trend of offshoring by retaining industrial activity in the UK. This implies that further reductions in industrial energy demand would need to come from technical or process changes that reduce energy demand per unit of material produced, or wider structural changes that reduce the demand for these materials, for example, through a greater focus on resource efficiency.

It is difficult to exaggerate the impact of the historical decoupling of energy demand from economic activity. It has contributed more to carbon emissions reduction than the combined effects of the UK's programmes in nuclear, renewable and gas-fired power generation. It has made energy services more affordable to households and businesses. It has improved UK energy security, both by reducing energy imports and enabling peak electricity demand to be met with less generation capacity. Much of this impact has been driven by public policy. It is recognition of this effect across the world that has led to the International Energy Agency (IEA) to call for energy efficiency to be treated as 'the first fuel' in energy policy (IEA, 2016).

Given this important role of energy demand, it features surprisingly little in public discourse about energy. The importance of demand is recognised in the Clean Growth Strategy, but the UK Government has not published an updated Energy Efficiency Strategy since 2013. Despite the evidence, many people still think that energy demand is inexorably rising and references to 'increasing energy demand' remain common in the mass media. This misapprehension applies even in parts of the energy sector, including, in one case, a serving Government Energy Minister (Carrington, 2015).

Another frequent misunderstanding is that energy efficiency is a short-term issue and that its potential for improvement will soon be exhausted. Historical evidence (NAS, 2010) is that the potential for cost effective efficiency improvement has remained relatively stable over 40 years. As efficient technology has been deployed, technological and organisational innovation has enabled new potential to be developed at broadly similar rates. Some options that are now widely used, such as LED lighting, represent a step-change in efficiency improvement, but were not even considered in analyses done 20 years ago. Energy using technologies and practices are still very far from their theoretical optimum (Cullen & Allwood, 2010). Moreover, as we discuss below, future energy supply-side changes will increase opportunities for improvement.

The Clean Growth Strategy provides a major opportunity to implement approaches to energy efficiency improvement that have already been shown to be effective, either in the UK or elsewhere in the world. This will involve a substantial shift in UK Government policy, which has become less effective in recent years (e.g. Rosenow & Eyre, 2016).

Energy demand in the UK energy transition

Delivering a secure, affordable and sustainable energy system, and particularly the goals of the Paris Agreement, requires an energy transition on the scale, for example, of the industrial revolution. Energy transitions are often described in terms of the change in dominant fuel (e.g. wood to coal, coal to oil), but this is a shorthand. Transitions have always been associated with major shifts in energy-using activities and therefore with wider patterns of economic development and social change (Foxon, 2017). There is no reason to think that the sustainable energy transition will be any different; it will not simply be a shift from unsustainable fuels to renewables, but also a change in how, when and where those fuels are used and what human activities they enable and support. Policy to promote the transition will need to take this into account.

Thus, the energy transition cannot be properly conceptualised without reference to questions about what energy is used for. People and businesses demand energy services (e.g. thermal comfort, mobility and industrial materials) rather than energy *per se*. Total energy demand is a function of this demand for energy services, as well as the efficiency with which that energy is used. The amount of energy needed to meet the demand for any given service therefore depends not only on the technologies used, but also on the wider social systems involved, including the user practices, business models, institutions and infrastructure associated with that service (Foxon, 2011).

This is why understanding energy demand is critical. But it is also complex. Active measures to change the demand for energy services can be controversial. In particular, in international climate negotiations 'demand reduction' can be interpreted to mean reducing the demand for basic services and therefore 'pulling up the ladder' on social development for developing countries. Similar issues apply to people living in fuel poverty in the UK. However, in advanced economies like the UK, improving human welfare no longer relies on massive expansion of energy intensive activities.

Not all consumption is useful: car dependence, unhealthy diets, over-heating and over-cooling of buildings; and use of new, rather than recycled materials, are obvious examples. So reducing the demand for energy services is a part of the agenda for change.

Achieving more significant energy demand reduction needs a focus on both efficiency and service demand. It is estimated that improvements in energy productivity, i.e. economic output per unit of energy used, of at least 3% per annum are needed to help achieve global carbon targets (ETC, 2017) by decoupling energy demand from economic output.

However, in the context of the energy transition, reducing demand is no longer the only issue. As the Clean Growth Strategy acknowledges, there are at least two other demand-side issues which need to be addressed – demand flexibility and decarbonisation of energy sources used at the point of demand.

Variable (intermittent) sources of electricity, such as wind and solar, will play the key role in decarbonising the electricity system, in the UK and globally. This will make balancing electricity supply and demand increasingly challenging. Integrating increasing levels of variable renewable energy focuses attention on temporal issues. A zero carbon electricity system will only be possible if demand is more flexible. Technologies and services for demand-side flexibility will be major growth areas in electricity markets. Demand response (shifting the timing of energy demand) will be important. The Clean Growth Strategy recognises the potential benefits and the role of a smart grid in delivering them. It focuses largely on opportunities based on energy storage, and therefore somewhat underplays the potential role of increasing the temporal flexibility in the demand for energy services.

Most analysis of the energy transition shows that electricity will be a key form of energy supply for heating and transport uses, as well as for power. But there is increasing recognition that it is unlikely to be a complete solution, as some categories of end use, notably industrial processes, freight transport and space heating, are difficult to electrify. In these sectors, other approaches to decarbonisation will be needed using other energy vectors. The best combination of options is not yet clear, and therefore there currently is no convincing storyline for complete decarbonisation. This implies development of solutions that deploy other zero carbon energy vectors and associated storage, notably hydrogen.

These multiple aims for demand change in the energy transition – efficiency, reduction, flexibility and a switch to sustainable fuels – cannot effectively be analysed separately. A sustainable, affordable and secure energy system will require all of them. Figure 2 sets out a simple representation of how we see them contributing to energy system transformation.

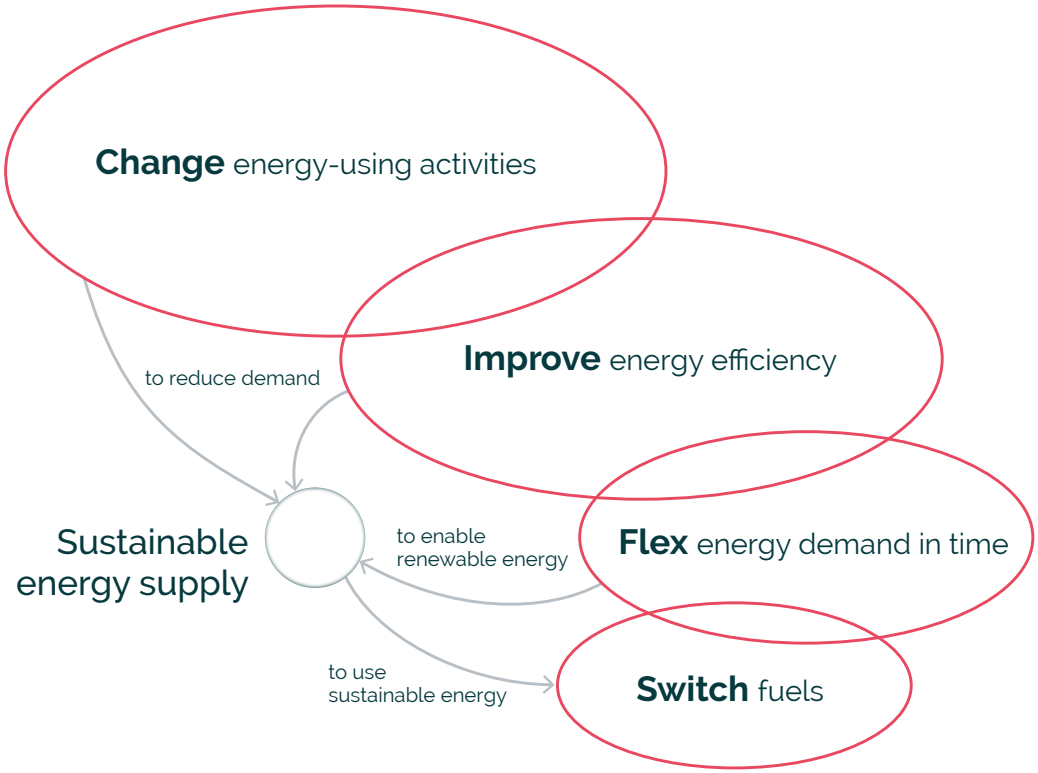

Figure 2. Contributions of the demand side to energy sustainability.

Thinking systemically about the role of energy demand

In the context of this complexity, a systems approach is useful in understanding the role of energy demand in a transition to a sustainable low carbon society. Insights from past energy transitions suggest that systemic change involves not only new forms of energy supply, but also changes in the way that energy is used. In this report, we discuss in more detail the types of change needed in buildings, industrial processes and transport.

In contrast to micro-economic and behavioural approaches that focus on individual responses to incentives, a systems approach focuses on interactions between individual and societal choices and wider systems that both enable and constrain those choices. For example, energy use in a car-dominated system of personal transport depends not only on the technological features of the car, but also on occupancy of vehicles, the choice between car use and other modes and the need to travel (which is influenced by factors such as commuting distance and virtual communications options). In turn, these features and choices depend on wider systemic features, such as car and fuel supply networks, road infrastructures and traffic systems, patterns of land use, institutions and regulations governing car use, engineering skills and knowledge, political power of relevant interest groups, routine practices of users, and wider cultural norms associated with car use and other forms of transport (Geels *et al*, 2012). Changes to these systemic elements combine to create significant changes in energy demand needed to meet mobility or other service requirements.

None of this implies that user decisions do not matter, indeed the recent analysis of the Committee on Climate Change shows that changing technology alone is insufficient for most of the carbon emissions reduction required to reach a net-zero target (CCC, 2019). A systems approach argues that individual choices cannot be considered separately from the socio-technical system in which they are embedded (Schot *et al*, 2016). For example, choices as to whether to make a journey by private car, public transport or by cycling or walking depend on the availability, cost, convenience and safety of different alternatives. While it will require considerable change for socially 'normal' activities to be different in future, there are plenty of precedents (e.g. smoking in public buildings). Thinking systemically about energy supply and demand together points to new opportunities for interventions to achieve the goals of a low carbon, secure and affordable energy system. This report highlights some of these opportunities in relation to meeting demands for energy services in the built environment, industrial processes, mobility and electricity systems.

Innovation

Socio-technical systems thinking also applies to innovation. It is not only about new technology, but also about the context of broader economic and social change. Innovations are only successful to the extent they are consistent with that broader change. The Clean Growth Strategy rightly emphasises the importance of investment in innovation, including to develop new technologies and bring down the costs of clean technologies. Energy innovation often focuses on supply technologies, but there are also major opportunities for innovation to deliver energy and resource efficiency improvements, in industry, buildings and transport, as well as to deploy low carbon end-use technologies.

However, we argue that this needs to be embedded in a wider understanding of the drivers of energy demand and the potential for changes in demand. Much research in recent years has argued for the need to think systemically about innovation and transitions, and that this can inform the difficult policy choices relating to demand reduction, flexibility and decarbonisation. If the goal of innovation is reframed from technological change to how those service demands can be met in a more sustainable way, we need to consider not only innovation in technologies, but also innovation in how energy is used, the business models for providing energy services and the institutional and regulatory frameworks that govern these systems.

Changes in energy use interact with wider social and technological changes, not least those associated with new technological and business opportunities created by smart systems and the digital economy. The increasing deployment of information and communication technologies (ICT) could enable economic value to be delivered in less energy intensive ways, but could also lead to the creation of new service demands (such as on-demand entertainment) that increase energy demand. Greater use of ICT linked to more distributed forms of energy generation could open up new market structures, such as via peer-to-peer energy trading, but this could create challenges for existing regulatory frameworks.

Recent research shows that ICT has large energy savings potential, but that realising this potential is highly dependent on deployment details, user behaviour and indirect effects that could either offset or amplify direct energy savings (Horner *et al*, 2016).

Implications for policy

It is well-established that demand reduction can support all three pillars of energy policy objectives – security, affordability and reductions in greenhouse gas emissions. Improving energy efficiency can play a major role in the goals for productivity, competitiveness and employment that are set out in the Clean Growth Strategy. Indeed, our analysis is that the goals of the Strategy are unachievable without a significant refocusing of policy effort towards energy demand.

Energy demand involves many actors – from households to major corporations and Government; it occurs where we work and where we live, it underpins the goods and services we purchase, the ways we travel and the public services we rely on. So addressing energy demand effectively will involve many technologies and stakeholders. Therefore we endorse the analysis of the Clean Growth Strategy (p59) that the move to a low carbon society needs to be a "shared endeavour between Government, business, civil society and the British people".

Framing the challenge of changing energy demand in this way points to a move away from individualist and incremental policy approaches towards an approach more focused on long-term systemic change. This implies recognising that policy also needs to consider changes in infrastructures, institutions and practices, as well as the traditional instruments of energy efficiency policy such as price incentives, product regulations and information programmes. There are also multiple potential benefits from a greater focus on demand in areas not usually considered in energy policy (IPCC, 2018), for example in cleaner air, more comfortable buildings, less waste and more liveable urban environments.

Government has a critical and unique role in setting the vision for this shared endeavour. The Climate Change Act and proposals to increase the stringency of targets to 'net-zero' provide a good starting point. The commitment of Government, supported by an overwhelming majority in Parliament, sets the framework for the more detailed policy development by Government, but also provides the foundation for action by other actors – for corporate planning, and for the wider public discourse on energy systems and personal commitments.

Policy analysis traditionally relies heavily on cost benefit analysis. In energy, there are good reasons for this, as the energy system is a major, capital intensive infrastructure, with significant cost implications for households, businesses and Government. Limiting the costs of delivering any desired outcome obviously matters. However, many of the benefits of demand reduction (e.g. health) are uncertain and difficult to value, and therefore often excluded from analyses. Moreover, aggregate costs and benefits are not the only issue for two reasons.

First, the distribution of those costs also matters, both because it is an important outcome in its own right, and because perceptions of fairness constrain political feasibility. Secondly, as set out above, changes to energy service demands drive the energy system. These are determined by infrastructures, institutions, preferences and practices that lie outside the usual scope of incremental cost benefit analyses. A more pluralistic approach is required to these challenges.

This report aims to contribute to that approach. The CREDS team looks forward to working further with a wide range of stakeholders to examine how the ideas proposed in this report could be implemented, in order to contribute to the achievement of a sustainable net-zero energy transition.

Report structure

The following sections of the report set out our analysis, based on research evidence, of some key energy demand issues. These are structured along the lines of the major sections of the Clean Growth Strategy in which energy demand plays an important role, as follows:

- **Section 2** considers how we might reduce and decarbonise energy demand in buildings;
- **Section 3** looks at decarbonising industrial processes and using material resources more efficiently;
- **Section 4** covers travel demand and low carbon transport;
- **Section 5** addresses the role of shifting demand as time-of-use becomes more important because of increasing generation from variable renewable sources;
- **Section 6** looks at the challenges associated with demand for, and use of, zero carbon fuels;
- **Section 7** considers the governance and policy approaches that may be required; and
- **Section 8** draws together our conclusions.

References

BEIS (2017). The Clean Growth Strategy: Leading the way to a low carbon future.

BEIS (2018). Energy consumption in the UK (online data).

Carrington, D. (2015). Renewable energy outstrips coal for first time in UK electricity mix.

CCC (2018). Clean Growth Strategy Assessment, January 2018.

CCC (2019). Net Zero: The UK's contribution to stopping global warming, May 2019.

Creutzig, F., Roy, J., Lamb, W.F., Azevedo, I.M.L., de Bruin, W.B., Dalkmann, H., Edelenbosch, O.Y., Geels, F.W., Grubler, A., Hepburn, C., Hertwich, E.G., Khosla, R., Mattauch, L., Minx, J.C., Ramakrishnan, A., Rao, N.D., Steinberger, J.K., Tavoni, M., Ürge-Vorsatz, D. & Weber, E.U. (2016). Towards demand-side solutions for mitigating climate change. *Nature Climate Change*, **8**: 260–271. doi: 10.1038/s41558-018-0121-1

Cullen, J. M. & J. M. Allwood (2010). Theoretical efficiency limits for energy conversion devices. *Energy*, **35** (5): 2059–2069.

ETC (2017). Better Energy, Greater Prosperity: Achievable pathways to low-carbon energy systems. Energy Transitions Commission.

Foxon, T.J. (2011). A coevolutionary framework for analysing a transition to a sustainable low carbon economy. *Ecological Economics*, **70**: 2258–2267. doi: 10.1016/j.ecolecon.2011.07.014

Foxon, T.J. (2017). Energy and Economic Growth: Why we need a new pathway to prosperity, Abingdon and New York: Routledge.

Geels, F.W., Kemp, R., Dudley, G. & Lyons, G. (2012) Automobility in transition? A socio- technical analysis of sustainable transport New York, NY: Routledge. pp 2012.

IEA (2016). Energy Efficiency Market Report 2016.

IPCC (2014). Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. [Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Farahani, E., Kadner, S., Seyboth, K., Adler, A., Baum, I., Brunner, S., Eickemeier, P., Kriemann, B., Savolainen, J., Schlömer, S., von Stechow, C., Zwickel, T. & Minx, J.C. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC (2018). Summary for Policymakers. In: Global Warming of 1.5˚C. An IPCC Special Report on the impacts of global warming of 1.5˚C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. [Masson-Delmotte, V., Zhai, P., Pörtner, H.-O., Roberts, D., Skea, J., Shukla, P.R., Pirani, A., Moufouma-Okia, W., Péan, C., Pidcock, R., Connors, S., Matthews, J.B.R., Chen, Y., Zhou, X., Gomis, M.I., Lonnoy, E., Maycock, Tignor, M. & Waterfield, T. (eds.)]. World Meteorological Organization, Geneva, Switzerland.

Hardt, L., Owen, A., Brockway, P., Heun, M.K., Barrett, J., Taylor, P.G. & Foxon, T.J. (2018). Untangling the drivers of energy reduction in the UK productive sectors: Efficiency or offshoring? *Applied Energy*, **223**: 124–133. doi: 10.1016/j.apenergy.2018.03.127

Horner, N.C, Shehabi, A. & Azevedo, I.L. (2016). Known unknowns: indirect energy effects of information and communication technology. *Environmental Research Letters*, **11**: 103001. doi: 10.1088/1748-9326/11/10/103001

McDowall, W., Trutnevyte, E., Tomei, J. & Keppo, I. (2014). UKERC Energy Systems Theme: Reflecting on Scenarios. UKERC, London.

National Academy of Sciences, National Academy of Engineering, and National Research Council (2010). Real Prospects for Energy Efficiency in the United States. Washington, DC: The National Academies Press. doi: 10.17226/12621.

Rosenow, J. & Eyre, N. (2016). A post mortem of the Green Deal: Austerity, energy efficiency, and failure in British energy policy. *Energy Research & Social Science*, **21**: 141–144. doi: 10.1016/j.erss.2016.07.005

Schot, J., Kanger, L. & Verbong, G. (2016). The roles of users in shaping transitions to new energy systems. *Nature Energy*, 16054. doi: 10.1038/nenergy.2016.54

2. Reducing energy demand from buildings

Peter Mallaburn, Tadj Oreszczyn, Cliff Elwell, Ian Hamilton, Gesche Heubner and Robert Lowe (University College London)

This chapter sets out the trends and drivers of energy demand in buildings. It also sets out the policy for buildings in the UK and recommendations for government policy and CREDS work.

Energy demand trends and drivers

Buildings are central to our lives because they provide us with shelter and comfort at home, enable us to carry out productive activities at work and to provide other services, such as warehousing. Heating, cooling, lighting and appliances dominate the use of energy in both domestic and non-domestic (commercial and public) buildings.

There are 27 million dwellings and 2 million non-domestic (industrial, commercial and public) buildings in the UK. Together they are responsible for around 698 TWh or 43% of total delivered UK energy of 1642 TWh[1] (BEIS, 2018a), and 29% of UK CO_2 emissions (Committee on Climate Change, 2018).

Energy demand trends for buildings come with several caveats. The weather, in particular external temperature, influences demand, but adjustments to official numbers to take account of this can be hard to interpret. There are also gaps in the official record, and variations in how buildings are categorised, particularly for non-domestic buildings, which can appear as industry, service or 'other'. Also, some energy vectors like electricity are not disaggregated by sector. Disaggregating industrial process use from building use is challenging in some non-domestic sectors. Most importantly drivers of demand such as floor area and heating demand and efficiency have not been consistently monitored and are instead modelled with many assumptions.

However, with these caveats, a number of trends in delivered energy can be identified for both domestic and non-domestic buildings.

1 Original data units (mtoe) have been converted to TWh.

Trends and drivers in domestic buildings

Overall, non-temperature corrected domestic energy consumption was 466.4 TWh in 2017, 8.8% higher than in 1970. Demand reached a peak of 573.4 TWh in 2004 and has since fallen by around 19%. Natural gas and electricity dominate domestic energy consumption with 64% and 23% respectively, with the remainder coming from solid fuels, biomass, petroleum and external sources of heat.

Gas consumption rose by 280% from 1970, to a peak of 396.6 TWh in 2004 before falling by 25%. Gas is used for heating (76%), hot water (23%) and cooking (1%).

Electricity consumption rose by 60% from 1970, peaking at 125.6 TWh in 2005 and then reducing steadily by 12%. Electricity is used mainly for appliances (59%), heating (17%) and lighting (13%).

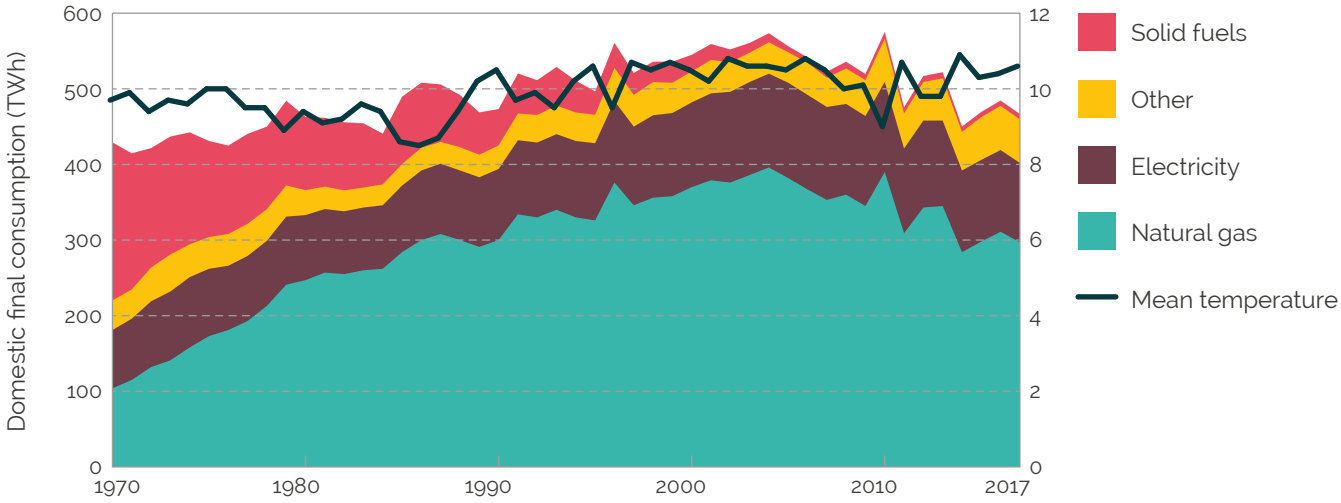

Figure 3: Final domestic energy consumption by fuel. Source: Energy Consumption in the UK, BEIS 2018.

The main factors increasing demand are the number of households (up by 50% from 18 million in 1970 to 28 million now), rising demand for heating and hot water (our homes are thought to be 4°C warmer now than in 1970 (DECC, 2013)), reductions in fuel prices (gas dropping in real terms by 41%, electricity by 32%, between 1983 and 2000) and increased electricity use from additional lights and appliances.

The rapid market penetration of energy efficiency measures has made a significant contribution to the fall in demand since 2003. Condensing boilers have become the dominant form of heating since they became mandatory in 2005, double glazing is in over 80% of homes now compared to 10% in 1983 and some degree of loft insulation is approaching market saturation (Committee on Climate Change, 2018). However significant potential remains: the Committee on Climate Change estimates that around 4 million cavity walls remain to be insulated (Committee on Climate Change, 2018).

For electricity the significant rise in the number of appliances in use has been offset by improvements in both operational and stand-by energy efficiency.

Between 2005 and 2012, gas prices more than doubled (+116%), and electricity costs increased by 42%. The Government considers that this, coupled with the economic downturn in 2008 and falling disposable income, is likely to have reduced energy demand over the period. However, there is no direct evidence for this.

There are some signs that the downward trend in domestic energy demand may be reversing, with 2016 and 2017 both showing temperature-corrected rises. However, is it too soon to predict any shifts in consumer behaviour.

Trends and drivers in non-domestic buildings

Overall service sector energy demand, of which around 93% comes from non-domestic buildings, was 238.4 TWh in 2017, which is 10% higher than 1970 (216.3 TWh) (BEIS, 2018a). The main energy consuming processes were space heating, lighting, catering, chilled storage and IT, detailed below.

- Commercial buildings dominate the sector with 67% of total demand. This has risen by 71% since 1970 (159.3 TWh in 2017 compared with 93 TWh in 1970). The main categories are industrial buildings, retail, leisure and hospitality.
- Public sector buildings accounted for 28% (65.1 TWh) of demand, which is 38% down on 1970 (101.2 TWh). The main categories are health, and central and local government.
- Agriculture accounted for 7% (17.4 TWh) which is 22% lower than in 1970 (22.0 TWh).

The upward trend in overall energy demand masks three sets of influences. Commercial sector activity has increased significantly as the UK has moved to a service-based economy. This has been largely offset by a 63% drop in energy intensity across the sector as a whole, although this intensity trend began to reverse in 2014 and has since risen by 11%. The improvements in efficiency in the commercial sector are thought to be due to higher densities of occupation, improved heating, cooling, ventilation and lighting efficiencies.

Policy principles and challenges

Policies for reducing energy demand in buildings have been well characterised in the academic literature, Government reports and by the work of Committee on Climate Change, most recently on the domestic sector (Committee on Climate Change, 2019). The main policy approaches are set out below.

1. Reducing demand and avoiding waste, e.g. heating fewer rooms and turning off lights and appliances. This is referred to as behaviour change and is a complex socio-technical phenomena involving interaction with control systems and new emerging uses of energy, sometimes stimulated by efficient technologies or building design.
2. Efficient conversion of delivered energy to useful energy by using more efficient heating systems, lighting and appliances.

3. Avoiding heat loss or heat gain by increasing fabric insulation, controlling ventilation and solar gains and integrating measures so that they work effectively together.
4. Integrating energy generation into buildings, for example solar thermal, passive heating via glazing, solar photovoltaics, or heat pumps. Although generation is not strictly demand reduction, it is hard to disaggregate unless it is separately metered and reported.

Buildings present many of the same barriers to change seen in other sectors. However, buildings, by nature and use, are highly diverse, which can make upgrading existing buildings difficult. As a result, policy has tended to focus on new buildings, and easier-to-install, more cost-effective interventions on existing buildings, such as like-for-like more efficient boiler replacements.

A wide variety of policy measures has been employed to do this: standards for building fabric and services e.g. Part L of the 2010 Building Regulations in England; performance standards for other technology used in the building (e.g. lights and appliances); and financial incentives, energy management standards and training, and feed-in tariffs or tax breaks to accelerate the market deployment of efficient and renewable generation technologies.

These policies have succeeded in reducing, or at least stabilising emissions. However, with 'low- hanging fruit' such as condensing boilers reaching market saturation, policy now needs to address the more difficult 'high hanging fruit' (also known as 'coconuts') such as heat pumps and solid wall insulation. A number of policy approaches can be used to accelerate the deployment of these technologies where the barriers to deployment are lower, for example installing heat pumps off the main gas grid (Cohen & Bordass, 2015).

However new buildings are a very small proportion of the stock: around 0.7% pa of the total UK commercial floor area (Property Industry Alliance, 2017) and 0.92%pa of dwellings in England (MHCLG, 2019). Sixty-five per cent of the existing UK non-domestic stock was built before 1991 and 24% before 1940 (BEIS, 2016). As a result, policy to deliver in the short- to medium-term such as the 5th Carbon Budget, needs to focus on existing buildings. However, in doing this policymakers face three significant challenges.

- The actual energy performance of a building can be twice as bad as predicted at the design stage (Cohen & Bordass, 2015). This performance gap is caused by a combination of poor modelling, deviations between design and build, and occupant behaviour (Carbon Trust, 2011). It is a problem for all buildings but is particularly well-characterised in non-domestic buildings (Innovate UK, 2016a & 2016b).
- Rented properties suffer from the so-called 'landlord/tenant divide': a principal-agent barrier where the landlord is reluctant to invest in energy efficiency measures (and as a result, respond to policy interventions) when the tenant benefits from the resulting lower energy costs.

- The construction sector faces significant supply-side barriers (Low Carbon Innovation Co-ordination Group, 2016; Zero Carbon Hub, 2014), such as fragmented supply chains, especially for large companies relying on outsourcing, unhelpful contractual conventions, poor management practice, a lack of the skills and capacity needed to specify and commission novel technologies and systems, and a general reluctance to try new approaches without prior demonstration.

A number of international policies and programmes are attempting to overcome these issues, and particularly the performance gap, by regulating operational energy performance as well the predictive approach used by conventional building codes. The Australian commercial building labelling scheme NABERS (The National Australian Built Environment Rating System) is a good example, although similar programmes are operating in the US and Singapore.

These programmes are attracting research attention because they are clearly transforming their markets. They appear to be doing this by raising the strategic important or 'salience' of energy savings by exploiting the value of other, non-energy 'multiple benefits' such as productivity, reputation, health, comfort or amenity (Mallaburn, 2016). However it is not yet clear how these processes work in detail or how this success can be replicated in a UK market or regulatory context.

Buildings policy in the UK

The UK was the first European country to introduce energy efficiency policies following the oil shocks in 1973 (Mallaburn & Eyre, 2016). Energy efficiency obligation policies were pioneered in the UK and used as a model for similar EU programmes in the late 1990s (Fawcett *et al*, 2018). However policy in recent years has stalled.

This section briefly outlines the recent history of buildings policy in the UK and the EU, sets out the current situation and assesses how the Clean Growth Strategy addresses the more serious policy gaps and shortcomings.

History

The period 2000-2010 saw a range of policies affecting buildings:

- Significant new funding for households through the Energy Saving Trust and (in 2001) a new Carbon Trust to support businesses and the public sector.
- An amendment to the England and Wales Building Regulations[2] requiring all domestic boilers fitted after 1st April 2005 to be condensing.
- A gradual tightening of the energy efficiency requirements of the Building Regulations, particularly in the 2006 revision in England and Wales[3].

2 Part L (England and Wales) has equivalents in Scotland (Part J) and Northern Ireland (Technical Booklets F1 and F2) – the exact dates of changes do not coincide.

3 Part L (England and Wales) evolved between 2002-2010 to make distinctions between residential / non-residential buildings and between new-build / existing buildings.

- The 2007 Carbon Reduction Commitment (CRC), requiring large non-energy intensive organisations to measure, disclose and manage their energy use.
- The 2008 Carbon Emissions Reduction Target (CERT) significantly ramped up the energy efficiency obligation on energy companies to subsidise energy efficiency measures.
- A 2008 requirement that all new buildings would need to be zero carbon from 2016 (households) and 2019 (commercial).
- Smart meters, and their roll-out by the Smart Meter Implementation Programme, established under the 2008 Energy Act.

At the EU level:

- The 2010 Energy Performance of Buildings Directive (EPBD) required Energy Performance Certificates (EPCs) to be provided at sale or lease to benchmark the theoretical energy performance of most buildings and give advice on energy efficiency options. Display Energy Certificates (DECs) measure actual energy performance in non-domestic buildings and must be prominently displayed in public buildings over 1000m^2 in floor area.
- EU product policy regulates the energy performance of technologies not regulated by the EPBD, mainly lighting and appliances. The two main measures are 2017 Energy Labelling Framework Regulation that governs the familiar A to G product labels and the 2009 Ecodesign Directive that sets minimum performance requirements to remove poorly performing products.

Current UK buildings policy

The UK and EU policies described above made a significant contribution to emissions reductions in the last 20 years, particularly in households (Committee on Climate Change, (2017). However, the Government's enthusiasm for buildings policy has waned since 2010 with many programmes being wound down or deprived of funding. This stop-start approach has been a characteristic of UK policy for over 40 years.

Policy for commercial buildings, which was never a UK strength, is now particularly weak, with a number of initiatives held back by industry lobbying or Government concerns about excessive burdens on business through the over-enthusiastic implementation or 'gold plating' of EU Directives (DCLG, 2015).

In 2012 direct, publicly-funded support for both business and household energy efficiency, estimated at around £100m pa, was removed from the Energy Saving Trust and the Carbon Trust (DECC, 2011). Conversely, support for public sector energy efficiency funding through Salix Finance has been maintained and, in 2017/18, significantly increased.

In 2013 the CERT energy efficiency obligation was replaced by the Energy Company Obligation (ECO) which stopped subsidies for better-off households and instead focused on the fuel poor.

In the 'able-to-pay' sector, CERT funding was replaced with the Green Deal, a repayable loan-based system aimed at overcoming up-front capital investment barriers. It was originally intended for both households and businesses, although most activity centred on the domestic sector.

The introduction of the Green Deal was widely recognised as a disaster both in emission reduction terms and, in combination with the removal of previous subsidies, by severely disrupting the retrofit market (Rosenow & Eyre, 2016). As Figure 4 shows, cavity wall and loft insulation rates have fallen dramatically compared to pre-Green Deal levels.

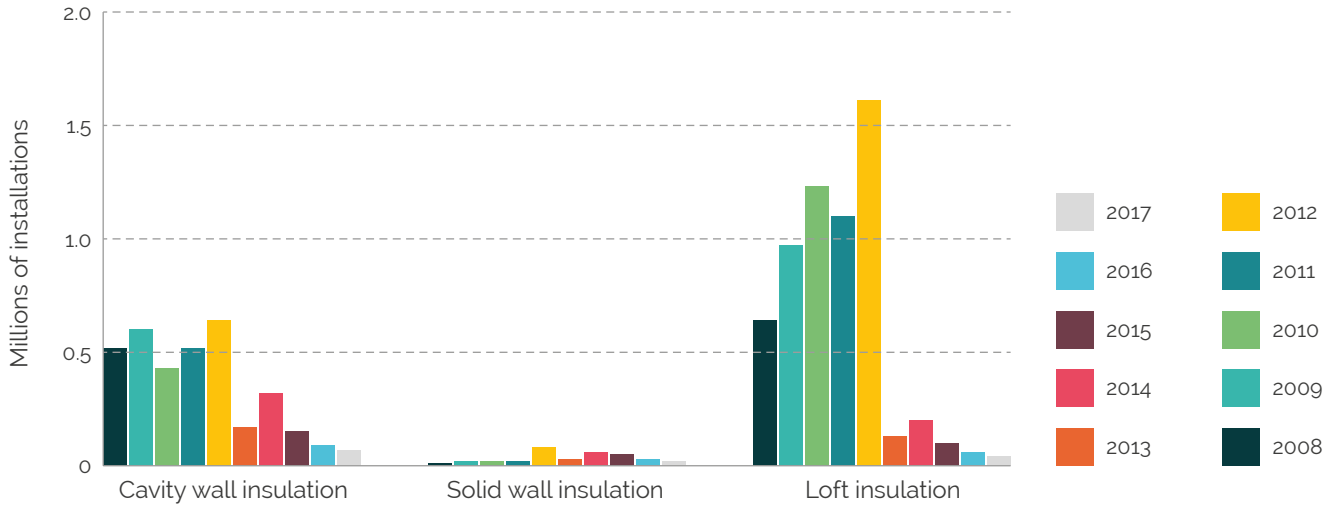

Figure 4. Annual insulation rates 2008-2017. Source: Reducing UK emissions. 2018 Progress Report to Parliament (Committee on Climate Change, 2018).

Zero carbon targets for both domestic and non-domestic buildings were abolished in 2015. The CRC Energy Efficiency scheme was fiercely resisted by businesses, progressively reduced in ambition and abolished in April 2019. Enhanced Capital Allowances for energy efficiency equipment will be abolished in April 2020 and the savings used to support a new industrial energy transformation fund for energy intensive companies.

Some new policies have been announced or enacted. For new buildings, in May 2018 the Prime Minister announced a 'Buildings Mission' to reduce energy use by 50% by 2030 (BEIS, 2018d). In the 2019 Spring Statement (HMT, 2019) the Chancellor announced a new Future Homes Standard which from 2025 effectively bans fossil fuel heating in new homes.

For existing buildings, the UK is developing its own operational energy performance scheme. From April 2019 all rented buildings are subject to minimum energy efficiency standards (MEES) under the Energy Efficiency (Private Rented Property) (England and Wales) Regulations 2015[4]. Rented properties must have an EPC rating of E or better unless the landlord registers an exemption. However, as discussed in the next section, the value of the EPC as a policy tool is open to question.

The grant regime under the Low Carbon Building Programme was replaced by feed-in tariffs under the Renewable Heat Incentive in 2011 where businesses and householders were paid according to the renewable energy they exported to the grid.

Several voluntary schemes are also under development for non-domestic buildings. The Soft Landings programme (BSRIA, 2012), developed by BSRIA, the buildings services trade body, aims to build capacity in the sector by providing guidance and support. The Design for Performance programme (Better Buildings Partnership, 2018), run by the Better Buildings Partnership, is piloting energy performance labelling, based on the Australian NABERS experience, in several large UK building developments.

Buildings in the Clean Growth Strategy

The Clean Growth Strategy (CGS), and subsequent initiatives related to it, proposes a number of new initiatives specifically aimed at households and non-domestic buildings.

Domestic buildings in the CGS

The key policy aim is to bring as many existing households as possible up to EPC band C by 2035 (where "practical, cost-effective and affordable") and 2030 for fuel poor and privately rented homes. This is an ambitious target, but the CGS does not explain how it will be delivered or funded. Also, there are no targets for new homes beyond the current Building Regulations. And finally, there are also significant concerns about the use of EPCs as a policy benchmark (Jenkins *et al*, 2017).

- A band C target is a blunt instrument. For hard-to-install measures such as solid wall insulation it may be more cost effective in the long run to upgrade to EPC band A or B at a relatively lower marginal cost compared with further intervention later.
- There are serious accuracy and reliability issues between different assessors, between different property types and within the same property type.
- An EPC uses annual fuel cost and annual carbon emissions as the main metric of evaluation. However, as we decarbonise energy supply this might become a less useful metric for managing demand compared to other metrics such as load flexibility at peak times.

4 MEES applies in England and Wales only. In January 2016, the Scottish Government published a draft of the Assessment of Energy Performance of Non-domestic Buildings (Scotland) Regulations 2016 which came into force on 1st September 2016.

- There is compelling evidence that regulatory bodies are not enforcing current EPC rules (Environmental Industries Commission, 2018) or indeed Building Regulations more widely (Zero Carbon Hub, 2014).

The Hackitt Review of Building Regulations and Fire Safety (MHCLG, 2018), commissioned following the Grenfell fire, will significantly affect the regulatory environment in the UK. It is essential that this cultural change happens not only to fire and safety, but also energy performance. Several of the review recommendations, if implemented, would address the performance gap.

- A new Joint Control Authority separating enforcement from the interests of supply chain actors, including clients, designers and contractors.
- A stronger change control process that requires more robust record-keeping of changes made to plans during the construction process.
- More rigorous enforcement powers and penalties including requirements to change work that did not meet Building Regulations.

The use of regulations, if implemented correctly, can have significant benefits. Condensing boiler regulations are considered to be an exemplar. In 2003 they were in around 7% of UK houses. Once they were made mandatory in 2005, this rose to 50% in 2011 and is now approaching 100%, saving 11 MT CO_2e pa (Elwell *et al*, 2015) or 17% of total household gas consumption. There is potential for further savings at minimal cost such as managing flow temperatures and balancing heating systems. This latter measure can increase the efficiency of the system by 10% (Sustainable Energy Association, 2016).

Non-domestic buildings in the CGS

A Call for Evidence (BEIS, 2018b) estimated that the package of measures set out in the CGS would deliver £6bn in cost savings and 22Mt of non-traded CO_2 emission reductions, split 45% from existing policies, 40% from buildings and the remainder from industrial processes and heat. This, if implemented, would make buildings the single biggest new policy element for delivering the 5th Carbon Budget.

In common with domestic sector proposals the CGS is thin on actual policies to deliver this target. Only three are mentioned: a new energy performance reporting framework, an industrial energy efficiency scheme and tightening of the MEES standards. Key issues are deferred to future consultations: on advice for SMEs, the energy services and finance markets and the role of the UK Energy Savings Opportunity Scheme (ESOS) and Climate Change Agreements (CCAs).

Non-domestic buildings attract almost no specific policy attention at all: just 4 paragraphs, compared to 11 pages for households. There is no substantive analysis of the nature and scale of the problem or of the specific policies and measures that might be needed.

The Government's response to the Call for Evidence on business policies, published in March 2019, promises a review of Part L of the Building Regulations in 2019 and recognises the importance of focusing on operational performance, but also promises further consultations. It is fair to say that the Government does not have a non-domestic buildings policy.

There are some encouraging signs. The CGS recognises the central role of regulation coupled to demand-side drivers, building on research into corporate strategic or 'salience' drivers (DECC, 2012) and the International Energy Agency's 'multiple benefits' approach (IEA, 2014).

The Government recognises that policies to deliver their objectives must combine market solutions with strong Government intervention. This is important because the lessons from successful overseas policies (van der Heijden, 2017) show the value of a hybrid policy approach, where carefully managed government/industry partnerships are exploiting the multiple benefits of improved energy performance to transform markets (Mallaburn, 2018).

Recommendations

Recommendations for Government policy

HMT, BEIS, MHCLG and devolved administrations:
Develop an overall policy framework for the building sector that unifies the existing fragmented, stop-start policy approach and provides a clear signal of Government ambition and intent in the medium and long-term that will deliver the buildings element of future carbon budgets. If business is to invest in delivering this long-term strategy and develop new models it needs long-term Government commitment.

BEIS and MHCLG:
Ensure that the implementation of the Hackitt Review addresses the energy efficiency performance gap on the evolution of and compliance with buildings standards and in the development of skills, standards, procedures and capacity within the building industry sector.

BEIS and MHCLG:
Broaden overall policy on to the actual, real-world 'as-built' energy performance of buildings. Shifting to a performance-based culture will allow tenants and householders to choose energy efficient buildings and enable the market to accelerate their uptake.

- For households, regulatory policy needs to focus on actual rather than modelled heat loss from the buildings, based on the principles set out in the recent BEIS Smart Meter Enabled Thermal Efficiency Ratings (SMETER) project (BEIS, 2018c).
- For non-domestic buildings the Government should introduce a performance-based policy framework based on successful overseas experience.

BEIS:
Introduce measures to deliver rapid, low-cost emission reductions from existing technologies and systems, for example using product labels to reflect the real-world, operational boiler efficiency based on the Government's 'Boiler Plus' approach (BEIS, 2017).

BEIS:
Produce credible roadmaps for new and existing buildings on the deployment of emerging technologies such as heat pumps, district heating and solid wall insulation, identifying sectors to be used to reduce costs and build supply-chain capacity, for example heat pumps installed in properties off the gas grid.

Recommendations for CREDS and BEIS working together

Continue to develop and build national, long-term energy performance datasets. Policymakers and researchers need reliable, real-world, in-use energy performance data. Significant progress has been made in recent years by both Government and researchers, but many areas need urgent attention.

- For households, we need a national longitudinal survey building on existing data and monitoring, such as the EPSRC Smart Meter Research Lab and the MHCLG/BEIS English Housing Survey and its Energy Follow-Up Survey. Together these can provide a coherent platform to develop the national tool for domestic policy, the National Household Model.
- EPCs for the twenty-first century. EPCs are the main currency for delivering building energy efficiency and cost millions to implement. However, the implementation is poor in part because the latest computational, digital and data practices are not utilised.
- For non-domestic buildings we need a national data strategy to bring together and rationalise the various official datasets and studies building on the work of 3DStock and SimStock.

Maximise the value of research and demonstration investments. UK Research & Innovation, Government and industry have funded several major projects such as the EPSRC Active Building Centre and the Energy Systems Catapult Smart Systems and Heat programme. It is important that maximum value is extracted from these investments, for example to help develop data and modelling tools.

Deepen our understanding of how to exploit the value of the multiple benefits of energy efficiency. We need to understand how they enhance the salience of energy demand measures, how salience varies between organisations, sectors and individuals and where the key, practical policy 'intervention points' lie.

- For households we need systematic ways of capturing the value of multiple benefits in policy evaluations, for example based on HIDEEM modelling of the health benefits of energy efficiency (Hamilton *et al*, 2015), used for fuel poverty policy appraisal (BEIS, 2016).
- Develop methodologies to characterise and better understand the relationships between the thermal performance of buildings and indoor environmental quality (IEQ – air quality, over-heating and noise).
- For non-domestic buildings we need to understand how energy productivity and other 'multiple benefit' policy approaches can transform the buildings and construction sectors by, for example, exploiting value drivers and building market capacity and skills.

Develop a long-term collaborative hybrid policy framework to decarbonise buildings based on successful experience overseas and the latest research that sets out the respective roles of industry and Government over a 10–15 year timescale.

References

BEIS (2018a). Energy consumption in the UK.

BEIS (2018b). Helping businesses to improve the way they use energy, Call for Evidence.

BEIS (2018c). Smart Meter Thermal Efficiency Ratings (SMETER) Innovation Competition.

BEIS (2018d). The Grand Challenge Missions.

BEIS (2017). Heat in buildings. Boiler Plus.

BEIS (2016). Building Energy Efficiency Survey 2014–15: overarching report.

BEIS (2016). Consultation Stage Impact Assessment: ECO: Help to Heat – Transitioning to a fuel poverty focused obligation.

Better Buildings Partnership (2018). Design for Performance to deliver better buildings.

BSRIA (2012). The Soft Landings Core Principles. BSRIA BG 38/2012.

Carbon Trust (2011). Closing the gap. Lessons learned on realising the potential of low carbon building design.

Cohen, R. & Bordass, B. (2015). Mandating transparency about building energy performance in use. *Building Research and Information*, **43** (4): 534–552. doi: 10.1080/09613218.2015.1017416

CCC (2019). UK housing: fit for the future?

CCC (2018). Reducing UK emissions. 2018 Progress Report to Parliament.

CCC (2017). Energy prices and bills – impacts of meeting carbon budgets.

DCLG (2015). Display Energy Certificates: current regime and how it could be streamlined and improved.

DECC (2013). United Kingdom housing energy fact file.

DECC (2011). Review of DECC's delivery landscape.

Elwell, C. A., Biddulph, P., Lowe, R., & Oreszczyn, T. (2015). Determining the impact of regulatory policy on UK gas use using Bayesian analysis on publicly available data. *Energy Policy*, **86**. doi: 10.1016/j.enpol.2015.08.020

Environmental Industries Commission (2018). Improving non-domestic energy efficiency after Brexit: the challenge and the opportunity.

Fawcett, T., Rosenow, J. & Bertoldi, P. (2018). Energy efficiency obligation schemes: their future in the EU. *Energy Efficiency*, **12** (1): 57–71. doi: 10.1007/s12053-018-9657-1

Hamilton, I., Milner, J., Chalabi, Z., Das, P., Jones, B., Shrubsole, C., Davies, M. and Wilkinson, P. (2015). Health effects of home energy efficiency interventions in England: a modelling study. *BMJ Open*. doi: 10.1136/bmjopen-2014-007298

HMT (2019). Spring Statement 2019: Written Ministerial Statement.

Innovate UK (2016a). 2016 Building Performance Evaluation Programme: Findings from non-domestic projects.

Innovate UK (2016b). 2016 Building Performance Evaluation Programme: Findings from domestic projects.

Jenkins, D., Simpson, S & Peacock, A. (2017). Investigating the consistency and quality of EPC ratings and assessments. *Energy*, **138**: 480–489. doi: 10.1016/j.energy.2017.07.105

Low Carbon Innovation Co-ordination Group (2016). Technology Innovation Needs Assessment (TINA). non-domestic buildings summary report.

Mallaburn, P. S. (2018). Principles of successful non-residential energy efficiency policy. Proceedings of the 2018 ECEEE Industry Summer Study.

Mallaburn, P. (2016). A new approach to non-domestic energy efficiency. Research report commissioned for Next steps for UK heat policy, Committee on Climate Change, 2016.

Mallaburn, P. & Eyre, N. (2014). Lessons from energy efficiency policy and programmes in the UK from 1973 to 2013. *Energy Efficiency*, **7**: 23–41. doi: 10.1007/s12053-013-9197-7

MHCLG (2019). Dwelling Stock Estimates 2017, England.

MHCLG (2018). Independent Review of Building Regulations and Fire Safety: final report.

Property Industry Alliance (2017). Property Data Report 2017.

Rosenow, J. & Eyre, N. (2016). A post mortem of the Green Deal: austerity, energy efficiency and failure in British energy policy. *Energy Research and Social Science*, **21**: 141–144. doi: 10.1016/j.erss.2016.07.005

Sustainable Energy Association (2016). Heating System Plus Policy Position Paper.

The National Australian Built Environment Rating System (NABERS).

van der Heijden, J. (2017). Innovations in Urban Climate Governance. Voluntary Programs for Low-Carbon Buildings and Cities. Cambridge University Press. doi: 10.1017/9781108233293.

Zero Carbon Hub (2014). Closing the gap between design and as-built performance. End of term report.

3. Industry, materials and products

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Introduction

Industry ultimately provides all the goods and services demanded by UK households, from major infrastructure to mobile phones. This clearly uses energy that leads to greenhouse gas (GHG) emissions. In fact, UK industry accounts for 16% of total final energy demand and 23% of the UK's GHG emissions (BEIS, 2017a; CCC, 2018). Since 1990, industrial GHG emissions have nearly halved, with 85% of this reduction occurring between 1990 and 2010. The reductions since 2010 have been more modest, with emissions actually increasing by 1% in 2017 (BEIS, 2017b). The reduction in emissions has been due to a complex mixture of structural change within UK industry, greater reliance on imports to meet the demand for energy intensive industrial products, changing demand for industrial products, and improved energy efficiency (Hardt *et al*, 2018; Hammond *et al*, 2012).

Industry is a diverse and heterogeneous sector and there are numerous ways to describe its structure and to identify opportunities to improve energy efficiency. For example, Griffin *et al,* (2016) identify 350 different combinations of technologies and sectors relating to industrial energy demand. This makes it challenging both to identify appropriate options and to propose generic solutions. Other studies consider industry from a resources and materials perspective, such as steel, cement and paper for example (Owen *et al*, 2018; BEIS, 2015[5]). When identifying mitigation options it can be misleading to treat industry as a single sector. Instead, it is necessary to disaggregate by subsector and identify current and available technologies, material and product outputs, trade patterns and infrastructures (Barrett *et al*, 2018).

5 Industrial roadmaps for a number of industrial sectors are available from: www.gov.uk/government/publications/industrial-decarbonisation-and-energy-efficiency-roadmaps-to-2050

Direct GHG mitigation options for industry are often grouped into four categories: improved energy efficiency, fuel switching, electricity decarbonisation and carbon capture and storage (Griffin *et al*, 2016). Clearly, there is role for all these options, however this chapter focuses on the role of energy efficiency in industry itself, plus broader measures to reduce energy demand from changing the mix of, and demand for, materials, products and services.

We achieve this by identifying the historical trends in UK industrial energy demand and explaining the reasons behind them. We review the current UK Government policy approaches as outlined in the Clean Growth Strategy and then consider whether there could be a more ambitious role for both industrial energy efficiency and broader options for reducing energy demand such as material efficiency. Before proposing some recommendations to reduce industrial energy demand, we explore the level of ambition needed in UK industry in relation to internationally agreed climate targets.

Recent trends in industrial energy efficiency and demand

A simple examination of historical trends in UK industrial energy demand suggests a major success story. While UK GDP has grown by ~70% since 1990, industrial energy demand has fallen by ~40% – indicating an absolute decoupling between the two (see Figure 5).

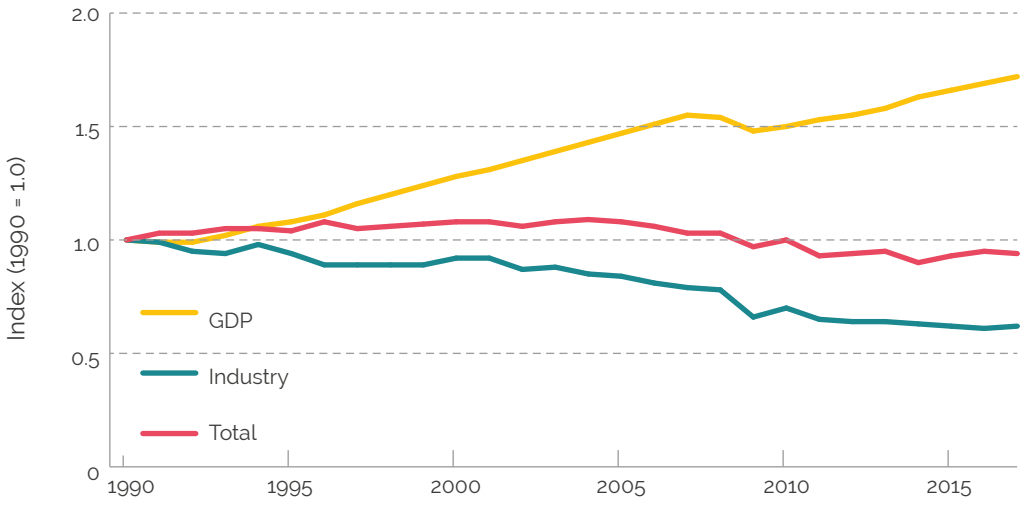

Figure 5: Industrial Energy Demand and UK GDP (1990 to 2016). Source: BEIS, 2017b with industry data added from BEIS, 2017a.

Reductions in industrial energy use have been greater than the average for all sectors in the UK. One of the reasons for this is a decline in the amount of energy used per unit of industrial output – known as energy intensity. Sometimes this metric is used as a proxy for energy efficiency, but this is misleading. It is influenced by a range of factors, including changes in the mix of industrial sectors and industrial products. For example, a shift away from heavy industry and towards consumer electronics would tend to reduce energy intensity. Hence, reductions in industrial energy intensity are not only a result of improvements in the technical efficiency of industrial processes.

Hardt *et al,* (2018) estimate that between the period of 1997 to 2013 half of the reduction in industrial energy intensity can be attributed to improvements in technical energy efficiency, with the rest being due to structural change and other factors.

Structural change, in turn, includes both changes in the mix of industrial sectors, and changes in the mix of domestically-produced versus imported goods and services. Since 1990, there has been a trend towards 'offshoring' industrial production to other countries, meaning that a smaller share of the goods and materials consumed in the UK are produced in the country. Figure 6 demonstrates that offshoring was the most important factor along with energy efficiency improvements between 1997 and 2013. While the offshoring of industrial energy use helps meet national GHG emission targets, it fails to deliver a global reduction in emissions.

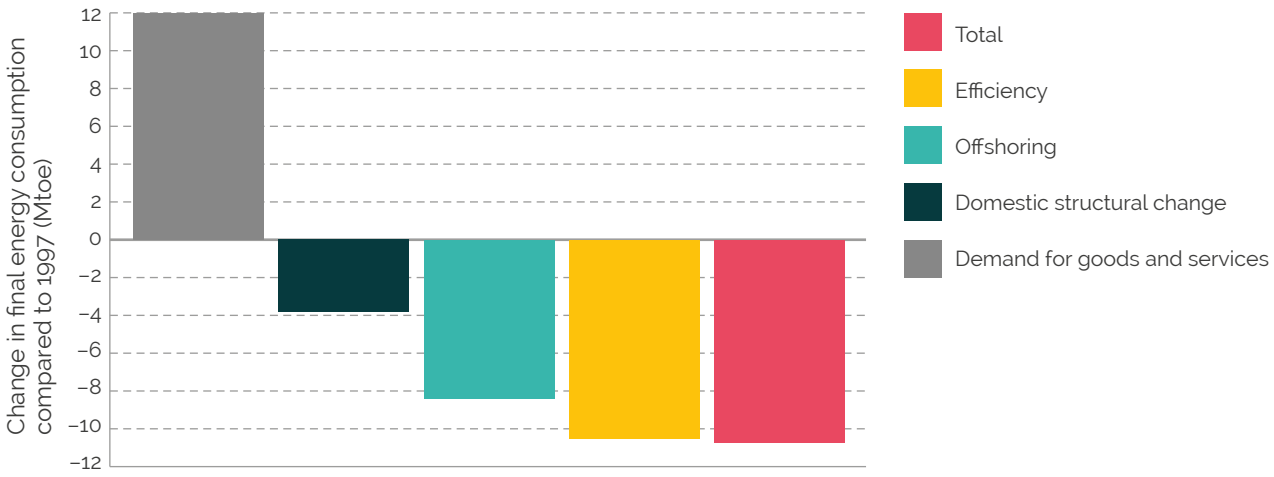

Figure 6: Decomposition analysis of UK industry, 1997–2013. Source: Hardt *et al*, 2018.[6]

In the more recent period from 2007 to 2013, the growth in demand for goods and services from industry resulted in increased energy demand. This increase was only partly offset by a reduction in energy demand from improved energy efficiency over the same time-period. Therefore, without the reductions from domestic structural change and offshoring, industrial energy demand in the UK would have been marginally higher in 2013 than in 2007.

6 Technical energy efficiency is very difficult to separate from other factors and could include both technical changes in processes along with structural changes within sectors which would not be captured in the assessment of structural change between sectors. Therefore, the assessment of the contribution of technical energy efficiency is an over estimate.

Current approaches to delivering industrial energy demand reduction

The Clean Growth Strategy (CGS) sets out a range of strategies to help decarbonise industry, including not only energy efficiency and demand reduction but also fuel switching and other abatement options. On energy efficiency, it sets a high-level goal for improvement across business and industry of at least 20% by 2030 and outlines a number of strategies to deliver this. From an historical perspective, this represents a 'business as usual' ambition with the level of improvements being similar to those seen in the past.

The CGS analysis (BEIS, 2017b) shows that overall industrial emissions savings in the region of 45MtCO_2 are technically possible by 2050 compared to baseline emissions in that year (CO_2 emissions being 123MtCO_2 from industry in 2015). This 37% reduction would be mainly achieved through carbon capture, usage and storage (CCUS) and fuel switching, with a very small role for energy efficiency of 5MtCO_2 (4% of 2015 emissions).

It is unclear when these reductions would be delivered and the issue of timing is extremely important when considering cumulative emissions, and therefore impact on climate. The Committee on Climate Change (CCC) however suggest that this 5Mt reduction relates to energy efficiency that could be achieved by 2030. However, this 5 Mt emissions saving may not be the total contribution to GHG reduction from energy efficiency, since the BEIS baseline projection already incorporates some energy efficiency improvements – based on extrapolating past relationships between energy use and GDP. This makes it difficult to assess what the total contribution by 2050 from energy efficiency might be. However, the impression given in the CGS is that the role of energy efficiency is expected to be minimal compared to other options.

The CGS and numerous other publications identify multiple economic barriers to achieving energy efficiency improvements such as split incentives, asymmetric information and high transaction costs. Therefore, it is difficult to reduce energy demand without some policy intervention as the business case for further improvements is weak, especially in the energy intensive sectors. A number of strategies are therefore outlined in the CGS to meet the high-level energy efficiency goal, building on the 'Industrial Decarbonisation and Energy Efficiency Action Plans' (BEIS, 2017c), and the earlier roadmaps (BEIS and DECC, 2015). The proposed strategies include: an Industrial Energy Efficiency Scheme providing support for large companies to invest in energy efficiency; increasing the Climate Change Levy rates after 2019; improving and reforming the Energy Savings Opportunity Scheme (ESOS); introducing a new energy and carbon reporting framework for business to replace existing schemes; and dedicating £18m to industrial heat recovery (BEIS, 2017b). In addition, the CGS proposes a funding framework for R&D in industrial decarbonisation, with £162m to be invested by 2021 (BEIS, 2017b) on a range of projects covering energy, resource and process efficiency, better low carbon fuels and CCUS. The Industrial Strategy Challenge Fund additionally has the 'Transforming Foundation Industries Challenge', covering glass, metals, cement, ceramics and chemicals.

However, the CGS provides little detail on the design and implementation of these strategies and it remains unclear how they would collectively deliver significant reduction in GHG emissions in line with UK and global ambitions.

Ultimately the success of these schemes will come down to the detail of their design and implementation, including the ability to target the most cost effective measures and to reduce the associated transaction costs. Learning from other countries is essential here. For example: Canada has introduced an industrial energy efficiency programme in four provinces; Denmark has established a 'Secretariat for Energy Savings', targeting industry with information-based measures providing assessment and analysis of energy use (IEA, 2017a; IEA, 2017b); the Netherlands has a system of 'Long-term Agreements' with industry; Germany has an energy efficiency framework, which has been highly effective at reducing energy intensity; and Japan has had their 'Top Runner Programme' since 1999, orientated towards the manufacturing sector (Geller *et al*, 2006; IEA, 2016; IEA, 2013; IEA, 2014).

We now consider what a successful programme could potentially deliver in relation to energy efficiency and whether there should be an increased level of ambition.

Energy efficiency options in industry

Energy efficiency is often seen as 'the first fuel', delivering cost saving as well as delivering environmental benefits. It is seen as highly attractive because it does not necessarily rely on changes to behaviour and lifestyles and allows the continuation of existing business models. Therefore, is the CGS right to identify such a small role for energy efficiency in industry to deliver GHG emission reductions?

The CGS analysis draws from a road-mapping exercise for eight sectors of UK industry (WSP, Parsons Brinckerhoff and DNV GL (2015)) and concludes that, under a scenario of incremental improvements, energy efficiency could annually contribute 5.3 Mt CO_2 savings by 2050 (4% reduction as noted above). Under a scenario of 'maximum technology', which ignores economic and commercial considerations, and includes technologies currently at low technology readiness levels, this figure increases to 7.6 Mt CO_2 (6% reduction).

Energy efficiency saving potentials were found to be lowest in percentage terms in energy intensive sectors, such as iron and steel, and cement manufacture, which aligns with the findings of other work (Griffin *et al*, 2014). This is consistent with the observation that energy efficiency improvements within energy intensive sectors have been plateauing in recent years (Hammond and Norman, 2016). The high share of energy in overall production costs of these sectors has driven energy efficiency improvements for decades, and so the remaining potential may be relatively small and difficult to realise. For example, it is widely acknowledged that several energy intensive industrial processes (such as steel production) are close to what is technically feasible in relation to energy efficiency (Norman *et al*, 2016). This broadly leaves two options for these sectors: radically different industrial processes as envisaged by the CGS and/or changes in demand for their products.

Options such as CCUS have yet to become economically viable and are unlikely to be implemented at scale in the short term. Rapid reductions in cumulative emissions to meet internationally agreed climate targets require changes in the next decade.

Conversely, the non-energy intensive sectors, having historically not had such strong drivers to improve efficiency, may have relatively greater opportunities remaining (often referred to as 'low-hanging fruit'). There is limited evidence of where such potential might lie as these non-energy intensive sectors represent a challenging area for analysis, with poor data availability and highly heterogeneous uses of energy (Griffin *et al*, 2016). The potential for opportunities related to 'cross-cutting technologies' used in multiple sectors of industry (such as boilers and motors) are often relied on to assess the emissions reduction opportunities in non-energy intensive sectors. This leads to an incomplete analysis of the improvement opportunities by not representing the diversity of energy-using processes and efficiency options. Examples of particularly complex sectors include food and drink, textiles, chemicals and engineering. More evidence is needed to ensure a thorough appreciation of the opportunity in the non-energy intensive sectors.

In conclusion, the level of ambition for industrial energy efficiency identified in the CGS should be increased. However, it is highly unlikely that dramatic gains are going to be possible in the short term. The most promising area for further rapid action may be the non-energy intensive sectors, but they also represent a smaller proportion (~35%) of total energy demand. Realising major additional improvements in the energy intensive sectors will require significant process change and therefore capital investment, which is unlikely to materialise in globally competitive markets without significant Government support. Therefore, identifying opportunities for sustained reductions in industrial energy use to 2050 also requires an understanding of how to reduce demand for the most energy intensive materials and products, which we explore in the following section.

Going beyond energy efficiency to reduce industrial energy demand

All energy demand in industry ultimately relates to goods and services provided for households and government. With limited options available to reduce energy demand through efficiency improvements, changing demand for the goods and services produced by industry offers further mitigation options. Energy is embodied in products as raw materials (e.g. minerals) are processed into useful materials (e.g. glass and metals) and manufactured into products (e.g. buildings, cars and electronics) which in turn are used as inputs to all intermediate sectors (e.g. agriculture, construction, transport and financial services) or sold to final consumers (e.g. households and government) (Scott *et al*, 2018). As 'carriers' of industrial energy, the trade of materials and products results in the transfer of embodied energy between sectors, countries and consumers (Scott *et al*, 2018). Figure 7 shows how UK and international energy supply flows (through materials) from the energy system, to industry and to final consumers of products in the UK, commonly defined as the UK's consumption-based GHG accounts[7].

7 Latest data for the UK is available from: www.gov.uk/government/statistics/uks-carbon-footprint

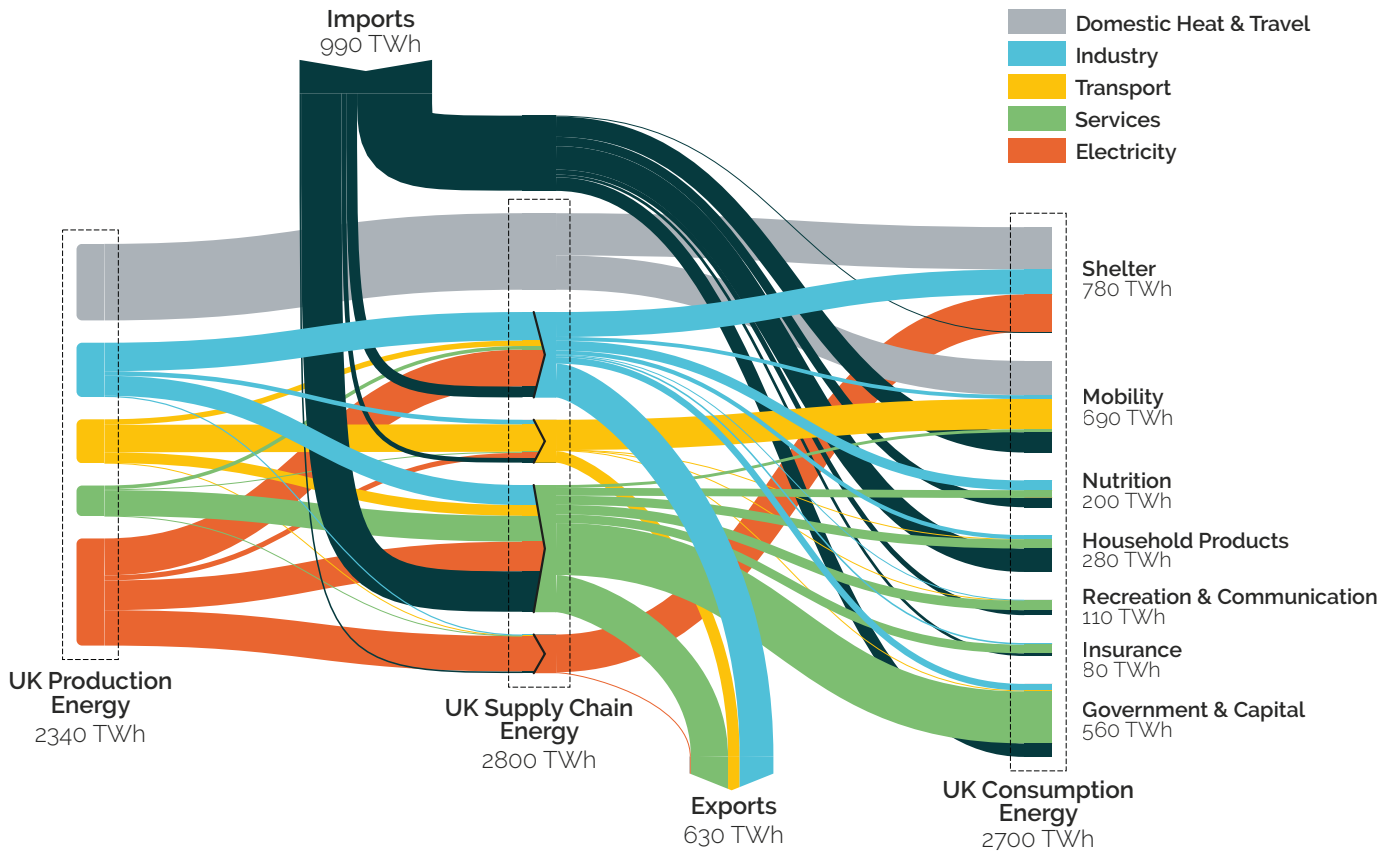

Figure 7: Embodied energy analysis of the UK, extracted from data in Scott *et al*, 2018. Source: All data from University of Leeds.

The left of the figure shows the energy demand of the UK (2340 TWh) for five sectors. The UK imports a further 990 TWh of embodied energy in materials that are imported either into industry (intermediate demand) or as final product to consumers (household demand). It also exports 630 TWh, making the UK a net importer of embodied energy. On the far right of figure 7 is the energy embodied in household services such as shelter, mobility and nutrition.

The value of this analysis is the ability to identify additional mitigation options beyond energy efficiency. These could be broadly described as 'Putting Less In' (production changes) and 'Getting More Out' (consumption changes) to change our use of materials and products that ultimately reduces the need for industrial energy. Production changes could include reducing waste in industry, lightweighting products and packaging, fabrication yield improvements, modular design or remanufacturing. Consumption changes could include household reductions in waste, shifts from recycling to refurbishing, using products longer, accessing services as opposed to ownership (car clubs for example) and sharing (higher occupancy rates in vehicles and buildings). Indirectly, all these changes have the potential to reduce industrial energy demand.

Scott *et al,* (2019) calculated the potential for material efficiency across seven sectors (see table 1), considering measures that include waste reduction, lightweighting of products, material substitution and product longevity.

Table 1: Summary of material productivity strategies. Source: Scott *et al*, 2019.		
Sector	**Putting less in (production)**	**Getting more out (consumption)**
Clothing & textiles	Reduce supply chain waste through efficiency improvements in fibre and yarn production, dyeing and finishing	Dispose of less and reuse more Dispose of less and recycle more Use for longer
Food & drink	Reduce avoidable food waste in food services and hospitality sectors	Reduce avoidable household food waste
Packaging	Reduce weight of packaging (metal, plastic, paper, glass) Waste prevention	n/a
Vehicles	Reduce steel, aluminium and additional weight without material or alloy changes Yield improvement (metals) in car structures through cutting techniques Steel fabrication yield improvement Reuse discarded steel products	Shift from recycling to refurbishing Car clubs Use cars longer
Electronics, appliances & machinery	Reduce steel without material or alloy changes Steel fabrication yield improvement Reuse discarded steel products in industrial equipment	Sharing less frequent electrical appliances (e.g. vacuum cleaners), power tools and leisure equipment Use for longer Remanufacturing instead of throwing away
Construction	Design optimization to reduce material inputs Material substitution Material reuse	n/a
Furniture	Reduce steel without material or alloy changes	Dispose of less and reuse more Dispose of less and recycle more

Collectively, these options offer a greater potential for emission reduction by reducing energy demand than all the current planned reductions in industry documented in the Clean Growth Strategy related to energy efficiency in industry (5 Mt CO_2 in 2030). These material efficiency options offer potential savings of 21 Mt CO_2 in 2030. The material efficiency measures documented in Scott *et al* (2019) represent a conservative assessment of the potential for emission reduction and are by no means the maximum potential. They rely on evidence from existing case studies and therefore once the UK started on a path towards material productivity further options are highly likely to emerge.

One of the key advantages of material efficiency strategies relates to timing. The reality of climate change is that it is the total cumulative GHG emissions that relate to temperature rises, meaning that reductions in the short term offer significantly more investigation potential, especially if the changes create a long-term change. Many of the material efficiency strategies listed above require no major breakthrough in technology and limited capital investment but do need Government intervention to ensure that they materialise.

The other advantage of these measures is that GHG emissions are not just reduced within the UK but would reduce emissions in other countries. The UK is a large importer of energy intensive materials and many of the strategies would reduce the UK's reliance on imports. While the analysis above only lists the emissions savings that would occur in the UK, other studies suggest that a similar, if not greater reduction, would occur in other countries as a result of UK action (Barrett *et al*, 2013). This reinforces the notion that the UK could become a global leader in tackling climate change while also reducing its reliance on imports.

Conclusions and recommendations

Industry is often considered a hard to mitigate sector and most emissions scenarios allocate a larger proportion of the carbon budget by 2050 to industry because of this. Under such scenarios further and faster emission reductions are required in other sectors to allow for the additional 'carbon space' allocated to industry. At the same time, demand for industrial energy has not declined as rapidly as may appear from national energy data, because some of it has simply been offshored, with no benefit for global efforts to reduce emissions.

The current UK Government strategy is framed around achieving an 80% reduction in GHG emissions by 2050 (based on 1990 levels). It is clear that this target is inconsistent with international efforts to reduce GHG emissions to net-zero in the 2050s, and therefore the UK Government is currently considering a net-zero target by 2050, in which case industry emissions would need to be much closer to zero than is currently assumed. Under this framing, choices between energy efficiency **or** fuel switching **or** CCUS disappear. The required framing is energy efficiency **and** fuel switching **and** CCUS **and** a comprehensive assessment of changing consumption patterns to reduce the needs for materials and products. With material efficiency measures potentially being three to four times more significant in reducing emissions than energy efficiency options, there is an urgent need to ensure that the Waste and Resource Strategy aligns with the CGS.

The good news is, collectively, these options could deliver substantial reductions ensuring that industry does not require a favourable allocation of future carbon budgets over other sectors. However, the efforts to achieve these reductions should not be under estimated, requiring additional policy and strong partnerships between the UK Government and industry. Without Government intervention they will simply not be realised. This requires alignment not just in climate and resource efficiency strategies but more broadly with economic objectives and future industrial strategy. With responsibilities cutting across Government departments (in particular Treasury, Business, Energy & Industrial Strategy, Ministry of Housing, Communities & Local Government, and the Department for Environment, Food & Rural Affairs), a joined-up, coherent and comprehensive plan is required. This plan is urgently needed to accompany the CGS, along with clarification of the rather vague measures currently proposed.

What all these schemes have in common is the need for high quality data, benchmarking and metrics to enable successful targeting, monitoring and measurement. At present, the UK lacks the data and institutional framework to deliver such a programme. Data on energy consumption linked to industrial processes is very poor, with economic data often being used to derive proxies for energy use. This makes assessments of progress and potentials very difficult, with non-energy intensive sectors being particularly poorly understood. The first step to implement an energy and material efficiency scheme for industry is to establish the necessary structures around data and management. This ensures that a transparent platform is in place for Government to engage in a transformative plan with UK industry to deliver a net-zero target by 2050.

In summary, our key recommendations are as follows.

- **We recommend that Government increases the ambition for energy demand and emission reductions goals in industry (BEIS)**. These needs to align with internationally agreed targets and goals for net-zero emissions.
- **We recommend that Government adopts industrial energy-use goals that include energy efficiency, fuel switching, process decarbonisation, CCUS and reducing the demand for materials and products (BEIS, Defra, Devolved Governments)**. The savings potentials to deliver stronger goals exist, but delivering them requires a more holistic approach, including energy efficiency and fuel switching, but also going further to include demand for materials and products for short-term reductions and transformative technologies for longer-term gains.
- **We recommend that Government develops a comprehensive industrial energy demand policy, providing support and incentives for innovation and deployment of new technology and business models, including for energy efficiency and material efficiency by final consumers (HMT, BEIS, Defra, Devolved Governments)**. The scale and pace of change required is not going to happen by itself and therefore needs more policy intervention. This needs to involve Government playing an active role in supporting innovation and creating markets, including by ensuring that their own procurement patterns reflect the changes needed.
- **We recommend that Government accepts the need to address questions of lifestyle and behaviour change to deliver energy and material efficiency (HMT, BEIS, Defra, Devolved Governments)**. The options for energy efficiency improvement in the energy intensive sectors are very limited in terms of emission reductions, in the short term. Therefore, the UK Government needs to openly recognise that technology alone will not be enough and initiate a public debate on our lifestyles and their lack of consistency with a net-zero future.
- **We recommend that Government develops a cross-Government approach to energy, climate, waste and industrial strategy (Defra, BEIS, Devolved Governments, HMT)**. This is needed to ensure that investment support, tax regimes and strategies are aligned. Energy, climate and waste policies need to be seen as integral parts of an economic policy that provides the right incentives to guide and support industry.

- **We recommend that Government aims to take a leadership position internationally on energy intensive material supply chains (BEIS, Defra, DIT, FCO, DfID)**. With the UK being heavily reliant on imported energy intensive materials and products, the UK Government must work internationally to reduce the energy and associated emissions of international supply chains.
- **We recommend that Government works with industry and the research community to develop and share better industrial energy and materials data (BEIS, Defra)**. Given the far-reaching nature of the changes, policies need to be evidence-based. Data availability and quality are currently not good enough for the level of analysis that is needed. Uncertainty is too high and not enough is known. An investment in more robust and transparent industrial energy data linking energy demand with key processes and infrastructure to allow more accurate benchmarking of sectors, materials and products is urgently required.

References

Barrett J., Scott K. (2013). Link between climate change mitigation and resource efficiency: A UK Case Study. *Global Environmental Change*, **22**: 299–307. doi: 10.1016/j.gloenvcha.2011.11.003

Barrett J., Scott K., Owen A. & Giesekam J. (2017). Invisible energy policy – analysis of the link between consumption and energy demand. Proceedings of the 4th Sustainable Thermal Energy Management International Conference, pp. 198–205.

Barrett, J., Cooper, T., Hammond, G.P., & Pidgeon, N. (2018). Industrial energy, materials and products: UK decarbonisation challenges and opportunities. *Applied Thermal Engineering*, **136** (1): 643–56. doi: /10.1016/j.applthermaleng.2018.03.049

CCC (2018) Reducing UK Emissions – 2018. Progress Report to Parliament.

BEIS and DECC (2015). Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050.

BEIS (2017a). Digest of UK Energy Statistics – 2017, National Statistics Publication.

BEIS (2017b). Clean Growth Strategy.

BEIS (2017c). Updated Energy and Emissions Projections – 2017.

Griffin, P. W., Hammond, G. P. & Norman, J. B. (2014). Prospects for emissions reduction in the UK cement sector. *Proceedings of the Institution of Civil Engineers – Energy*. **167** (3): 152–61. doi: 10.1680/ener.14.00007

Griffin, P. W., Hammond, G. P. & Norman, J. B. (2016). Industrial energy use and carbon emissions reduction: a UK perspective. *WIREs Energy Environment*, **2016**, 5: 684–714. doi: 10.1002/wene.212

Hardt L., Owen A., Brockway P., Heun M., Barrett J., Taylor P. & Foxon T. (2018). Untangling the drivers of energy reduction in the UK productive sectors: Efficiency or offshoring? *Applied Energy*, **223** (2018): 124–133. doi: 10.1016/j.apenergy.2018.03.127

Hammond, G &. Norman, J. (2012). Decomposition analysis of energy–related carbon emissions from UK manufacturing. *Energy*, **41**: 220–227. doi: 10.1016/j.energy.2011.06.035

IEA (2013). Energy Policies of IEA Countries: Germany 2013 Review.

IEA (2014). Energy Policies of IEA Countries: The Netherlands 2014 Review.

IEA (2016). Energy Policies of IEA Countries: Japan 2016 Review.

IEA (2017a). Energy Efficiency 2017: Market Report.

IEA (2017b). Energy Policies of IEA Countries: Denmark 2017 Review.

Norman, J.B., Serrenho, A.C., Cooper, S.J.G., Owen, A., Sakai, M., Scott, K., Brockway, P.E., Cooper, S., Giesekam, J., Salvia, G., Cullen, J.M., Barrett, J.R., Cooper, T., Hammond, G.P. & Allwood, J.M. (2016). A whole system analysis of how industrial energy and material demand reduction can contribute to a low carbon future for the UK. CIEMAP report.

Owen, A., Scott, K. & Barrett, J. (2018). Identifying critical supply chains and products: UK decarbonisation challenges and opportunities. *Applied Energy*, **210**: 632–642. doi: 10.1016/j.applthermaleng.2018.03.049

Peake L. (2018). Less in – more out. Report by the Green Alliance and Centre for Industrial Energy, Materials and Products.

Scott, K., Roelich, K., Owen, A. & Barrett, J. (2018). Extending European energy efficiency standards to include material use: an analysis. *Climate Policy*, **18** (5): 627-641. doi: 10.1080/14693062.2017.1333949

Scott, K., Giesekam, J., Barrett, J. & Owen, A. (2019). Bridging the climate mitigation gap with economy-wide material productivity. *Journal of Industrial Ecology*, **2018**: 1–14. doi: 10.1111/jiec.12831

WSP, Parsons Brinckerhoff and DNV GL (2015). Industrial Decarbonisation & Energy Efficiency Roadmaps to 2050. Cross-sector Summary. London, UK.

4. Transport & Mobility

Jillian Anable (University of Leeds) and Phil Goodwin

Introduction

Road transport accounted for just under three-quarters of transport energy consumption in the UK in 2017, with the remainder almost entirely from air travel (23%). Of the road component, energy use from cars accounts for more than half (60%), with most of the remainder coming from light duty vehicles (vans) (16%), heavy goods vehicles (HGVs) (17%) and buses (3%) (BEIS, 2018a – figures derived from Tables 2.01 and 2.02). Energy use from transport has increased by 16% since 1990 (6% since 2013) against a UK economy-wide decrease of 4% (CCC, 2018a) and remains 98% dependent on fossil fuels. It has grown as a share of overall carbon emissions with no net reduction between 1990-2017 (vis-à-vis –43% for all sectors combined) (CCC, 2018a).

The treatment of transport in the Clean Growth Strategy (CGS), as well as subsequent pronouncements in the Road to Zero (R2Z) (DfT, 2018a) and the Future of Aviation (DfT, 2018e) strategies, assumes that the demand for travel will continue to grow, and seeks to reduce the use of fossil fuels by:

- accelerated deployment of more efficient end-use technologies (road vehicles, trains, aircraft and ships); and
- changes in the dominant fuel source, predominantly from electrification and biofuels.

The primary focus is changing the vehicle fleet from petrol and diesel, first to ultra low emission vehicles (ULEVs), and then to zero-emission vehicles (ZEVs)[8], primarily through electrification. This focus is reflected in 44 actions out of the 46 listed in the R2Z Strategy (DfT, 2018a).

8 ULEVs produce < 75 gCO_2/km under the existing test cycle and includes pure Battery electric vehicles (BEVs), Plug-in hybrid electric vehicles (PHEVs). Zero emission vehicles emit no carbon or pollution from the tailpipe and include BEVs and Fuel cell vehicles. Strictly these are only zero emission when powered by renewable or zero emission electricity (DfT, 2018a).

This chapter reinforces the growing consensus that the ambition in relation to fuel switching and vehicle efficiency could and should be strengthened. We nevertheless question the almost exclusive reliance upon technical improvements for two main reasons.

- The Department for Transport's (DfT) own scenario forecasts (DfT, 2018b) show that the uptake of ULEVs is likely to put upward pressure on traffic growth by lowering the costs of motoring. 'Clean' growth involves more than attending to the carbon implications; it means considering the combined effects of continued car dependency leading to more urban sprawl, inactive lifestyles and congestion together with the lifecycle impacts of vehicles and batteries, charging infrastructure, and road and car parking capacity.
- The almost exclusive reliance on technical solutions will only be able to produce the necessary reductions if the DfT's lower traffic growth futures are assumed. Evidence suggests a lower rate of demand for passenger mobility is credible, but this would require a different policy package to achieve and 'lock in' the new demand patterns. Thus, whether we assume underlying high growth trends whereby technological developments cannot hope to mitigate the externalities from traffic demand, or we assume that lower or even negative rates of growth could instead be enabled, a different suite of policies focused on shaping the demand for travel is required.

In its rather critical response to the DfT's R2Z strategy, the Committee on Climate Change (CCC) also pointed to the dangers of relying on technical solutions, suggesting that policies influencing the demand for travel should have a more significant role. They recommended that the DfT should "set out a vision for future travel demand" (CCC, 2018b) and this chapter contributes to that vision[9]. The remainder of this Chapter focuses largely on road passenger transport. Issues related to low carbon fuels for heavy vehicles are addressed in Chapter 6.

Uncertainties in forecasts of the volume of traffic

The context of forecasting traffic has changed fundamentally in recent years, and this is reflected in future scenarios which span from continual high growth (as happened up to the late 1980s), to low growth or even decline, as has happened since the 1990s). In either case, the demand for the mobility itself (i.e. the distances travelled and the travel modes used) will be at least as crucial to future energy demands as the fuel types and efficiencies of the vehicles.

For many years, DfT forecasts of traffic volume, used as the basis for calculating projected energy use, comprised a long-term uninterrupted continuation of high rates of growth, with rather narrow sensitivity tests intended to allow for uncertainty in economic performance, population, and fuel costs.

9 The early work in CREDS will focus on passenger demand, including some limited focus on aviation. Additional funding may be directed to heavy goods vehicles and freight. Whilst the core arguments expressed here will apply also to freight, aviation and shipping, the balance of the issues will differ.

However, it became apparent that the forecasts systematically overestimated traffic growth (for reasons which are not entirely agreed) and since 2015 the official traffic forecasts have used a scenario approach with a much wider range of possible futures, none of which are given precedence as a 'most likely' official view of the future. The 2018 scenarios, and the DfT's estimates of their CO_2 implications, are shown in Figures 8 and 9.

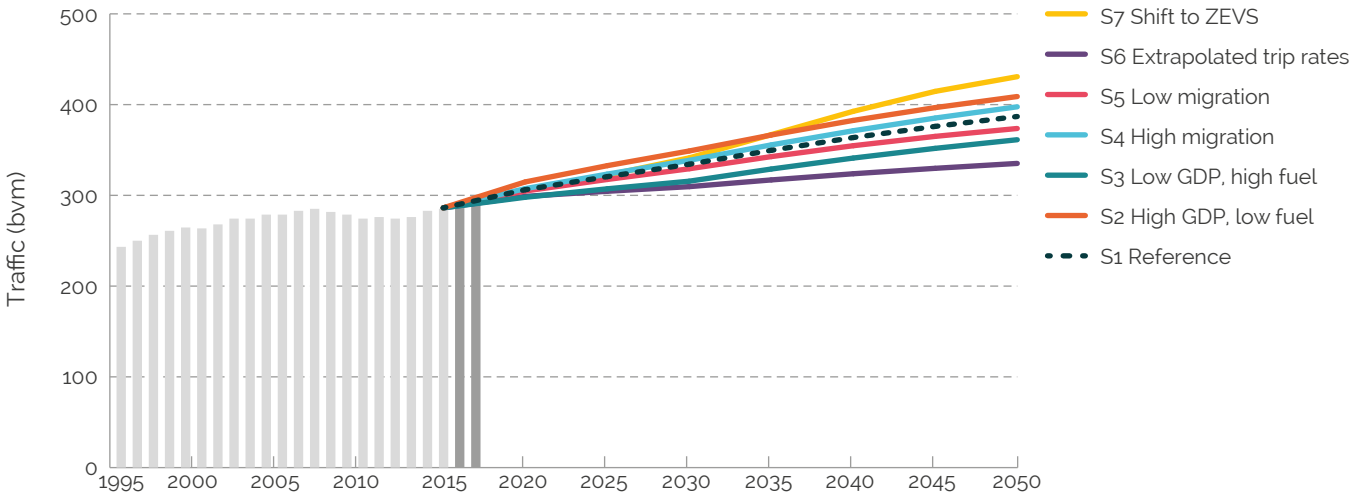

Figure 8: Vehicle miles forecasts for England and Wales. Source: DfT (2018), Road Traffic Forecasts 2018. Moving Britain Ahead. September 2018. Figure 25, pp 51.

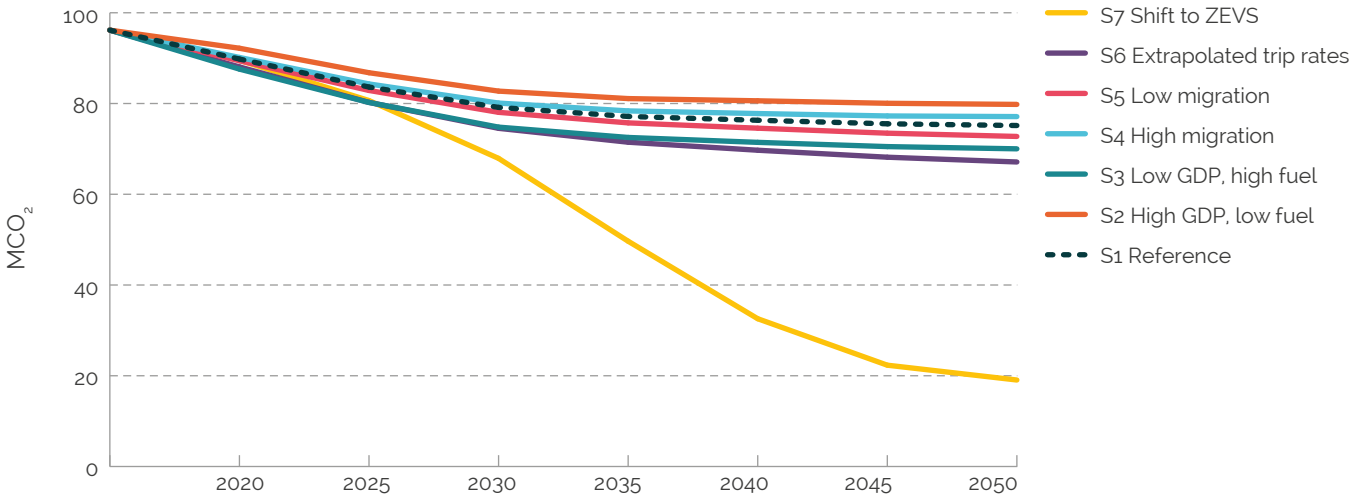

Figure 9: CO_2 emissions associated with the vehicle miles forecasts in England and Wales. Source: DfT (2018), Road Traffic Forecasts 2018. Moving Britain Ahead. July 2018. Figure 40, pp69.

Scenarios 1 to 5 are forecasts with different assumptions about economic growth, population and fuel price, with Scenario 1 as a 'reference case' using long-standing assumed demand relationships. It predicts an increase in traffic volume of 35% and a calculated reduction in CO_2 of 22%, with the share of electric cars and light goods vehicles (vans) growing to 25% of miles travelled by 2050.

Clearly a penetration of 25% electric vehicles by 2050 is not compatible with meeting carbon reduction commitments. Scenario 6 is an alternative reference case forecast based on the trend for decline in trip rates recently observed, which gives substantially lower demand growth, and proportionately less CO_2 emissions. This is discussed further below. Scenario 7 is not a forecast as such, but a trajectory of what would happen if electric vehicles are assumed to meet nearly 100% penetration of cars and vans by 2050. In this case, CO_2 would fall by about 80%, with most of the deficit accounted for by non-car and van road traffic. Upstream and embodied emissions are not accounted for.

This base then allows us to consider the feasibility of relying only on technical change, and a starting point for considering the scope for changes in the volume and structure of traffic.

Feasibility of relying on energy efficiency improvements and electrification

The CGS and R2Z's aims for a reduction in CO_2 emission from transport emissions by technology, without changing demand, do not appear to be based on a realistic assessment of what is practically possible. We outline two further points of potential failure: an inadequate treatment of targets for ULEVs, and the gap between declared vehicle performance and real-world results.

Weak targets for uptake of ultra-low emission vehicles (ULEVs)

Only targets defined in terms of the penetration of ULEVs, rather than the energy service they provide, are used to frame UK transport policy and its carbon and energy implications. Moreover, these targets are themselves weak and muddled, with relevant Government departmental and CCC publications recommending, or working with, different targets (Table 1). The differences relate to the target years (mostly either 2030 or 2050), the inclusion of cars and vans or just cars, the expression of the target in relation to new vehicle sales or the proportion of vehicles on the road. Only the DfT traffic forecasts supply a figure in terms of the proportion of vehicle miles travelled. Targets are further weakened by the continued confusion about which technologies are expected to be included in the definition of a ULEV. These differences make it challenging to compare ambition across reports, Government departments and over time.

Table 1 demonstrates how policy has evolved very slowly, even on road vehicle technology: by allowing hybrid vehicles to be included, the 2040 target in the R2Z strategy is possibly even less stringent than was proposed six years earlier in the 2011 Carbon Plan. Moreover, the official 2040 target is weak by international standards: Norway aims for all new car sales to be ULEVs by 2025; Scotland by 2032, and the Netherlands, Denmark, Ireland, Austria, Slovenia, Israel, India and China aim for this by 2030 (Committee on Climate Change, 2018a for a review of these targets).

Table 1: Targets and recommendations for uptake of ULEVs in England and Wales			
	2030 (/35)	**2040**	**2050**
HM Government, December 2011		All new cars and vans to be "near zero emission at the tailpipe"	
Committee on Climate Change, November 2015	60% of new cars/vans ULEV by 2030		
Defra & DfT, July 2017		End the sale of all new conventional petrol and diesel cars and vans by 2040	
HM Government/ CGS, October 2017	30% of new car sales will be ULEVs and possibly as much as 70%	End the sale of new conventional petrol and diesel cars and vans by 2040	Every car and van on the road should be zero emission in 2050
DfT RTF, July 2018	Approx. 35% of the car and van on road fleet (deduced from figure 19, page 42 of DfT, 2018)	Approx 80% of on road fleet and 100% of sales of cars and vans are zero emission by 2040	25% (S1) – 100% (S7) of miles travelled by cars and vans in the fleet.
DfT / R2Z (July 2018)[a]	At least 50% (and up to 70%) of new cars (and up to 40% of new vans) will be ULEVs	All new cars and vans will have "significant zero emission capability" and the majority will be 100% "zero emission"	"By 2050 we want almost every car and van to be zero emission" (not specified if this is sales or on road)
Committee on Climate Change, October 2018[b]	100% of new cars/vans ULEV by 2035		
BEIS Committee, Oct 2018	100% of new cars/vans ULEV by 2032		

a The proportion of zero emission mileage is modelled as if these were electric vehicles (p30).

b The CCC net-zero advice published in May 2019 kept this target but added "If possible, an earlier switchover (e.g. 2030) would be desirable"

In any case, a stated target is not seen to be a strong enough signal for all actors concerned [10]. Instead it needs to be a ban to be supported by (potentially UK-independent) legislation. In addition to 'fuzzy' targets, the R2Z contains only unspecified delivery mechanisms. This is especially surprising given the slower than expected uptake of electric vehicles thus far, especially pure battery variants which only comprised around 0.5% of car sales at end 2018, compared to 1.5-2% for plug-in hybrids (PHEVs).

10 Including by the CCC, the National Infrastructure Commission, the UK Energy Research Centre and others.

Preliminary analysis by researchers involved in CREDS shows the inclusion of hybrid technologies could lock significant amounts of fossil fuel into the sector well beyond any target date[11]. Figure 10 shows the Internal Combustion Engine 'ICE ban 2040' scenario representing the loosest definition of ULEVs which allows both conventional hybrids (HEVs) and PHEV cars and vans. When compared to 1990 levels, this scenario shows reductions in tailpipe CO_2 emissions of only 61% by 2050. When also banning new HEVs from 2040, the results show a 88% drop, or 93% if from 2030. This suggests that the trajectory for urgent CO_2 savings requires phasing out all forms of conventionally fuelled ICE and HEV cars and vans by 2030 and that net-zero (for tailpipe emissions) may only be achieved by also phasing out PHEVs by this date.

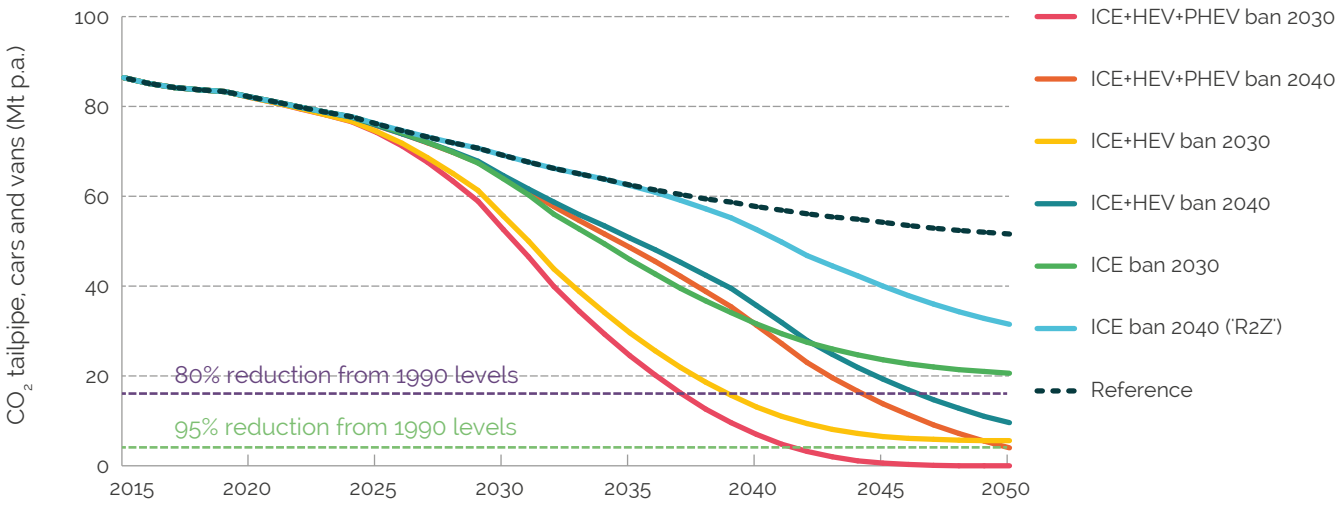

Figure 10: Tailpipe CO_2 reductions by 2050 from UK cars and vans based on different combinations of Internal Combustion Engine (ICE) and (Plug-in) Hybrid Electric Vehicle ((P)HEV) phase-out. Source: Anable, J. & Brand, C. (2018). Consumer behaviour: priorities for progress. Presentation at the Low Carbon Vehicle Partnership annual conference, June 2018.

This analysis is heavily dependent on the assumption that new car and van CO_2 emissions for all propulsion systems will undergo continuous improvement (Brand *et al*, 2017) and that a generous proportion of miles undertaken in PHEVs will use the electric battery (largely for urban driving, i.e. approx. 40% of the total mileage with motorway and rural driving assumed to mostly use the ICE). This compares to 73% of PHEV driving done in electric mode assumed in the R2Z analysis (DfT, 2018c pp. 130)[12]. This is important because, so far, 3 out of every 4 plug-in vehicles sold in the UK has been a PHEV. In the summer of 2018, analysis of real-world fuel consumption data on 1,500 company owned PHEVs (comprising seven models) (Middleton, 2017; Hollick, 2018) found the vehicles only achieved an average of 45mpg or 168 gCO_2/km compared to their advertised average consumption of 130mpg or 55 gCO_2/km.

11 Based on new approach in Brand *et al*, 2017.

12 Note that in the linked report on the modelling methodology, this figure is reduced to 62%.

The report concludes: "On the evidence of our sample, one has to question whether some PHEVs ever see a charging cable" and suggests PHEVs would attract the highest rate of company car tax if they were to be assessed on their real instead of on laboratory test results.

Real-world performance

Until recently, the EU mandatory regulations for new cars would appear to be a resounding success for CO_2 standards. The rate of reduction in official average tailpipe CO_2 values of new passenger cars in the EU increased from roughly 1% per year to more than 3% per year after their introduction in 2009. However, two factors mean this success is not all that it appears.

Firstly, there has been no improvement in tailpipe emissions in the UK since 2015 and average level of CO_2 emissions of new cars sold in September 2018 was 128.3 gCO_2/km, the highest recorded since July 2013. A switch away from diesel only accounts for a small proportion of this increase, the main culprit being the swing over the past decade towards larger passenger cars, particularly SUVs (dual purpose vehicles) while the rest of the market declines (SMMT, 2018). SUVs now account for around a quarter of car sales in the UK with no sign of slowing down. Somewhat shockingly, this proportion holds true for electric vehicles (BEVs + PHEVs) – 25% of all the 32,048 plug-in cars registered by the end of 2017 comprised one make and model only (Mitsubishi Outlander) – an SUV in the form of a PHEV and one of the most polluting cars on the road when not driven on the electric battery.

Secondly, although the above figures suggest a 30% reduction in tailpipe CO_2 emissions since 2000, these are based on test cycle measurements. In practice, there has only been an estimated 9% reduction in tailpipe emissions in real-world conditions, and only 4% since 2010. The performance gap between official and real-world values has grown over time, standing at 42% in 2016 (Teitge *et al*, 2017), although this gap has now stabilised. This gap has effectively negated any reported savings from efficiency improvements over the past decade.

The regulatory failure of the test cycle versus real-world emissions was not mentioned in the CGS but was addressed in the narrative of the subsequent R2Z which frequently noted it would be considering "real-world" emissions. A new test procedure, the Worldwide Harmonized Light Vehicles Test Procedure (WLTP), is being currently being phased in. Whilst a step in the right direction, the WLTP is not a silver bullet and will not close the performance gap on its own. The discrepancy matters to how meaningful the regulatory or stretched targets are and thus how quickly forward projections will be met. Whilst it could be argued that if electricity is zero carbon this should not matter, the energy efficiency of the transport system is an important issue in its own right and will become more important as vehicles play a key part of the electricity storage solution to balance electricity demands on the grid.

Prospects for travel demand change

Collapse of 'business as usual' trajectories of travel demand

The CGS generally adopts an approach of identifying a firmly established baseline forecast of demand, given by reasonably clear economic trends, and treating this as either inevitable or as a target for policy intervention only after other largely technical solutions have been exhausted. Yet, in the context of travel, there is now a strong evidence base that the trends have changed, and continue to do so. Since the early 1990s (but only now being retrospectively understood), actual road traffic growth has been systematically less than forecast so that the hitherto uninterrupted growth in car use is no longer the dominant trend. Periodic discussion of 'peak car' has led into investigations of the evidence (Marsden *et al*, 2018; Chatterjee *et al*, 2018), which reveal that structural changes in travel demand due to shifts in the pattern and location of activities, social changes including delayed family formation, economic changes in the nature of retail and employment (especially youth employment), and possible impacts of mobile internet access, all correlate with a downward trend in overall trip rates. These trends are manifesting differently among different groups and in different types of built-up area (BUA) (Figure 11).

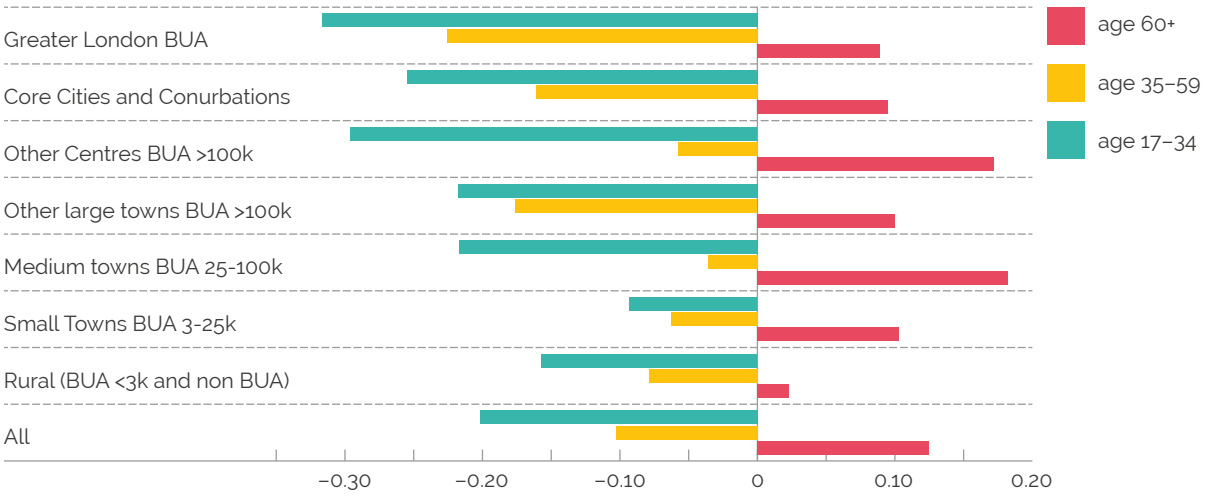

Figure 11: Percentage change in car driver miles per head per year by age group and area type (England 2002–05 to 2011–14). Source: Analysis by P. Headicar as Chart 17, pp18 in DfT (2018). Analyses from the National Travel Survey Statistical Release.

This shows a reduction of 20% and 10% respectively among the two younger groups, an increase of 12% among 60+ year olds with differences in the magnitude (but not direction) of these changes in different places. The outcome is that since the early 1990s, aside from general population growth, it is only an aging cohort of people, now over 60, that has contributed to traffic growth, whereas successive cohorts of younger people have shown a reduction in driving licence-holding, car ownership, and car use.

Such findings sit alongside a very substantial body of experience and evidence about the effects of policy interventions intended to address a much wider range of policy objectives than energy use alone, including health, quality of life, commercial vitality, safety, and equity. These various objectives have all tended to converge on policy packages aimed at reducing the need to travel by better land-use planning, restrictions on car use in central, residential, and environmentally sensitive locations, and facilitating transfer of car trips to public transport, walking and cycling by reallocation of expenditures, street design, pricing and regulation. This allows for a policy perspective where reduced energy use does not run counter to quality of life but arises from measures designed to enhance it. Conversely, relying mainly on electrification of vehicles to reach carbon targets can have the consequence of increasing traffic congestion because of the lower cost and lower taxation of electric fuel. This is seen in the DfT Scenario7 above, where 100% electrification has the highest level of traffic growth.

Thus, it is no longer adequate to adopt what used to be the central or most likely traffic forecasts produced by the DfT as the official view of future trends in demand and, from these, calculate the scale of technological deployment needed to mitigate the carbon consequences of this growth. There is a need for new approaches to demand analysis on how to treat the scope for such policies. Underpinning the observed changes, there are new theoretical understandings of the dynamic processes of travel demand, where changes can happen through demographics, migration, churn, habit formation and breaking, and interactions with land use outcomes, disruptions and social norms. In other words, **"societal needs and demands are not given: they are negotiable, dynamic, and in part constituted by technologies and policies, including those of efficiency"** (Shove, 2017).

Thus, the pattern of co-benefits, empirical evidence on trend shifts and policy implementation, and better understanding of influences on demand, give scope for considerably more ambitious reductions in passenger transport energy and carbon use than has been assumed in the CGS, DfT and CCC publications. Moreover, evidence suggests a lower rate of demand for passenger mobility is a necessary and a credible future, but that this would require a different policy package to achieve and lock-in the new demand patterns, alongside new vehicle technology.

Recommendations for policy

Travel behaviour is already changing in ways that provide opportunities to enable a lower growth trajectory to be deliberately locked-in. National and international examples of sustained lower car-dependent lifestyles indicate that this can be achieved at least in some localities. Such a prospect puts much greater emphasis on policies which influence and provide for more energy-conserving lifestyles, including: emerging models of car 'usership', changing social norms around mobility, new spatial patterns of population growth, the changing nature and location of work, education, housing, healthcare and leisure, reconfiguration of travel by digital technology, and new ways of paying for road use or energy (electricity).

The Avoid-Shift-Improve (Schipper & Liliu, 1999) hierarchy has been used to emphasise the priority ordering and layering of our recommendations that stand apart from the dominant supply and vehicle technology-oriented approach to energy reduction and decarbonisation in the sector. The recommendations focus on surface passenger travel and are targeted at national and local policy makers.

Avoid travel demand and car ownership

Lock-in recently evidenced demand changes

Where specific groups have already shown flexibility in demand, there should be targeting to lock-in those changes, and to extend the behaviour to wider numbers. This can be done through policies such as car clubs, smart ticketing, investment in rail and in digital technology. Access to subsidised or free public transport is at present largely determined by age, and it is clear that behaviour patterns also show strong age effects, but making best use of this may justify an overall review of age boundaries both for the young and old. Improving the experience for these sub-groups of living without a car should not only improve the chances of them opting to live without one (or with fewer per household than they might have done) for longer, but will simultaneously improve non-car travel for a wider set of people and places.

Design regulatory frameworks to steer emergent innovations (e.g. On-Demand mobility, autonomous vehicles) to deliver societal benefit and avoid high travel lock-in in the future

Ignoring the dynamic interactions between society and technology led to the performance gap in real-world energy consumption of vehicles. We are in danger of repeating this mistake with respect to new forms of 'on-demand' mobility services, relinquishing of ownership in favour of shared assets, autonomous vehicles and the two-way integration of vehicles and the electricity grid (see for example Wadud *et al*, 2016). To ensure these developments reduce vehicle miles travelled, a 'preventative' regulatory framework designed to enable these innovations to result in a net increase in co-benefits such as social inclusion and transport and energy system flexibility is needed. Specific interventions such as mandating the use of autonomous vehicles in shared contexts, public investment in car-clubs or on-demand services in rural areas and designing car scrappage schemes to accelerate the uptake of mobility packages as opposed to new vehicles, will be necessary[13].

Develop a cascading framework of national and local support for car clubs

Having access to a shared vehicle has been shown to lead to reductions in personal car ownership and miles driven, as well as increased use of other modes of transport (Marsden *et al*, 2018). This reduction includes households giving up a car completely, but equally important is reducing from, say, two cars to one car. More creative support options can be explored at the national and local levels to ensure that more people can opt out of owning a car in favour of accessing shared car club services.

13 Transport for West Midlands is trialling a Mobility Credits Scrappage Scheme from March 2019.

These support options can take the form of both carrots (e.g. supporting interoperable underpinning ICT infrastructure, 'smart' design of car scrappage, integrating shared travel into multi-modal journey-planning apps, providing dedicated car parking, charging and signage to car club vehicles) and sticks (e.g. parking charges and restrictions in residential areas and workplaces for privately owned vehicles). The benefit of a nested approach to national and local support for car clubs is evident from Scotland, where there was membership growth of 29% between 2016 and 2017 (Steers Davies Gleave, 2018). The overall aim would be to reduce the size of the passenger car fleet as well as accelerate its decarbonisation as vehicles are utilised more intensively and renewed more frequently.

Incentivise the coordination of transport and planning objectives to reduce the need to travel

Enabling travel avoidance is chiefly a matter of coordination of planning and transport objectives in the housing type and location, density of development and location as well as timing of services (including workplaces, schools and healthcare). Local authorities receive bonuses for achieving housing targets with none of this bonus tied to the travel and energy efficiency of the developments. Businesses also need to be engaged through incentivisation of the reduction of their travel footprint, including commuting, perhaps linked to an expanded system of Display Energy Certificates. Similarly, there should be greater integration between the planning and prioritisation of investment in digital infrastructure and transport to support many of the above initiatives but also to deliberately substitute some travel by virtual access in ways that avoids further spatial fragmentation and net increases in demand.

Develop a zero-growth indicator

By adopting a scenario approach for car travel, the DfT analysis suggests de facto acceptance of a varied range of potential growth scenarios for alternative modes. Under this multiple scenario approach, policies need to be appraised themselves not under a single scenario, but under the assumptions of at least the high growth and low growth possibilities. This itself means that flexibility and adaptability – if (when) forecasts turn out to be wrong – becomes an advantage. This flexi-appraisal would be extended to non-transport transport policies – i.e. traffic-generating land use developments, service reductions in rural areas and policies leading to the centralisation of core services such as health and education.

From this, it is possible to imagine the development of a zero traffic or transport energy growth objective, or indicators based on capacity constraints on the electricity grid. For instance, Norway has adopted a zero-growth objective for car traffic in urban areas embedded in a national transport plan which introduced 'urban environmental agreements' (Norwegian National Rail Administration, 2016). This will involve environmental and time differentiated road tolls linked to "stronger investment in urban areas".

Incentivise local authorities to achieve a zero-growth indicator

The CGS does not address the issue of scale and location. Nevertheless, place-based industrial strategy is gaining traction as a key principal of innovation programmes at the European and UK levels. Just as we have highlighted that recent changes in travel demand have been unevenly distributed, the uptake of technology, including energy generation, will also differ. Methods of analysis, policy design and appraisal need to work with this geographical diversity. In particular, local authorities need to be incentivised to reach the zero-growth target indicator outlined above.

Shifting travel to the most sustainable modes

Systematic support for the very lowest energy modes of transport

Enabling and encouraging a shift from private motorised travel to more energy efficient modes requires systematic support for the very lowest energy methods of transport – walking, cycling (including e-bikes and e-scooters) and public transport, through investment programmes on both capital and revenue spending, priority use of road space, and an expansion of 'soft' or 'smarter' methods of encouraging behavioural change. The goal would be to design **"a mobility system where it is more normal to take part in activities using the most sustainable modes more of the time"** (Marsden *et al* 2016).

Institute a new approach to prices and taxes to reflect a fuller range of costs and benefits

A new approach to transport pricing would ensure that the relative prices of different transport options reflect the full range of costs and benefits to the consumer, including health, energy, embedded emissions, congestion and other environmental impacts. Restructuring prices could include direct subsidy to lock-in sustainable travel choices by charging for use of scarce resources at a rising unit rate where more is used. Such pricing mechanisms would therefore expand the traditional notion of road user charging to reflect wider transport and energy system usage and will incorporate thinking on how to avoid increases in demand that may be stimulated by lower motoring costs of ULEVs.

Improving efficiency of individual modes

Improve the efficiency of vehicles in use, particularly through increased occupancy

A focus on efficiency of vehicles in use is much more than eco-driving. It considers maximising assets in ways that substantially reduce single car occupancy and individual ownership. There is no detectable policy weight placed on the efficiency of vehicles in use, even though increasing vehicle occupancy, potentially through mobility sharing platforms, would ratchet down energy intensity of travel considerably. There are a number of potential types of initiative targeting both businesses and individuals, again falling into carrot (mileage fee reimbursement rates and salary sacrifice incentives) and stick (regulation of the 'grey fleet' (use of own cars on business travel), parking restrictions and fees) as well as a review of company carbon accounting to incorporate commuting travel.

Restructure ULEV targets to include phasing out hybrid cars

As our own empirical work has highlighted, the trajectory for urgent CO_2 savings requires phasing out all forms of conventionally fuelled ICE and HEV cars and vans by 2030 and that net-zero (for tailpipe emissions) may only be achieved by also phasing out PHEVs by this date. The current wording of targets is at best muddled, but at worst leaves the door open for hybrid vehicles, and subsequent locking-in of a substantial amount of fossil-fuelled mileage during and beyond the target dates.

Regulate to reduce the availability and sales of large cars

The stagnation in average CO_2 emission values of new passenger cars in the UK in recent years has much to do with an upsurge in purchase of larger cars. Some of this trend is likely to be due to people choosing to apply the savings from greater energy efficiency to buy more comfortable, more reliable, or more prestigious vehicles which, being larger and heavier, use more energy than necessary for like-for-like journeys. The implication is that measures of energy efficiency which reduce costs can only be fully effective if they are combined with other measures to prevent or offset such countervailing processes. In this case, regulation of sales-weighted average new car carbon emissions is failing and needs to be redesigned to, once again, lock-in the net benefits of this policy. This could potentially involve regulating to phase out the largest vehicles or restrict their use to genuinely appropriate circumstances.

References

BEIS (2018a). Energy Consumption in the UK Data Tables 2018 Update.

Brand, C., Cluzel, C. & Anable, J. (2017). Modelling the uptake of plug-in vehicles in a heterogeneous car market using a consumer segmentation approach. *Transportation Research Part A: Policy and Practice*, **97** (March 2017): 121–136. doi: 10.1016/j.tra.2017.01.017

BEIS Committee (2018). Electric Vehicles: driving the transition. Fourteenth Report of Session 2017–19. HC 383.

CCC (2018a). Reducing UK emissions – 2018 Progress Report to Parliament.

CCC (2018b). Letter to Chris Grayling and Greg Clark – assessment of the Road-to-Zero Strategy. 11 October 2018.

CCC (2015). The Fifth Carbon Budget. The next steps towards a low carbon economy. November 2015.

Chatterjee, K., Goodwin, P., Schwanen, T., Clark, B., Jain, J., Melia, S., Middleton, J., Plyushteva, A., Ricci, M., Santos, G. & Stokes, G. (2018). Young people's travel – what's changed and why? Review and Analysis. Report to Department for Transport. UWE Bristol, UK

Defra & DfT (2017). UK Plan for tackling roadside nitrogen dioxide concentrations. An overview. July 2017.

DfT (2018a). Road to Zero Strategy. July 2018.

DfT (2018b). Road Traffic Forecasts 2018. Moving Britain Ahead. July 2018.

DfT (2018c). Transport Energy Model Report.

DfT (2018d). Analyses from the National Travel Survey Statistical Release.

DfT (2018e). Beyond the Horizon. The Future of Aviation. Next Steps towards an aviation strategy. April 2018.

Hollick, P. (2018). Fleets and the company car business urgently need to change their approach to plug-in hybrids. TMC Blog.

Marsden, G.R., Anable, J., Chatterton, T., Docherty, I., Faulconbridge, J., Murray, L. & Roby, H. (2016). Fleximobility: Unlocking low carbon travel.

Marsden, G.R., Dales, J., Jones, P., Seagriff, E. & Spurling, N. (2018). All Change? The future of travel demand and the implications for policy and planning. The first report of the Commission on Travel.

Middleton, N. (2017). Fleet misuse of PHEVs revealed in TMC analysis. Fleetworld.

Norwegian National Rail Administration, the Norwegian Coastal Administration and the Norwegian Public Roads Administration (2016). National Transport Plan 2018 – 2029 – English Summary.

Schipper, L. & Lilliu, C.M. (1999). Transportation and CO_2 emissions: flexing the link. a path for the World Bank. The World Bank, Washington, DC.

Shove, E (2017). What is wrong with energy efficiency? *Building Research & Information*, **46** (7): 779–789. doi: 10.1080/09613218.2017.1361746

SMMT (2018). UK new car market declines in 2017 but demand still third highest in 10 years. 5 January 2018.

Tietge, U., Mock, P., German, J., Bandivadekar, A. & Ligterink, N. (2017). From laboratory to road. A 2017 update of official and 'real-world' consumption and CO_2 values for passenger cars in Europe. International Council on Clean Transportation.

Wadud, Z., MacKenzie, D. & Leiby, P. (2016). Help or hindrance? The travel, energy and carbon impacts of highly automated vehicles. *Transportation Research Part A: Policy and Practice*, **86**: 1–18. doi: 10.1016/j.tra.2015.12.001

5. Electricity: making demand more flexible

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Background

The UK Government's Clean Growth Strategy (CGS) places significant importance on flexibility in electricity demand. Flexibility is important because the integration of intermittent renewables in the supply mix, as well as high penetration of electric vehicles and electric heat pumps, will challenge the balance of demand and supply. The CGS considers demand flexibility will need to play a vital role for a stable electricity system as existing approaches to balancing are inadequate. In this context, there are opportunities to reduce the costs of electricity if smart systems and battery storage are used to flex demand at times when it is high. In a nutshell, demand-side flexibility is portrayed in the CGS as a win-win solution, as consumers will help balance the grid in return for lower bills if they take advantage of smart appliances and smart tariffs.

The key part of the CGS on demand-side flexibility is in 'Delivering Clean, Smart, Flexible Power'. This points to investments from the UK Government of £265 million between 2015 and 2021 in research, development and deployment of smart systems to reduce the cost of electricity storage, advance innovative demand-side response (DSR) technologies and develop new ways of balancing the grid. The move to low carbon generation will increase the variability of electricity supply, as key technologies depend on both weather (e.g. wind speed) and daily and annual cycles (e.g. solar radiation). The general view is that a more flexible system is required. Most of the principles underpinning the vision for demand flexibility are set out in the 2017 smart systems and flexibility plan (BEIS and Ofgem, 2017). The plan is based on a report that shows a system using DSR and distributed storage to provide flexibility would be between £17bn and £40bn cheaper over the period to 2050 compared to a system that relies on enhancing flexibility through interconnectors and pumped hydro storage (Carbon Trust & Imperial College, 2016).

This chapter focuses on drawing together existing research evidence to inform an independent analysis of the flexible energy demand aspects of the CGS. Given the importance and relative novelty of flexibility at the scale envisaged in the CGS, the policy implications need to be thought through carefully and based on evidence. Research needs to ask fundamental questions around whether flexibility benefits systems as well as consumers. The two key aims of this chapter are: (i) to assess whether different/additional policies and measures will be required, and (ii) to identify important research gaps to be filled by CREDS through co-created research. In order to deliver these two aims, this chapter compares the overall level of flexibility forecast in the CGS with other studies; presents alternative approaches to achieve flexibility; and suggests areas of research in this emerging field. It is concluded that moving to higher levels of demand flexibility will require radical shifts. This calls for more clarity at the planning stage on the following questions: will flexibility be achieved through technology interventions alone? What role do smart tariffs play at different levels of penetration? Critically, research is needed to assess the win-win proposition stated in the CGS, i.e. that consumers and the electricity grid will both benefit from the introduction of greater flexibility.

This chapter questions how ambitious the flexibility target in the CGS is compared with existing studies; describes what is planned in the CGS; proposes a radically different Government approach on flexibility; and concludes by identifying three significant research gaps.

How much flexibility? An unambitious target

The CGS presents figures on levels of flexibility for the future based on BEIS' 2032 pathway calculations for an 80% renewables future. Electricity demand is projected to increase by 3% (10 TWh), with an increase in peak demand of 4% (2.8 GW), by 2032 from 2016 levels. The extra capacity and flexibility is proposed in the CGS to originate from DSR (4.9 GW), storage (0.3 GW), clean generators (0.5 GW) and fossil fuels (1.2 GW). The increase in peak demand is argued to arise from the uptake of electric vehicles and heat pumps. This allows for some implicit DSR (i.e. the effect of consumer response to time-dependent pricing), which would consist of shifting to overnight charging for most electric vehicles and smart controls of heat pumps.

This proposed increase in DSR is a relatively unambitious target. National Grid estimates that 2.7 GW of DSR capacity, equivalent to two large power stations, participated across their portfolio of balancing products and services in 2017 (National Grid, 2017). A report by the Association for Decentralised Energy suggests that by 2020 DSR could provide 4.5 GW thanks to 2.8 GW from industrial demand flexibility and 1.7 GW from commercial and public sector demand flexibility (ADE, 2016). A report by Element Energy estimated that the non-domestic potential of DSR in 2011 was in the range of 1.2–4.4 GW (Element Energy, 2012). The scenarios prepared by the Carbon Trust and Imperial College suggest DSR deployment of between 4.1–11.4 GW by 2030. This variation highlights the opportunities, yet clear uncertainty, in the DSR potential offered by the electrical assets in UK businesses.

Figure 12 shows future levels of DSR in the UK according to different studies and reports. The size of the bubble represents how large forecast DSR levels are and the position of the bubble indicates the year to which the forecast applies. The red line represents the trend and, notably, the purple bubble (i.e. CGS) has the lowest ambition in terms of DSR penetration.

Figure 12: Forecast future levels of UK Demand Side Response (in GW) in different years.

The flexibility target in the CGS is not sufficiently ambitious. This is because the analysis underpinning the target relies heavily on the "five-day stress test", which was designed only to address the challenge of balancing the electricity system during adverse winter weather conditions of high demand and low renewable electricity output. This approach to the need for flexibility and DSR is anchored in the old 'plan and provide' approach to system operation, in which flexibility is only needed to ensure adequate total capacity. However, in any highly renewable future, flexibility will be needed to meet a variety of requirements, including capacity adequacy under stress conditions, but also the ability to increase, decrease, or shift electricity demand frequently.

Actions planned in the CGS

The 2017 Smart System and Flexibility plan outlines 29 actions under three areas (removing barriers to smart technologies; smart homes and businesses; and markets which work for flexibility).

With regards to market arrangements, the actions are aimed at amending issues preventing DSR participation, including ensuring that storage and demand flexibility participate on a level playing field in the Capacity Market; delivering efficient access for independent aggregators to the Short Term Operating Reserve (STOR); simplifying ancillary services and making them more transparent; changing network charges; and improving stakeholder engagement in flexibility.

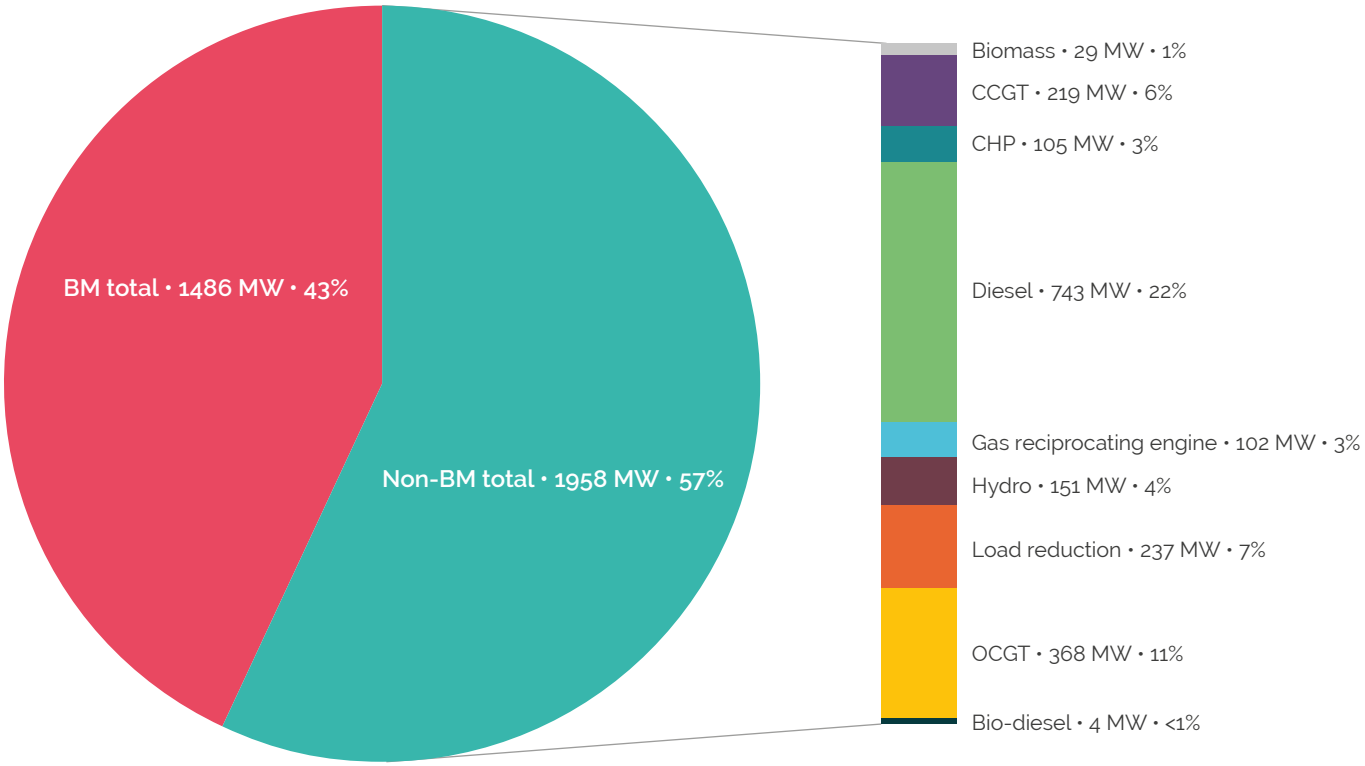

Figure 13: Detailed breakdown of non-balancing mechanism. Source: National Grid, 2015.

Figure 13 provides a breakdown of the resources used by the System Operator (National Grid) to balance supply and demand at different times. The Balancing Mechanism (BM) uses price signals to incentivise generators to come on or off the network. Outside the BM are several other options that can be deployed quickly, for example through STOR. The figure shows that 237 MW (7% of overall STOR capacity) is from load reduction (which in this case is likely to also include load shifting DSR, as the National Grid uses the term 'load response' to cover both load shifting and 'turn-down') (National Grid, 2017). In addition, DSR contributes to the provision of adequate capacity. The turn-down DSR only Capacity Market auction in March 2017 resulted in Ofgem awarding 300 MW of contracts to DSR (Ofgem, 2017). These two MW figures cannot simply be added as each could be provided from the same assets. Therefore, based on the figures obtained from published reports and assuming additional amounts have been provided via other sources, a rough estimate of turn-down DSR is between 300-500 MW. This represents only 6-10% of what is required to meet the CGS target of 4.9 GW of DSR. A much more radical approach is required for flexible demand as explained in the section below.

Changing approach completely on flexibility

The CGS and the 'Smart systems and flexibility plan' can be seen as the first positive steps towards the inclusion of demand-side flexibility in a low carbon energy system. However, in order to accommodate high levels of flexibility the actions they put forward will be insufficient. This section puts forward more radical suggestions for the integration of flexible demand in a low carbon future.

If flexibility is to play a major role, the rules have to be changed entirely

There is no specific market programme for flexibility in the UK and DSR is instead contained within the current electricity balancing services of the Electricity System Operator (a company in the National Grid Group). While STOR is a means of providing DSR, its current structure provides a number of barriers to uptake and discourages investments in DSR. These market rules favour generator-based services and restrict turn-down solutions. Battery storage is currently charged fees for using the energy network as both a demand customer and a generator, i.e. both when drawing power from and discharging power back to the system.

Table 1 – Review of DSR barriers

Barrier Category	Barrier	Research Source							
		1	2	3	4	5	6	7	8
End user	Lack of DSR awareness / understanding	●							●
	Impact Concerns	●	●			●	●		●
	Risk aversion / trust issues		●				●		●
Regulatory	Regulations unfavourable for DSR	●		●	●	●	●	●	●
	Current regulations preventing DSR							●	
Technical	Lack of ICT infrastructure	●				●			
	Cost of enablement			●			●		●
	Equipment not suitable for DSR			●			●		●
Market	Lack of DSR market options	●		●		●		●	
	Insufficient financial incentives		●	●		●	●		●
	Traditional large generation bias			●	●	●			

Source Key:

1 (Strbac, 2008) Demand Side Management: Benefits and Challenges

2 (Owen, Ward, & Pooley, 2012) What Demand Side Services Could Customers Offer?

3 (Cappers, MacDonald, Goldman, & Ma, 2013) An Assessment of Market and Policy Barriers for Demand Response Providing Ancillary Services in U.S. Electricity Markets

4 (Warren, 2014) A Review of Demand-Side Management Policy in the UK

5 (Nolan & O'Malley, 2015) Challenges and Barriers to Demand Response Deployment and Evaluation

6 (Olsthoorn, Schleich, & Klobasa, 2015) Barriers to Electricity Load Shift in Companies: A Survey-based Exploration of the End User Perspective

7 (SEDC, 2017) Explicit Demand Response in Europe: Mapping the Markets 2017

8 (The Energyst, 2017) Demand-side Response: Shifting the Balance of Power: 2017 Report

Box 1 – key barriers for DSR uptake:

The research literature on DSR identifies many different types of barriers, which fit into the four main categories of: end user, regulatory, technical, and market (Table 1). The end use barrier focuses on issues that end users have direct influence over, such as lack of interest in DSR. Examples of regulatory barriers include the fact that several Governments do not yet acknowledge the role of independent DSR aggregators in enabling uptake. One of the major technical barriers is end user equipment being deemed as unsuitable for DSR. Market barriers consist primarily of the absence a specific market programme for DSR.

National Grid's estimate of the DSR contribution to overall balancing (2.7 GW in 2017) is probably an overestimate as it includes smaller scale diesel generation, which is not truly DSR as diesel generators are not associated with an energy user; rather, they are dedicated supply-side assets as illustrated in Figure 13. Considering only user-led demand management and on-site generation participating in the Balancing Services, the amount of DSR used for balancing the system in 2017 was approximately 700 MW. Changing the rules entirely might involve, for instance, the development of a flexibility market which can place a higher value on more flexible resources (DECC, 2013).

The capacity market is an ineffective instrument to provide flexibility

The UK's Electricity Market Reform policy aims to deliver low carbon energy and reliable supplies. A key mechanism this uses is the creation of a Capacity Market that "provides a regular retainer payment to reliable forms of capacity (both demand and supply side), in return for such capacity being available when the system is tight" (DECC, 2013). While this policy specifically includes DSR and storage as a measure for meeting the mechanism's aims, it has been criticised for restricting participation, arbitrarily limiting contract lengths and offering only uncertainty about storage capacity during transitional arrangements (Yeo, 2014). The Capacity Market only offers one-year storage contracts compared with the up to 15-year terms available for fossil fuel generator contracts. The problem with supporting flexibility through the Capacity Market is that the latter was originally intended for security of supply and, where auctions award long-term contracts, to help de-risk power station construction. Balancing the electricity system depends on two conditions: capacity adequacy, i.e. enough power generating capacity to meet demand; and flexibility, i.e. the system's responsiveness to changing conditions. In the past, capacity adequacy has been the dominant concern of policymakers and the Transmission System Operator. However, the structural shift to renewables is making flexibility a priority.

Following the ruling by the European Court of Justice, the Capacity Market is currently in a 'standstill period'. The last auction for delivery in winter 2019 cleared at £6 per kW. This very low price reflects the high level of capacity, 10.7 GW, bidding for a target of 4.9 GW, although around 5.8 GW was awarded. The Capacity Market standstill provides an opportunity to think collectively about its rules. Is a Capacity Market really needed? If a Capacity Market needs to be in place, we suggest that different rules in terms of size, duration and notice periods should be considered in order to ensure participation of flexibility assets (Grunewald & Torriti, 2013).

Demand turn-up should not be isolated – it will become a vital part of the system affecting wholesale prices

The CGS defines the need for flexible capacity (6.9 GW) as the need to meet peak demand (4.9 GW in addition to current peak demand). This mainly relates to peaks in winter evenings, which traditionally are associated with the lowest margins between supply and demand. However, in a low carbon future, flexibility will need to be integral to the system, not only a small resource to be drawn upon in an emergency as an aid to capacity adequacy. For instance, electricity wholesale markets in Germany and GB have, on several recent occasions, moved into negative prices, which is to say that buyers are paid to use power by sellers. Examples of sunny and windy Sundays in which demand is low and renewable generation is high abound and will increase the need for increasing demand ('turn-up') (Torriti, 2016). Some examples of questions currently unaddressed in the CGS include the following: are there monetary benefits for consumers in relation to demand turn-up; will these be seized be specific categories of consumers? In research, as well as in policy, there needs to be greater clarity over the role of demand turn-up.

The CGS does not address how much flexibility will come from implicit DSR

Over the past couple of decades, flexible electricity demand, in the form of turn-down and load-shedding has predominantly taken place through the participation of industrial and large commercial users[14]. Whilst there are studies which suggest that much more flexibility is technically and economically available from industry, ambitious targets will need to consider various forms of flexibility from different types of consumers. Moreover, 'implicit' demand response, in the form of time of use (ToU) and other time-dependent tariffs is generally seen as a way to increase flexibility in residential use. The CGS is not explicit about the levels of flexibility to be derived from the residential sector. This may be due to uncertainties about the social and political acceptability of a system in which tariffs are no longer flat. The timing of electricity use by individual households is currently estimated using average 'profiles'. The introduction of smart meters provides an opportunity to collect more detailed data and use this to allocate electricity to suppliers based on a customer's actual demand in each half-hour. Whilst moving away from profiling to half hourly metering does not imply that there will have to be variable tariffs, some of the main benefits of smart meters (e.g. reducing the need for new generation and network capacity) are supposed to be associated with the introduction of variable tariffs. The impact of more cost-reflective pricing will vary between consumers and this will need to be better understood.

Areas in which different and/or additional policies and measures will be required

We recommend that BEIS should create a common policy for DSR in order to maximise the flexibility potential of electricity demand. DSR to date has been mainly an operational decision in the hands of National Grid, relying mostly on the flexibility of industrial and commercial end-users. National Grid is currently revisiting the services in which DSR operates. However, the next step, possibly in the next two years is for BEIS to introduce a common GB policy, which would encourage uptake from residential end-users with significant implications for grid balancing and cost reduction.

14 This has been explained as a reflection of interruptible programmes and aggregators having higher incentives for higher capacity in Torriti *et al*, 2010.

The policy should improve the current rules of the game of DSR (as highlighted in Box 1) as they significantly prevent participation from smaller energy users and leads to limited participation of load turn-down which requires more than 10 minutes' notice (see Figure 14).

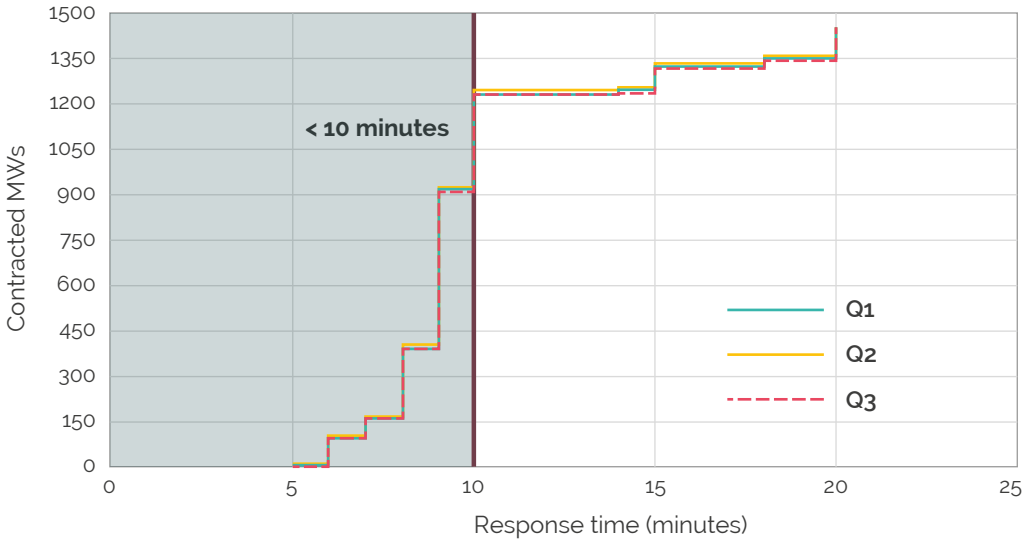

Figure 14: Distribution of STOR contracted loads by response time. Source: National Grid (2017). STOR Market Information Report.

1. **We recommend that consumers should be enabled to benefit from the reform of the pricing settlement**. Ofgem's recent decision to move to **half-hourly settlement** enables suppliers to know how much their customers consume every half hour. Hence, suppliers could offer tariffs based on **dynamic pricing**, such as ToU tariffs, which have the potential to shift demand away from times when demand is higher. A reduction in the amount of consumption at peak times should reduce the need for investment in new generation and network capacity and hence bill payer cost.
2. **We recommend that the National Grid Capacity Market should aim to increase storage and DSR participation, extending the one-year contracts under transitional arrangements for a longer time period**. This will decrease investors' uncertainty and boost the uptake of storage technologies. BEIS should consider contract duration as part of their review of Capacity Market rules. BEIS should review Capacity Market rules also in terms of the balance between capital expenditure (Capex) and operational expenditure (Opex). The current low Capex and high Opex system means that capacity payments are more certain than market revenue, investors are incentivised to build diesel and gas engines, at the expense of low carbon and more efficient gas solutions.
3. **We recommend reform of the current system of double charging for storage**. To avoid this, the Ofgem Access Framework should be modified to develop clearer definitions of capacity rights as distinct from connection capacity. In practice, changes to the Electricity Act 1989 will need to include the definition of storage as a subset of generation asset class and not as end consumers of energy.

Research gaps

This brief review of the CGS points to three main areas in which further research is needed.

First, any transition brings about change that could potentially disrupt the more vulnerable and strengthen those who have capital means. If the transition to a low or zero carbon economy is to be equitable, there will be a need for research on how vulnerable consumers will be impacted. An example comes from ToU tariffs, which in principle offer significant potential benefits to the system by enabling responsive electricity demand and reducing peaks. However, the impact of more cost-reflective pricing will vary between consumers. In particular, those who consume electricity at more expensive peak periods, and who are unable to change their consumption patterns, could end up paying significantly more. Understanding the distributional effects of ToU tariffs becomes vital to ensuring affordability of energy bills, while making demand more flexible. Research will shed light not only on average responses to changes in prices, but also on how people's flexibility varies based on the time of the day, location, work and social commitments.

Second, the CGS views technologies as (the only) enablers of higher flexibility. Attempting to engineer solutions may not lead to the desired effects of higher flexibility unless there is a deep understanding of how everyday life changes along with the new technologies. If such solutions and interventions are only developed to meet current 'need' and their business case assumes this 'need' is fixed, then the risk of developing rapidly obsolete and uneconomic interventions is high. Research can help understand the trajectories of change that must be considered and thus inform adaptive intervention design. Research is needed to understand, for instance, how electric vehicles and home battery storage might shape, and be shaped by, patterns of demand in people's everyday lives.

Third, the CGS views flexibility as originating from DSR, storage, clean generation and fossil fuel generation. However, flexibility could be derived from a variety of actions and changes, some of which may originate from the non-energy sphere. The impact of electric vehicles is an obvious example of new possibilities for flexibility which has only gained currency in recent years. The decarbonisation of heat could provide fuel switching and other opportunities for flexibility. Similarly, flexibility could be the result of non-energy changes in society and technology. Research which breaks the boundaries of sectors could shed light on opportunities for flexibility beyond existing options. For instance, in the future flexible work arrangements and an increase in work from home might have implications for when and where energy is consumed and the types of flexibilities available at different scales.

References

ADE (2016). Flexibility on demand, Giving customers control to secure our electricity system.

BEIS and Ofgem (2017). Upgrading our energy system: smart systems and flexibility plan.

Carbon Trust and Imperial College (2016). An analysis of electricity system flexibility for Great Britain.

DECC (2013). Electricity Market Reform (EMR).

Element Energy (2012). Demand side response in the non-domestic sector.

Grunewald, P. and Torriti, J. (2013). Demand response from the non-domestic sector: early UK experiences and future opportunities. *Energy Policy*, **61**: 423–429. doi: 10.1016/j.enpol.2013.06.051

National Grid (2017). Non-BM Balancing Services Volumes and Expenditure.

Ofgem (2017). Annual Report on the Operation of the Capacity Market.

Torriti, J., Hassan, M. G. & Leach, M. (2010). Demand response experience in Europe: policies, programmes and implementation. *Energy*, **35** (4): 1575–1583. doi: 10.1016/j.energy.2009.05.021

Torriti, J. (2015). Peak energy demand and demand side response. Routledge Explorations in Environmental Studies. Routledge, Abingdon, pp.172.

Yeo, T. (2014). Matthew Hancock 090914 DSR Cap Market letter.

6. Using zero carbon energy

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Introduction

Earlier chapters of this report set out the scope for reducing energy demand through deployment of improved efficiency and changes to energy-using practices. These are very significant and, in many cases, likely to be cost effective in a zero carbon economy. However, even with significant improvements in efficiency and reductions in demand, the fuels used throughout the economy will need to be decarbonised. This has obvious implications for the energy supply system, but it will also require major changes in the way that energy is used.

This chapter sets out the issues involved in moving towards the use of decarbonised fuels. Using a demand-side perspective allows the incorporation of important questions such as 'How much energy do we need?', 'What are the alternatives for providing a similar service?' and 'How socially acceptable are they?' into the analysis.

To date, the main focus of the transition to zero carbon fuels has been on electrification. Decarbonisation of energy services that are difficult to electrify remains less well-addressed. This is now widely accepted as the major challenge for decarbonisation of energy. It is clearly a challenge for new forms of energy supply to scale up to replace petroleum and natural gas. However, there are also huge implications for energy users. In most cases, switching from high carbon to zero carbon fuels cannot be achieved without changes in technology and practices at the point of energy use.

Current UK policy set out in the Clean Growth Strategy (CGS) reflects some of these issues and the potential role of fuels other than electricity, particularly in its hydrogen pathway in the sections on "transforming manufacturing and heavy industry" (page 68), "the future of heat decarbonisation" (page 82) and "lower carbon (transport) fuels" (page 91). In each case, some relevant innovation challenges are identified. However, the demand-side challenges associated with use of zero carbon fuels are not fully addressed.

Electrification of demand and its limits

Electricity has proven to be the easiest energy vector to decarbonise. There are multiple low and zero carbon options. There has been huge progress in reducing the cost of solar and wind technologies; these are now broadly competitive with conventional generation under UK climate conditions, and further price reductions are likely.

The potential role of increased electrification in decarbonisation has been known for many years in buildings (Johnston *et al*, 2005), transport (Romm, 2006), and more broadly (Edmonds *et al*, 2006). However, only more recently have mainstream studies projected electricity to become the dominant energy vector, both in the UK (CCC, 2008; BEIS, 2017) and internationally (IEA, 2015; IPCC, 2014; Sugiyama, 2012).

The extent to which electrification will increase total demand for electricity will depend on the balance between demand reduction and electrification (Eyre, 2011). Assumptions about demand reduction opportunities, in particular, have led to very different official projections for electricity demand growth, for example much lower in Germany (BMWi, 2015) than in the UK (DECC, 2011). Many models designed to address global climate issues are insufficiently detailed to address energy demand questions reliably (Lucon *et al*, 2014). Only recently have global analyses emerged that allow for known demand reduction opportunities (e.g. Grübler *et al*, 2018), showing the important potential of demand-side change for climate mitigation.

Greater levels of electricity demand flexibility will be needed in a system with increasing levels of variable and inflexible generation (see Chapter 5). However, this is far from the only constraint on electrification. There are several energy services for which use of electricity as a replacement for other fuels is problematic. These are discussed below.

- Industrial processes. These are highly diverse, but many rely on fossil fuels for reasons other than their energy content. These include the roles of high temperature flames in heat transfer, and the chemical properties of fuels, for example as a chemical reducing agent or a feedstock.
- Freight transport, shipping and aviation. Whilst electric vehicles (EVs) are now widely expected to become the low carbon choice for light vehicles, electricity storage for electrification of road freight, shipping and air transport is more problematic, because of the weight and volume of batteries required.
- Space heating in buildings. The scale and seasonality of space heating demand imply that complete electrification would require very large investments in either or both of peaking generation and inter-seasonal energy storage. Both are likely to remain expensive, making complete electrification an unpromising strategy.

Low carbon vectors other than electricity are required to address user issues in these sectors, but also to replace the long-term energy storage provided by fossil fuels.

Alternatives to electrification

The most commonly considered non-fossil alternative in these applications is biomass. There is a very active debate about its role in global decarbonisation driven by concerns about its availability, its potential to compete with food crops, biodiversity impacts and the sustainability of the natural carbon cycle. In the UK, constraints are amplified because of the high population density: the practical resource is only ~10% of current UK energy use (Slade *et al*, 2010; CCC, 2018a). Whilst importing biomass is possible, it seems unlikely to be a secure option for the UK in the context of global demand for low carbon fuels. Moreover, in terms of climate mitigation, these limited supplies of biomass are better used for sequestering carbon than for combustion without carbon capture (CCC, 2018a).

More recently, attention has focused on hydrogen (BEIS, 2017; CCC, 2018b). Whilst the investment costs of a transition to hydrogen would be very large, there seems little doubt that it is technically possible to convert gas distribution grids to hydrogen (Sadler *et al*. 2016). This would offer significant benefits in avoiding stranded assets in the gas sector. The Clean Growth Strategy assumes that the preferred route to hydrogen production will be steam methane reforming of natural gas with carbon capture and storage (CCS). Analysis indicates it is likely to be the cheapest option (CCC, 2018b). However, CCS is not well-established at a commercial scale, so costs are uncertain. Other options exist (RS, 2018). The most promising is electrolysis, as lower costs and rising output from variable renewables will increasingly make cheaper electricity available for large parts of the year (Philibert, 2017).

There are other hydrogenous gases and liquids which are potentially easier to store and transport. There is increasing attention to ammonia produced from renewables, as an industrial feedstock, a fuel for shipping and an energy storage medium. Carbonaceous liquid fuels, synthesised from hydrogen and carbon dioxide, can be carbon neutral and have obvious attractions in transport. However, feedstocks and/or conversion processes would have to change for costs to be competitive with other low carbon options.

A demand-side approach

Perspectives that focus solely on decarbonising energy supply imply that there will be wholesale change to the energy supply system, but no significant change to the structure of demand. This is contrary to the experience of previous energy transitions. The development of coal supply and steam power is synonymous with the industrial revolution, in which human economic and social activities were transformed. Similar effects can be expected in the low carbon transition. Supply technologies will coevolve with the activities and technologies that use energy. Buildings, transport and industry, and their energy uses, are all likely to be very different after a zero carbon energy transition. **We therefore recommend that analysis of fuel decarbonisation includes assessment of the implications for energy use and the potential for alternative approaches to providing energy services**.

Demand-side approach – industrial processes

Chapter 3 of this report sets out the opportunities for reducing energy demand in industry by improving process efficiency and reducing the demand for new materials. Decarbonisation of fuels will also be required. It is difficult to make generic statements about energy use in industry, given the wide range of processes used. Electricity is already dominant in some sectors, notably aluminium and chlorine manufacturing, as well as important sub-sectors such as secondary steel-making. Some additional electrification is possible, for example in relatively low temperature processes such as drying, where heat pumps can provide a more efficient option than fossil fuel technologies.

Similar easy wins are not available in many high temperature process sectors, such as primary steel and cement, and therefore more radical decarbonisation options need to be explored. There is a growing literature (Philibert, 2017; BZE, 2017; ETC, 2018a; ETC 2018b; CCC, 2019), which explore options that go beyond the UK Government's road maps (BEIS, 2015) and the related actions plans that were published alongside the Clean Growth Strategy (BEIS, 2017b). These have some common elements, including a short-term focus on energy efficiency, with future decarbonisation based on some combination of CCS, hydrogen and biomass.

The longer-term options will require policy intervention to support innovation and to displace the incumbent, fossil fuel intensive processes. There are welcome signs of innovation support under the Industrial Strategy Challenge Fund. However, the road maps and action plans developed in collaboration with industrial stakeholders are too restricted. Their focus is on decarbonising existing processes, with insufficient attention to fundamental changes in demand. This is most obvious in the documents addressing the oil refining sector. These assume a significant continuing role for petroleum products in transport in 2050, which we judge incompatible with global and UK Government energy system decarbonisation goals.

Decarbonisation of production will raise the costs of key materials. These and other changes will change the demand for those materials. Decarbonisation analyses need to include potential new processes and materials with lower energy and carbon intensities. The Government roadmaps include on-site material efficiency options, but exclude demand-side resource efficiency. We believe this is a significant omission. Industrial process energy use is a prime example of where we need to think about 'what energy is for', and whether the services provided by the materials and products can be delivered in different, and more sustainable ways. For example, the process and manufacturing emissions involved in making cement can be reduced upstream – by more efficient processes, different fuels and CCS – but also downstream by recycling, new materials and new construction techniques. **We recommend that the analyses underpinning the UK industrial roadmaps is extended to include material efficiency options**. Existing analysis (see Chapter 3) and future research by CREDS can feed into this.

Demand-side approach – freight transport, shipping and aviation

Chapter 4 of this report sets out the opportunities for changing energy demand through changed patterns of mobility and new passenger road transport technology. Light goods vehicles in urban areas offer some early opportunities for electrification due to the potential for dedicated recharging facilities. Heavy road freight, shipping and aviation are not so amenable to electrification and will require different approaches to decarbonisation.

Electrification of long-distance road freight using batteries has weight and volume penalties. The most widely-considered alternative is hydrogen-powered vehicles, using either internal combustion engines or fuel cells. This raises the issues about large-scale production of hydrogen that are discussed above. However, the filling stations used for liquid transport fuels may be an easier early market for electrolytic hydrogen than gas grid decarbonisation.

Battery operated ships and planes appear technically feasible over short ranges, but these transport modes are principally used for long-range transport. There is interest within the shipping and aviation sectors in use of biofuels. However, the underpinning assumption that long-range transport is the best use of limited bioenergy resources is not supported by current evidence (CCC, 2018a). Moreover, at the altitudes used for most long-distance aviation, any combustion releases emissions that contribute to climate change.

We welcome the commitments in the Clean Growth Strategy to supporting technological innovation for advanced fuels and improved efficiency in road freight, aviation and shipping. These will undoubtedly be necessary to achieve energy policy goals. However, the analysis assumes the continuation of existing trends of growth in long-distance freight transport, driven by increased consumption and trade. As Chapter 4 of this report indicates, demand growth is not inevitable and projections need to be subject to critical review.

Demand-side approach – space and water heating

Chapter 2 of this report sets out the importance of, and scope for, improving the energy performance of UK buildings, in particular by using better insulation and ventilation. It is theoretically possible to reduce the energy demand for space heating to zero. However, this is not practically possible, even with Passivhaus new-build construction, and is inconceivable for the whole UK building stock over the few decades within which the transition to a zero carbon economy has to be achieved. Energy demand reduction for water heating is more difficult to deal with. Decarbonisation of the fuels used for providing heat in buildings is therefore unavoidable if carbon targets are to be met.

The Clean Growth Strategy recognizes that decarbonisation of heating is a major and long-term challenge. More recently, Government has published the evidence base on heat decarbonisation (BEIS, 2018). Both reports cover energy sources (e.g. renewable electricity, bioenergy), energy vectors (e.g. electricity, mains gas) and conversion devices (e.g. boilers, heat pumps), but do not always distinguish their roles clearly.

It seems likely that the dominant energy vectors for heating will be electricity, mains gas and district heating (DH). None of these is a priori low carbon, but all can support low carbon sources and their use. Conversion devices at the point of end use will be important. They have to be affordable and socially acceptable if they are to be adopted. Their efficiency has a major impact on overall system efficiency, and therefore the scale and cost of the whole energy system. A critical constraint is the ability to deal with periods of system stress, which are likely to remain associated with high winter demand. There will be a requirement for the energy system to store energy, including over periods much longer than a day. In developing plans for decarbonisation of heat, a whole system analysis is needed of heat options, including the performance of energy conversion devices and energy storage. **We recommend that greater attention is given to energy conversion devices and energy storage in the analysis of heat decarbonisation**.

There is broad agreement that significant electrification of building heating is very likely to be required for complete decarbonisation. Heat pumps, rather than electric resistance heating, are the efficient means with which this could be delivered. However, heat pumps are not simple replacements for fossil fuel boilers; their effectiveness in retrofit depends on being able to operate heating systems at lower than conventional temperatures. This in turn requires some combination of reduced heat loss, larger radiators, or a shift to continuous heating. Deployment of heat pumps, particularly in retrofit, requires careful design and sizing, and skilled installation (RAPID-HPC, 2017). Expanding the supply chain will take time and is unlikely to happen without Government intervention. **We recommend that financial support for heat pump heating systems be continued and that more policy attention be given to the building heating supply chain**.

Some early scenarios with high heat pump adoption (e.g. DECC, 2013) overlooked the multiple challenges delivering a systemic change in building heating. In particular, the impact on peak electricity demand of very high levels of electrification is unlikely to be acceptable, and therefore a more diverse mix of energy carriers will be needed (Eyre and Baruah, 2015).

Exemplars of high DH use that are often cited (notably Denmark and Sweden) have been based on an evolving mix of energy sources (Danish Energy Agency, 2017; Werner, 2017). The advantages of DH are its flexibility with respect to sources of heat, its ability to support significant economies of scale in heat conversion and thermal storage, and the fact that it removes technical complexity from dwellings. The UK Government is supporting the expansion of heat networks through the Heat Network Development Unit. These networks require regulation, which has been slow to materialise in the UK, but which is now under consideration (BEIS, 2018b).

However, for DH to play a significant part in the decarbonisation of heat a number of additional measures are needed, including development of the supply chain, reduction of perceived risk and thus financing costs, linking to the availability of low carbon heat sources, and development of models for the effective integration of heat, electricity and gas networks. **We recommend BEIS develops a comprehensive strategy for heat, including heat networks, but also other options**.

More recently, there has been attention to decarbonising gas, through some combination of biogas and hydrogen. As set out above, there is an ongoing debate about the relative merits of steam methane reforming with CCS and electrolysis for hydrogen production. However, end-use perspectives are equally important. A major proposed benefit of hydrogen is enabling households to retain existing end-use technologies. However, whilst the ability to use existing household appliances has obvious short-term merit, transition to higher levels of hydrogen will almost certainly require new end-user equipment. Much UK analysis (e.g. BEIS 2018; CCC, 2018b; CCC, 2019) has focused on the option of using hydrogen (or biogas) in hybrid heat pumps, in order to avoid meeting peak heat demand solely with electricity. This implies a long-term commitment to burning zero-carbon gas in a boiler, which is a sub-optimal use of a high cost vector. It will be important to explore more efficient options, including combined heat and power and gas-fired heat pumps. Analysis of hydrogen as a heating fuel cannot be separated from its potential value in providing inter-seasonal energy storage. **We recommend that ongoing analysis of hydrogen as a heating fuel by both BEIS and the CCC covers questions of end use and storage, as well as production and networks**.

Most current analysis (e.g. CCC, 2016) points to early growth in electricity use in areas off the gas grid. It accepts that more research and trials are needed to explore the merits of different options in other locations. Our key message is that decarbonising heat is very different from decarbonising electricity, as it has major implications for energy users. Demand for thermal comfort, building fabric performance, heating technology efficiency and choice of vector are all likely to be important. And they will be the key determinants of the low carbon fuels used.

Implications for policy

In our chapters relating to demand reduction and flexibility, we set out specific short-term actions for Government, along with some longer-term challenges requiring further research. For decarbonisation of end-use fuels, the agenda is less well-developed, there are more unknowns, and therefore we place greater emphasis on research. Some decisions, notably strategic investment in gas, electricity and heat networks, imply very substantial infrastructure costs, and therefore the value of information is potentially high in helping to avoid stranded investment and to improve our knowledge of the different options for decarbonisation.

However, this is not an excuse for inaction. Early action is required, not just to deliver quick wins, but also to develop learning, skills and supply chains. Basic research is still needed, but there are already options in transport, buildings and industry where demonstration, trials and deployment are appropriate. These will be some of the key technologies of the low carbon transition. Developing a UK industrial strength in low carbon technology requires investment in these areas. The UK Government announcement in December 2018 of a 'net-zero carbon cluster' is a welcome development. **We recommend that Government develops and maintains a comprehensive programme of innovation support for decarbonisation of difficult sectors**.

In the short to medium term, many of the options set out above are unlikely to be cost effective against current technologies. To make this the test of financial support would be a strategic mistake. Whether a new option can out-perform the gas boiler, the diesel engine or the blast furnace in the high carbon economy is irrelevant in the face of the Paris Agreement. The right question is whether a technology or practice has a significant chance of forming part of an approach to long-term decarbonisation that is likely to be socially acceptable, and, if it does, how to support it on its pathway to widespread use.

Changes to technologies for buildings, vehicles and industrial processes will be important. However, as we have emphasised, there is every reason to expect very significant changes in user practices and commercial business models, as well as supply infrastructure as these sectors decarbonise. **We recommend that changing practices among end users and throughout supply chains should be more central to the decarbonisation innovation agenda**.

References

BEIS (2015). Industrial Decarbonisation & Energy Efficiency Roadmaps to 2050.

BEIS (2017). The Clean Growth Strategy: Leading the way to a low carbon future.

BEIS (2017b). Industrial decarbonisation and energy efficiency action plans.

BEIS (2018). Clean Growth – Transforming Heating. Overview of Current Evidence.

BEIS (2018b). Heat Networks: Ensuring Sustained Investment And Protecting Consumers.

BMWi (2015). Federal Ministry of Economic Affairs and Energy. The Energy of the Future: Fourth 'Energy Transition' Monitoring Report – Summary.

BZE (2017). Beyond Zero Emissions. Zero Carbon Industry Plan: Rethinking Cement.

CCC (2008). Building a low-carbon economy – the UK's contribution to tackling climate change.

CCC (2016). Next steps for UK heat policy.

CCC (2018a). Biomass in a low-carbon economy.

CCC (2018b). Hydrogen in a low-carbon economy.

CCC (2019). Net Zero Technical Report.

Danish Energy Agency (2017). Regulation and Planning of District Heating in Denmark, Copenhagen.

DECC (2011). The Carbon Plan – reducing greenhouse gas emissions.

DECC (2013). Heat Strategy.

Edmonds, J., Wilson, T., Wise, M. & Weyant, J. (2006). Electrification of the economy and CO_2 emissions mitigation. *Environmental Economics and Policy Studies*, **7** (3): 175–203. doi: 10.1007/BF03353999

ETC (2018). Energy Transitions Commission. Reaching zero carbon emissions from cement.

ETC (2018). Energy Transitions Commission. Reaching zero carbon emissions from steel.

Eyre, N. (2011). Efficiency, Demand Reduction or Electrification? Energy Efficiency First: The Foundation of a Low Carbon Society. European Council for an Energy Efficient Economy Summer Study, Presqu'ile de Giens, France, eceee.

Eyre, N. & P. Baruah (2015). Uncertainties in future energy demand in UK residential heating. *Energy Policy*, **87**: 641–653. doi: 10.1016/j.enpol.2014.12.030

Grübler, A., Wilson, C., Bento, N., Boza-Kiss, B., Krey, V., McCollum, D.L., Rao, N.D., Riahi, K., Rogelj, J., De Stercke, S., Cullen, J., Frank, S., Fricko, O., Guo, F., Gidden, M., Havlík, P., Huppmann, D., Kiesewetter, G., Rafaj, P., Schoepp, W. & Valin, H. (2018). A low energy demand scenario for meeting the 1.5° C target and sustainable development goals without negative emission technologies. *Nature Energy*, **3** (6): 515. doi: 10.1038/s41560-018-0172-6

IEA (2015). International Energy Agency. Energy Technology Perspectives 2015 – Mobilising Innovation to Accelerate Climate Action. Paris, IEA.

IPCC (2014). Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. [Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Farahani, E., Kadner, S., Seyboth, K., Adler, A., Baum, I., Brunner, S., Eickemeier, P., Kriemann, B., Savolainen, J., Schlömer, S., von Stechow, C., Zwickel, T. & Minx, J.C. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Johnston, D., Lowe, R.J. & Bell, M. (2005). An exploration of the technical feasibility of achieving CO_2 emission reductions in excess of 60% within the UK housing stock by the year 2050. *Energy Policy*, **33** (13): 1635–1651. doi: 10.1016/j.enpol.2004.02.003

Lucon, O., Ahmed, A.Z., Akbari, H., Bertoldi, P., Cabeza, L.F., Eyre, N., Gadgil, A., Harvey, L.D.D., Jiang, Y., Liphoto, E., Mirasgedis, S., Murakami, S., Parikh, J., Pyke, C. & Vilariño, M.V. (2014). Chapter 9: Buildings. Intergovernmental Panel on Climate Change, 5th Assessment Report, Working Group III., Cambridge University Press.

Philibert, C. (2017). Renewable Energy for Industry. Paris: International Energy Agency.

RS (2018). The Royal Society. Options for producing low-carbon hydrogen at scale. ISBN: 978-1-78252-318-5

RAPID-HPC (2017). Detailed analysis of data from heat pumps installed via the Renewable Heat Premium Payment Scheme (RHPP), Series of 5 reports prepared for BEIS.

Romm, J. (2006). The car and fuel of the future. *Energy Policy*, **34** (17): 2609-2614.

Sadler, D., Cargill, A., Crowther, M., Rennie, A., Watt, J., Burton, S. & Haines, M. (2016). H21 Leeds City Gate. Northern Gas Networks, London.

Slade, R., Bauen, A. & Gross, R. (2010). The UK bio-energy resource base to 2050: estimates, assumptions, and uncertainties. UKERC.

Sugiyama, M. (2012). Climate change mitigation and electrification. *Energy Policy*, **44** (0): 464–468. doi: 10.1016/j.enpol.2012.01.028

Werner, S. (2017). District heating and cooling in Sweden. *Energy*, **126**: 419–429. doi: 10.1016/j.energy.2017.03.052

7. Policy: delivering further and faster change in energy demand

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Introduction

Policy to reduce energy demand will be critical in delivering the Clean Growth Strategy (CGS), helping to achieve the low carbon energy transition. The UK has been a pioneer in low carbon policy, with some influential energy demand policies in addition. The Climate Change Act is internationally leading, the GB energy efficiency obligation scheme has strongly influenced EU policy, and the London Congestion Charge has inspired similar schemes elsewhere. However, more significant change is needed if the UK is going to meet the 2050, and intermediate, targets for 80% GHG emissions reduction (CCC, 2018). Further, the 80% target will need to be strengthened if the UK is to contribute fairly to the Paris Agreement ambition of restricting global temperature rise to 1.5C (Pye *et al*, 2017). This challenge has been addressed by the Committee on Climate Change (CCC), whose 2019 report advises that the UK should adopt a net-zero carbon target by 2050 (CCC 2019).

The unprecedented challenge of decarbonising energy means that, while we can and should learn from past UK, EU and international policy experience, we are likely to need new approaches to the design, types and mixes of policy, institutions and delivery mechanisms. We will need to rethink governance and expand the ambition and reach of policy. The energy transition will require changes in technologies, practices and choices for every household and business, many of which we do not currently know how to organise technically, cost-effectively or in a socially acceptable way. To aid this transition, CREDS' 'policy and governance' research theme will contribute new ideas, analysis and evidence to help characterise and meet the multiple challenges involved.

This brief review of policy and policy processes within the CGS is based on existing research and knowledge. It makes recommendations for change by Government, and highlights where CREDS can contribute new knowledge. First, there are detailed comments on the policy approach and policy mix within the CGS. Then governance and institutional aspects are discussed. Finally, policy innovations to deliver further, faster and more flexible change are presented.

Policy approach

First the contents of the CGS are briefly analysed and compared with the policy making approach of the Scottish Government Climate Change Plan. Then the policy mix and policy types employed within the CGS are discussed. Finally, a case is made for the importance of including equity in policy design and delivery.

From a strategy to a plan

The CGS is a report required under the UK Climate Change Act in which the Government has to set out the policies and proposals it considers necessary to keep emissions within the legislated carbon budgets. The carbon budgets, therefore, provide an overarching constraint on the future envisaged by the CGS. The CGS contains many policies and proposals – over 200 by our count. However, many do not have timescales, funding or targets attached (for detailed analysis see Appendix 1 or Reiss 2018). There are very few policies that impose specific obligations on anyone.

A generous interpretation would be that this lack of detail is a function of the stage of policymaking (although the publication had been repeatedly delayed, and came six years after the first 'Carbon Plan'). The CGS points forward to a range of consultations and sector-specific plans, which will create openings for more detailed policies, but these are yet to emerge. By contrast, the Scottish Government has produced a Climate Change Plan (Scottish Government, 2018) which sets out sectoral emissions' envelopes and specific indicators against which progress in policy development and outcomes can be judged. The UK Government however has more powers than the Scottish Government, including some which affect Scottish emissions; powers over energy taxation and regulation, for example, are reserved to the UK Government.

A significant difference between the CGS and the Scottish Climate Change Plan is that the UK government does not expect to produce a single Clean Growth Plan against which progress is measured. Hence the CGS does not break the overarching carbon budget down into budgets for specific sectors. Sector-specific emission levels are mentioned, but only to illustrate emissions along "one of several plausible pathways" (Appendix 2 or Hawkey 2018). Instead regular reporting is promised, in combination with the response to the CCC's Annual Progress Report. Using a sector-specific approach would, however, have the advantage of allowing the UK Government to set differential targets for sectors of the economy where climate policy is perceived to threaten international competitiveness (energy intensive industries) and sectors where this is not a significant issue (particularly buildings and transport).

Recommendation: Government should work swiftly to turn CGS proposals into policies with specific targets, dates and budgets. This should include setting sectoral targets, or envelopes.

Policy types and policy mixes

The CGS does not specify an approach to policymaking, neither does it explain how it will determine the mix of policies needed to meet particular goals, beyond saying it will use "all the tools available" (p49). The majority of proposals are related to innovation investment, i.e. delivering clean growth through technological breakthroughs; only about a quarter of proposals aim to address clean growth through regulatory or fiscal measures (Appendix 1 or Reiss, 2018). While innovation is important, adoption of innovative products does not generally happen without the support of policy instruments.

The importance of policy mixes in delivering effective energy efficiency improvement has long been recognised, given the variety of instruments needed to overcome different barriers or to support different technologies at various stages of development (Rosenow *et al*, 2016). For many traded goods – including lighting, electrical appliances, motors, vehicles and boilers – an EU-wide market transformation approach has been taken, which incorporates standards for testing, minimum efficiency and labelling, and product bans, complemented by national information, advice, training and subsidy programmes. Policies to encourage fuel switching, or policies to change behaviours, practices or management of energy also require a mix of instruments.

Recommendation: In developing its more detailed plans, the Government should detail the mix of policies, regulatory and market-based, needed to deliver innovations.

Equity in the energy transition

Equity and justice need to be integral to the energy transition, for principled and pragmatic reasons (Parkhill *et al*, 2013). Fairness and perceptions of fairness are critical to successful policy in the UK; perceived unfairness has undermined many past policies, e.g. VAT on fuel, fuel duty escalator, feed-in tariffs. UK policymakers have long-acknowledged that householder access to energy/energy services and transport/mobility are unevenly distributed. For household energy use, this has led to considerable policy attention on fuel poverty. Policy has not, however, succeeded in ending fuel poverty (BEIS, 2018). Energy prices have increased at a higher rate than incomes for poorer households, and energy efficiency policies have not reduced energy demand in homes sufficiently such that adequate energy services are affordable for all.

More attention is needed on how the costs and benefits of the energy transition are going to be distributed between different groups in society and different sorts of organisations. This topic is not addressed in detail in the CGS (Appendix 1 or Reiss 2018).

Recommendation: More detailed equity and fairness analysis/questions should be included in consultations and other documents following up the CGS.

Governance

This section considers the governance of policy and the role of actors at different scales from individuals to national administrations. It proposes new institutional arrangements for delivering policies in the CGS, and finishes with comments on the role of politics in policymaking.

Individuals, intermediaries and organisations

Despite its focus on technological innovation, the CGS has limited focus on the users or adopters of new technology, and the supply chains and installers which will deliver it. Research shows that these groups are critical to the adoption of innovations (Owen *et al*, 2017). Future research funding for helping people to 'stop wasting energy' is announced (CGS, p81); this frames people as the problem, rather than as integral to the low carbon transition. A wealth of research – some of it commissioned by Government – shows that more sophisticated conceptualisation and engagement with people and organisations as decisionmakers, investors and users of energy pays dividends.

The CGS has little to say about micro-businesses and SMEs, although they are responsible for 55% business energy use (as noted in the CGS, p61). SMEs have less capacity and resources to adapt to change than larger firms, and require distinctive forms of policy and financial support (Hampton and Fawcett, 2017). To enable and encourage them to contribute to the energy transition, SMEs collectively will require additional research and tailored policy attention.

Recommendation: Government to assess the effectiveness and impacts of policy design and delivery in relation to specific groups, including householders, intermediaries, SMEs and other organisations.

CREDS contribution: To undertake research focused on people and organisations and their centrality to, and many roles in, the energy transition.

Governance within the UK

There is as yet no strategy for coordinated governance of policy on energy efficiency and demand in the different nations and regions of the UK. Regional action is mentioned in only one CGS policy proposal, despite the focus on driving regional growth through local industrial strategies, highlighted in CGS Chapter 1. Earlier work has however argued that more systematic, comprehensive and faster improvements in energy saving could be achieved through explicit UK, devolved national and local/regional government frameworks for action on low energy buildings and clean energy (Webb *et al* 2017).

Scotland, Wales and Northern Ireland currently have different devolved powers relevant to energy policy, with Northern Ireland having most autonomy; in Britain energy taxation, regulation and licencing is reserved to Westminster. Within this framework, Scotland has developed the Energy Efficient Scotland programme, and Wales the Energy Efficiency Strategy for Wales, each emphasising coordinated national and regional action.

The Scottish Government is also now consulting on a new statutory power for local government to develop comprehensive Local Heat and Energy Efficiency Strategies (LHEES) and implementation plans. In England, governance arrangements are more piecemeal and experimental, including for example recent BEIS funding for six pilots to test locally-customised supply structures for private housing retrofit.

Local government needs guidance if it is to make high quality, locally sensitive decisions around energy. Scottish LHEES pilots are testing proposals for development and adoption of standard socio-economic assessment metrics for evaluating cost effectiveness of different energy saving strategies suited to each locality. In the Smart Systems and Heat programme, local energy planning tools have been developed to model cost-optimal routes to a low energy, low carbon building stock at locality scale, but underlying cost calculations are contingent on multiple future uncertainties, and resulting scenarios can be difficult to evaluate for local governments with limited technical capacity. More work is needed on development of standards for assessing the cost effectiveness of different approaches responsive to local problems and priorities.

Recommendation: UK Government to work with devolved national and regional governments to develop clearer frameworks, mandates and metrics to support further, faster local authority action to reduce energy demand through local and regional energy planning and implementation.

CREDS contribution: Our research programme will develop knowledge and capacity on emerging comparative governance strategies within Britain, with a particular focus on energy use in buildings.

Institutions and approaches for policy delivery

Delivering energy efficiency through policy requires a complex mix of policy instruments (Rosenow *et al*, 2017). Most OECD countries use some form of energy agency to manage this complexity. An external agency also adds specialist market and project management expertise, which is difficult to provide via a generalist civil service with restrictive procurement rules (Mallaburn & Eyre 2014). However, this approach comes with risks, particularly around loss of Government control and accountability, which was the main reason why public funding was removed from the Carbon Trust and Energy Saving Trust in 2012.

A new generation of hybrid energy efficiency programmes is emerging that fuse industry-led, voluntary programmes with selective Government intervention (van der Heijden, 2017). For example, the National Australian Built Environment Rating System (NABERS) is a voluntary initiative, supported by the Government, to measure and compare the environmental performance of commercial buildings and tenancies. It has been widely adopted, and is considered to have been successful in increasing environmental and energy performance (Mallaburn, 2018). The German energy efficiency networks apply the same approach to industry (Durand *et al*, 2018).

Recommendation: The overnment should evaluate the case for hybrid energy efficiency programmes run by a new national Energy Agency or similar facility to help deliver the CGS.

CREDS contribution: to review the impact of hybrid energy efficiency programmes and the agencies that run them and to consider how the approach could work in the UK.

The politics of policymaking

Policymaking is not an apolitical process: policies are made by governments with particular political priorities and values, and within a wider socio-economic context (Appendix 2 or Hawkey, 2018). At certain times there may be 'policy windows' for ambitious climate change policies, but such windows may also close unpredictably (Carter and Jacobs, 2014). Nevertheless, some policies have achieved lasting cross-party support, and the UK has shown leadership in establishing carbon reduction as a priority shared across the mainstream political landscape. Analysis of 40 years of UK energy efficiency policy has shown that energy efficiency can meet different goals and fit with different political philosophies (Mallaburn and Eyre, 2014). However, other emerging approaches to demand reduction, such as sustainable prosperity in a circular economy (Jackson, 2017) or sufficiency (Darby and Fawcett, 2018), are more politically contentious. These, too, are legitimate and important subjects of research.

CREDS contribution: to explore the full range of policy solutions, including radical options, and to consider their robustness against different political priorities.

Further, faster and more flexibly

To reduce energy demand further and faster, and to make it more flexible, innovation in energy and relevant non-energy policy will be required. A number of changes to current policymaking are suggested: joined-up policy, going beyond short-term win-win and energy efficiency, and taking the reduction of demand more seriously.

Joined-up policy: Heat decarbonisation as an example

The call for more joined-up policy is not new. However, given the scale of change envisaged in the energy transition and the interconnected nature of the changes required, a joined-up, systematic approach will be essential. The changing nature of the energy system itself is widely acknowledged with, for example, distributed generation, increasing renewables and smart meters all opening up new opportunities for policy intervention, and requiring new policy frameworks. The relationship between supply and demand of energy is different and more joined-up now. It is important that analysis by researchers and Government identifies the social/technical/economic systems surrounding new flexibility, low energy or low carbon innovations, and that policy builds on this.

Heat decarbonisation, a CGS priority, demonstrates the complexity of change envisaged and the need for joined-up policy. Low carbon heating systems, such as low temperature heat delivered by heat pumps or low carbon gas (hydrogen/biogas + Carbon Capture Use and Storage – CCUS), are currently more expensive, complex and problematic than the incumbent technologies. To enable adoption of these technologies, it will be vital to reduce the energy used for heating and hot water in buildings (Webb, 2016). Reducing energy demand in buildings is the best-understood and lowest risk element of a heat decarbonisation strategy. However, this is not acknowledged in the CGS, where the focus is on supporting low carbon heating technology through a) supporting measures to become more attractive so that homeowners will adopt them; b) investing in long term knowledge generation for fuel switching; c) investing £320 million in heat network infrastructure to develop a self-sustaining market post-2021 (Heat Networks Investment Project, 2018). There is a notable lack of policies to deliver more efficient existing buildings, particularly in the non-residential and able-to-pay residential sectors (as discussed in Chapter 2). Policy for new buildings is also less strong than it could be. Thus, by focusing primarily on the supply of heating systems, and not addressing demand for the energy services they supply, the CGS is left without an overarching strategy to govern the decarbonisation of space and water heating.

Recommendation: Government needs to join up policy on all aspects of decarbonisation of heating, and prioritise policies to ensure high standards of efficiency of the new and existing building stock. More generally, a joined-up systematic approach to policy is required.

Beyond short-term win-win

The CGS expects mitigation actions to be win-win: in the short-term, actions should deliver both carbon reductions and economic benefits to their adopters. This is constraining. For example, a decarbonised heat system is forecast to lead to cost increases (Energy Research Partnership, 2017) which are difficult to reconcile with short-term win-win framings. The costs of low carbon options can fall more quickly than expected, reducing the economy-wide cost of the energy transition – with solar PV and batteries being good examples (CCC, 2109). Policy support prior to these technologies being win-win options, both in the UK and abroad, has helped deliver cost reductions. Nuclear and off-shore wind generation are not subject to a win-win expectation. Public subsidy is considered justified, despite cost increases in the case of nuclear power. Government is also prepared to support controversial supply-side options, e.g. fracking (not mentioned in the CGS); such support has been lacking when demand-side policies become controversial, e.g. in the debate about the impact of 'green charges' on energy bills in 2013 (Carter and Clements, 2015).

There are alternatives to a short-term win-win approach. In Scotland, the Government announced in 2015 that it would treat energy efficiency as a national infrastructure priority. This approach to demand-side policy is leading to a requirement for specific policy instruments (Scottish Government, 2017). Another option is the 'energy efficiency first' approach taken by the European Union, which builds on the principles of integrated resource planning.

Policy could be framed around energy services, rather than energy itself, as proposed under the ETI/Energy Systems Catapult 'Smart Systems and Heat' programme (Energy Systems Catapult, 2018). This is intended to create incentives for suppliers to invest in building fabric retrofit, where this is the more cost effective route to provision of contracted service levels. Finally, a multiple benefits approach to developing policy would ensure that the full social, environmental and economic effects are taken into account. This approach can provide a powerful case for action which appeals to a variety of values and priorities (IEA, 2014). Each of these proposals would have different implications for policymaking.

Recommendation: Government should reconsider the requirement for short-term win-win from technologies and energy saving, low carbon options at the earlier stages of innovation and adoption.

CREDS contribution: to build capacity on energy demand policy which is not necessarily win-win in the short-term and learn from the emerging approaches elsewhere.

Beyond energy efficiency

For the UK as a whole, energy efficiency has been, and will continue to be, an important route to demand reduction – but this is truer for some sectors than others. For buildings, energy efficiency has been key to reducing demand over recent years and offers significant scope for further reductions (Chapter 2). For industrial energy use, energy efficiency has delivered one-third of the savings due to reducing energy intensity, but the remaining efficiency opportunity is limited (Chapter 3). However, for transport, internal combustion engine vehicle energy efficiency improvement has been insufficient to deliver decreases in energy use, with considerable concern about the mismatch between lab test and real world energy efficiency (Brand, 2016; Chapter 4). In addition to energy efficiency, demand-side policy must also encompass fuel switching and flexibility. Government must also acknowledge its own role in shaping demand.

The current policy approach to fuel switching varies by sector. The CGS has set a date for the phase out of fossil-fuelled cars and vans (albeit not as ambitious as called for in Chapter 4). Until recently, the same drive to require fuel switching has not been seen in the buildings sector. . However, in March 2019, a 'future homes standard' was announced which will ensure that new UK homes will be built without fossil fuel heating from 2025 (Hammond, 2019). This is a good start, but covers just a small part of the building sector (i.e. not the existing building stock). The electrification of heating and transport are both likely to require planned withdrawal of existing fossil fuel supplies and their infrastructures – a complex social/technical/economic process which now urgently requires policy development.

Government policy contributes to shaping demand for energy, energy services, travel and mobility. This is arguably most strongly the case in the transport sector, where nearly all infrastructure is publicly funded (Marsden *et al*, 2018). Decisions to expand airport capacity inevitably increase energy use and carbon emissions.

However, more indirectly, economic, tax and monetary policies also contribute to stimulating and shaping demand. Acknowledging tensions between climate goals and economic goals, where these exist, is important. Not all growth can be clean growth.

The CGS does not challenge existing energy-intensive practices, such as long-distance air travel, or the growth of new energy uses, e.g. the internet of things, big data storage and exchange, or cooling of buildings. It does not consider any substantial policy to reduce demand for mobility or the services that energy provides. While such policy may be thought contrary to the usual aims of Government, it is important to recognise that the Government has already expanded policy into new areas in order to deliver energy savings and the multiple benefits these bring. For example, it has introduced minimum standards for energy efficiency of (some) existing privately owned homes – an intervention previously considered politically impossible. The Government will need to find new intervention points if carbon reduction targets are to be met.

Recommendation: Government to develop stronger policy on switching away from carbon-intensive fuels. Also to recognise the role of its own policies in stimulating and shaping demand, and to consider how these could contribute instead to the net-zero transition.

CREDS contribution: By analysing policy across sectors, and taking a whole systems view, to develop new evidence and arguments for more rapid change.

Taking demand more seriously

Demand reduction and flexibility will be hugely important in delivering the energy transition – but policy still focuses disproportionately on energy supply. For example, the CGS dedicates almost three times more investment to the electricity system (responsible for 21% of emissions), via power and smart systems investments, than to businesses and homes (responsible for 38% of carbon emissions, including the 32% of national emissions for heating). This is despite recognising the necessity to decarbonise heat and its status as "our most difficult policy and technology challenge to meet our carbon targets" (CGS:p75). Given the expected future role of electricity across all sectors, this may be the right balance of investment. However, the apparent mismatch does require closer attention.

Recommendation: Government to reassess the relative priority given to supply and demand policy.

CREDS contribution: Research on reasons for policy asymmetry between energy supply and demand

Conclusions: raising the ambition level

As the CCC concluded, the CGS will not deliver sufficient carbon savings to meet Government-legislated targets. This chapter has suggested a number of ways of raising ambition within the current framing of policy – by setting more detailed policy targets and stronger standards, designing appropriate policy mixes, involving and coordinating with multiple actors at different levels of governance, and considering new institutional arrangements. There is also the more challenging call to reconsider the limits and purpose of policy. Successful policymaking also requires paying attention to equity, and to the individuals and organisations who make up (and meet) the demand for energy services and mobility.

CREDS aims to conduct research on reductions in demand which go further, faster and more flexibly – options beyond 'business as usual'. This will include investigating demand for energy services and mobility, and proposals for reducing these, consistent with equity, climate protection and energy policy goals. CREDS will provide recommendations and evidence for radical or non-marginal changes in delivering emissions reduction, as well as incremental improvements.

References

BEIS (2018). Annual fuel poverty statistics report 2018 (2016 data).

Brand, C. (2016). Beyond 'Dieselgate': Implications of unaccounted and future air pollutant emissions and energy use for cars in the United Kingdom. *Energy Policy*, **97**: 1-12. doi: 10.1016/j.enpol.2016.06.036

Carter, N. & Clements, B. (2015). From 'greenest government ever' to 'get rid of all the green crap': David Cameron, the Conservatives and the environment. *British Politics*, **10**: 204-225. doi: 10.1057/bp.2015.16

Carter, N. & Jacobs, M. (2014). Explaining radical policy change: The case of climate change and energy policy under the British Labour government 2006–10. *Public Administration*, **92**: 125-141. doi: 10.1111/padm.12046

CCC (2018). Reducing UK emissions – 2018 Progress report to parliament.

CCC (2019). Net zero: The UK's contribution to stopping global warming.

Darby, S. & Fawcett, T. (2018). Energy sufficiency: an introduction. Concept paper for ECEEE. ECEEE.

Durand, A., Joest, S., Quezada, A., Chassain, E. & Roser, A. (2018). Energy Efficiency Networks: lessons learned from Germany, Proceedings of European Council for an Energy Efficient Economy, Industrial Summer Study 2018, Berlin.

Energy Research Partnership (2017). The transition to low-carbon heat. Energy Research Partnership.

Energy Systems Catapult (2018). Smart systems and heat. Energy Systems Catapult.

Hammond, P. (2019). Spring Statement 2019: Philip Hammond's speech. HM Treasury, London.

Hampton, S. & Fawcett, T. (2017). Challenges of designing and delivering effective SME energy policy, Proceedings of European Council for an Energy Efficient Economy, Summer Study 2017, Belambra Les Criques, France.

Heat Networks Investment Project (2018). Delivering financial support for heat networks: England and Wales. BEIS & Triple Point Heat Networks, London.

IEA (2014). Capturing the multiple benefits of energy efficiency. International Energy Agency, Paris.

IPCC (2018). Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. [Masson-Delmotte, V., Zhai, P., Pörtner, H.-O., Roberts, D., Skea, J., Shukla, P.R., Pirani, A., Moufouma-Okia, W., Péan, C., Pidcock, R., Connors, S., Matthews, J.B.R., Chen, Y., Zhou, X., Gomis, M.I., Lonnoy, E., Maycock, Tignor, M. & Waterfield, T. (eds.)]. World Meteorological Organization, Geneva, Switzerland.

Jackson, T. (2017). Prosperity without growth: Foundations for the economy of tomorrow, Second edtion ed. Routledge, Abingdon, Oxfordshire.

Mallaburn, P.S. (2018). Principles of successful non-residential energy efficiency policy. Proceedings of the 2018 ECEEE Industry Summer Study.

Mallaburn, P.S. & Eyre, N. (2014). Lessons from energy efficiency policy and programmes in the UK from 1973 to 2013. *Energy Efficiency*, **7**: 23–41. doi: 10.1007/s12053-013-9197-7

Marsden, G., Dales, J., Jones, P., Seagriff, E. & Spurling, N. (2018). All change? The future of travel demand and the implications for policy and planning. First report of the Commission on Travel Demand.

Owen, A., Morgan, E., Morgan, M. & Killip, G. (2017). Supply chain dynamics in the UK construction industry and their impact on energy consumption in homes, ECEEE Summer Study, Belambra, Pres'que Ile de Giens, France.

Parkhill, K., Demski, C., Butler, C., Spence, A. & Pidgeon, N. (2013). Transforming the UK Energy System: Public Values, Attitudes and Acceptability – Synthesis Report. UKERC, London.

Pye, S., Li, F.G.N., Price, J. & Fais, B. (2017). Achieving net-zero emissions through the reframing of UK national targets in the post-Paris Agreement era. *Nature Energy*, **2**: 17024. doi: 10.1038/nenergy.2017.24

Rosenow, J., Fawcett, T., Eyre, N. & Oikonomou, V. (2016). Energy efficiency and the policy mix. *Building Research & Information*, **44**: 562–574. doi: 10.1080/09613218.2016.1138803

Rosenow, J., Kern, F. & Rogge, K. (2017). The need for comprehensive and well targeted instrument mixes to stimulate energy transitions: The case of energy efficiency policy. *Energy Research & Social Science*, **33**: 95-104. doi: 10.1016/j.erss.2017.09.013

Scottish Government (2017). Scotland's Energy Efficiency Programme: Second consultation on local heat and energy efficiency strategies, and regulation of district and communal heating. Scottish Government.

Scottish Government (2018). Climate Change Plan: The Third Report on Proposals and Policies 2018-2032.

van der Heijden, J. (2017). Innovations in urban climate governance: Voluntary programmes for low carbon buildings and cities. Cambridge University Press, Cambridge, UK.

Webb, J. (2016). Heat and energy efficiency: making effective policy. A report for the UK Committee on Climate Change. University of Edinburgh.

8. Conclusions

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Why energy demand?

Our analysis shows that changing energy demand is critical to the development of future energy systems that are secure, affordable and sustainable. In particular, meeting the ambitious climate goals of the Paris Agreement and the UK's Climate Change Act involves a systemic change in the energy sector – for energy demand as well as energy supply.

Supporting energy efficiency is consistent with the central goal of the Government's Industrial Strategy of improving UK productivity. Energy efficiency is not just a 'nice to have' green add-on to energy policy. It is, by definition, energy productivity. It is productive investment, creating employment, supporting competitiveness and contributing to an innovative economy.

The analysis in the previous chapters shows the diversity of measures to change energy demand across the sectors in which energy is used. We deliberately use the term 'changing energy demand' to emphasise that the demand-side agenda is now broader than its traditional agenda of implementing modest efficiency improvements. It includes action on the fundamental drivers of energy demand – the human activities that require energy services. It also increasingly involves flexibility; changing when energy is used, and decarbonisation; the fuels used. So the energy demand agenda is complex.

Learning from experience

Improving energy efficiency at the point of use remains critically important. Efficiency improvement generally supports all three pillars of the energy trilemma (security, affordability and emisson reductions). It has the potential to deliver policy goals at a lower cost than by relying on supply-side options alone. The International Energy Agency (IEA, 2016) now refers to energy efficiency as 'the first fuel', that is, the first option to consider in developing energy policy.

Our evidence supports this approach. Of course, not all conceivable energy efficiency investments are sensible or cost effective, but the scale of historical under-investment means that there remain major opportunities that have bigger benefits than investments in new supply. Reducing demand should be a priority. **We therefore recommend that the Government adopts the position that policymaking should, as a principle, consider energy efficiency improvement and other measures that reduce demand as 'the first fuel'**.

Drawing on the analysis set out in the previous chapters, we believe that the evidence shows that there have been three important factors in driving demand reduction.

The first important factor is innovation. As recognised in the Clean Growth Strategy, this involves more than research and development. It also includes demonstration, deployment and adoption processes through to mass deployment. Innovation needs to be considered as a systemic process as we set out in Chapter 1.

Innovation expenditure is currently strongly weighted towards energy supply. Whilst Research Council commitments to energy efficiency have increased in recent years, support for deployment has fallen. Major subsidies for deployment of some energy supply technologies dwarf the sums now allocated to supporting energy demand innovation. **We recommend that the imbalance is corrected by ensuring that energy innovation support gives equal priority to energy supply and energy demand**.

The second important factor is the role of energy users. The energy transition cannot be delivered without greater engagement of energy users – both in households and businesses. Some individuals already play a key role as early adopters of clean technology and advocates of lower carbon living. Similarly in the business sector, companies for which energy is a strategic priority perform better (Cooremans, 2012). But many energy users are disengaged. So the ambition of the Clean Growth Strategy for "a shared endeavour between Government, business, civil society and the British people" is important. There are decades of programme experience with a variety of users (Mallaburn and Eyre, 2014), but the lessons do not feature strongly in the Clean Growth Strategy. There is increasing evidence motivation may be driven by benefits other than cost and carbon savings. **We recommend the Government develops a systematic approach to engagement on energy demand across all sectors of the economy as part of the next Energy White Paper**.

The third factor is the role of public policy, which affects both technological innovation and engagement. Incentives, information and regulation all have a role, with a policy mix generally providing the most effective approach (Rosenow *et al*, 2016). Government has a central role in helping business and householders capture the value of energy efficiency by providing support and advice and where necessary intervening to overcome barriers and remove poor performers.

Within such a policy portfolio, clear and well-enforced standards, announced well in advance, have an important role, as shown by the effectiveness of efficiency standards for key products such as domestic heating boilers.

There is uncertainty about future product standards if the UK leaves the EU Single Market. **We recommend that Government commits to ensuring a continued framework of increasingly ambitious product standards, as part of a portfolio of policy instruments**.

Unfortunately, much UK Government policy has become less ambitious and effective in recent years. The scale of policy-driven investment in home energy efficiency has been reduced substantially. The Green Deal policy is widely recognised to have failed and has not been replaced. There is, in effect, no support policy at all on commercial buildings. Energy efficiency advice programmes have been cut and business energy efficiency incentives and support weakened. Transport energy use has begun to rise again as fiscal measures have weakened and investment has fallen in alternatives to private road travel.

Developing a vision and framework

A vision for energy demand is missing and is now urgently required. There has been a drift in public policy towards assuming that energy demand is solely a consumer responsibility. Of course, improvements in energy efficiency result in financial benefits for households and businesses, which should be encouraged to invest without financial support where possible. However, energy demand change also has important public benefits: in improved energy security, better public health and urban environments, and major employment opportunities, as well as lower carbon emissions. Research is increasingly able to quantify these impacts. **We recommend that Government assess the scale of public benefits from potential energy demand change**.

Many of the assets requiring energy efficiency investment, notably buildings and mass transit infrastructure, have the characteristics of infrastructure. They should receive the same focus and support as energy supply infrastructure. **We recommend that Government departments and the National Infrastructure Commission should develop plans to ensure low cost capital is available for infrastructure investments in energy demand reduction**.

These benefits should be reflected in policy support. The Government accepts the case for a stable framework for low carbon energy sources in order to reduce investment risk. The case for similar support for energy efficiency is even stronger, as the public benefits are at least as big and the non-financial barriers to investment are often larger. The higher cost effectiveness of energy efficiency means the public benefits derived from public investment tend to be higher. We welcome the fact that the Clean Growth Strategy sets ambitious targets. If these are to be achieved, the weakening of policy needs to be reversed, through comprehensive policy intervention. **We recommend that Government develops a long-term framework for incentivising demand-side investment in all sectors that at least matches the priority assigned to supply-side policy. This should cover demand reduction, demand response and fuel decarbonisation**.

This would be consistent with the broad approach of the Clean Growth Strategy of setting clear long-term visions, within which business and civil society can plan. We welcome the commitments to ending the sale of petrol and diesel vehicles. Other areas where Government could take a similar lead with the potential for popular support include: a shorter timescale for requiring net-zero carbon new-build than 2025; ambitious goals for high-performance building renovation; targets for reduced road vehicle use in urban centres; and goals for reducing the use of carbon intensive materials.

Winning the broad argument for change will need to accompany the legal and policy framework required to implement it. People are therefore central to any coherent programme on energy demand. Long term, systemic change inevitably involves the energy practices and services that drive the need for energy. We recognise the reluctance of policymakers to be seen to interfere in consumer decision-making, and therefore to prefer policies relating to 'things' rather than people. But it is a false dichotomy. Many policies frame, shape or constrain individual decisions and there is ample evidence that consumers want and expect Government to make decisions that are in the public interest. They do not want the 'right' to have a cold home, a polluted environment or throwaway products. The key issue is to ensure that decisions are understood in terms of public good and working with the community, rather than as arbitrary constraints on individual freedom. It will be important for Government to be explicit about this and to build support within civil society. **We recommend that Government consults on and develops a long-term 'national conversation' of citizen engagement, addressing both the personal impact of policy measures and wider issues**.

Developing a transition plan

The Clean Growth Strategy provides a starting point. What is now needed is a Clean Growth Implementation Plan. The detail will be important as any plan for energy demand has implications for consumer behaviour, business decisions, innovation and governance.

In the buildings sector, energy demand has fallen, but the trend is now weakening, as there has been a reduction in ambition for both the energy performance of new buildings and the rate of renovation of the existing stock. The latter is the tougher challenge, but both need to be addressed. Both housing and non-domestic buildings need to be addressed. This will need a range of interventions, including tighter standards, better enforcement and incentives. One critical aspect of delivery will be to re-skill the workforce to meet the task of delivering buildings that are high performing in practice, not just on paper. The longer-term challenge is complete decarbonisation of heating in buildings, where options need to be opened and a route map developed.

In the transport sector, there are many similar challenges in ensuring the continued improvement of vehicle efficiency. Again, the progress in practice recently has not matched what is claimed by the industry due to poor enforcement. There are clear signs of the early stages of light vehicle electrification; this is welcome although it raises new challenges for generation and distribution.

Freight transport, aviation and shipping remain more difficult. In transport, there is also very large potential for reducing demand by changing the patterns of land use and by modal shift. This is frequently neglected in discussions about transport and energy demand, and this deficiency needs to be addressed.

In industry there remains significant scope for technical efficiency improvement, although less so than in other sectors. The potential is least in energy intensive manufacturing processes. This points to the need for consideration of two more fundamental issues. The first is the role of energy intensive materials and products in modern society – how they are used, reused and recycled, and the extent to which they can be substituted. The second is the development of different process technologies, using electricity and/or other decarbonised vectors to replace fossil fuels.

In all sectors, there needs to be a focus on performance rather than merely technology. There is a long history of both energy management in business and energy advice to the general public that shows the scope for performance improvement with any given set of technology. New technology will be critical to the transition, but is not a panacea. There is a chronic performance gap, between design and use in both vehicle and buildings technologies. Better real-time data provides a huge opportunity to help address these, both by improving the quality of policy instruments such as labels and standards, and by enabling smart technologies to provide real-time support for energy decision-makers.

Ultimately, to meet the UK's obligations under the Paris Agreement, it is likely that the fuels used in every sector will need to be completely decarbonised. To date, priority has largely been given to decarbonising electricity. Decarbonisation has therefore been seen as primarily a supply-side issue. However, attention will increasingly need to be paid to decarbonising heat and other difficult sectors, whether by electrification or otherwise. The practices, preferences and choices of energy users are then critical. Hence the importance of a national conversation about what is needed.

In all sectors, what is needed is more than marginal efficiency improvement. To facilitate the transition to a society powered largely by renewables, demand needs to be reduced and made more flexible. Flexibility is a newer challenge and is particularly important for electricity use. It can be delivered both by enabling energy using practices to be more flexible and by using various forms of energy storage. Our judgement is that both approaches are likely to be required, and that both need policy support.

It will be tempting for policymakers to focus on the technical innovation required to deliver such fundamental change. However, for the reasons set out above, 'end users' cannot be neglected in considerations of 'end use'. Policies will need to address people as well as technologies. In a sustainable energy system, deep demand reduction, flexibility and decarbonisation are likely all to be critically important. This is a newer research agenda than modest demand reduction. However, for both demand response and fuel switching, there is a substantial amount to be learnt from energy demand reduction experience in consumer behaviour, supply chain development and policy design.

CREDS plans to develop the evidence base and an approach to policy integration. **We recommend the Government coordinates the development of policies for demand reduction, flexibility and decarbonisation in an Energy White Paper**.

The energy sector also needs reform. Energy demand and supply can no longer be governed separately. The UK led the way in the mid-1990s in ensuring that energy regulation required energy suppliers in liberalised markets to deliver energy saving programmes. This catalysed similar activity across Europe, but this leadership has now been thrown away. The very strong focus of existing policy on wholesale markets in energy policy, e.g. in the process of Electricity Market Reform (EMR), is very unhelpful. With the growth of distributed generation and the increasing availability of storage, the assumption that energy will be sold as an undifferentiated commodity is under threat. Self-supply and peer-to-peer trading are increasing and may undermine existing markets. A new vision is needed in which energy retail policy does more than control unit prices. We welcome the renewed interest in retail market design issues in Ofgem, but a more fundamental review is required. **We recommend that Government initiate a review of the fundamentals of electricity and gas retail markets, and whether their focus on commodity sales is fit for purpose in the context of the energy transition electricity**.

Throughout this report, the implications of digitalisation for energy demand are apparent. These are likely to be mixed, but are also unpredictable and rapidly moving. The obvious early impact for energy demand in the UK is from the roll-out of smart meters. The initial cost-benefit analysis relied heavily on reducing demand through improved user engagement. This relies on meters being installed with this as an objective (Darby, 2010), which is an example of the need for better engagement in general. From our analysis, smart meters are important, not primarily to achieve modest demand reductions, but to enable innovation and make demand flexibility a realistic option.

Understanding the benefits of action on demand

We welcome the emphasis in the Clean Growth Strategy on the need to consider the energy transition in the context of its wider implications for the economy and society. This is particularly important when considering the role of the demand side.

Local studies (BEIS, 2017 page 26) show the extent to which low carbon sectors are increasingly important within local economies. There is a range of contributions, but it is changes in energy demand that are frequently the source of most benefits. We know enough about these multiple benefits of addressing demand to better inform policy. So our research will focus on how decision-making might better use this type of analysis, including at the local level and through the Commission on Travel Demand.

We can also improve our knowledge. Our research on industrial energy efficiency and on digitisation aim to quantify the macroeconomic effects of improved energy productivity. Our research on buildings will address the importance of the comfort and health benefits that are often neglected. Our work on transport will also consider the health benefits of transport technology change, but importantly also the multiple benefits of lower-impact travel modes.

References

BEIS (2017). The Clean Growth Strategy: Leading the way to a low carbon future.

Cooremans, C. (2011). Make it strategic! Financial investment logic is not enough. *Energy Efficiency*, **4** (4): 473-492. doi: 10.1007/s12053-011-9125-7

Darby, S. (2010). Smart metering: what potential for householder engagement? *Building Research & Information*, **38** (5): 442-457. doi: 10.1080/09613218.2010.492660

IEA (2016). Energy Efficiency Market Report 2016.

Mallaburn, P. & Eyre, N. (2014). Lessons from energy efficiency policy and programmes in the UK from 1973 to 2013. *Energy Efficiency*, **7** (1): 23-41.

Rosenow, J., Fawcett, T., Eyre, N. & Oikonomou, V. (2016). Energy efficiency and the policy mix. *Building Research & Information*, **44**: 562–574. doi: 10.1080/09613218.2016.1138803

9. Detailed recommendations

The complexity of energy demand means there is no 'silver bullet' solution or policy: a range of policy instruments is required to meet energy policy goals. These involve many sectors, institutions and stakeholders, with a range of different timescales for action. We list a large number of recommendations in this report, and bring them together in this chapter. They can be considered under six broad headings.

1. Prioritise energy demand solutions

Energy demand change can support all the key goals of energy policy – security, affordability and sustainability – with more synergies and fewer trade-offs than supply-side solutions. For this reason, treating demand reduction as 'the first fuel' is already the policy of the International Energy Agency (IEA) and the European Union. Demand-side solutions also form a key part of implementing sustainable supply, through using zero carbon fuels and enabling greater use of variable renewables. In UK energy policy, there has been a tendency to focus on energy supply options. We recommend that this is reversed and demand-side solutions are given at least equal weight, and that Government should:

- work swiftly to turn proposals in the Clean Growth Strategy into policies with specific targets, dates and budgets, including setting sectoral targets or envelopes (BEIS)
- reassess the relative priority given to supply and demand policy and adopt the principle that energy efficiency improvement and other measures that reduce demand are considered as 'the first fuel' (BEIS)
- develop a long-term framework for incentivising demand-side investment in all sectors that at least matches the priority assigned to supply-side policy. This should cover demand reduction, demand response and fuel decarbonisation (BEIS, DfT)
- review the fundamentals of electricity and gas retail markets, and whether their focus on commodity sales is fit for purpose in the context of the energy transition (BEIS)
- develop a policy for demand-side response to maximise the flexibility potential of electricity demand (BEIS, Ofgem)

- reform settlement in electricity markets to enable consumers to benefit from half-hourly pricing (BEIS, Ofgem)
- increase storage and demand participation in the Capacity Market by extending the duration of contracts (BEIS)
- reform the current system of double charging for electricity storage (BEIS).

2. Consider and promote all the benefits of demand-side solutions

UK policy with respect to energy demand tends to focus on the benefits of lower carbon emissions and lower bills for energy users, often using the latter as an argument for minimal intervention. Reduced demand, improved energy efficiency, greater flexibility and decarbonised fuels have a much wider range of benefits, notably for health and employment. Addressing energy demand is generally more likely to promote sustainable development than increasing energy supply. As importantly, recognising all the benefits is more likely to motivate action. We recommend that all the benefits of demand-side solutions are considered in developing and promoting policy, and that Government should:

- assess the scale of public benefits from potential energy demand change (BEIS)
- improve understanding of how to exploit the value of the multiple benefits of energy efficiency in buildings (BEIS)
- institute a new approach to transport prices and taxes to reflect a fuller range of costs and benefits (DfT, HMT)
- analyse and consider equity and fairness issues in delivering the Clean Growth Strategy (BEIS)
- assess the effectiveness and impacts of policy design and delivery in relation to specific groups, including householders, intermediaries and SMEs (BEIS, DfT, MHCLG, devolved governments)
- reconsider the requirement for short-term win-win outcomes from energy saving options (BEIS, HMT).

3. Scale up policies that work

UK energy demand policy has featured numerous policy changes in last decade. In some cases, such as Carbon Emissions Reduction Target, the Carbon Reduction Commitment and the proposed Zero Carbon Homes standard, policy instruments that were well-designed and effective have been modified, or much reduced in scale. This has significantly reduced the effectiveness of UK energy policy. We recommend greater consistency in demand-side policymaking and, in particular, scaling up policies that have been shown to work, and that Government should:

- use a mix of policies, regulatory and market-based, in developing its more detailed plans (BEIS, DfT, Defra, MHCLG, HMT)
- develop plans to ensure low-cost capital is available for infrastructure investments in energy demand reduction (BEIS, National Infrastructure Commission).
- focus policy on the 'as built' energy performance of buildings (BEIS, MHCLG, devolved governments)
- for household heating, focus on actual rather than modelled heat loss from the buildings (BEIS, MHCLG, devolved governments)
- for non-domestic buildings, introduce a performance-based policy framework based on successful overseas experience (BEIS, MHCLG, devolved governments).
- introduce measures to deliver rapid, low-cost emission reductions from existing technologies and systems, for example using product labels to reflect operational boiler efficiency (BEIS)
- continue financial support for heat pump heating systems, giving greater attention to the building heating supply chain (BEIS)
- increase the ambition of energy demand and emission reductions goals in industry (BEIS)
- commit to ensuring a continued framework of increasingly ambitious product standards, as part of a portfolio of policy instruments (BEIS, DfT)
- adopt policies to lock-in recent changes in reduced travel demand (DfT, devolved governments)
- develop a cascading framework of national and local support for car clubs (DfT, devolved governments)
- provide systematic support for the very lowest energy modes of transport (DfT, devolved governments)
- improve the efficiency of vehicles in use, particularly through increased occupancy (DfT)
- regulate to reduce the availability and sales of large cars (DfT).

4. Develop long-term plans for demand-side innovation

There has been a tendency in policymaking to see the demand side as having the potential to provide quick wins, but not to have a major role in the transition. Our analysis indicates that this is unhelpful. Energy demand reduction, flexibility and decarbonisation will need to play a critical role and this should be recognised in energy innovation policy. We recommend that Government should develop long-term plans for demand-side innovation, including:

- energy innovation support that gives equal priority to energy supply and energy demand (BEIS, UKRI)

- stronger policies on switching away from carbon-intensive fuels (BEIS)
- a comprehensive programme of innovation support for decarbonisation of difficult sectors (BEIS)
- restructuring of ultra-low emission vehicle (ULEV) targets to include phasing out hybrid cars (DFT)
- regulatory frameworks to steer emergent travel innovations to deliver societal benefit and avoid high travel lock-in in the future (DfT)
- industrial energy-use goals that include energy efficiency, fuel switching, process decarbonisation, carbon capture use and storage, and reducing the demand for materials and products (BEIS, Defra, devolved Governments)
- a comprehensive industrial energy demand policy, providing support and incentives for innovation and deployment of new technology and business models, including for energy efficiency and material efficiency by final consumers (HMT, BEIS, Defra, devolved Governments)
- extending the analyses underpinning the UK industrial roadmaps to include material efficiency options (BEIS, Defra)
- a long-term policy framework to decarbonise buildings based on successful experience overseas and the latest research (BEIS)
- an overall policy framework for the building sector that provides a clear signal of Government ambition and intent in the medium and long-term that will deliver the buildings element of future carbon budgets (BEIS)
- credible roadmaps for the deployment of emerging technologies such as heat pumps, district heating and solid wall insulation in new and existing buildings (BEIS).
- a comprehensive strategy for heat, including heat networks and other options (BEIS)
- greater attention to energy conversion devices and energy storage in the analysis of heat decarbonisation (BEIS)
- analysis of hydrogen as a heating fuel that covers questions of end use and storage, as well as production and networks (BEIS, CCC)
- assessment of the potential for alternative approaches to providing energy services in overall decarbonisation (BEIS).

5. Build effective institutions for delivery of demand-side solutions

Energy-using activities are diverse, and therefore the policy agenda set out above involves influencing a wide range of stakeholders, including both specialists and the general public. Doing this effectively will require a major increase in activity in demand-side policy delivery in Government at a range of levels. This will require better coordination across departments, more capacity and clearer responsibilities for specialist agencies, devolved Governments and local government departments.

We recommend that Government should reform the existing delivery structures and develop an institutional framework designed for delivering the energy transition. This should include:

- the development of policies for demand reduction, flexibility and decarbonisation in an Energy White Paper (BEIS)
- evaluation of the case for energy efficiency programmes to be delivered by a new Energy Agency
- joined-up policy on all aspects of decarbonisation of heating, prioritising policies to ensure high standards of efficiency of the new and existing building stock (BEIS, MHCLG, devolved Governments)
- development of a national, long-term energy performance dataset for buildings (BEIS, UKRI)
- more effective collaboration to maximise the value of research and demonstration investments (HMT, BEIS, MHCLG and devolved countries)
- a cross-Government approach to energy, climate, waste and industrial strategy (Defra, BEIS, Devolved Governments, HMT)
- commitment to a leadership position internationally on energy-intensive material supply chains (BEIS, Defra, DIT, FCO, DfID)
- development and sharing of better industrial energy and materials data, working with industry and the research community (BEIS, Defra)
- clearer frameworks, mandates and metrics to support further, faster local authority action to reduce energy demand through local and regional energy planning (BEIS, MHCLG, devolved Governments)
- incentivisation of coordinated transport and planning objectives to reduce the need to travel (DfT, devolved Governments)
- a zero-growth objective for traffic or transport energy growth and incentives for local authorities to achieve it (DfT, devolved Governments).

6. Involve wider stakeholders to build capacity across society

A transformation in the way that energy is used needs to be led by Government, but cannot be delivered by Government alone. There is some good practice on which to build, but there needs to be a concerted effort to engage, enthuse and empower stakeholders across business and civil society. We recommend that Government should develop a strategy for Involving wider stakeholders to build capacity across society. This should include:

- a systematic approach to engagement on energy demand across all sectors of the economy as part of the next Energy White Paper (BEIS)

- a long-term national conversation of citizen engagement, addressing both the personal impact of policy measures and wider issues (BEIS, devolved Governments)
- ensuring that the implementation of the Hackitt Review addresses the energy efficiency performance gap on the evolution of and compliance with buildings standards and in the development of skills, standards, procedures and capacity within the building sector (BEIS and MHCLG)
- accepting the need to address questions of lifestyle and behaviour change to deliver energy and material efficiency (HMT, BEIS, Defra, devolved Governments)
- making practices among end users and throughout supply chains more central to the decarbonisation innovation agenda (BEIS).

References

BEIS (2017). The Clean Growth Strategy: Leading the way to a low carbon future.

Cooremans, C. (2011). Make it strategic! Financial investment logic is not enough. *Energy Efficiency*, **4** (4): 473-492. doi: 10.1007/s12053-011-9125-7

Darby, S. (2010). Smart metering: what potential for householder engagement? *Building Research & Information*, **38** (5): 442-457. doi: 10.1080/09613218.2010.492660

IEA (2016). Energy Efficiency Market Report 2016.

Mallaburn, P. & N. Eyre (2014). Lessons from energy efficiency policy and programmes in the UK from 1973 to 2013. *Energy Efficiency*, **7** (1): 23–41. doi: 10.1007/s12053-013-9197-7

Rosenow, J., Fawcett, T., Eyre, N. & Oikonomou, V. (2016). Energy efficiency and the policy mix. *Building Research & Information*, **44**: 562–574. doi: 10.1080/09613218.2016.1138803

Photo by Natalya Letunova on Unsplash

This report

'Shifting the focus: energy demand in a net-zero carbon UK' is CREDS' first major publication. It builds on research undertaken by members of the consortium over many years to address the question: "What can changes in energy demand contribute to the transition to a secure and affordable UK energy system that is compatible with net-zero carbon emissions?". It examines the most recent comprehensive statement of UK Government Energy policy – the Clean Growth Strategy. Drawing on expertise in the CREDS consortium across the buildings, transport, industry and electricity sectors, the report sets out a vision for the role of energy demand changes and develops detailed recommendations for action.

About CREDS

The Centre for Research in Energy Demand Solutions (CREDS) was established as part of the UK Research and Innovation's Energy Programme in April 2018, with funding of £19.5M over 5 years. Its mission is to make the UK a leader in understanding the changes in energy demand needed for the transition to a secure and affordable, low carbon energy system. CREDS has a team of over 90 people based at 13 UK universities.

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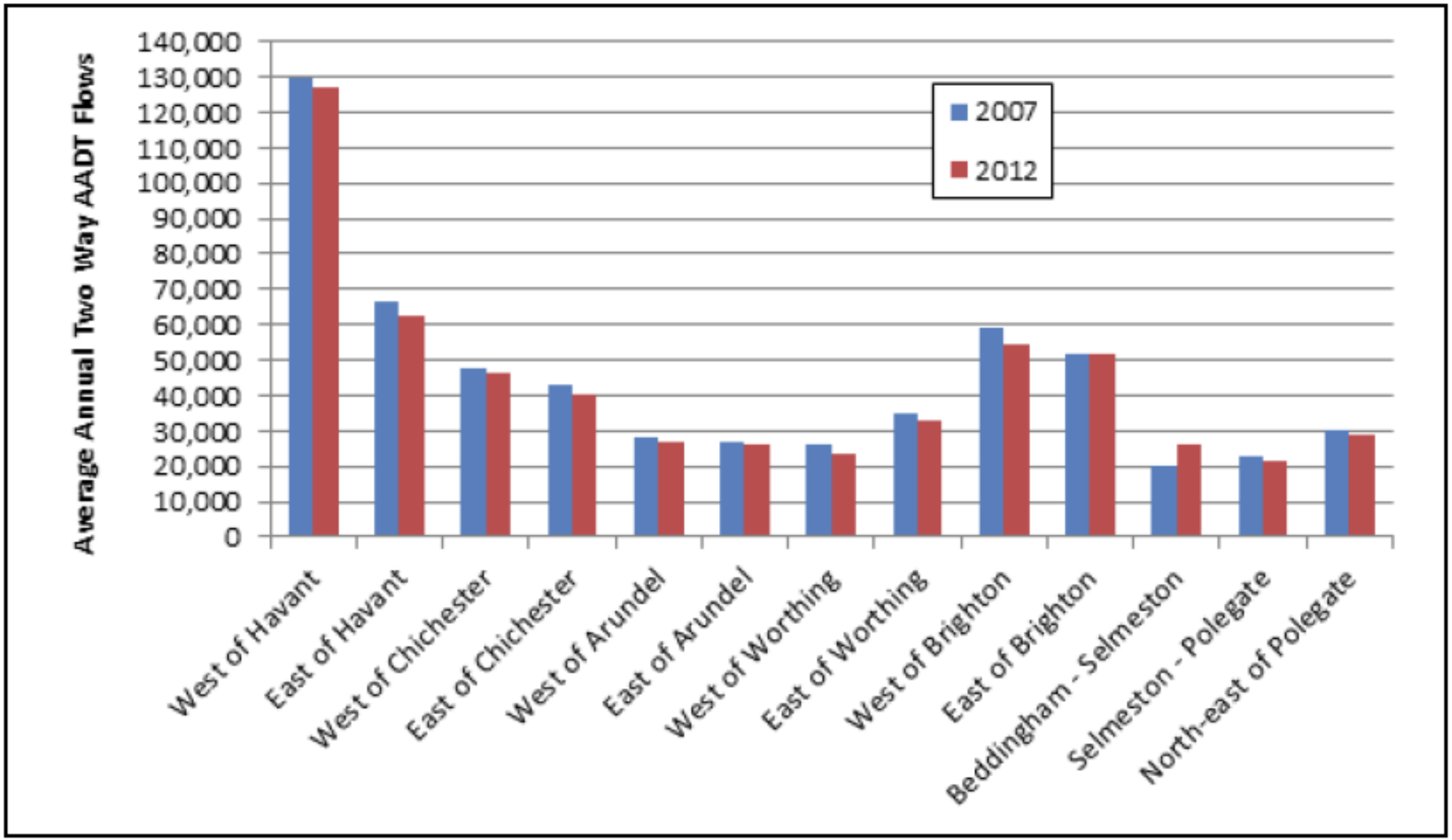
4.7.2 The average traffic volumes are close to or above the theoretical capacity of the road (a single carriageway is expected to accommodate AADT volumes up to 13,000 vehicles) along the single carriageway sections. For example, AADT volumes in 2013 were over 15,300 at Arundel, over 17,800 at Worthing and over 11,400 on the stretch between Lewes and Polegate.

Figure 4-3: Average Daily Traffic Volumes along the A27 (two-way)



Hello

Clymping Parish Council has the following views on the A27 Arundel By-pass consultation which it would like taken in to account:

- There is an overriding need for the Arundel Bypass
- A southerly route crossing Ford Road is our strong preference rather than the inline options
- The southerly route should be chosen on a balance of the sustainability factors – impact on the community especially Binsted and Walberton, the environment and the economic factors
- Council welcomes the proposal to design a junction with Ford Road if a southerly route is adopted

Please let me know if these views need to be entered in to the online survey somehow or whether this email can be accepted.

Regards

[redacted]
Clerk of Clymping Parish Council
[redacted]