Review of the Future Homes Standard

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Executive summary

Purpose of this document

This report explores the issues highlighted by the Future Homes Standard[01] and the resultant changes to the Building Regulations, specifically the impact of the prohibition of the installation of gas boilers in new homes from 2025.

This Future Homes Standard review is in the context of other related Government policies which have objectives such as, (i) reducing carbon emissions from homes as a contribution to the Climate Change Committee's recommendation to target a 78% reduction in carbon emission by 2035,[02] (ii) improving housing affordability,[03] (iii) levelling up economic performance across the UK[04] and (iv) COVID-19 pandemic related economic recovery.[05] The report also considers the implications of the Future Homes Standard on the wider exploitation of alternative decarbonising heat technologies, the use of hydrogen in the gas network, as well as the transition to the Future Homes Standard and the implications for house builders and and energy network providers.

Methods employed in drafting the report

This report undertakes a high level qualitative and quantitative review of the Future Homes Standard and the other relevant Government policies. The analysis also draws upon the information collected during interviews with a selection of stakeholders.[06]

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01 Ministry of Housing, Communities & Local Government, 'The Future Homes Standard: 2019 Consultation on changes to Part L (conservation of fuel and power and Part F (Ventilation) of the Building Regulations for new dwellings- Summary of responses received and Government response' (Jan 2021)

02 https://www.gov.uk/government/news/uk-enshrines-new-target-in-law-to-slash-emissions-by-78-by-2035

03 HM Treasury, Autumn Budget 2017 (November 2017 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/661583/autumn_budget_2017_print.pdf

04 HM Treasury, 'Levelling Up Fund: prospectus' (3 March 2021): https://www.gov.uk/government/publications/levelling-up-fund-prospectus

05 HM Treasury, 'A Plan for Jobs' (8 July 2020) https://www.gov.uk/government/publications/a-plan-for-jobs-documents/a-plan-for-jobs-2020

06 The list of the interviews held as part of the study is provided in Appendix B.

Our key findings

The Future Homes Standard sets a pathway to zero carbon homes

Heating and powering homes accounts for approximately 22% of the UK's greenhouse gas emissions,[07] therefore reducing their carbon emissions is essential to meeting net-zero targets. The Future Homes Standard sets out enhanced building fabric specifications, as well as heating and ventilation requirements (the so called 'fabric plus' option),[08] the combination of which are expected to reduce emissions from domestic premises by some 75% to 80%, starting with a 31% reduction in 2021, compared to current standards.[09]

We recognise therefore that the Future Homes Standard makes an important contribution to the overall reduction in carbon emissions.

Need for an impact assessment

Ahead of implementing policies, there is a general expectation that Government departments will undertake an impact assessment,[10] which is an analysis used to inform policy decision-making by using cost-benefit and other analysis tools to build a robust evidence base.[11]

Neither the Government response to the consultation on the Future Homes Standard or the original consultation[12] were accompanied by a departmental analysis of its impact.[13] It is stated that the impact assessment on the Future Homes Standard will be based on the full technical consultation planned for spring 2023.[14] Therefore, decisions could be taken by Government and industry participants prior to the impact analysis being made available which could negatively influence the transition to, or implementation of, the Future Homes Standard.

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07 Op.cit 1 Section 1.2 pg. 7
08 Ibid – Table 2 Pg. 18
09 Ibid – Section 3.3 Pg. 27
10 Department for Business, Energy & Industrial Strategy (2020), Better Regulation Framework Interim Guide https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/916918/better-regulation-guidance.pdf
11 Ibid. p. 11
12 Ministry of Housing, Communities & Local Government (2019), The Future Homes Standard: 2019 Consultation on changes to Part L (conservation of fuel and power) and Part F (ventilation) of the Building Regulation for new dwellings https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/852605/Future_Houses_Standard_2019_Consultation.pdf
13 MHCLG did publish an impact assessment alongside its consultation in 2019, but the impact assessment focused on updates to the standards for new houses in 2021 and did not cover setting the standard for new houses such that they cannot be built with fossil fuel heating from 2025 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/836925/REQUEST.pdf
14 Ministry of Housing, Communities & Local Government, 'The Future Homes Standard – 2019 Consultation on changes to Part L (conservation of fuel and power) and Part F (ventilation) of the Building Regulations for new dwellings: Impact Assessment' (Jan 2021) p.5

Interviewees have expressed concerns about the transition timetable for the Future Homes Standard

The Government's response to the Future Homes Standard consultation in January 2021, sets what is clearly a 'fabric plus technology' policy,[15] that is to say it seeks to both increase the insulation standards of homes to reduce overall energy demand and mandate low-carbon heating.

It should be noted that a further consultation on the exact nature of the building's fabric specification for compliance with the Future Homes Standard is not due until the spring of 2023, thus the specification will not be available to house builders until late 2023 or early 2024. This means that the exact 'recipe' for the fabric of new houses may not be known until close to the current implementation date for the Future Homes Standard in 2025.

Therefore, putting in place a robust supply chain (UK manufacturing of heat pumps, component supply and qualified installers) in the period between confirmation of the fabric specification for new homes and the implementation of the Future Homes Standard may present challenges that need to be considered further.

The legislative basis underpinning the Future Homes Standard is not scheduled to be presented to Parliament until 2024. Hence any delay to this timetable puts at risk the implementation of the Standard, should Parliamentary time become constrained or other elements of the Government's legislative agenda become delayed.

Bringing forward both the consultation and the legislative programme would de-risk the implementation and provide clarity as to the pathway.

The UK heat pump supply chain will need to ramp up rapidly to support the target of 300,000 new homes per year

Only a few tens of thousands of heat pumps are currently installed annually, compared to the annual boiler installations of approximately 1.67mn[16] (mostly gas and oil[17] across the 24.4mn dwellings in England at 31 March 2019).[18] The Government target to build 300,000 new homes per year by 2025 would significantly increase this install level. Additionally, the Government has a target of 600,000 heat pump installations in total per year by 2028 (which includes the 300,000 heat pumps for new homes).[19]

Currently there is limited domestic heat pump manufacturing capacity, with most heat pumps produced in Asia.[20] Of the just under 33,600 heat pumps installed in the UK in 2019, 22,753 were imported and only 10,830 were manufactured in the UK.[21] Thus to meet the 300,000 or the 600,000 annual installation target with UK manufactured heat pumps, there will have to be a significant increase in capacity if the UK is to avoid relying on global manufacturing capacity. It should be noted that global manufacturing capacity is not seen by Government as a constraint.[22]

As well as heat pump manufacturing it is important to support the development of a UK component manufacturing sector. For example, around 25% of the value of a heat pump is derived from the compressor, whose design and manufacture is dominated by a small number of global suppliers (Danfoss, Bitzer, Mitsubishi, Hitachi and Daikin), with only one from the UK – Emerson Copeland.

An enhancement of the UK's heat pump manufacturing capacity would be an economic and employment boost (manufacturing being £1.38bn at the factory gate,[23] leading to £5.5bn for the economy as a whole), creating thousands of skilled jobs in the manufacturing sector.[24]

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15 Op.cit. 1, Table 2 Pg. 18
16 https://www.eua.org.uk/record-boiler-sales-show-how-decarbonisation-will-work/
17 Statista UK: number of heat pumps in operation 2013–2019 https://www.statista.com/statistics/740491/heat-pumps-in-operation-uk/
18 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/886251/Dwelling_Stock_Estimates_31_March_2019_England.pdf
19 Ministry Housing Communities and Local Government 'Planning for the future' (2020) https://www.gov.uk/government/consultations/planning-for-the-future
20 Department of Business Energy and Industrial Strategy (BEIS), 'Heat Pump Manufacturing Supply Chain Research Project' (2020) Pg. 54 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/943712/heat-pump-manufacturing-supply-chain-research-project-report.pdf
21 Ibid, Pg. 54
22 Ibid, Pg. 14
23 Ibid, Pg. 11–34,896 heat pumps have a factory gate value of £78mn, thus 600,000 heat pumps equals £1.38bn
24 Ibid. p. 97

To be ready for 2025, increased UK manufacturing capacity is likely to require a targeted support scheme covering start-up grants and other forms of innovation funding. Government research states, and interviews with sector experts have confirmed, that a 24 to 36 month period is necessary to develop a manufacturing facility for heat pumps.[25] Thus to be ready for 2025 the construction processes and support scheme for heat pump manufacture in the UK would need to be developed promptly.

It has been reported that there will also be a need for a considerable increase in the number of qualified heat pump installers if the 300,000 target is to be achieved.[26] The UK is said to currently have approximately 1,200 qualified installers, whereas the Heat Pump Association believes that just under 10,000 qualified installers will be required by 2025,[27] increasing to 44,000[28] by 2035. If this is to be achieved immediate action is required.

Certain manufacturers offer free training seeking to attract new installers to the sector. Thus, the constraint may not be heat pump availability, but the number of installers available.[29]

This could also be thought of as a considerable opportunity/ requirement for technical colleges and other training providers to put in place applicable training courses and set certification standards for installers as the install rate for heat pumps rises.

The Future homes Standard essentially narrows the choice of heating systems to heat pumps, thus care must be taken not to choose a technology too early

The Future Homes Standard specifies that the heating system for new homes must be low-carbon (specifically stating 'e.g., a heat pump') and is characterised as 'low flow temperature' which means that a traditional gas or hydrogen fuelled boiler with hot water radiators cannot be installed.[30]

The Future Homes Standard makes this technology choice even as the HyDeploy, Hy4Heat and the National Grid test facility in Spadeadam, Cumbria are testing hydrogen appliances, and manufacturers such as Baxi, Worcester Bosch and Vaillant have committed to have hydrogen boilers available from 2025.

The Future Homes Standard also states that direct electric heating should only be used in homes that have an extremely low heat demand.[31] The other option considered by the Future Homes Standard is the use of heat networks, which the Climate Change Committee believes will be a significant contribution to meeting net-zero targets.[32] However, as most areas have a heat density too low to allow heat networks to be cost-effective[33] individual heating systems are likely to be the chosen technology for the majority, unless an alternative technology is developed which is compliant with the Future Homes Standard.[34]

In specifying heating systems in this way the Government has effectively narrowed the heating technology choice to heat pumps. Thus, the Government must be careful not to pick a heating technology winner ahead of completing pilot studies on the effectiveness of other heating options.

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25 Ibid, Pg. 90
26 Ibid, Pg. 18
27 The Heat Pump Association 'Delivering Net Zero' www.heatpumps.org.uk Pg. 20
28 It should be noted that a number of qualified installers does not equate to persons working full time in the heat pump sector as a qualified heat pump installer may well also install gas boilers or take on other work, these figures represent the number of people necessary to give the required flexibility to install the target number of heat pumps
29 Department for Business, Energy & Industry Strategy (BEIS), Prime Minister's Office, 10 Downing Street, 'The Ten-Point Plan for a green industrial revolution' (2020) Available online: https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution
30 Ibid
31 Ibid – Pg. 15
32 https://www.gov.uk/guidance/heat-networks-overview
33 Committee on Climate Change 'Research on district heating and local approaches to heat decarbonisation Annex 1: Overcoming barriers to district heating' (2015) https://www.theccc.org.uk/wp-content/uploads/2015/11/Frontier-Economics-for-CCC-Research-on-district-heating-and-overcoming-barriers-Annex-1.pdf
34 Department of Energy & Climate Change, 'The future of heating: Meeting the challenge' (2013) https://www.gov.uk/government/publications/the-future-of-heating-meeting-the-challenge

A Heat pump costs more to install than a gas boiler and is likely to cost more to run than a new 'A rated boiler'

The capital cost (purchase price) of a heat pump is between £6,500 and £8,600 more than a new A rated gas boiler. Additionally, a heat pump is estimated to cost between £95 and £110 a year more in energy costs to run than an A rated boiler.

By contrast the incremental cost of a hydrogen boiler is forecast to be only £100 more than that of a gas boiler.[35]

Whilst heat pump technology provides a solution to decarbonising new homes, the figures above indicate that they cannot be justified purely on economic grounds.

The cost of a heat pump is a material component of the cost of developing a new home

House builders may seek to pass on the increased capital costs of heat pumps to home buyers, despite new house prices being effectively capped at a level set by the existing housing market (after allowing for a 'new homes premium'). As a result, the costs of the heat pump system will be shared between the house builder, the seller of the land upon which the new development is situated and, to a lesser extent the house buyer.

This additional cost may reduce the desire of landowners to sell, house builders to construct on certain sites and ultimately purchasers to buy, hence there may be a curtailment to the supply of new homes at a time when Government is looking to increase the numbers of new homes.

The increased use of heat pumps will be challenging in terms of the connection capacity of the electrical distribution network

The transition from gas to electric heating will increase the connection capacity required for homes from 9kW to circa 14.3kW, and this will increase further if new homes need to be made electric vehicle ready.[36] The electricity regulator (Ofgem) has stated that the provision of this level of increased connection capacity will require significant network reinforcements. This could both slow down the connection of new homes and potentially raise costs for consumers.[37] To mitigate against these issues, electricity network companies are working to understand how these loads can be time shifted using smart technology so they are not simply stacked on top of each other but have a diversity of occurrence. This will require time to complete.

The 2025 implementation date for the Future Homes Standard is out of step with key upcoming reforms to how the electricity distribution networks will be managed and charged for (i.e., the new price control mechanism, RIIO ED2, running from 2023 to 2028 and the load diversity work outlined above) jeopardising the success of the ramp-up of heat pumps.

Implementing the Future Homes Standard in 2028 would allow the load diversity work to be completed and fully embedded in network planning custom and practice. Also the implementation of this new load diversity technical guidance would be synchronised with the following electricity price control period (ED3) which starts in 2028.

35 https://www.theccc.org.uk/publication/sixth-carbon-budget: Fuel Supply pg. 63
36 The minimum recommended installation for a domestic E charge point is 3.6kW (6–10-hour overnight charging); a rapid charge point is 7kW
37 Ofgem 'Innovation Stimulus Update' BEIS briefing 14 May 2021

House builders are facing an uncertain path in preparing for the new standard

Under the Planning and Energy Act 2008, Local Authorities can set local energy efficiency standards for new homes. Some Local Authorities (for example London)[38] are currently implementing the Future Homes Standard in their consideration of planning applications whilst others are not, creating uncertainty in the market.

The Scottish Government has confirmed that all planning permissions granted before 2024 can continue to apply the buildings standard that applied at the time the planning permission was granted.[39]

The transitional arrangements[40] for the Future Homes Standard will not be determined until after the 2023 consultation on the detailed technical specification. This means that for larger developments in England there would be a need to change building design and utility connection requirements part way through a development. Interviewees have confirmed that the lack of clarity surrounding the transitional arrangements means some housing developments are being re-scheduled, placing at risk the delivery of 300,000 new homes annually.

Due to the five to ten-year gap between the implementation of the Future Homes Standard and hydrogen being available at scale there is a risk that new homes built in the coming years will not be able to access hydrogen and other low-carbon gaseous fuels

The December 2020 Energy White Paper[41] states that decarbonising the energy system over the next 30 years means replacing, as far as it is possible, fossil fuels with clean energy technologies such as hydrogen and other low-carbon gases. Hydrogen is considered an important contributor to carbon emission reduction because when used as a fuel its main by-product is water vapour.[42]

The UK's gas network companies have published a Hydrogen Network Plan which sets out how they could deliver the world's first extensive 100% hydrogen network for the 85% of UK homes connected to it.[43] Associated with this plan are a number of hydrogen test projects which act to demonstrate the deliverability of a hydrogen network.[44] Despite initial indications being favourable for a wider exploitation of hydrogen, the fully validated results from these trials will not be known until after 2025.

As a result of the Future Homes Standard a growing number of homes from 2025 would be unable to take advantage of hydrogen or other low-carbon gaseous fuels as they become available.

38 https://www.london.gov.uk/sites/default/files/fhs_consultation_response.pdf
39 https://www.gov.scot/news/setting-housing-standards-to-cut-climate-change-emissions/
40 Op.cit.1 Section 7.16 Pg. 103
41 UK Government Energy White Paper 'Powering our Net Zero Future' (December 2020, CP 337) https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future
42 Sema Baykara, 'Hydrogen: A brief overview on its sources, production and environmental impact' (2018) 43(23) International Journal of Hydrogen Energy
43 Energy Networks Association, 'Britain Hydrogen Network Plan' January 2021 https://energynetworks-newsroom.prgloo.com/news/gas-grid-companies-plot-course-to-britains-first-hydrogen-town
44 Details of these projects can be found in Appendix D

Coordination of the Future Homes Standard with other Government policies and initiatives

In addition to the Future Homes Standard the Government has other related policies and initiatives which seek to reduce carbon emissions from buildings such as:

- Improving the way businesses use energy, supporting a 20% reduction in business energy use by 2030, via initiatives such as Industrial Heat Recovery Support Programme and the Industrial Energy Transformation Fund.
- Promoting heat networks in areas of denser heat demand, through the Heat Networks Investment project.
- The Heat Policy Roadmap published in 2020.

Considering the initiatives outlined above any decisions related to the Future Homes Standard should be coordinated with these initiatives and the Heat Policy Road Map. Thus, care should be taken not to make decisions for new homes which would foreclose heat options which will only be fully considered during the journey envisaged by the Heat Policy Road Map.

UK consumers may not be aware of the practicalities of heat pumps, resulting in an inferior customer experience and curtailing deployment

Consumers are generally not aware that domestic heating is a significant source of carbon emissions hence, without an education programme, there may not be the demand from prospective homeowners to buy homes with heat pumps or install them in existing homes. Therefore, building on the public awareness of climate change likely to stem from the COP26 meeting in Glasgow in November 2021, a public communication programme can help to improve the knowledge of domestic carbon emissions that could expand public familiarity of low-carbon heating.

Increased public awareness is needed, as according to a survey conducted by National Grid, only 20% and 18% indicated they are familiar with Ground Source Heat Pumps (GSHP) and Air Source Heat Pumps (ASHP) respectively, despite Government schemes such as the Renewable Heat Incentive being available for both types of heat pumps.

This communications programme should also improve consumer knowledge surrounding the operation of low-carbon heating as this will maintain customer experience and reduce operational costs. Ensuring an acceptable consumer experience of low-carbon heating will be critical to its wide deployment.[45] As UK consumers have been found to lag behind other countries in accepting and understanding low-carbon heating technology,[46] the public information campaign should be multifaceted.

45 Op.cit. 27
46 Ibid, Pg. 12

Diagram E1: Current Future Homes Standard timeline and illustrative timetable to address the recommendations

1 Undertake an impact assessment on the details of the Future Homes Standard (see recommendation #1).

2 To have UK manufacturing capacity available at the start of 2025, planning and construction needs to start immediately (see recommendation #7).

3 The supply chain for building fabric needs to start pre-production planning and testing no less than 12 months ahead of need (see recommendation #2).

4 The UK has only 1,200 heat pump installers currently. A robust training and certification scheme is needed to bring this to broadly 10,000 by 2025 (see recommendation # 8).

5 Hydrogen boilers and alternative heat technologies can be available by 2025 provided support frameworks are commenced promptly (see recommendation #5).

6 Consumer education and public communication will be vital to the delivery of a low-carbon heating strategy (see recommendation #9).

7 To design a housing development and obtain planning permission with an 'on site' date of 2025 the process needs to start in early 2022 (see recommendation # 3).

8 To have a connection to the electricity distribution system available for 2025, the process needs to start by the end of 2022 – Access and Regulatory reviews conclude after this date (see recommendation #4).

9 Electricity distribution companies submit their business plans to Ofgem end 2021/early 2022, some 3 to 4 years ahead of Future Homes Standard implementation (see recommendation #4).

Recommendations

Considering the findings set out above the following recommendations are proposed:

Recommendation 1 – Undertake an impact assessment for the Future Homes Standard

Undertake an impact assessment for the Future Homes Standard, so that any decisions made in relation to the Standard are robustly based on the assessment.

Recommendation 2 – Bring forward the consultation on building fabric and legislation for the Future Homes Standard

Bring forward the consultation on the building specification/ fabric elements of the Future Homes Standard planned for 2023 and legislation planned for 2024.

Recommendation 3 – Provide planning continuity for house builders

Consider a phased implementation of the Future Homes Standard to allow committed developments to proceed based on the planning permission already granted to prevent delays to housebuilding that may lead to Government homebuilding targets not being met.

Recommendation 4 – Coordinate the implementation of the Future Homes Standard with electricity and gas network planning and regulatory milestones

Coordinate the implementation of the Future Homes Standard with the network load planning guidance on heat and electric vehicle load, the report back from the hydrogen network trials that are in progress and the electricity price control period in 2028 (ED3).

Recommendation 5 – Hydrogen integration

Implement the Future Homes Standard such that it is coordinated with the availability of data from the hydrogen pilot projects currently ongoing to reduce emissions from across the economy.

Recommendation 6 – Improve clarity on regulatory reforms

Providing more clarity around network charging and other reforms would help housebuilders and others to plan more effectively for the planned ramp-up of heat pumps. Without this clarity, the risks of delays to housebuilding and the necessary network reinforcement will increase.

Recommendation 7 – Provide support for the supply chain to increase UK heat pump manufacturing capacity

With limited UK heat pump manufacturing capacity available, if the implementation of the Future Homes Standard is to be based on UK manufactured heat pumps, a support scheme (including start-up grants and innovation funding) should be put in place as soon as possible.

The support scheme's design will need to consider applicable State Aid and competition implications.

Recommendation 8 – Provide support for heat pump installer training

To address the potential qualified installer skills shortage, a training support and installer certification scheme should be put in place.

Recommendation 9 – Undertake public communications to increase consumer acceptance

A public communications programme, coinciding with COP26 and continuing thereafter, would help to increase awareness of the significant carbon emissions from homes and increase acceptance of low-carbon heat technologies.

1. Introduction

Ernst & Young LLP has been engaged by the Independent Networks Association to undertake a review of the Future Homes Standard and associated changes to the Building Regulations. The review specifically considers the impact of the transition to low-carbon heating (with low temperature radiator systems such as heat pumps). This effectively prohibits the installation of gas boilers in new homes from 2025.

In writing this report the need to decarbonise the economy to combat climate change is recognised and acknowledged.

This report considers the Future Homes Standard in the context of other Government decarbonisation policies and initiatives such as the drive for additional renewable energy capacity, together with the pathway to the decarbonisation of heat and transport.

In considering the Future Homes Standard and how to reduce carbon emissions it should be noted that the externalities associated with climate change mean that the true cost of emissions are not always included in energy usage.[47] Additionally, information is not readily available on long term energy prices, and therefore it may not be possible for consumers to make robust decisions on the value of the energy performance of buildings. As a result, regulation such as the Future Home Standard is needed to drive change.

Gas is one of the key elements of the UK's energy mix, accounting for circa 30% of the United Kingdom's energy production. Gas is particularly important for electricity generation as well as space heating, both residential and across the economy. The importance of gas as an energy source is illustrated in Table 1, which shows the portion of gas used for heat and total energy usage in several sectors:[48]

Table 1: Gas usage by sector (2019)

	Heat	Total Energy
Residential	77%	65%
Services	63%	40%
Industry	59%	46%
Electricity Generation	n/a	41%

Energy use in the residential sector is responsible for 22% of the UK's carbon emissions.[49] In recognition of this level of emissions it is Government policy to reduce the sector's carbon emissions to meet UK Climate Change Act targets.[50] Hence the Government's Ten-Point Plan[51] outlines a number of initiatives to reduce the emissions from the sector, including (i) the use of hydrogen, (ii) the installation of 600,000 heat pumps, (iii) improving the energy efficiency of 2.8mn homes and brining 1.5mn homes to an EPC rating of C or better and (iv) putting in place the Future Homes Standard.

47 Joyashree Roy, Duke Ghosh, Anupa Ghosh and Shyamasree Dasgupta, 'Fiscal Instruments: Crucial Role in Financing Low Carbon Transition in Energy Systems' (2013) 5 Current Opinion in Environmental Sustainability 261

48 BEIS, Digest of UK Energy Statistics 2020: Electricity, Table 5.1 https://www.gov.uk/government/statistics/electricity-chapter-5-digest-of-united-kingdom-energy-statistics-dukes; BEIS, Energy Consumption in the UK, 2019, End Use Tables, Table U3 (domestic – heat includes space heating, water heating, and cooking), Table U4 (industry – heat includes high temperature processes, low temperature processes, drying/separation, and space heating), Table U5 (services – heat includes hot water and heating) https://www.gov.uk/government/statistics/energy-consumption-in-the-uk

49 Op.cit.1Section 1.2 pg. 7

50 www.legislation.gov.uk/ukdsi/2019/9780111187654/contents – see also The Climate Change Act 2008 (2050 Target Amendment) Order 2019

51 Op.cit 29

Diagram 1: Current Future Homes Standard timeline and illustrative timetable to address the recommendations

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1.1 Background

The Intergovernmental Panel on Climate Change (IPPC) in its first assessment report in 1990, stated that the greenhouse effect[52] was real, increasing and caused by human activity.[53] Additionally, reports from the 2006 Stern Review[54] to the 2018 Graham Institute Study[55] have indicated a need to act on climate change and have contributed to the placing of environmental protection at the centre of energy policy, due to the reported economic,[56] environmental[57] and social/ethical[58] costs of failing to mitigate climate change.

With this as a background, the UK has set a path to achieve a status of net zero[59] carbon emissions[60] by 2050 to reduce the environmental impact of human activity.[61] The Committee on Climate Change has said that getting to net-zero is 'technically feasible but highly challenging',[62] thus doing so will require sustained policy interventions across several sectors – many of which will be complex, costly and time-consuming. Since 1990, the UK has reduced emissions by 43% overall,[63] but this achievement is not uniform across all sectors, with domestic emissions only falling by 14% in that period.[64]

1.2 Purpose of this report

This review of the Future Homes Standard covers regulatory, policy, supply chain, economic and social elements, based on the assumption that the direction of travel to a 'net-zero' carbon emission point is beneficial for society.

The purpose of this report is to review the Government's findings in relation to 'The Future Homes Standard'.[65] In particular, this report seeks to present:

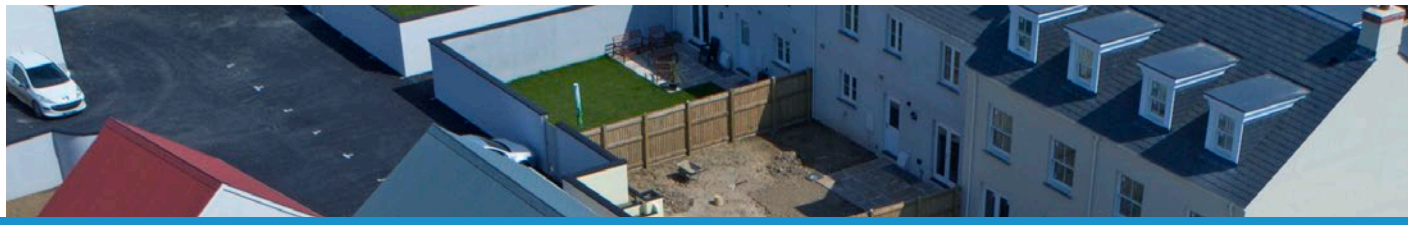
- The interaction of the Future Homes Standard with other Government policies such as improving housing affordability,[66] levelling up economic performance across the UK[67] and COVID-19 pandemic related economic recovery[68] including the Government's acceptance of the Climate Change Committee's recommendation to target a 78% reduction in carbon emission by 2035.[69]
- The need for a clear pathway in the implementation of the Future Homes Standard.
- How other initiatives, such as the use of hydrogen as an alternative to natural gas, could affect the analysis and conclusions reached on options chosen and the implementation timing of the Future Homes Standard.

52 The Climate Change Act 2008 – see Glossary greenhouse gas
53 The Intergovernmental Panel on Climate Change 'Report Prepared for IPCC by Working Group 1' Intergovernmental Panel on Climate Change (IPCC) -; Also known as John Houghton, Gareth Jenkins, J Ephraums (Eds.), Climate Change: The IPCC Scientific Assessment, (Cambridge University Press, 1990), pXI www.ipcc.ch/ipcreports/far/wg_i/ippc_far_wg_i_full_report.pdf;)
54 Nicholas Stern, 'Stern Review: The economics of climate change', (2006), Report presented to the UK Prime Minister and the Chancellor of the Exchequer on the Economics of Climate Change. http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm
55 Simon Dietz, Alex Bowen, Baran Doda, Ajay Gambhir, and Rachel Warren, 'The Economics of 1.5°C Climate Change' (2018) 43 Annual Review of Environment and Resources
56 William Nordhaus The Climate Casino: Risk Uncertainty and Economics of a Warming World (Yale University Press, 2013)
57 Daniel Bodansky The Art and Craft of International Environmental Law (Harvard University Press, 2010)
58 Stephen Gardiner, Simon Caney and Dale Jamieson Climate Ethics: Essential Readings (Oxford University Press, 2010)
59 Net-zero see glossary
60 Carbon Gases see glossary
61 Net-zero – The UK's contribution to stopping global warming, The Committee on Climate Change, 2019 https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/
62 Committee on Climate Change, Net Zero: The UK's contribution to stopping global warming, 2 May 2019, www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/
63 BEIS, Final UK greenhouse gas emissions national statistics 1990–2018, Table 3 https://data.gov.uk/dataset/9568363e-57e5-4c33-9e00-31dc528fcc5a/final-uk-greenhouse-gas-emissions-national-statistics
64 Office for National Statistics, October 2019, Figures 11–12 https://www.ons.gov.uk/economy/nationalaccounts/uksectoraccounts/compendium/economicreview/october2019/Thedecouplingofeconomicgrowthfromcarbonemissionsukevidence
65 https://www.gov.uk/government/consultations/the-future-homes-standard-changes-to-part-l-and-part-f-of-the-building-regulations-for-new-dwellings
66 Op.cit. 3
67 Op.cit 4
68 Op.cit 5
69 https://www.gov.uk/government/news/uk-enshrines-new-target-in-law-to-slash-emissions-by-78-by-2035

1.3 Structure of this report

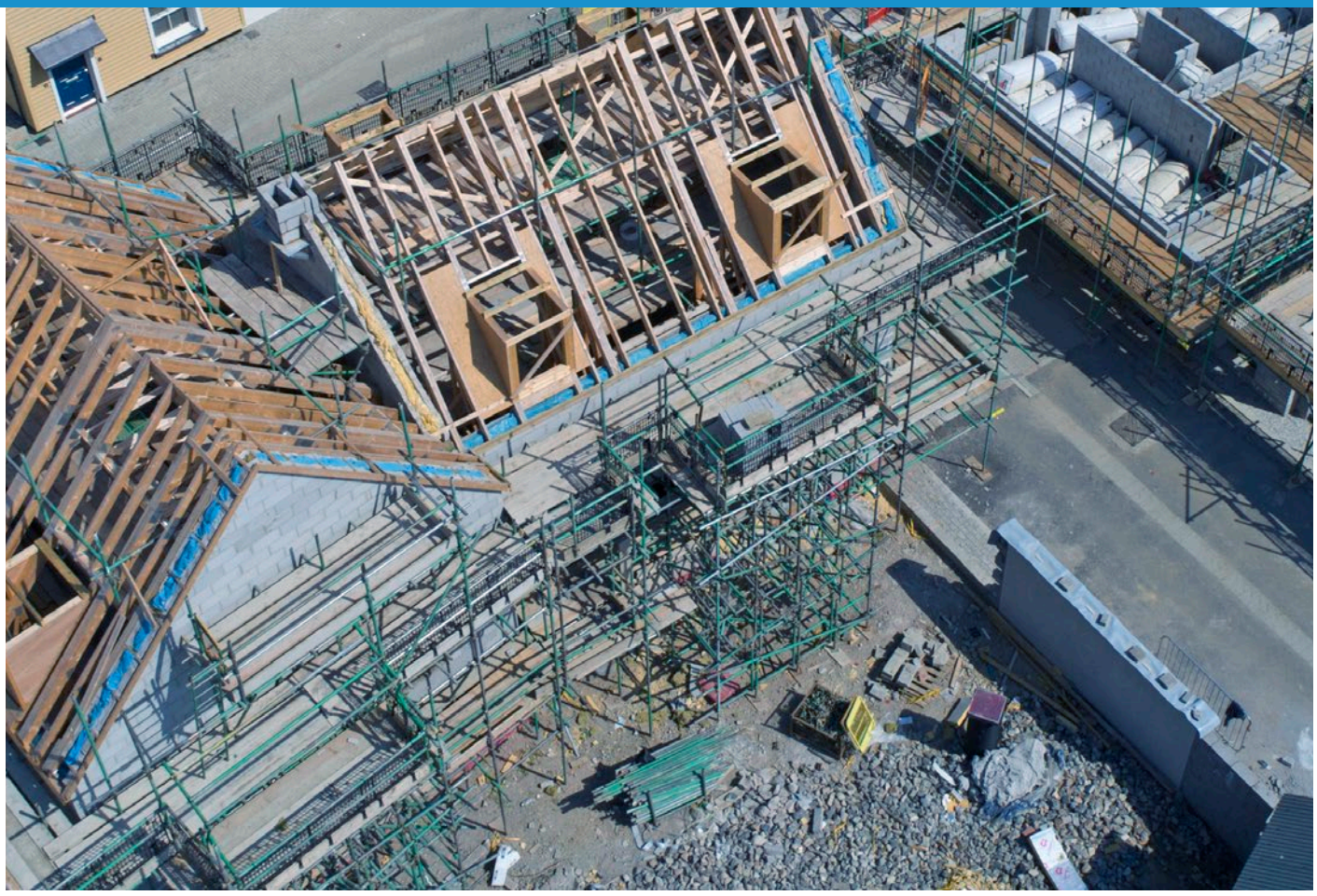
The report is structured as follows:

- Section 1 introduces the report, its context and structure.
- Section 2 presents an overview of the Future Homes Standard and other Government policies with which it interacts.
- Section 3 considers how low-carbon technologies can be used to reduce emissions and assist in achieving a net-zero emissions position.
- Section 4 outlines an analysis of the impacts of the Future Homes Standard.
- Appendix A provides a glossary.
- Appendix B provides the list of the interviewees who have provided input to the study.
- Appendix C sets out the background and basis of the Future Homes Standard
- Appendix D sets out brief details of a number of projects to assess the transition pathway from gas to hydrogen.
- Appendix E outlines details of a selection of national policies on the development of hydrogen as an alternative to gas.
- Appendix F illustrates the implications and costs associated with the development of a large scale UK hydrogen generation sector.



2. Future Homes Standard

Heating and powering the residential sector accounts for 40% of the total energy usage in the UK,[70] amounting to 22% of the UK's greenhouse gas emissions.[71] Accordingly, reducing carbon emissions from homes is essential to meeting the net-zero emission target set by Government.



70 Department for Business, Energy & Industrial Strategy, 'The Grand Challenge Missions' (26 Jan 2021). Available online: https://www.gov.uk/government/publications/industrial-strategy-the-grand-challenges/missions

71 Op.cit.1

This section provides an overview of the Future Homes Standard: 2019 Consultation on changes to Part L (conservation of fuel and power)[72] and Part F (ventilation)[73] of the Buildings Regulations for new dwellings, specifically the impact of the decision to implement low-carbon heating in new homes from 2025, effectively prohibiting the installation of gas boilers. Without the imperative of heating homes with gas, it is likely new homes will not be connected to the gas network as the cost of the gas connection for cooking would be prohibitive. It is also unlikely these homes would be retrofitted with a gas connection in the future for cost reasons.

The process to fully implement the Future Homes Standard in 2025 has set out a graduated pathway with, for example, certain changes to Part L (conservation of fuel and power – effectively insulation, glazing, etc.) being implemented in 2021.

2.1 Building Regulations (change to Part L and F for new homes)

2.1.1 Overview and vision of the 2019 consultation

In the 2019 Spring Statement, the Government announced that it would introduce a Future Homes Standard to future-proof the housing sector by introducing low-carbon heating and world-leading levels of energy efficiency.[74] The underlying target was to reduce carbon emissions from new homes by at least 75% compared to homes built under the then current Building Regulations.[75]

A consultation[76] document was published in October 2019, on proposed changes to the Building Regulations Part L (conservation of fuel and power), Part F (ventilation) and the Future Homes Standard.

In January 2021, the Government published its response and confirmed that all new homes will require insulation levels of the highest standards and be equipped with low-carbon heating by 2025, effectively prohibiting fossil fuel heating such as gas boilers[77] and becoming what is known as the Future Homes Standard. The January 2021 Government response document sets what is clearly a 'fabric plus technology' policy, that is to say it seeks to both increase the insulation standards of homes to reduce overall energy demand and mandates low-carbon heating. However, in declaring that the heating must have a low flow temperature the Government has effectively narrowed the heating technology choice to heat pumps. With this in mind, care must be taken not to pick a heating technology winner before trials of alternative technologies have concluded.

72 Conservation of fuel and power – in effect the insulation levels of new homes
73 Ventilation – the air tightness of new homes
74 HM Treasury and The Rt Hon Philip Hammond, 'Spring Statement: Written Ministerial Statement' (13 March 2019) https://www.gov.uk/government/publications/spring-statement-2019-written-ministerial-statement
75 Op.cit 1
76 The Consultation ran from 1 October 2019 to 7 February 2020. A total of 3,310 individual responses to the consultation from a wide range of stakeholders including Designer/Engineer/Surveyor (1,449 responses), Local authorities (247 responses), Builder/Developer(134 response), Manufacturer/Supply chain (88 responses), Energy sector (83 responses), Professional body or institution (56 responses), Installer/Specialist sub-contractor (51 responses), National representative or trade body (48 responses), Property management (37 responses), Building control approved inspector (15 responses) and Competent persons scheme operator (7 responses).
77 Op.cit. 1

David Thomas, CEO of Barratt Homes, felt the choice of heating technology should be driven by the overall need to reduce carbon emissions from homes and it should be for the housing industry to make the choice of technology.

> The Future Homes Standard should define the carbon standard of new homes, driving the industry to identify and make a long-term investment in the best technological solutions.
>
> **David Thomas**
> **CEO of Barratt Homes**

The January 2021 Government response document also sets out a timetable which includes an interim upgrade to the Building Regulations in late 2021, consultative steps in 2022/23 and potential legislation to introduce the Future Homes Standard in 2024.

2.1.2 No impact assessment for the Future Homes Standard

Ahead of implementing policies there is a general expectation that Government departments will undertake an impact assessment,[78] which is an analysis used to inform policy decision-making by using cost-benefit analysis to build a robust evidence base.[79]

The full impact assessment on the Future Homes Standard will only be prepared after the full technical details consultation planned for spring 2023.[80] However, neither the Government response to the consultation on the Future Homes Standard, nor the original consultation[81] were accompanied by a departmental analysis of its impact.[82]

Additionally, Section 1.3 of the impact assessment for building fabric and ventilation, states that the Future Homes Standard is not part of the impact analysis, although it is noted that a consultation on the full technical specification and impact assessment has been confirmed to take place in 2023.

With the details of the technical specifications associated with the Future Homes Standard not being available until 2023 and no impact analysis being undertaken until after the validation of the Future Homes Standard, which could be 2024, this does not currently comply with Section 1.2.3 of the Better Regulation Framework Interim Guide.[83]

In order to prevent any potential challenge to the implementation of the Future Homes Standard an impact assessment should be conducted and published promptly.

An impact assessment has been published in relation to the 2021 initial step.

78 Op.cit. 10
79 Ibid. p. 11
80 Op.cit.1, p.5
81 Op.cit.1
82 MHCLG did publish an impact assessment alongside its consultation in 2019, but the impact assessment focused on updates to the standards for new houses in 2021 and did not cover setting the standard for new houses such that they cannot be built with fossil fuel heating from 2025 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/836925/REQUEST.pdf
83 Op.cit. 10

2.1.3 2021 Initial implementation

As an initial step towards the implementation of the Future Homes Standard, an upgrade to the fabric of new homes has been put in place for October 2021. The assessment of the 2021 initial step uses four new performance metrics,[84] based on a 'fabric-first approach' and the belief that such an approach will provide a smoother transition to the Future Homes Standard and the introduction of heat pumps in new homes.[85] Within the responses to the Government's consultation and interviews undertaken in the process of drafting this report the 'fabric first' approach was welcomed, for example:

> "Energy efficiency of the UK housing stock is a clear issue. We should be very much focused on the building's fabric with loft insulation, cavity wall insulation and double glazing being a priority, ensuring this is right. This is particularly important before sizing and installing a heat pump system, but equally relevant to reducing the carbon emissions from gas-based heating.
>
> **Steve Keeton**
> **Director of External Affairs and Future Portfolio at Vaillant Group**

The initial step to be implemented in 2021 will deliver a 31% reduction in carbon emissions from new homes. The proposal still allows the installation of a gas boiler, provided there is a wastewater heat recovery system and photovoltaic (solar) panels installed on the house. The economic analysis of this option indicates that there would be a £4,850 increase in capital costs, with a reduction in annual running cost of £260.[86]

The main benefit put forward by Government in relation to the 2021 'initial step' is that it has the potential to increase the capacity of supply chains and readying skills prior to the introduction of the Future Homes Standard. However, the 2021 'initial step' is focused on the building's fabric rather than heating, when it is the availability of UK manufactured heat pumps and qualified installers that are the concern of the industry, as outlined in Section 4.3. Therefore the 2021 initial step may not be focused on those parts of the supply chain which are the industry's main concern for 2025.

2.1.4 2023 Consultation on building fabric and heating systems

A further consultation on the exact nature of the building's fabric specification for compliance with the Future Homes Standard is not due until the spring of 2023, thus the specification will not be available to house builders until late 2023 or early 2024. This means that the exact 'recipe' for the fabric of new houses may not be known until close to the current implementation date for the Future Homes Standard in 2025.

Therefore, putting in place a robust supply chain in the period between confirmation of the fabric specification for new homes and the implementation of the Future Homes Standard will be challenging.

84 i) primary energy target; ii) carbon dioxide emissions target; iii) fabric energy efficiency target and iv) minimum standards for fabric and fixed building surfaces. Op.cit 1. p.30
85 Ibid. p.38
86 Op.cit, 14 p.11–12

2.1.5 2024 Legislation for the Future Homes Standard

The legislative underpinning of the Future Homes Standard will be placed before Parliament during 2024. Should either (i) other legislation become delayed which has a knock-on effect on the timetable for the Future Homes Standard legislation, or (ii) the Future Homes Standard legislation itself become delayed, the legislation could be approved very close to the currently proposed implementation date of 2025.

2.1.6 Transition to the Future Homes Standard[87]

In addition to some of the responses to the Government's 2019 consultation on the Future Homes Standard, several interviewees for this report stated that they would like greater clarity on the transition process to the Future Homes Standard, and in particular a clear road map to implementation. They commented that the timing of the building standard consultation (in 2023), and legislation not being placed before Parliament until 2024, did not give sufficient clarity on the implementation approach and its timing.

> "The Future Homes Standard brings a number of important changes needed in the drive for net-zero, but guidance from Government is needed on making the transition work.

Vicki Spiers
Chair of the Independent Networks Association

> "The Future Homes Standard has the potential to disrupt the housebuilding market therefore Government guidance is required to provide certainty. The worry is for inflight connection projects. There is a real potential for a hard stop on connecting housing developments.

Clive Linsdell
CEO of BUUK

In seeking to deliver the Future Homes Standard, consideration should be given to a revised timetable so that the detailed specifications are made available prior to the current timeline envisaged for 2023. This would allow the associated consultation process to take place and house designs and supply chains to be put in place in readiness for the 2025. Additionally, several interviewees stated they would like to see the legislation brought forward from 2024.

87 Reducing UK emissions: 2020 Progress Report to Parliament, Committee on Climate Change (2020) https://www.theccc.org.uk/publication/reducing-uk-emissions-2020-progress-report-to-parliament

2.2 Overview of relevant Government policies and their interaction with the Future Home Standard

To help deliver net zero carbon emissions and economic recovery the Government has put in place a considerable number of policy initiatives. These policies include not only the Future Homes Standard but also include the desire to build 300,000 new homes per year (Section 2.2.1), both of which are administered by the Ministry of Housing, Communities & Local Government. In addition, there are a number of policies being administered by the Department for Business, Energy and Industrial Strategy, such as clean growth, transforming heat, heat and buildings, plus hydrogen. One of the determinants of success will be the coordination of these policies across Government, making sure that an individual policy does not disadvantage the chance of success of other policies.

2.2.1 New homes agenda

2017 Budget target of 300,000 new homes per year

In 2017, the Government announced its ambition to increase the levels of housebuilding in order to make housing more affordable by building more homes where needed by consumer demand, usually coinciding with areas of economic growth.[88] Despite the Government's support for home ownership such as 'Help to Buy schemes', home ownership rates have declined by 20% since 2003-4. The Government believes the decline in home ownership has an economic effect on the younger generation as its productivity and employment opportunities are reduced.[89] Accordingly, section 5 of the 2017 Budget sets out a New Homes Agenda, which aims to deliver 300,000 homes per year by 2025.

The Government has announced the prospectus for the 2021–26 Affordable Homes Programme, with plans to build up to 180,000 new homes.[90] On the basis that occupiers of these homes will be those least able to afford higher energy costs and the Energy Savings Trust showing that a heat pump could cost between £95 to £110 per year more to run than a modern A rated gas boiler,[91] the occupiers of these affordable homes are placed at risk of fuel poverty by the Future Homes Standard.

The 2021 Queen's Speech set out plans to simplify the planning system to allow housing developments to be taken forward with greater speed. It was affirmed that the current system does not lead to enough homes being built, particularly in areas of greatest need.

The Planning White Paper is seeking to remove any systematic delays in the planning system. Thus, robust plans and support mechanisms must be put in place to ensure the lack of a UK heat pump supply chain, lack of capacity in the electricity networks or lack of qualified heat pump installers do not become an impediment to the building of new homes.

Qualitative analysis of a delay to providing 300,000 new homes

Whilst the plan to build 300,000 new homes and achieve net zero are not mutually exclusive, a coordinated plan is needed to build the homes the UK requires whilst protecting the environment.[92]

The target of 300,000 new homes a year by 2025 makes house builders reliant on the following:

- Electricity distribution companies (due to the increased electricity requirements of heat pumps).
- Local authorities for grant of planning permission.
- The supply chain being able to deliver heat pumps and installers to the required quality and volume.
- Consumer acceptance and understanding of low-carbon heating systems in new homes.

88 Op.cit. 3
89 Ibid. within citation English Housing Survey headline report 2015 to 2016: section 1 household tables', Department for Communities and Local Government, March 2017. Percentage change in homeownership for 25-34 year olds was 20.4% between 2003-04 (58.6%) and 2015-16 (38.2%)
90 https://www.gov.uk/guidance/apply-for-affordable-housing-funding
91 https://energysavingtrust.org.uk/advice/air-source-heat-pumps/
92 Op.cit.1 p.13

The Future Homes Standard is currently scheduled to be implemented in 2025. In looking to deliver new homes house builders will seek to obtain planning permission for the totality of a development, which for some larger developments may have a construction programme which spans the 2025 date. This requires a change to building design and utility connection requirement part way through a development. Some interviewees stated that the lack of clarity surrounding the transitional arrangement and the uncertainty in the housing market meant some developments were being deferred, thus placing at risk the 300,000 new homes target.

> “
>
> The UK Government's transitional arrangements uncertainty is already impacting the speed of housing development. The current ambiguity is in stark contrast to the clarity already provided by the Scottish Government.
>
> **Mike Pearce**
> **CEO of Last Mile**

The Scottish Government has confirmed that all planning permissions granted before 2024 continue to apply and the Buildings Regulations that applied at the time the planning permission was granted can be used until the homes granted permission are completed.[93]

Additionally, local authorities retain their powers under the Planning and Energy Act 2008 to set local energy efficiency standards for new homes. For example, whilst England generally is implementing the Future Homes Standard via transitional arrangements focused on 2025, some local authorities are applying the requirements of the Future Homes Standard in their planning decisions now (e.g., Greater London Authority who set overall planning standards for London).[94]

In relation to the current use of the known details of the Future Homes Standard by local authorities, Mike Pearce said

> “
>
> There needs to be specific advice on how local authorities should use the new standards[95] in granting planning permission to ensure a uniform approach.
>
> **Mike Pearce**
> **CEO of Last Mile**

Good practice example — Residential Green Retrofit Agenda

The Northern Housing Consortium has set out a roadmap to retrofit over 5mn homes in the North East, North West and Yorkshire and Humberside to achieve an EPC Rating of C by installing heat pumps in 4.6mn homes and connecting a further 1.1mn homes to a heat network[96] as a step towards achieving the net zero target by 2050. This project would require a total investment of £2.36bn a year over its first 10-years (half of which would be committed by Government funding as a minimum).

This is a substantial project and as such is forecast to deliver approximately 77,000 jobs by 2035.[97] This project is an example where housing innovation can satisfy the objectives of multiple policies, for example: The Ten-Point Plan, Future Homes Standard and the Government's 'levelling up' agenda.

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93 https://www.gov.scot/news/setting-housing-standards-to-cut-climate-change-emissions/
94 https://www.london.gov.uk/what-we-do/regeneration/regeneration-publications/design-standards-new-homes-london
95 The new standards include proposed changes to the Building Regulations, which include the uplift in Part L and F, and the Future Homes Standard that will be fully introduced in 2025.
96 Nathan Spencer, 'Northern Housing Consortium — The Residential Green Retrofit Agenda', Built Environment Networking, 5 April 2021. Available online https://www.built-environment-networking.com/news/northern-housing-consortium-retrofit/
97 Ibid.

2.2.2 Levelling Up Fund

Given substantial regional differences in economic performance across the UK,[98] 'levelling up' has been high on the policy agenda in the UK since 2003.[99] Announced at the March 2021 Spending Review, the Levelling Up Fund of £4.8bn invests in infrastructure that improves everyday life across the UK by supporting town centre and high street regeneration, local transport projects and cultural and heritage assets.[100] Whilst the Fund is open to every local area in the UK, the Government's focus is to revive left-behind towns outside of London and the South East.

The Future Homes Standard and the associated supply chain affords a unique opportunity to initiate projects that would have a direct impact on levelling-up. The target of 300,000 new homes which would be covered by the Standard provide a market for insulation and glazing, not to mention heat pumps, all of which will need additional supply capacity. The construction jobs would be transformative for an area, followed by permanent skilled manufacturing jobs.

If the projects associated with levelling up are expanded to hydrogen as a low-carbon gas, then deprived coastal towns are the very locations that could become a hub for hydrogen production. These hubs would not only comprise the hydrogen electrolyser[101] but could also be locations for the renewable generation needed for the electrolysis process.

2.2.3 Government Heat Strategy

The Government has stated it is committed to expanding the low-carbon economy whilst complying with applicable carbon budgets.[102] Government is looking at ways to cut carbon emissions from heat during the 2020s, whilst reducing reliance on subsidies. The Government outlined that it is not currently clear which heat technology will work best at scale, with different approaches needing to be tested further.[103]

The Government has affirmed it wants to develop a viable supply chain for heat pumps beyond the Renewable Heat Incentive (RHI),[104] whilst not closing off heat technology options over the longer term.

The Government has other related initiatives such as:

- Improving the way businesses use energy, supporting a 20% reduction in business energy use by 2030, via initiatives such as Industrial Heat Recovery Support Programme[105] and the Industrial Energy Transformation Fund.[106]
- Promoting heat networks in areas of denser heat demand, through the Heat Networks Investment project.[107]
- The Heat Policy Roadmap published in 2020.

Considering the initiatives outlined above any decisions related to the Future Homes Standard should be coordinated with the Heat Policy Road Map. Thus, care should be taken not to make decisions for new homes which would foreclose heat options which will only be fully considered during the journey envisaged by the Heat Policy Road Map.

98 Lord Sainsbury of Turnville "Levelling up the UK's regional economies" 2 Mar 2021. Available online https://www.centreforcities.org/levelling-up/
99 HM Treasury, 2003
100 Op.cit 4
101 Hydrogen is produced using electricity in an electrolyser to split water into hydrogen and oxygen
102 https://www.gov.uk/government/groups/heat-in-buildings
103 Ibid
104 https://www.gov.uk/government/publications/2010-to-2015-government-policy-low-carbon-technologies/2010-to-2015-government-policy-low-carbon-technologies#appendix-6-renewable-heat-incentive-rhi
105 https://www.gov.uk/guidance/industrial-heat-recovery-support-programme-how-to-apply
106 https://www.gov.uk/government/collections/industrial-energy-transformation-fund
107 https://www.gov.uk/government/collections/heat-networks-investment-project-hnip-overview-and-how-to-apply

2.2.4 Plan for Jobs

Respondents to both the Future Homes Standard consultation and the interviewees for our study expressed concern that the real challenge in meeting net zero emission target by 2050 is decarbonising the 24.4mn existing UK homes.[108]

> “A real issue is the 24.4mn existing housing stock — we need to solve the carbon emissions from these houses. Whilst the Future Homes Standard is of course very important, tackling emissions from existing houses will reduce the 22% of UK emissions from the residential sector and be more significant.
>
> **Dr. Tony Ballance**
> **Chief Regulation Officer of Cadent Gas**

Properly insulating and replacing the heating systems of the 24.4mn existing homes is a project of considerable scale.

This is on top of the 20,000 jobs the heat pump sector is forecast by Government to support as outlined in Section 4.1.2, or the 44,000 qualified installers the Heat Pump Association believes will be necessary. It should be noted that a qualified heat pump installer may also install other systems and thus this should not necessarily be seen as 44,000 full time installers, this is the number of persons qualified to install which give the necessary flexibility across the workforce.[109]

The jobs outlined in Section 4.1.2 are in addition to those to be created via the 2020 Plan for Jobs. The Plan for Jobs sets out a UK-wide policy to support job growth post COVID-19.[110] The Plan for Jobs includes a £1bn public sector decarbonisation scheme to halve greenhouse gas emissions from the public sector by 2032 by offering grants to public sector bodies to fund energy efficiency and low-carbon heat upgrades.[111]

2.2.5 Ten-Point Plan (Green Revolution)

Overview of the Ten-point plan and its purpose

In November 2020, the Prime Minister announced the Ten-Point Plan for a Green Industrial Revolution which aims to create and support up to 250,000 jobs whilst continuing commitments to tackling greenhouse gas emissions. This plan covers multiple industry sectors such as clean energy, transport, nature and innovative technologies to meet the UK’s carbon budgets and target of net zero by 2050.

108 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/886251/Dwelling_Stock_Estimates_31_March_2019_England.pdf
109 Op.cit. 27
110 Op.cit 5.
111 Ibid.

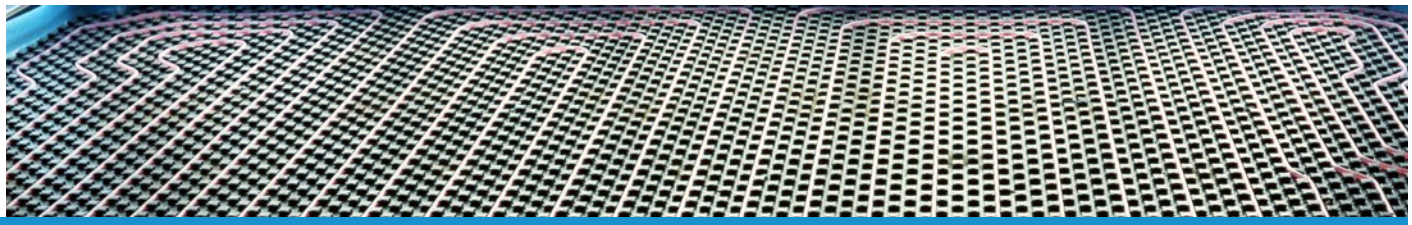
Points 2 and 7 of the Ten-Point Plan, directly affect the Future Homes Standard and energy usage within the UK:

- Point 2 'Driving the Growth of Low-Carbon Hydrogen' shows the Government's commitment to low-carbon hydrogen as an important element in achieving the net zero emissions by 2050. The Government is aiming for 5GW of hydrogen production capacity by 2030 by working with industry partners, which could deliver around 8,000 jobs by 2030, potentially 100,000 jobs by 2050 in a high hydrogen net zero scenario.[112]
- Point 7 'Greener Buildings' sets an ambition of installing 600,000 heat pumps per year by 2028, which is a combination of the 300,000 new homes built compliant with the Future Homes Standard and retrofitting in existing homes. The installation of non-fossil fuel boilers (e.g., heat pumps) is part of the drive for new homes to have at least 75% lower carbon dioxide emissions than homes built to current standards. This plan is stated to support around 50,000 jobs by 2030 and building and expanding new supply chains and manufacturing within the UK. The UK saw 1.67mn gas boilers installed in 2019.[113] Thus if 600,000 heat pumps are to be installed each year this would imply that approximately 1mn gas boilers will still be installed each year. On this basis it would seem to be a 'no regrets' policy to mandate that these boilers are hydrogen ready. Section 3.1.6 indicates that hydrogen boilers will be ready for installation by 2025 a timeline compatible with the Future Homes Standard.

Ten-Point Plan and coordinate with the Future Homes Standard

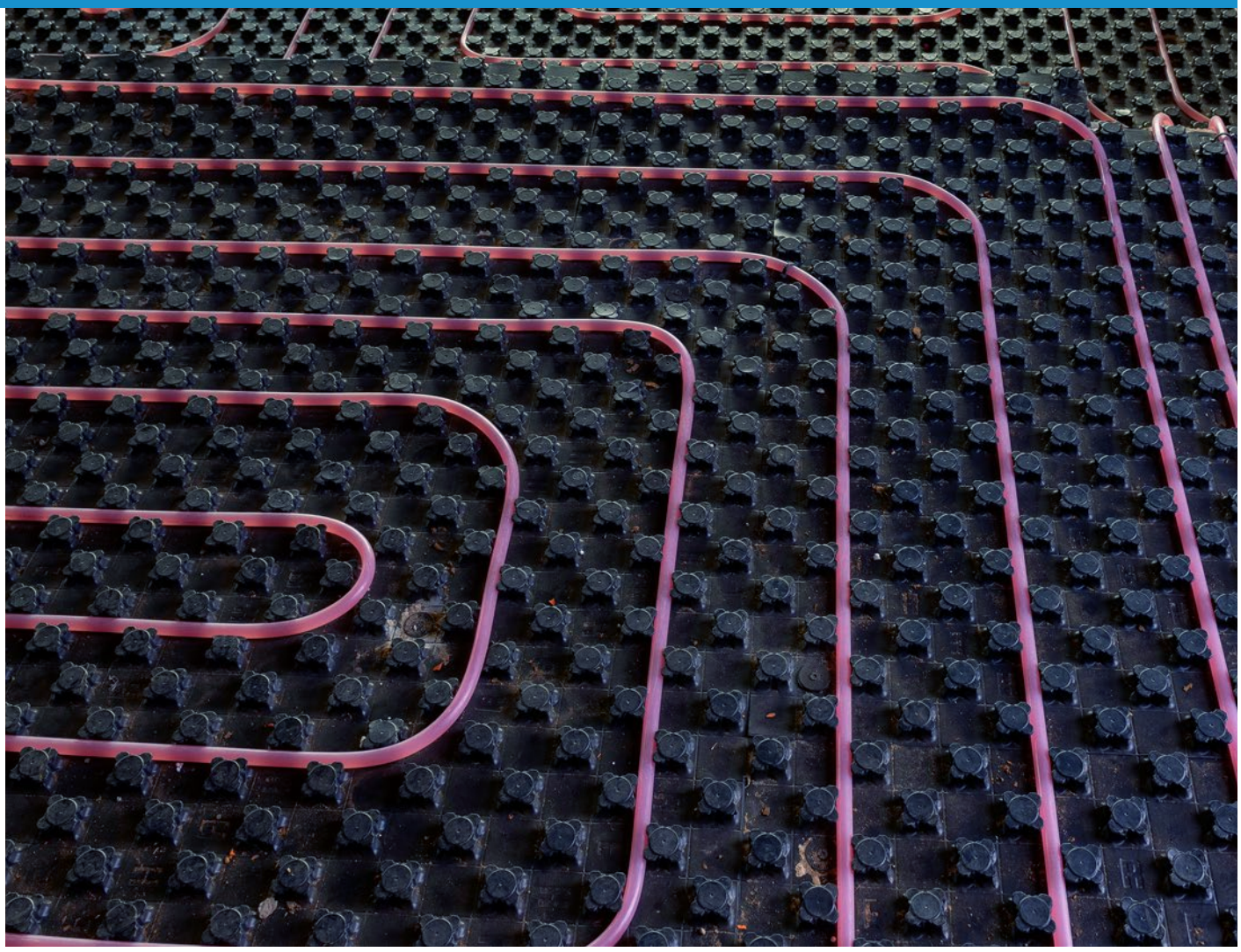
The Ten-Point Plan provides the Government's overall strategy to respond to the climate crisis whilst supporting the economy post COVID-19. This plan requires that the implementation of the Future Homes Standard is completed in the shortest possible timeline.[114] Making homes low-carbon and energy efficient is not just a heat technology problem but a systemic problem as it can only be fixed by a combination of strict fabric-first design, enhanced building standards in accordance with the Future Homes Standard, use of cleaner energy sources and innovation.[115] Therefore having the integrative aspects via the Ten-Point Plan, which covers offshore wind, hydrogen, nuclear, electric vehicles, public transport, jet zero and greener maritime, greener buildings, carbon capture and innovation, provides a systemic view to solve the current climate change and emissions issues. It is crucial the UK legislates to ensure future homes have high insulation standards with low-carbon heat technology via the Future Homes Standard to support the mandate provided by the Ten-Point Plan.

112 Op.cit 29 Pg. 10
113 https://www.eua.org.uk/record-boiler-sales-show-how-decarbonisation-will-work/
114 Ibid.
115 Op.cit 1.



3. Low-carbon technologies

This Section sets out the considerations regarding other low-carbon heating technologies that could assist in achieving net zero.



3.1 Hydrogen

This section reviews the ability of hydrogen to assist in the decarbonisation of the gas network. Hydrogen can act as an alternative decarbonised heat source where it is not possible to install enough insulation to allow a heat pump or other low temperature heat source to provide an acceptable consumer experience. It should be remembered that the so called 'town gas', widely used in the UK until the switch to natural gas in the 1970s, was broadly 50% hydrogen. Therefore the UK has considerable historical experience of a blended gas stream, a high proportion of which was hydrogen.

3.1.1 Introduction

The December 2020 Energy White Paper[116] states that decarbonising the energy system over the next 30 years means replacing, as far as it is possible, fossil fuels with clean energy technologies such as hydrogen. The White Paper maps the approach to energy system development over the period to 2050. Hydrogen can contribute to the reduction of carbon emissions within the heavy industry, power, heat and transport sectors as when used as fuel its main by-product is water vapour.[117] Hydrogen can be transported readily and as such is a versatile element in the low-carbon energy mix. One of the advantages of hydrogen is that it can be used to store the energy generated by excess output from renewable sources such as wind farms.

Around 95% of global hydrogen production is currently fossil-fuel based.[118] If hydrogen is to be part of the solution to achieving net zero it will be necessary to both change to cleaner hydrogen production methods, and achieve a major increase in its production capacity. The UK currently makes around 27TWh of hydrogen annually.[119]

The UK's Climate Change Committee has suggested a broadly ten-fold increase to 225TWh by 2050 may be required (their-so-called Balanced Scenario), to serve the power, heat and transportation sectors.[120]

Additionally, the UK's gas network companies have published a Hydrogen Network Plan which sets out how the gas network companies could deliver the world's first extensive 100% hydrogen network, for the 85% of UK homes connected to it.[121]

The main elements of the hydrogen landscape are discussed below as they interact with the Future Homes Standard.

3.1.2 The Hydrogen Road Map

If the UK's gas networks are to transition from the transport of natural gas (predominately methane) to hydrogen there is broad consensus that a series of transition steps will be required. As was outlined in Section 1.1 natural gas meets 77% of residential heating and 65% of total residential energy,[122] therefore swapping gas for hydrogen requires a well-planned transition.

To develop the transition plan, a number of gas network operators have consulted their customers and broader stakeholders to understand the requirements which a 100% hydrogen network would need to fulfil:[123]

- Maintain current levels of supply security.
- Be funded in a way that continues to be affordable for customers, to minimise fuel poverty and maintain industrial competitiveness.
- Meet net-zero emissions by transporting low or zero-carbon hydrogen (or biomethane).
- Be demonstrably safe.

116 Op.cit. 41
117 Op.cit. 42
118 CCC (2018), 'Hydrogen in a low-carbon economy' https://www.theccc.org.uk/publication/hydrogen-in-a-low-carbon-economy
119 Energy Research Partnership (2016), Role of hydrogen in the UK Energy System, http://erpuk.org/wp-content/uploads/2016/10/ERP-Hydrogen-report-Oct-2016.pdf; CCC (2018), Hydrogen in a low-carbon economy, https://www.theccc.org.uk/wp-content/uploads/2018/11/Hydrogen-in-a-low-carbon-economy.pdf
120 CCC (2019), 'Net Zero – Technical Report', https://www.theccc.org.uk/publication/net-zero-technical-report
121 Energy Networks Association, 'Britain Hydrogen Network Plan' January 2021 https://energynetworks-newsroom.prgloo.com/news/gas-grid-companies-plot-course-to-britains-first-hydrogen-town
122 BEIS, Digest of UK Energy Statistics 2020: Electricity, Table 5.1 https://www.gov.uk/government/statistics/electricity-chapter-5-digest-of-united-kingdom-energy-statistics-dukes ; BEIS, Energy Consumption in the UK, 2019, End Use Tables, Table U3 (domestic – heat includes space heating, water heating, and cooking), Table U4 (industry – heat includes high temperature processes, low temperature processes, drying/separation, and space heating), Table U5 (services – heat includes hot water and heating) https://www.gov.uk/government/statistics/energy-consumption-in-the-uk
123 Energy Networks Association, 'Britain Hydrogen Network Plan' January 2021 https://energynetworks-newsroom.prgloo.com/news/gas-grid-companies-plot-course-to-britains-first-hydrogen-town

A multi-workstream approach is required to address these issues, covering engineering, policy and regulatory, ownership and organisational structures. For example, the IMRRP[124] is already installing polyethylene pipelines to solve the iron pipe embrittlement[125] problem caused by hydrogen. Additionally, the Hydrogen Plan considers the implementation of lessons from a series of pilot schemes to understand hydrogen usage in the residential sector,[126] e.g., HyNet, GMaP (H_2 workstream) and Aberdeen Vision.[127]

In parallel to these engineering steps being taken within the network, the 2020 Energy White Paper states that the Government will continue to work with the Health and Safety Executive to enable up to 20% hydrogen blending on the network by 2023.[128]

The road map also considers the requirement for a full framework that appropriately incentivises the installation of hydrogen boilers and the production facilities necessary to deliver the required volumes of hydrogen. The first step in developing this regulatory framework is that during 2021 the UK Government will consult on the details of a revenue mechanism to incentivise private sector investment into industrial hydrogen projects.[129]

3.1.3 Hydrogen initiatives in other countries

A number of other countries have hydrogen initiatives designed to test the viability of hydrogen as an alternative to natural gas. These initiatives are important as they demonstrate a global commitment to transition away from gas, but also provide a source of comparator pathways from which lessons can be learnt and incorporated into the UK's hydrogen plans. A summary of several national hydrogen strategies can be found in Appendix E.

3.1.4 Hydrogen production

If hydrogen is to be used to decarbonise the energy sector the ideal hydrogen type is 'green' hydrogen which uses renewable/low-carbon electricity in its production and is therefore effectively zero carbon. Hydrogen production in the UK is currently 27TWh per year, with most of this being made from fossil fuels.[130] This is likely to be replaced in any drive for net zero.

The Government has stated in its Industrial Decarbonisation Strategy[131] that it will consult on the role of hydrogen during 2021. This consultation is in advance of strategic decisions on the role of hydrogen for heating. The Government has stated that it wants to assess the case for encouraging or requiring, new gas boilers to be readily convertible to hydrogen (so-called hydrogen-compatible boilers), in preparation for any future conversion of the gas network.[132]

Conclusions from the hydrogen consultation and the route forward are unlikely to be available before 2022. This means that the decisions on the Future Homes Standard, may set an unrealistic timetable for the deployment of hydrogen ready appliances and the scale up of hydrogen production facilities. As set out in Section 3.1.5 the manufacturing sector has committed to bring hydrogen ready boilers to market by 2025. Hence the Future Homes Standard and the Government's hydrogen policy may end up at odds with each other.

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124 The Iron Mains Risk Reduction Programme (IMRRP) addresses the failure of 'at risk' iron gas mains (i.e., those pipes within 30 metres of buildings) and the consequent risk of injuries, fatalities and damage to buildings. It is designed to secure public safety whilst allowing efficiency, environmental, strategic and customer service factors to contribute to driving the programme https://www.hse.gov.uk/gas/supply/mainsreplacement/index.htm

125 Hydrogen embrittlement refers to the phenomenon where certain metal alloys experience a significant reduction in ductility (becoming brittle and subject to cracking) when hydrogen penetrates the material. The term hydrogen embrittlement has been used to express the degradation of metals due to hydrogen — Yukitaka Murakami Metal Fatigue Effects of Small Defects and Nonmetallic Inclusions (Academic Press, 2019)

126 To understand how domestic appliances, react to a hydrogen blend the HyDeploy 1 trial, which injected up to a 20% blend of hydrogen by volume to 130 homes and faculty buildings at Keele University in Staffordshire, showed that gas appliances functioned normally and householders and campus businesses did not notice any differences to their gas supply. The next phase — HyDeploy 2 sees a 20% hydrogen blend being provided to 670 homes near Gateshead. These projects can be characterised as the hydrogen street (HyDeploy 1) and then the hydrogen village (HyDeploy 2) and are meant to demonstrate operational issues within proximity of the domestic setting

127 Details of these projects can be found in Appendix D

128 Op.cit. 41 pg.113 e

129 Ibid. pg.13

130 https://www.theccc.org.uk/publication/sixth-carbon-budget: Fuel Supply pg. 11

131 https://www.gov.uk/government/publications/industrial-decarbonisation-strategy

132 Op.cit. 41 pg.113

Table 2: Cost of Hydrogen Capacity

		20% of gas supply derived from Hydrogen by 2030	Climate Change Committee Balanced Scenario (225TWh by 2050)	Energy White Paper 2030 target
2030	Hydrogen Capacity	12GW delivering 100TWh	3.5GW delivering 29.5TWh	5GW delivering 42TWh
	Cumulative Capital Cost	£8.7bn	£2.53bn	£3.6bn
	UK Construction jobs in 2030	2,200	630	890
2050	Hydrogen Capacity	n/a	26.7GW delivering 225TWh	n/a
	Cumulative Capital Cost		£72.5bn	
	Construction jobs in 2050		5,000	

Table 2 sets out the volume of hydrogen production needed to assist in achieving net zero by 2050 as set out by the Climate Change Committee's Balanced Scenario and the Energy White Paper's 2030[133] target. The table also sets out an illustrative case to achieve a 20% hydrogen/gas blend in the network by 2030 as an acceleration of the Balanced Scenario. The table further provides indicative capital costs and construction jobs to achieve these ambitions (a more detailed narrative being found in Appendix F).

To produce sufficient hydrogen to achieve a 20% blend with natural gas by 2030 will require an installed capacity of approximately 12GW of production electrolysers, producing approximately 100TWh (allowing for demand reduction from the current 800TWh by 2030). Hence when the Government publishes its hydrogen strategy later in 2021 in order to facilitate a gas network containing up to 20% hydrogen it will need a production target above its currently published ambition of 5GW by 2030. A more ambitious target will continue to accelerate the achievement of the net zero target.

To produce the approximately 225TWh of green hydrogen needed to achieve net zero by 2050 would also mean that renewable energy production would have to increase to around twice the current UK capacity; noting this would be dedicated solely to hydrogen production, whereas current renewables capacity largely supplies the electricity network.

3.1.5 Hydrogen storage

One of the advantages of hydrogen is that it can be produced and stored for future use. Hence with an increased deployment of renewable energy generation (wind and solar) hydrogen can be produced via electrolysers when climatic conditions allow renewable generation to operate.

Hydrogen storage in salt caverns and depleted oil wells has already been successfully demonstrated in a number of locations for more than 30 years, including Teesside. The UK has approximately 100 salt caverns which are either already being used for natural gas storage or which have gas storage planned, which could be used for hydrogen.

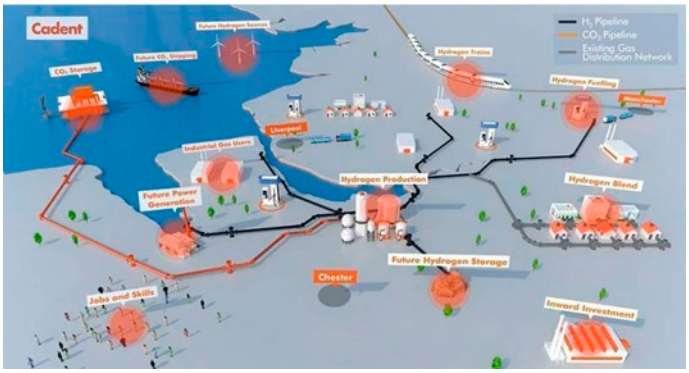
For example the Scottish Gas Network H100 Fife project at Methil is investigating the link between wind energy, electrolysis, hydrogen storage and network demand in a domestic trial. This initiative is part of a broader H100 Fife project designed to explore the potential for power-to-hydrogen to deliver decarbonisation benefits and will report in 2027.[134]

3.1.6 Hydrogen hubs and local benefits

As stated above there are a number of hydrogen pilot schemes underway which will be important sources of lessons for the wider exploitation of hydrogen in the future (Appendix D).

For example, the HyNet project (see graphic below) involves the development of a hydrogen production facility north of Chester. The HyNet project will therefore form an industrial cluster aiming to become the UK's first net-zero industrial zone using hydrogen, as well as carbon capture and storage technology. The hydrogen production could therefore form the basis of a regional hub which can be used by local communities to provide zero carbon heat for homes.

These initial hubs could form the nucleus of the hydrogen production facilities set out in Section 3.1.4 above.



Reproduced with permission of Cadent Gas

133 Ibid. pg.12
134 https://sgn.co.uk/H100Fife

3.1.7 Hydrogen compatible boilers

The boiler manufacturing sector has committed to making available hydrogen compatible boilers from 2025. Such boilers are believed to have a capital cost as little as £100 more than current gas boilers.[135] Over time, with the economies of scale that would come with volume manufacture, this is expected to reduce to broadly zero.

The use of hydrogen boilers would allow those homes not able to install sufficient insulation to use a heat pump system, to transition to a lower carbon form of heating, provided that hydrogen is used in the gas grid either as a blending element or completely over time.

When considering the use of hydrogen boilers, Dr Tony Ballance Chief Regulation Officer, Cadent Gas said

> “Roughly 1.6mn boilers get replaced each year and requiring these to be hydrogen ready would help create a market for hydrogen and be a relatively ‘no regrets’ move.

Dr. Tony Ballance
Chief Regulation Officer of Cadent Gas

Using funding from the Hy4Heat[136] programme, boiler manufacturers are developing hydrogen appliances to demonstrate their safety in the domestic setting for heating, hot water and cooking. The programme aims to provide critical evidence of end use applications, safety, in-use emissions, and functionality.

Hydrogen boilers are in general the same size as a conventional gas boiler and broadly fit the same physical space as the existing boiler. The main difference between the two boiler technologies is the burner system although, for most consumers, this difference would not be apparent. The boiler can be installed without disruption or modification to the existing hot water pipework or radiator systems in most homes. This is to be contrasted with heat pump systems which require larger radiators, a hot water and buffer tank and potentially new pipework throughout the home.

Other than the installation space and disruption considerations the advantage of hydrogen boilers is that they will produce broadly the same heat experience that consumers in the UK have become accustomed to, for several decades.

> “We are committed that any new products launched to market will be hydrogen ready, post-2025.

Steve Keeton
Director of External Affairs and Future Portfolio at Vaillant Group

135 https://www.theccc.org.uk/publication/sixth-carbon-budget: Fuel Supply pg. 63
136 Hy4Heat is a BEIS sponsored initiative to support the development of Hydrogen domestic appliances https://www.hy4heat.info/

3.1.8 Hydrogen and implications of Future Homes Standard

With the Future Homes Standard effectively prohibiting the installation of gas boilers in new homes it is unlikely that house builders will want to incur the costs of a gas network connection from 2025.

> “We can work with hydrogen either blended with gas or over time as the main fuel for heating.
>
> **Kevin O'Connor**
> **CEO of ESP Utilities Group**

The key implication of new homes not having a connection to the gas grid is that this prevents these homes easily accessing hydrogen in the future. The capital cost of retrofitting a connection to the gas network (e.g., laying pipes) is likely to be prohibitive. Additionally, the heating infrastructure in a house previously fitted with a heat pump system (such as larger low temperature radiators) would have to be replaced. Therefore, even if homes built in compliance with the Future Homes Standard wanted to change to a hydrogen or other low-carbon heating system they would not, from a cost and practicality perspective, be able to do so.

Hydrogen heating systems have several benefits which make their overall contribution to the energy system valuable. Hydrogen as a gas can be stored for use in the winter months and used for electricity generation. Its versatility of form (gas, liquid or solid) means it can be moved easily and be burned for energy in different sectors such as heat and transport.

Furthermore, despite having a limited effect initially, the Future Homes Standard would start to move residential heating from the gas to the electricity network, thus parts of the gas network will take on the status of a stranded asset. The stranded parts of the gas network may have to be decommissioned for safety reasons placing additional costs on network operators/consumers. Also, remaining off takers/users of gas will be required to share an increasing burden of network costs as these are not being shared with users whose predominant gas usage was ‘heat’.

Overall hydrogen is likely to be a valuable element in achieving net zero. Using hydrogen and heat pump technology in the housing sector should allow the most technologically effective solution to be taken forward over time. However, regulation must seek to avoid stranded assets and significant regret costs from these two technologies, both of which are seeking to assist in the achievement of net zero carbon emissions.

3.2 Review of alternative heat options

The analysis below presents the qualitative review of the carbon footprint and ability of each technology to fill the ‘gap’ in the home heating sector across the most common residential property types. Also commented upon is the supply chain for the options such as installation issues, costs and the current degree of consumer acceptance.

3.2.1 Heat pumps

Background – the increased use of heat pumps

Heat pumps are already a well-established technology that can immediately and substantially reduce emissions from both heating and hot water consumption as they do not emit any NOx, SOx or particulate matter locally, all of which are key contributors to air pollution.[137]

The Future Homes Standard specifies that the heating system for new homes must be low-carbon and is characterised as ‘low temperature’ which makes a traditional gas boiler with hot water radiators non-compliant with the Standard.[138] Therefore, heat pumps are expected to play a major role in delivering low-carbon heating solutions for homes built to the Future Homes Standard[139] with around 19mn heat pumps expected to be installed by 2050.[140]

137 Op.cit. 27
138 Ibid
139 Op.cit. 1
140 Committee on Climate Change, ‘Net Zero: Technical Report’ (May 2019). Available online: https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-Technical-report-CCC.pdf.

As has been outlined previously the starting point for this ambition is the 600,000 heat pump installations per year outlined in the Ten-Point Plan.[141] It should be noted to achieve these levels of market penetration by heat pumps there will have to be a substantial project to insulate homes across the UK. Also, the reduction in gas demand from the residential sector would be significant, placing considerable cost burdens on other network users (See Section 4.2.3)

The increased use of heat pumps will require an increase in the electrical connection capacity to manage overall peak demand and the rate of change in that demand.[142] This is an issue returned to in Section 4.2.2, where the network capacity issues are set out in more detail.

3.2.2 Hybrid heat pump solutions for existing homes

New homes built in compliance with the Future Homes Standard could provide the most cost-effective deployment of the heat pumps as the improved energy efficiency, air tightness and sizing of radiators make them suitable for heat pumps and it could also avoid the potential for expensive retrofit costs.[143] Therefore, new homes will need to be built to high standards of thermal efficiency in order to make heat pumps viable and practical. [144]

Existing homes where insulation levels cannot be brought to the level of the Future Homes Standard, may experience operational issues using a heat pump, especially in cold conditions. In this situation, hybrid heat pumps which combine an Air Source Heat Pump (ASHP) or a Ground Source Heat Pump (GSHP) with an existing gas boiler may be preferred.[145] Currently, UK boiler manufacturers are targeting a transition to hybrid heat pumps, and hydrogen compatible boilers by 2025.[146] This may provide a solution for decarbonising the 24.4mn existing homes,[147] though servicing and maintaining two heating systems is required.

> “There is a big potential for hybrid systems to be used in the retrofit market. By combining a heat pump with an existing combi boiler, the heat pump could satisfy up to 80% of the total seasonal demand. That means it could achieve up to 80% of the carbon benefits. The boiler would be used for hot water and during peak heat demand in winter.
>
> **Steve Keeton**
> **Director of External Affairs and Future Portfolio at Vaillant Group**

3.2.3 Cost comparison of heat pump solutions

Among various types of heat pump technologies, the most popular types are Air Source Heat Pumps (ASHP) and Ground Source Heat Pumps (GSHP), which are both eligible under the domestic RHI scheme (UK Government backed initiative encouraging the use of renewable heat).[148]

141 Op.cit 29
142 https://www.energynetworks.org/industry-hub/resource-library/?search=heat&id=267
143 Op.cit. 27
144 Energy & Utilities Alliance (EUA), ‘Decarbonising Heat in Buildings- Putting consumers first’ (April 2021) Available online: https://eua.org.uk/without-a-choice-of-different-heat-technologies-for-uk-housing-stock-decarbonisation-of-heat-will-fail-says-new-eua-report/
145 Ibid.
146 Op.cit. 20
147 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/886251/Dwelling_Stock_Estimates_31_March_2019_England.pdf
148 Domestic Renewable Heat Incentive (RHI) see Glossary.

Table 3 below sets out the costs of heat pump solutions in comparison with a new A rated gas boiler. It is reported that heat pumps and gas boilers both have an operational design life of 10 to 15 years and as such will need to be replaced at some point, therefore affordability is important.

Table 3: Heating system installation costs

Heating system	Installation cost range
Cost of A rated gas boiler in a new home	£2,250-£6,228
Cost of installed air source heat pump[149]	£8,750-£14,900
Cost of installed ground source heat pump[149]	£13,200-£27,350
The costs of retrofitting an insulation and glazing package into an existing home to allow an acceptable consumer heat experience using a heat pump[150]	£10,800-£48,000

3.2.4 Supply chain constraints within the heat pump sector

The supply chain barrier remains high due to challenges, including a lack of qualified installers and low UK manufacturing capacity.

As has been stated previously, the UK Government has a target to build 300,000 new homes by 2025[151] and a separate target of installing a total of 600,000 heat pumps per year in total by 2028 (both new build and retrofit).[152] These targets are further underwritten by the proposed changes to the planning regime announced in the 2021 Queen's Speech, which should make planning permission for new homes easier to obtain.

However, there is currently a high reliance on heat pump imports in the UK (of just under 33,600 heat pumps installed in the UK in 2019, 22,753 were imported and 10,830 were manufactured in the UK).[153] Although it is expected large international manufacturers, such as Mitsubishi, Samsung, Panasonic and Daikin, would meet any envisaged growth in UK demand,[154] attracting the manufacturing of heat pumps to the UK could be worth around £1.3bn in manufacturing (at the factory gate)[155] and more than £5.5bn per year to the UK economy as a whole and create thousands of skilled jobs in the manufacturing sector.[156]

The 2021 Queen's Speech[157] stated that the Government seeks to support a lifetime skills guarantee to enable flexible access to high quality education and training (Skills and Post-16 Education Bill). Thus, support for the heat pump manufacturing sector could aid the fulfilment of this commitment via the delivery of high-quality manufacturing and installation jobs. In order to develop a significant manufacturing base for heat pumps and installer cadre, a robust regulatory framework and support mechanisms should be put in place.

> "To have the confidence to invest in a heat pump manufacturing facility here in the UK we would need to see a clear transition pathway to 2025 and beyond — with associated supporting mechanisms and funding to drive uptake — particularly in retrofit.
>
> **Steve Keeton**
> **Director of External Affairs and Future Portfolio at Vaillant Group**

149 Delta Energy & Environment, 'The Cost of installing heating measures in domestic properties' (July 2018) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/913508/cost-of-installing-heating-measures-in-domestic-properties.pdf
150 Carbon Trust 'Heat pump retrofit in London' (Aug 2020) pg. 115 https://www.london.gov.uk/sites/default/files/heat-pump-retrofit-in-london-v2.pdf
151 Op.cit 3
152 Op.cit. 29
153 Ibid, Pg. 54
154 Op.cit. 20 p.20
155 Ibid, Pg. 11-34,896 heat pumps have a factor gate value of £78mn, thus 600,000 heat pumps equals £1.3bn
156 Ibid. p. 97
157 https://www.gov.uk/government/speeches/queens-speech-2021

Although boilers and heat pumps are technologically different, there is an opportunity to utilise existing UK boiler manufacturing facility space and to upskill the existing boiler workforce to meet future demand for heat pumps in the UK. Both gas boilers and heat pumps are manufactured from similar raw materials and have compatible hydronic and plumbing systems.[158] Established boiler manufacturers could therefore benefit from entering in the UK's heat pump market.

3.2.5 Consumer challenges to heat pump deployment

One of the key challenges to the deployment of low-carbon heating is that the British public underestimates the contribution of heating their homes to UK greenhouse gas emissions, with just 15% mentioning it in the top three sources of emissions in the UK.[159]

As noted in Section 4.1.2, heat pumps have a higher capital cost than a gas boiler system, and they also can have higher running costs compared to a new 'A rated' gas boiler. Consumers are therefore unlikely to choose a heat pump on purely economic grounds, thus a support scheme is likely to be required. This was a point set out by Steve Cox, Engineering and Technical Director for Electricity North West when he said:

> "Some 94% of ENW customers are connected and comfortably served by the gas network and thus use gas for 'heat'. Without a financial impetus, households are unlikely to adopt heat pumps due to the upfront cost.
>
> **Steve Cox**
> **Engineering and Technical Director for Electricity North West**

In putting together a support scheme for installation of heat pumps and the necessary associated insulation, lessons should be learnt from the failure of the Green Homes Grant[160] scheme. The scheme must be based on a simple to navigate application process, the support with costs (vouchers or other certificates) must be made available promptly and the availability of well qualified local installers must be a priority.

Whilst air sourced heat pumps are generally quiet, some installations may not comply with the permitted development limit of noise levels below the 42dB, 1mn away from a neighbours' window, as once sensitised to a noise, almost any level can be an annoyance.

Heat pumps require larger radiators than a gas boiler and in a retrofit environment this can make installation particularly challenging. In addition, the need for an outdoor unit, hot water tank and buffer tank will reduce the living space in many homes.

In further considering the consumer challenges, a clear message from the interviews conducted for this report was questioning whether there would be enough trained installers to meet the increasing demand for heat pumps. The potential total number of qualified Heat Pump installers needed is expected to grow from around 1,200 in 2020, to 10,000 in 2025, or over 44,000 in 2035 (it being noted that heat pump installers are likely to install other heating systems so these numbers should not be regarded full time roles in the sector),[161] which means there is a strong need to train existing gas boiler installers and others to a higher level as well as new installers. Interviewees state the current level of training offered is not sufficient and, more importantly, despite free training being made available new installers cannot be attracted into the sector. Thus, to avoid any potential delay in achieving accepted targets, an urgent training support and certification scheme should be developed. This could also be thought of as a considerable opportunity for technical colleges and other training providers to put in place applicable training courses and set certification standards for installers as the install rate for heat pumps rises.

The lack of an installer and technical support base may negatively affect consumer acceptance of heat pumps as consumers often rely on technical advice and knowledge from installers when adopting new technologies such as heat pumps.

158 14 manufacturers who account for around 40% of ASH_P units sold also sell boilers. Op.cit. 20
159 https://www.imeche.org/docs/default-source/1-oscar/reports-policy-statements-and-documents/public-perceptions-greenhouse-gas-emissions-report-50321.pdf?sfvrsn=66159812_2
160 https://www.gov.uk/guidance/apply-for-the-green-homes-grant-scheme
161 Op.cit. 20

> Making sure installers are qualified to consider the technicalities of installation is key. We have found numerous occurrences where things have not been done correctly by others and we've had to put things right.

Martin Smith
CEO of Dynamis Associates

> One of the biggest constraints we have in terms of heat pump installation is engaging and upskilling sufficient numbers of qualified installers to meet the Government ambition. Installers need to be upskilled for retrofitting heat pumps, with room by room heat losses and system sizing parameters it is more complicated than installing a retrofit replacement gas boiler.

Steve Keeton
Director of External Affairs and Future Portfolio at Vaillant Group

According to a survey conducted by National Grid, only 20% and 18% indicated they are familiar with Ground Source Heat Pumps (GSHP) and Air Source Heat Pumps (ASHP) respectively[162] despite Government schemes such as the Renewable Heat Incentive being available for both types of heat pumps.[163] Older consumers are less disposed to initially accept heat pumps as they are concerned by the more practical challenges in terms of space requirements, potential noise disruption and being not 'warm enough', especially in cold climates.[164] However, there has been significant industry progress in reducing the noise from heat pumps in recent years along with other innovative measures.[165]

In terms of the consumer experience, once installed, the key issue is the awareness that heat pumps operate more efficiently at low flow temperatures and are slower to reach room temperatures than traditional gas boilers. This requires a behavioural change in consumers such that heat pumps are generally left to run for long periods and are not switched on and off. The consumer experience, and thus operation of the heat pump, is therefore best managed via an automated control system.

> In order to create an acceptable consumer experience a heat pump must be installed with control technology that can manage the operation of the heat pump, considering external ambient temperatures and the required internal temperature of the property.

Martin Smith
CEO of Dynamis Associates

162 National Grid, 'Heating our homes in a Net Zero Future: Understanding what matters to consumers' (September 2020), p. 10
163 Ofgem, About the Domestic RHI (April 2021) Available online: https://www.ofgem.gov.uk/environmental-programmes/domestic-rhi/about-domestic-rhi
164 Op.cit.167 p. 12
165 Op.cit. 27

Steve Keeton, Director of External Affairs and Future Portfolio at Vaillant Group, also considered this point:

> Consumer behaviour is a very important factor– consumers need to see a real benefit (e.g., running costs as well as carbon reduction) and be more familiar with heat pump technologies and how they operate.
>
> **Steve Keeton**
> **Director of External Affairs and Future Portfolio at Vaillant Group**

To facilitate the installation of heat pumps it is critical to improve consumer knowledge surrounding the operation of low-carbon heating as this will maintain customer experience and reduce operational costs. Ensuring an acceptable consumer experience of low-carbon heating will be critical to its wide deployment.[166] UK consumers lag other countries in accepting and understanding low-carbon heating technology,[167] therefore a suitable public information campaign is needed.

> A major public education campaign on the carbon emissions from homes and their heating system is crucial to get consumers on board.
>
> **David Thomas**
> **CEO of Barratt Homes**

This point has also been echoed by Citizen's Advice where it calls on the Government to invest in a significant programme of public engagement to explain the forthcoming changes.[168]

3.2.6 Industrial waste heat recovery

In order to develop district heating that is low carbon the use of large-scale heat pumps systems can recover waste heat from industrial settings, such as coal mines, sewage facilities and data centres.

For example, heat recovery schemes using abandoned flooded mine workings, are a viable option for low-carbon heating solutions within many abandoned British coalfields. Following the closure of the majority of the British underground coal mines during the 1980s–1990s, the requirement to dewater ceased and many collieries were left to progressively flood.

In response to rising mine water levels mine water treatment schemes were constructed across Britain by the Coal Authority. However, more recently, as the potential for heat recovery mine water is increasingly being regarded as a potential geo-energy asset.[169]

Heat recovery from coal mines is in its initial stages, with a number of issues to resolve, including ownership of the heat, identification of flooded workings, development of regulatory and licensing frameworks and reduction of the initial capital costs. However, given a UK temperature differential related to depth of between 17°C/km and 34°C/km,[170] if locations can be identified towards the upper end of this range, close to the surface, they might be viable. Also given the location of the abandoned mine workings, such schemes could also address the levelling up and jobs agendas.

3.2.7 Heat networks

A heat network – also known as 'district heating' – is a distribution system that takes heat from a central source and delivers it to a number of domestic or non-domestic consumers. Heat networks can offer a low-carbon solution for housing where it would be difficult or unreasonably expensive to upgrade the fabric of the building to the insulation levels suitable to use a heat pump. There are around 5,500 district scale and 11,500 communal scale heat networks in the UK, together providing 10TWh of heat per year (around 2% of UK buildings heat demand).[171]

166 Ibid
167 Ibid, Pg. 12
168 https://wearecitizensadvice.org.uk/people-must-be-at-the-heart-of-the-transition-to-net-zero-944ae731b466
169 P L Younger, 'Abandoned coal mines: From environmental liabilities to low-carbon energy assets' (2016) 164 International Journal of Coal Geology
170 G Farr, J Busby, L Wyatt, J Crooks, D I Schofield and A Holden, 'The temperature of Britain's coalfields' (2021) 54 Quarterly Journal of Engineering Geology and Hydrogeology
171 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/212565/summary_evidence_district_heating_networks_uk.pdf.

The heat source tends to benefit from the economies of scale is terms of heat production efficiency and the purchase of fuel. Heat networks work best in urban areas where consumers have a higher density and are closer to the heat source.

District heating schemes have traditionally been based on combined heat and power technology where gas is used in a gas turbine to generate electricity whilst the exhaust gases are used in a boiler to generate steam for heat. Although highly efficient such schemes do emit carbon.

Modern district heating networks do not use combustion on-site and have zero emissions of CO_2 and NO_2 on-site; they employ heat transfer technology using electricity, which may be generated from renewable energy or from remote fossil-fuelled power stations.

Heat networks have a number of features of 'natural monopolies' – they can require a relatively large initial capital outlay during construction and operators derive income over long periods of time through billing consumers for heat, and potentially raising entry barriers for other operators. Additionally, once installed consumers have limited ability to switch to an alternative heat supply. A Government survey found that heat network customers paid, on average, around £100 less per year for their heating and hot water compared with non-heat network consumers.[172]

Heat networks form part of the Government's plan to reduce carbon emissions and cut heating bills for consumers (domestic and commercial), although savings seem to be modest.

It is estimated by the Climate Change Committee that around 18% of UK heat will need to come from heat networks by 2050 if the UK is to meet its carbon targets cost effectively.[173] Heat networks will need to be developed employing heat transfer technology based on renewables and have a regulatory framework that protects consumers if this ambition is to be fully realised.

3.2.8 Wastewater heat recovery

As part of the 2021 implementation of higher insulation levels and other energy saving devices (see Section 2.1.3), wastewater heat recovery systems are included as a key element used in reducing the energy requirements of heating systems. [174] Waste water heat recovery technology is designed to use the residual heat from drained waste water, such as shower or bath water, via an instantaneous heat exchange to pre-heat incoming mains water, which allows consumers to save energy by reducing the energy consumptions of hot water heating equipment such as boilers.[175] Whilst it is an established technology elsewhere across Europe, recovering heat from waste water at home is a relatively new option in the UK.[176] The technology is inexpensive and easy to maintain as it has no electrical components, pumps or controllers.[177] As a result it has been recognised as one of the most cost effective, low-carbon and energy efficiency technologies available.[178] However, the device normally consists of a long vertical copper pipe, which means it is likely to only be viable in a new build property as it cannot be easily retrofitted.[179]

The proposed Future Homes Standard is based on low-carbon heating systems (heat pumps), and as such the waste water heat recovery and solar PV array which form part of the 2021 initial step will be removed from the Standard going forward and thus this type of technology may have a limited overall use in the UK.[180]

3.2.9 Biomass boilers and stoves

Biomass boilers generate heat through burning organic matter, such as wood in the form of logs, pellets or wood chips, thus producing hot water or steam.[181] Biomass is arguably a carbon-neutral fuel as when the trees are felled and then burnt, they release the same level of carbon dioxide that they took in as part of photosynthesis. Burning biomass is not considered as harmful to the environment compared to burning gas, coal or oil, as growing plants or trees can be achieved quickly.[182]

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172 BEIS 'Heat Networks Consumer Survey: Results Report' (2017) https://www.gov.uk/government/publications/heat-networks-consumer-survey-consumer-experiences-on-heat-networks-and-other-heating-systems

173 https://www.theccc.org.uk/publication/next-steps-for-uk-heat-policy/174 Op.cit. 1

175 Energy Technology List, BEIS, 'Wastewater heat recovery systems' Available online: https://etl.beis.gov.uk/products/wastewater-heat-recovery-systems

176 S Farman Ali & A Gllich, 'Determining the UK's potential for heat recovery from wastewater using steady state and dynamic modelling-preliminary results' (2019) Weentech Proceedings in Energy, Vol 5. P. 107

177 Ibid.

178 It is recognised in the Standard Assessment Procedure (SAP), which is the methodology used by the Government to assess and compare the energy and environmental performance of dwellings. Source: Op.cit1

179 Energy Technology List, BEIS, 'Wastewater Heat Recovery Systems' Available online: https://etl.beis.gov.uk/products/wastewater-heat-recovery-systems/wastewater-heat-recovery-systems-instantaneous

180 Op.cit 1. p.18

181 Department of Energy & Climate Change, 'Renewable Heat Incentive' (March 2011)

182 Houses of Parliament, Parliamentary Office of Science & Technology, "Carbon Footprint of Heat Generation" (May 2016)

Biomass boilers are more controllable and affordable[183] compared to a gas or oil boiler. Such systems can receive MCS[184] accreditation and are eligible for the Renewable Heat Incentive (RHI) provided they meet certain thresholds.[185] However there are concerns, including manual pellet loading and ongoing boiler cleaning – especially for vulnerable or elderly users. Other challenges include the potential impact of biomass boiler emission on local air quality[186] and the considerable space requirement for storing pellets at home.[187]

A National Grid study showed that 37% of consumers who responded were either 'very or quite' familiar with biomass boilers, which makes biomass boilers the low-carbon heating option with the highest awareness. Despite this, biomass boilers were considered the least acceptable option due to their obvious downside and challenges – carbon emissions, fuel storage and maintenance requirements.

3.2.10 Solar thermal panel

Solar thermal systems consist of a solar photovoltaic (PV) panel combined with a cooling system where warm water or air is circulated around the panel to cool the solar cells used for domestic heating.[188] This emission-free technology significantly increases the efficiency of solar photovoltaic (PV) systems, which use only 15–20% of the incoming solar energy,[189] by capturing the 'lost' energy from the PV system for space heating.[190]

This technology has failed to achieve significant market share in both the domestic and commercial sectors in the UK[191] due to its complex system design and more technically demanding installation.[192] Often, it also needs to be operated in conjunction with another heating system or equipped with separate thermal storage within the property, as the levels of heat generated are not sufficient to meet the spare heating requirements of UK homes, especially in the winter months when the demand is at its highest and performance is at its lowest.[193]

3.2.11 Electric storage heaters

Electric storage heaters store up the heat during the cheapest electric tariff period then release it gradually throughout the day. This is the best solution for small homes with space constraints, in which installing other low-carbon heating technology such as heat pumps requiring outdoor space, larger radiators and a hot water storage tank is not an option.

Although it offers relatively inexpensive heating from electricity options[194] as well as a low-carbon heating option in line with the policy agenda,[195] consumers using traditional electric storage heaters in inadequately insulated homes are likely to struggle to control releasing heat when needed.[196] According to a study conducted by Scottish & Southern Electricity Networks (SSE), only 43% of consumers had a positive experience using electric storage heating whilst 85% of gas based heat users were satisfied.[197]

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183 Costs range from £4,000 to £10,000 (manual-fed) and £9,000 to £21,000 (automatically fed pellet). Source: Boiler guide, 'Biomass boilers' Available online: https://www.boilerguide.co.uk/biomass/biomass-boilers-prices-costs

184 Microgeneration Certification Scheme (MCS).

185 Biomass boiler can be eligible provided they provide space heating and/or domestic hot water heating and the fuel is bought from a registered supplier. The installer must be a member of MCS, and the boiler should also comply with the air quality requirement. Source: Department of Energy & Climate Change, 'Renewable Heat Incentive' (March 2011)

186 Wood Heat Association, 'Is biomass heating causing urban air pollution?' (2017) Available online: http://www.woodheatassociation.org.uk/is-biomass-heating-causing-urban-air-pollution/

187 Op.cit. 167

188 Moharram K.A., Abd-Elhady M.S., Kandil H.A., El-Sherif H., (2013), "Enhancing the performance of photovoltaic panels by water cooling", Ain Shams Engineering Journal, Volume 4, Issue 4, Pages 869–877, Available online: https://doi.org/10.1016/j.asej.2013.03.005

189 International Renewable Energy Agency (IRENA), 'Future of Solar Photovoltaic – Deployment, investment, technology, grid integration and socio-economic aspects' (November 2019)

190 Ibid.

191 Ibid.

192 Department for Business, Energy & Industrial Strategy, 'Evidence Gathering-Low-Carbon Heating Technologies – Hybrid Solar Photovoltaic Thermal Panels' (2016)

193 Ibid.

194 Scottish &Southern Electricity Networks (SSE), 'An electric heat pathway – looking beyond heat pumps' (2020)

195 Sarah J Darby, 'Smart electric storage heating and potential for residential demand response' (2018) Energy Efficiency 11:66–77

196 Ibid

197 'Op.cit. 194

Modern 'smart storage heaters' are designed to take advantage of fluctuations in electricity prices throughout the day with the ability to program remotely and control temperatures by room, therefore user experience may be different than reported previously.[198] Smart electric storage technology potentially provides for the future by bridging the electricity industry, affordability and user familiarity[199] gap with smart metering, adequate consumer information on tariffs, and Government funding.[200]

3.2.12 Microwave boilers (Heat Wayv boiler)

A small UK-based firm, Heat Wayv, has created the world's first microwave-powered boiler, which uses electricity to heat water which can be pumped through existing radiators and to taps, showers and baths.[201] According to the company, the microwave boiler is the same size as a gas boiler with 10 metres of pipe coiled inside which is heated at multiple points, and it is completely compatible with existing home radiators. [202]

A unit suitable for a 3- or 4-bedroom home would cost around £3,500, similar to an equivalent gas boiler,[203] and is the same cost to run as a gas boiler.[204] Heat Wayv claims their microwave boilers are about 96% efficient, whilst modern gas boilers have an efficiency of approximately 92%.[205] The microwave boiler can heat water quickly enough, like existing gas boilers, to provide it when it is needed, thus it does not need to run continuously to deliver water at suitable temperature.[206]

Heat Wayv is currently building prototypes and expects to run a trial in homes by 2022. It is planning to produce microwave boilers for sale by 2024.[207] However, before the Heat Wayv system is deployed a technical assessment of its compliance with the Future Homes Standard will be required.

3.3 Conclusions

Analysis of the available technologies show that each has a place.

The issue of insulation is a common thread running through all options and thus before any heating technology solutions are addressed insulation should be at the forefront of carbon emission reduction.

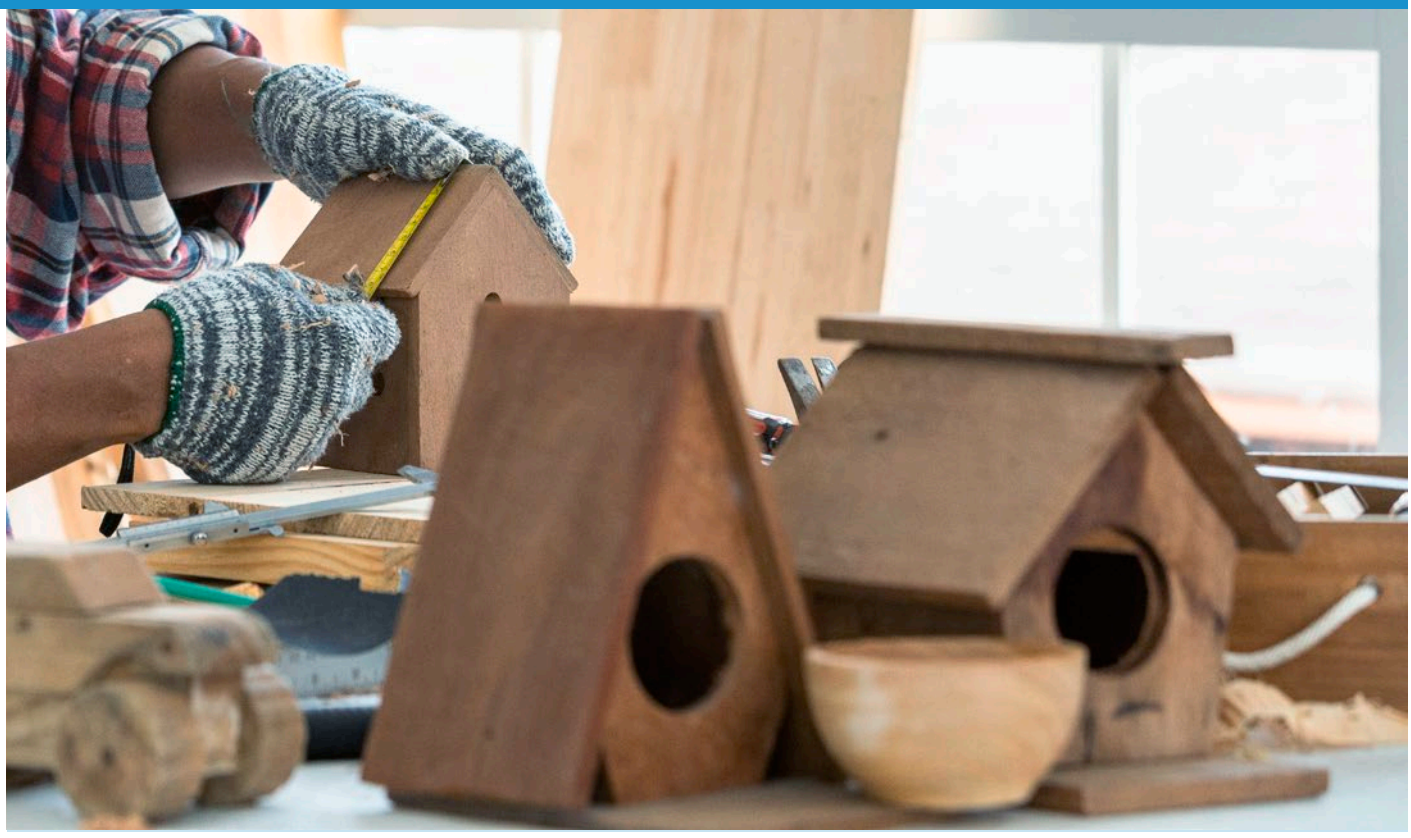
Care must be taken by Government in progressing decisions around heat technology compatible with the Future Homes Standard not to pick a winner ahead of completing pilot studies on the effectiveness of a range of heating options.

The fundamental requirement is the reduction in carbon emissions from homes and thus policies should be as technology neutral as possible allowing all effective technologies to develop.

198 Op.cit. 198
199 Ibid.
200 Op.cit 154
201 The Guardian, Damian Carrington, 'First microwave-powered home boiler could help cut emissions' (16 Mar 2021) Available online: https://www.theguardian.com/environment/2021/mar/16/first-microwave-powered-home-boiler-could-help-cut-emissions
202 Ibid.
203 Ibid.
204 Ibid.
205 The Economist, 'If you can have microwave ovens, why not microwave boilers?' (10 April 2021)
206 Ibid.
207 Ibid.

4. Impacts on energy sector and supply chain

This section sets out a high level qualitative and quantitative review of the impacts of the Future Homes Standard, and the status of the Government's impact analysis for the Future Homes Standard. The section then reviews the position of the network companies and how they will be affected by the Future Homes Standard.



4.1 Quantitative and qualitative review of the impact on the consumer and energy industry participants

4.1.1 Introduction

The proposed changes under the Future Homes Standard will affect all new homes in the UK and the impact will be felt both at the point of construction and over the life of the building.[208] The Future Homes Standard and the proposed policy changes will affect all dwellings, therefore the impact will be extended to manufacturers of construction products, the construction industry in general and building owners and occupants.

As outlined in Section 4.1.2, due to the increased capital costs of heat pumps compared to gas boilers, the Future Homes Standard for the 300,000 new homes per year desired by Government could cost an additional £1.95bn to £2.6bn per year, although with efficiencies and economies of scale this figure is expected to reduce over time.

The offsetting potential savings are considered at a national level, including energy, network connections and carbon emissions and show a modest £6.1mn to £9.6mn saving.

4.1.2 Quantitative and qualitative impact analysis conducted for this report

To understand the impact of the Future Homes Standard we have conducted an illustrative analysis of the costs and issues for different groups in society. This analysis compares the implementation of the policy with a 'no change option'.

It has been assumed that heat pumps are installed in new houses to comply with the Future Homes Standard and that these homes will not be connected to the gas network, and that in the absence of the policy change gas boilers would have been installed in new houses.

208 Op.cit.1, p.11

Table 4: Review of the impact for different groups in society of installing a heat pump in new houses compared to installing a gas boiler.

Group	Potential impact
All energy consumers	The impact on all energy consumers is uncertain, with a large driver of the cost impact being whether network reinforcement is required. As has been stated above the network operators and Ofgem are currently undertaking a network charges review[209] and as such network upgrade costs could be mutualised over all consumers connected to that same distribution network, thus a small increase in network charges would be seen by all consumers. ▸ On the basis that heat pumps are installed in new homes these consumers would avoid gas network connection charges. Additionally, the costs of any wider gas network reinforcement costs which might have been incurred will also be avoided. ▸ If the new homes had been fitted with a gas boiler and the additional gas demand from these consumers could have been supplied without network reinforcement costs, then overall network costs remain the same, but would have been mutualised over a larger number of consumers and thus decreased for the individual. ▸ If electricity network reinforcement is required to accommodate heat pumps in new houses, consumers will face higher retail electricity prices to cover the reinforcement cost.[210] ▸ If electricity network reinforcement is not required to accommodate heat pumps in new houses, consumers may actually enjoy lower delivered retail electricity prices as the same costs of electricity networks will be mutualised over a larger number of consumers, i.e., the owners of the new houses will be part of the consumer group. However, on a strictly comparison basis costs will remain the same as new homes would be connected to the electricity network irrespective of their connection status to the gas network. ▸ Electricity consumers could also face higher retail electricity prices as a result of higher wholesale electricity prices. This would be driven by the increase in electricity demand from the heat pumps in new houses, meaning that more expensive generation is required to meet demand and set prices. Any such increase is expected to be small as electricity demand from heat pumps in new houses will be relatively small compared to total electricity demand. Gas consumers are not expected to face lower retail gas prices using the reverse logic as wholesale gas prices are determined by global markets. ▸ Any increase in the overall cost of energy to the consumer will increase the number of consumers experiencing fuel poverty which would be an unintended consequence of seeking to reduce the carbon emissions from homes and a reason for ensuring policy initiatives are carefully coordinated across Government.

209 Ofgem, Reform of network access and forward-looking charges https://www.ofgem.gov.uk/electricity/transmission-networks/charging/reform-network-access-and-forward-looking-charges

210 To the extent the cost of reinforcement was not covered by the connection charge

Group	Potential impact
House building companies	▸ The house builder will need to purchase and arrange for the installation of a heat pump, which is more expensive than the purchase and installation of a gas boiler. A study commissioned by BEIS presented a cost range for fully installed heat pumps of £8,750–£14,900 compared to £2,250 – £6,228 for a gas boiler in a new build.[211] ▸ If the house builder incurs additional costs due to the Future Homes Standard, these additional costs are assumed passed on, to the extent possible, through higher sales prices for the new houses. However, during interviews with house builders it was stated that the sales price of a new home is generally capped by the sales price of the existing housing stock, and therefore there is a limit to the extent these additional costs can be passed on in the sales price for the new house. If the additional cost is not covered by the sales price for the new house, a house builder may seek to defray the additional costs by paying less for the land on which it will build the new houses. If a house builder cannot fully pass on or defray the additional costs, the new houses are less likely to be constructed. ▸ The house builder will not need a 'last mile' gas pipe to be constructed to connect the new house to the existing gas network,[212] therefore reducing costs (as costs relate to the assets required to make the connection an exact saving cannot be determined).[213] However, to give an indication of the potential savings it should be noted that a typical annual charge of connection is £131.[214] With a level of saving of around £131 it would take several years to offset the additional capital cost of a heat pump. ▸ The house builder will need a 'last mile' electricity cable to be constructed to connect the new house to the existing electricity network, as would have been the case if a gas boiler for heating were to be used. However, with a heat pump the cable and connection to the existing electricity network will need to be large enough to accommodate the additional electricity demand from the heat pump, in addition to lighting and all other electricity appliances in the house. The cost of the larger connection and electricity cable is likely to be higher, again subject to the exact assets required to make the connection.[215]
Gas boiler manufacturers and installers	▸ There will be a decrease in demand for gas boilers as there will be no demand for them in new houses resulting from the policy change, and demand for gas boilers to replace old ones in existing houses is not expected to grow and may even decrease. The impact on jobs and the economy is set out in Table 5. ▸ It is noted that the Ten-Point Plan sets out the Government's ambition for 600,000 heat pump installations per year by 2028.[216] If this target were achieved, demand for gas boilers would be negatively impacted regardless of whether they are installed in a new or existing house. There would be an upturn in heat pump production, but for the UK economy not to be negatively impacted the UK heat pump manufacturing capacity would need to increase significantly as it currently only produces around 10,000 heat pumps per year.

211 Op.cit 154
212 It has been further assumed that if there is no gas boiler for heating, gas is not used for cooking either
213 Or have been incurred by iGT if it was involved in the construction of the 'last mile' pipe
214 https://www.ofgem.gov.uk/data-portal/estimated-network-costs-domestic-customer-gb-average
215 Or have been incurred by iDNO if it was involved in the construction of the 'last mile' cable
216 Op.cit. 29

Group	Potential impact
Heat pump manufacturers and installers	▸ There will be an increase in demand for heat pumps and their installation in new houses resulting from the policy change. ▸ As stated above, the Government has an ambition for 600,000 heat pump installations per year by 2028, therefore UK heat pump manufacturing capacity should be increased. A support framework may be needed to initiate the capacity increase if the economic opportunity is to be retained within the UK (See Section 3.2.4).
Energy network companies	▸ There will be no 'last mile' gas pipes constructed for new homes. ▸ The gas networks will continue to transport gas to the existing consumers with demand continuing its slow decline overtime as old gas boilers are replaced with new 'A rated' boilers and the efficiency of heating systems on average increases. The cost of any reinforcement to the network that would have been required if gas boilers were installed in new houses will also be avoided. ▸ The electricity network will have a higher electricity load as it will be needed to power heat pumps in new houses. Initially the additional load on the electricity network will require network reinforcement in specific locations. Over time there will need to be reinforcement work carried out across the electricity distribution and transmission networks to accommodate the additional load for heating new houses. From information received during the interviews conducted as part of drafting of this report, 600,000 heats pumps are believed to have a demand on the network of 300MW and 3TWh pa. ▸ Plans for these local and regional upgrades will need to be included within the distribution network operators (DNO) business plans for their upcoming regulatory price control period (known as RIIO-ED2) commencing in 2023. However, if the electricity market regulator (Ofgem) makes a determination as part of the price control process and does not allow for enough reinforcement of the electricity distribution networks to meet demand from heat pumps there could be long time lags to connect new houses to the existing electricity distribution network. In an extreme case some connections could be deferred to ED3 which commences in 2028. ▸ It should be noted that within the price control mechanism there is a level of flexibility provided through what is known as the 'uncertainty mechanisms' (a mechanism to allow for network capacity increases which are found to be needed but were not known at the time the business plan was put together). When the capacity required for heat pumps and electric vehicles are considered, the capacity allowed by Ofgem may not be sufficient, even with the uncertainty mechanism.

Group	Potential impact
The owners of new houses	The owners of the new houses will face different energy bills[217] with a heat pump compared to a gas boiler: ▸ **Gas bill** ▸ There will be no gas bill, representing a cost saving for the houseowner. ▸ **Electricity bill** ▸ The electricity bill will be higher due to the increase in volume of electricity required to heat the house with a heat pump compared to a gas boiler. The increase in the volume of electricity will increase the wholesale cost, the network cost and the cost of social and climate change policies, which are charged based on the volume of electricity consumed. These components account for approximately 80% of an electricity bill for an average household.[218] ▸ A typical home uses 12,000kWh of gas and 3,100kWh of electricity per year.[219] With an illustrative increase in electricity of 5,000kWh for the use of a heat pump, the indicative analysis below shows that a typical user could see a slight increase in energy costs of around £100 per year if the comparison is undertaken against an 'A rated' gas boiler typical of a new house. There are carbon emission savings for the use of a heat pump, however, due to electricity generation not being 100% renewable the use of heat pump is not carbon free. (It should also be noted that if the comparison is made between a heat pump and an older G rated boiler the energy cost saving is around £400 per year. However, swapping an old G rated boiler for a new A rated boiler will also generate a saving in energy costs and carbon emissions). ▸ Electricity network costs could also be higher as a result of the Future Homes Standard if network reinforcement is required which cannot be directly associated with a particular connection or housing development.[220] ▸ Over time, as more new houses are built with heat pumps, there could be an increase in the wholesale electricity price as electricity demand from the heat pumps increases, meaning that more expensive generation is required to meet demand and set prices. Any such increase is expected to be small as electricity demand from heat pumps in new houses will be relatively small compared to total electricity demand. ▸ The owner of the new house will not be able to take advantage of any dual fuel energy tariffs from suppliers. ▸ The new house will not be connected to the gas network and therefore, without the considerable expensive of retrofitting pipes, will not be able to access hydrogen in the future if the existing gas network in the area is converted to use either hydrogen or hydrogen blended with natural gas.
All societal groups	▸ Heat pumps as a unit do not emit greenhouse gases, whereas gas boilers do. There is no certainty that the increased electricity used by heat pumps will necessarily have come entirely from renewable sources therefore heat pumps are not a completely carbon free form of heating. It is not possible to give an exact figure as to carbon emissions as this will depend on the portfolio of generation capacity dispatched on the day.

217 Gas and electricity and gas bills are determined by the retail gas and electricity prices and the volume of gas and electricity consumed. Retail gas and electricity prices are made up of a number of components: the respective wholesale commodity costs, network costs, the cost of social and climate change policies, supplier operating costs and margin, and VAT

218 Ofgem (2021), Infographic: Bills, prices and profits https://www.ofgem.gov.uk/publications-and-updates/infographic-bills-prices-and-profits

219 https://www.ofgem.gov.uk/data-portal/estimated-network-costs-domestic-customer-gb-average

220 To the extent the cost of reinforcement was not covered by the connection charge

Assumptions for illustrative quantitative analysis

Purely for the purposes of quantitative analysis and the illustrative examples set out below we have assumed there is no obstacle to the target of 300,000 new houses being built each year due to supply chain constraints for heat pumps as either UK manufacturing capacity will increase, or the heat pumps will be imported.

Similarly, we have assumed that electricity networks have no constraints in their ability to connect housing developments to their networks or for electricity to be provided due to a sufficiency of generation capacity.

If these assumptions were found not to be true, the impact on individuals, housing developers or others seeking connection, who would not be able to access housing as a result would also need to be considered.

Impact on jobs of the change from gas boilers and heat pumps

The UK had approximately 1.67mn gas boilers installed in 2019.[221] A study commissioned by BEIS stated that 55% of the UK demand for boilers is met through domestic manufacturing, supporting a workforce of 6,000 in the manufacture of boilers and radiators.[222] Table 5 below sets out the relative positions in relation to jobs resulting from the change from gas boilers to heat pumps.

Table 5: Assessment of the impact of installing heat pumps instead of gas boilers

	Impact on gas boilers	New heat pump installations
Assumed number of installed units by 2028	↓ 600,000 p.a. Note: 1.67mn boilers currently installed pa (2019)	↑ 600,000 p.a. Note: 300k (FHS) plus 300k (Ten-Point Plan)
Current Import/ domestic production split (2019)	Imported 45% / 55% Domestic manufacturing	Imported 70% / 30% Domestic manufacturing
Impact on jobs	Assumption made for this example: Jobs increase/loss affected by installation of **600k heat pumps p.a. by 2028.**	**330,000 fewer gas boilers would be manufactured in the UK** from 2028 (based on the import/domestic production split).	Heat pump import ratio maintained; **180,000 heat pumps manufactured in the UK.**
Direct manufacturing	↓ 3,900 jobs[223]	↑ 9,000 jobs
Other supply chain	↓ 16,000 jobs	↑ 5,000 jobs Components largely imported
Installers & Maintenance	↓ 4,000 jobs[224]	↑ 22,000 jobs Heat pumps are more complex to install
Jobs total	↓ 23,900 jobs in total **Equivalent to £980mn loss to the UK economy**	↑ 36,000 jobs[225] in total **Equivalent to £1.5bn increase to the UK economy** Note: Ten-Point Plan states the sector could support 20,000 jobs (by 2030) which would be lower than the lost jobs in the boiler sector – £820mn
↑ Estimated net impact on jobs, 12,100 ↑		

221 https://www.eua.org.uk/record-boiler-sales-show-how-decarbonisation-will-work/
222 Op.cit. 20
223 6,000 manufacturing jobs in the UK – simple ratio Op.cit. 20
224 Ibid, Pg. 100 (Simple Ratio). Assuming 600,000 heat pumps installed per year, replacing boiler installs, and further assuming there are 220 working days per year and boiler install and maintenance takes 1 day and 0.5 day respectively, the number of installers to have lost their jobs is 2,700 for installation and 1,300 for maintenance.
225 33,600 heat pumps currently installed in the UK per year, supporting circa 2000 jobs – European Heat Pump Association (2019) Heat pump country cards, http://www.stats.ehpa.org/hp_sales/country_cards/

The issues related to the need for trained installers and domestic heat pump manufacturing capacity have been previously set out in Section 3.2.4 above. According to a study commissioned by BEIS, the UK boiler manufacturing workforce's skill set is complementary to heat pump manufacturing,[226] and therefore the loss of jobs in the UK economy due to a decrease in demand for gas boilers may be mitigated by an increase in demand for jobs in the heat pump sector.

The jobs balance set out in Table 5 illustrates the importance of a strong UK manufacturing base for heat pumps. A more detailed explanation of supply chain issues is set out in Section 3.2.4, and can be understood from the comment by Steve Keeton, Director of External Affairs and Future Portfolio at Vaillant Group when he said:

> "To have the confidence to invest in a heat pump manufacturing facility here in the UK we would need to see a clear transition pathway to 2025 and beyond — with associated supporting mechanisms and funding to drive uptake — particularly in retrofit.
>
> **Steve Keeton**
> **Director of External Affairs and Future Portfolio at Vaillant Group**

Financial impact on electricity and gas bills for owners of new houses and the potential impact on houses where an old gas boiler is replaced with a heat pump

The capital costs for a heat pump are in the range £8,750 to £14,900[227] (some £6,500 to £8,672 above the cost of an 'A rated' gas boiler). Additionally, heat pumps may cost around £100 more per year to run (in terms of energy costs) compared to an 'A rated' gas boiler.

Table 6 shows the costs compared to those of a new A rated boiler and a G rated old boiler. These two boiler types are chosen for comparison purposes to show (i) the costs of installing a direct alternative to a new heat pump – the new 'A rated' boiler, and (ii) the cost compared to an old 'G rated' boiler which might be comparable with a boiler in need of replacement in any number of homes across the UK.

Table 6: Impact on Consumer Electricity Bills

	Swap A Rated Boiler for Heat Pump	Swap G Rated Boiler for Heat Pump
Energy Bill[228]	↑ £95 – £110 (increase in bill)	↓ -£395 to – £425
Connection charge saving for gas[229]	↓ -£131	↓ -£131
Increased connection cost for electricity from 9kW to 16kW connection	↑ £50	↑ £50
Overall annual impact per household	↑ £14 to £29 (increase in bills)	↓ -£476 to -£506
Heat pump capital cost uplift verses gas boiler	£6,500 to £8,672 above the cost of an A rated gas boiler	
Insulation (insulation plus glazing) package costs for existing home	£10,800 to £48,000	

226 Op.cit.20
227 Op.cit. 154
228 https://energysavingtrust.org.uk/advice/air-source-heat-pumps/
229 https://www.ofgem.gov.uk/data-portal/estimated-network-costs-domestic-customer-gb-average

Financial impact of a policy wide view on bills

Table 7 below illustrates the policy wide view of the Future Homes Standard, such that costs across the fleet of 300,000 heat pumps is considered. The table shows the costs compared to those of a new A rated boiler and a G rated old boiler for the reasons outlined above.

Table 7: Policy Wide View of Costs

	Swap A Rated Boiler for Heat Pump	Swap G Rated Boiler for Heat Pump
Energy & network saving (or increased costs) across the 300,000 households	↑ £4.2-£8.7mn (increase in bills)	↓ £143-152mn
Carbon saving[230] per year per home **A return flight London to New York as a typical passenger emits 2,100 kg per flight[231]**	↓ 2150-2250kg/yr.	↓ 4450-4750 kg/yr.
Carbon saving across 300,000 homes	↓ 645,000-675,000 Tonnes	↓ 1,335,000-1,425,000 Tonnes
Cost of Carbon Saved (21.93 £/Tonne,[232])	↓ £14 – £14.8mn	↓ £29-£31mn
Total Savings per annum	↓ £6.1 to £9.8mn	↓ £172-£183mn
Incremental cost of 300,000 new heat pumps versus new A rated gas boiler	£1.95-£2.6bn	

These costs do not take account of the potential costs of retrofitting insulation and glazing to upgrade the energy efficiency of an existing home. To gain an acceptable consumer experience, it could be necessary to spend, between just under £10,800 for a property with an average 'intervention' requirement, to just over £48,000 for properties requiring a higher level of retrofit of energy efficiency elements.[233] Across the existing housing stock of 24.4mn dwellings,[234] even allowing for the between 8 to 13mn homes which may not be suitable for heat pumps,[235] this would cost between £122bn and £787bn.

On this basis the Future Homes Standard cannot be justified on purely economic grounds.

4.1.3 Rebalancing the cost of electricity and gas

A key factor for heat pumps being more expensive to run than a new 'A rated' gas boiler is that the delivered cost of electricity includes a number of energy policy costs. These costs are broadly 23% of electricity bills and mostly related to the recovery of monies paid to renewable electricity generation as incentive or subsidy payments, such as renewable obligation and feed-in tariff costs.[236]

In a recent Public First report the authors call for the rebalancing of these policy costs between electricity, gas and general taxation.[237] This would reduce the cost of electricity and increase the cost of gas, thus closing the cost differential between heat pumps and gas boilers. Public First also call for carbon taxes to be levied on gas at a rate of £50/tonne rising to be £75/tonne by 2030. It should be noted that the current cost of carbon allowances is circa £21.93/tonne.

230 https://energysavingtrust.org.uk/advice/air-source-heat-pumps/
231 Return trip to New York is 11,170 km with a typical passenger emitting 2.1 kg/Km https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2020
232 https://www.gov.uk/government/publications/determinations-of-the-eu-ets-carbon-price
233 Carbon Trust 'Heat pump retrofit in London' (Aug 2020) pg. 115 https://www.london.gov.uk/sites/default/files/heat-pump-retrofit-in-london-v2.pdf
234 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/886251/Dwelling_Stock_Estimates_31_March_2019_England.pdf
235 https://eua.org.uk/without-a-choice-of-different-heat-technologies-for-uk-housing-stock-decarbonisation-of-heat-will-fail-says-new-eua-report/
236 https://www.ofgem.gov.uk/data-portal/breakdown-electricity-bill
237 http://www.publicfirst.co.uk/options-for-energy-bill-reform.html

Thus irrespective of the balance of these carbon taxes between gas and electricity, either a doubling or near tripling of the carbon tax price will increase energy prices and thus increase fuel poverty amongst low income households.

The Public First report, showed that under all combinations of rebalancing of policy costs between electricity and gas, including or not including a carbon tax, increase the total cost of heat to the consumer, unless a heat pump is installed. The main reason for this is that gas is no longer used for heat and the additional insulation required to make the consumer experience acceptable reduce the overall energy requirement of the home. The savings in energy costs are reported by Public First to be circa £440 per year by 2030 which would still mean a broadly 15-year period to recover the capital cost of a heat pump alone, not considering the additional insulation costs.

The capital costs of a heat pump and the cost of the insulation required to make the consumer experience acceptable means that only those householders with the applicable financial means to cover these costs can capture the savings of heat pumps when policy costs are rebalanced between electricity and gas. This means that low income households who cannot install heat pumps and insulation will experience increased energy costs – hence there is potential for increased fuel poverty.

4.2 Review of the considerations for the electricity and gas networks

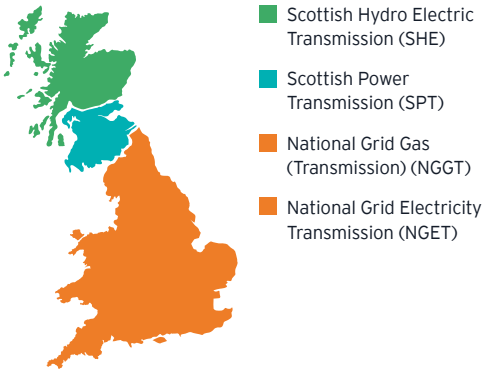
4.2.1 An introduction to UK electricity and gas networks

The UK has a highly sophisticated gas and electricity network providing a safe and secure transport service for energy from production plant to consumers. In Britain there are:

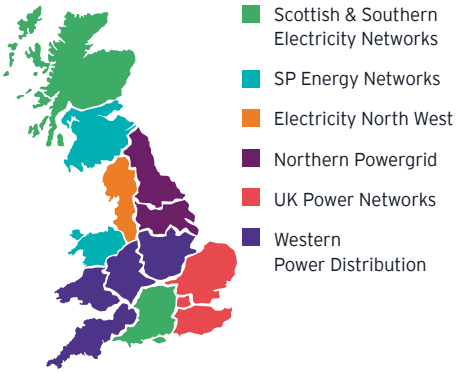
- 14 licensed electricity distribution network operators (DNOs), each is responsible for a regional distribution services area.
- 3 electricity transmission operators.
- 1 gas transmission transporter.
- 7 gas distribution transporter.

Since energy networks are natural monopolies they are regulated by a single economic regulator, Ofgem,[238] to protect consumers from potential abuse of monopoly power.

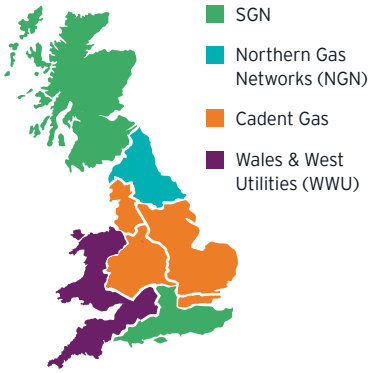
Electricity and gas transmission networks



Electricity distribution networks



Gas distribution networks



238 Office of Gas and Electricity Markets – is the government regulator that oversees the energy system in Great Britain. In Northern Ireland, it's the Utility Regulator and in Ireland it's The Commission for Regulation of Utilities

In addition, there are also a number of Independent Network Operators. They operate across Britain. The Independent Network Operators compete to construct and/or own networks that connect new housing or industrial and commercial developments into the main electricity and gas distribution systems. Independent network operators are regulated in much the same way as the distribution network operators. Ofgem regulates the amounts the independent networks can charge their customers for using their networks via a 'Relative Price Control', which requires charges to be capped for all customers at a level broadly consistent with the distribution network via an equivalent charge.

In 2019 more than 300,000 gas and electricity connections were provided by independent networks. Independent Gas Transporters now serve more than 2.3mn UK users; a million more than in 2010.[239] This makes them now of roughly equivalent scale in terms of connections to either Wales and West Utilities or Northern Gas Networks, with more than 10% of all new and existing connections. As businesses they are usually capable of providing multiple utility connections — electricity, gas, water and telecoms. This makes them a valuable business partner for house builders as they relieve the builder of the burden to coordinate utility connections.

The gas network in the UK and Ireland comprises around 300,000km of pipes — enough to go around the world seven times.[240] The electricity network in the UK and Ireland comprises around 1,000,000km of cables — enough to go around the world 25 times.[241] There are circa 30mn homes and businesses connected to the electricity networks, approximately 22mn homes and businesses are connected to the gas networks.[242] The energy network's costs account for circa 23% of the average annual UK energy bill.[243]

The networks are being redesigned to facilitate the connection of renewable energy, electric vehicles, electric heating and hydrogen within the gas network. Just over 25% of all renewable electricity generation and 100 green gas production sites are now connected to the local energy distribution networks.[244]

4.2.2 Obtaining an electricity connection & connection charges

Essentially network operators are required by their operating licence to offer terms for connection to their network to all those who apply, whether the applicant is directly connecting to a distribution network or via an independent network connecting a new development (subject to applicable technical data and financial guarantees being in place from the applicant). Connection offers are made based on the capacity available on the network. Should the required capacity not be available then network upgrade works will be required, and the connection offer will be made with a connection date subject to these works being completed. From interviews with network operators during this review connection offers are predominately made based on a cable connection. This is done to remove many of the planning permission issues (visual amenity, land use restriction, height restrictions) that would occur should an overhead line be considered as the basis of the connection offer. However, it is considerably more expensive and therefore has implications related to (i) equity in sharing the available capacity between those seeking connection to the network and (ii) the charging for network upgrades, both discussed below.

As outlined above, an independent network operator would usually be involved in the distribution system directly associated with the immediate network around a housing estate or other commercial development. As this network is usually purpose built there is not normally any network capacity issues, the network being designed for the load it is required to serve.

239 https://www.lse.ac.uk/business-and-consultancy/consulting/assets/documents/Building-Back-Faster-22-October-2020.pdf
240 https://www.energynetworks.org/energy-networks-explained/
241 Ibid
242 Ibid
243 https://www.ofgem.gov.uk/data-portal/breakdown-electricity-bill
244 https://www.ofgem.gov.uk/system/files/docs/2018/12/ofg1050_riio_fast_facts_web.pdf

The change away from gas heating to heat pumps will increase the required electrical connection capacity from circa 9kW to 14.3kW per home (9kW for existing load in the house and 5.3kW on a Diversity Maximum Demand basis for the heat pump),[245] and this will increase further if new homes are made electric vehicle ready.[246] During winter periods for the average UK house the energy demand for heating (mostly supplied by gas) can reach around five times the magnitude of energy demand for other items (mostly electricity for lighting and other non-heat activities).[247] As such a high uptake of individual heat pumps will have a significant effect on electric power demand both in terms of peak demand and the rate of change in that demand (known as ramp rate). The network consequences of the combination of heat pumps and electric vehicle charging were summarised by Steve Cox, Engineering and Technical Director for Electricity North West when he said:

> “When you combine heat pumps and electric vehicles the demand on the network is considerable, with heat load adding 10% to demand. We estimate that 200,000 heat pumps will add 100MW in capacity and 1TWh in energy.

Steve Cox
Engineering and Technical Director for Electricity North West

Using these capacity and energy figures an initial 300,000 heat pumps will have an energy requirement of approximately 1.5TWh and a capacity requirement of 150MW (for the 600,000 heat pump target in the Ten-Point Plan these figures would typically double). In addition to network capacity considerations, additional generation capacity is needed to supply the 150MW. In an electricity system with just under 78,000MW of generation capacity available and an energy supply of 345TWh (2019 figures) this is not initially a significant amount. However, given that wind generated renewables will become more significant over time, the risk scenario is the ‘low wind cold day’, where wind generation is reduced, and heat demand is high with heat pumps running constantly. This scenario means that once heat pumps are widely deployed the network could run out of electricity generation capacity to supply the heat load. This issue means that heat storage technology should be deployed with heats pumps which further increases the capital cost.

The network operators are currently working on load diversity factors and other means of managing the concurrence of demand.

> “We need to develop national network planning standards to calculate peak demand based on electric vehicles, lighting, heating and their natural diversity of peak.

Ian Cameron
Head of Customer Service & Innovation for UKPN

245 https://www.energynetworks.org/industry-hub/resource-library/?search=heat&id=267
246 The minimum recommended installation for a domestic E charge point is 3.6kW (6–10 hour overnight charging); a rapid charge point is 7kW
247 Department of Energy and Climate Change, (2012) Op.cit.

> Diversity and flexibility of usage patterns are crucial factors for ensuring the required network capacity can be delivered efficiently. Considerable work had been done in trials, but we are still researching the impact of wide scale adoption of heat pumps.

Steve Cox
Engineering & Technical Director for Electricity North West

> Heat pumps are more of a network issue due to the longevity of their demand. The circa 7kW of demand could be on constantly for 6 to 7 hours at a time. Also, when it is cold, say lower than -5°C then a resistive heating element is going to kick in and it is this load that we need to plan for.

Steve Cox
Engineering & Technical Director for Electricity North West

Several house builders (as well as other parties) seeking connections in parts of the country experiencing the highest economic growth[248] have said the available network capacity can be exhausted rapidly.

> On large sites in the South and Midlands of England and Wales where the build programme is expected to extend beyond 2025, we've already seen connections delayed. The longer the uncertainty persists, the more likely it is that annual housebuilding volumes will be adversely impacted which jeopardises the UK Government's own target to build 300,000 properties per annum by the mid-2020s.

Mike Pearce
CEO of Last Mile

248 Real GDP growth per year West Midlands 2.0%, London 2.0%, East of England 1.7%, North West (Manchester) 1.4%, Wales 1.3% https://www.ons.gov.uk/economy/grossdomesticproductgdp/bulletins/regionaleconomicactivitybygrossdomesticproductuk/1998to2018

> Adding heat load on top of making homes electric vehicle ready means that a number of the DNOs don't have the capacity available within the timeline of a number of housing developments already under construction.

Kevin O'Connor
CEO of ESP Utility Group

The DNOs have instituted a new process related to managing the queue for capacity[249] from 2021.[250] This new capacity queue process allows the DNO to assign available capacity to contracted parties, such as housebuilders who are progressing with their projects, by reassigning the capacity assigned from projects that might be delayed for any number of reasons. This new capacity queuing arrangement clearly assists in providing 'capacity equity'. However, the process is still managing a limited resource amongst parties which have contracted to connect to the network.

The other aspect of capacity equity relates to the costs of network upgrades. Ofgem and network operators are undertaking a review of the network charging arrangements (Network Access Code Review),[251] which is expected to report in 2022 and which may recommend a change to this charging philosophy. One of the options within the Network Access review is to remove the need for those connecting to the distribution network to directly pay for the infrastructure upgrades. If this charging philosophy were adopted the individual consumer making the actual connection requiring the network infrastructure upgrade would not directly pay the costs of the infrastructure upgrade, as is the current situation.

It should be noted that (i) connection assets are those directly associated with making the link between the consumer and the existing network, and (ii) infrastructure assets are those more remote from the connection which might be needed as part of the wider network to facilitate higher demand or flows across the network, but do not directly link the consumer to the existing network.

The network infrastructure upgrade costs would be spread across all users of the network, as all potentially benefit from the enhanced infrastructure. Should a new network connection philosophy be implemented, it could be implemented during the next price review period (ED2 – 2023 to 2028), although it is likely to be from 2024 (for further information on the price control process see Section 4.2.3).

The combination of the uncertainties surrounding the network access pricing change and the ED2/ED3 regulatory submissions are causing certain interviewees to consider the scheduling of certain housing developments.

> Taking account of electric vehicles, lighting and electrical heat the DNOs just don't have the capacity available where it is always needed.

> A proper utility infrastructure plan will be required to increase the electricity network capacity.

Clive Linsdell
CEO of BUUK

249 Queue management is the process by which network companies manage contracted connections which have not yet connected to the network and are held in a queue of other projects all seeking connection. This enables network companies to: a) Effectively manage contracted projects if they are not progressing against agreed milestones; b) Remove stalled or slow-moving projects to release capacity for g other projects in the connection queues; and c) Utilise flexible resources in connection queues to better utilise the available capacity

250 https://www.energynetworks.org/assets/images/Resource%20library/ON21-WS2-P2%20Queue%20Management%20Open%20Letter%20(01%20Mar%202021).pdf

251 https://www.ofgem.gov.uk/publications-and-updates/electricity-network-access-and-forward-looking-charging-review-significant-code-review-launch-and-wider-decision

In considering a road map and plan for network operators, Ian Cameron, Head of Customer Service & Innovation for UKPN said:

> “The road map needs to focus on the risks of transition.
>
> **Ian Cameron**
> **Head of Customer Service & Innovation for UKPN**

4.2.3 Electricity network regulatory review

Electricity and gas distribution networks are effectively regional monopolies as consumers cannot choose the local network to which they are connected. As regulated companies the total amount of money that can be recovered for what is called the ‘distribution service’ is set by the industry regulator (Ofgem), a process known as ‘price control’. Ofgem also set incentives within the price controls to encourage companies to innovate so they become more efficient at cutting their financing and running costs and invest intelligently to meet future energy needs. Ofgem also set targets within the price control covering items such as customer service, network reliability and environmental performance.

As part of this process network operators will submit their plans for capital and operational spend on their networks across the price control period. In relation to the Future Homes Standard the DNOs will submit plans for network upgrades for their upcoming regulatory price control period, known as RIIO-ED2, commencing in 2023. The business plans are likely to have a high degree of uncertainty due to the implementation of the Future Homes Standard still being several years ahead at the time of submission. Also, the submission will be required based on a policy with which the DNO have no experience.

As has been said there are uncertainty mechanisms within the price control to manage issues such as this, but should demand be such that these mechanisms are exceeded then delay to a number of connections is likely.

4.2.4 Implications of the Future Homes Standard on the gas network

The Future Homes Standard will clearly put an end to gas demand growth from the new build residential sector. With the switch to low-carbon heating in new homes there will be little economic sense in connecting new homes to the gas network for cooking and as such new homes will be ‘off the gas grid’. Furthermore it should be noted that the Energy White Paper suggests new homes should be prohibited from being connected to the gas network. The effective disconnection of new homes from the gas network has implications for not only demand, but usage patterns and the price of gas, network charges and simple network diversity, each of which is discussed in turn below.

Gas demand

In recent years, gas demand has fallen across the residential sector as boilers have become more efficient. Overall UK residential gas demand has fallen by 16% since 2000.[252] This is despite a rising population and a growing number of homes. Increased efficiencies, including greater levels of home insulation, are partly responsible for this demand reduction. Additionally, through the Boiler Plus[253] project modern gas boilers are now broadly 92% efficient.

The Future Homes Standard will bring to an end gas demand growth from new homes. Further, as approximately 1.67mn gas boilers[254] are replaced each year and modern boilers are more efficient, over time, gas demand will fall further.

252 UK Energy Market Trends Chapter 4 Pg. 65 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/912021/DUKES_2020_Chapter_4.pdf
253 https://www.gov.uk/government/consultations/heat-in-buildings-the-future-of-heat
254 https://www.eua.org.uk/record-boiler-sales-show-how-decarbonisation-will-work/

Gas usage patterns

Gas is responsible for 77% of all heat within the residential sector and 65% of energy overall.[255] The residential sector is broadly 32% of UK gas demand.[256] Gas demand on a cold winter day is broadly 300GWh/d whereas in the summer demand can be 20GWh/d. With the installation of heat pumps in new houses via the Future Homes Standard and the installation of more efficient boilers, the peak winter demand is likely to fall, whereas the summer minimum will be more stable overtime as this is composed of cooking load.

Network charges

As gas demand in the residential sector reduces, the balance of network charges will fall on industrial (including electricity generation) and commercial consumers. If the network stays as currently constituted, the overall total amount of network charges recovered will stay the same. This means that the remaining users of the network will experience an increasing burden to pay these network charges which may induce further gas consumers to switch away from gas, or at the very least to reduce their demand in turn.

To make heat pumps a viable heat source the insulation levels of property must be compatible with that in the Future Homes Standard. Many homes in the UK would not be able to insulate to this level (mostly older houses) and will have to retain some form of gas heating. With the same network cost falling on fewer consumers, the level of fuel poverty amongst low income households may increase.

Implications of gas network decommissioning

The net asset value of the gas transmission and distribution networks is £23.6bn.[257] With network companies employing tens of thousands of employees, the economic and social impact of decommissioning such an undertaking would be considerable. Additionally, the technical complexity of planning and executing the task would be significantly beyond any previous pipeline decommissioning project undertaken.

To decommission the network, it would have to be run down to minimum pressure and then be flushed to remove the residual natural gas. In order not to add to the volume of greenhouse gas in the atmosphere the residual gas will have to be captured and stored in a suitably modified depleted gas field.

As a point of comparison, it is estimated that North Sea oil and gas decommissioning will cost between £45bn and £77bn.[258]

Costs developed by the Federal Energy Regulatory Commission,[259] have been used to calculate an indicative decommissioning costs for the UK gas network. Considering the National Grid gas transmission system,[260] with a route length of 7,660km and pipeline diameter of 900mm the cost of shutting the network down and making safe is circa £7bn. Additionally, looking at the decommissioning of the 275,000km[261] of the gas distribution system taking an illustrative diameter of 200mm, the shut down costs could be £70bn to £80bn.

The cost of removing the pipeline would be considerably higher and in addition would induce considerable disturbance to the environment.

Diversity of network

Achieving a net zero carbon emissions position requires the decarbonisation of the electricity sector (renewable energy), the transport sector (electric and hydrogen vehicles), heat, change to hydrogen in the gas network and demand side efficiencies.

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255 BEIS, Digest of UK Energy Statistics 2020: Electricity, Table 5.1 https://www.gov.uk/government/statistics/electricity-chapter-5-digest-of-united-kingdom-energy-statistics-dukes; BEIS, Energy Consumption in the UK, 2019, End Use Tables, Table U3 (domestic – heat includes space heating, water heating, and cooking), Table U4 (industry – heat includes high temperature processes, low temperature processes, drying/separation, and space heating), Table U5 (services – heat includes hot water and heating) https://www.gov.uk/government/statistics/energy-consumption-in-the-uk

256 UK Energy Market Trends Chapter 4 Pg. 69 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/912021/DUKES_2020_Chapter_4.pdf

257 https://www.ofgem.gov.uk/regulating-energy-networks/current-network-price-controls-riio-1/riio-1-forums-seminars-and-working-groups

258 https://publications.parliament.uk/pa/cm201719/cmselect/cmpubacc/1742/174206.htm

259 FERC decommissioning costs, on an abandonment basis (flushing the pipelines and leaving them safe in-situ), is broadly £138,000 per km plus £1,250 per m3 – Mark Kaiser, 'Decommissioning Forecasting And Operating Cost Estimation' (2019) Gulf Professional Publishing https://www.sciencedirect.com/science/article/abs/pii/S0308597X1630632

260 https://www.nationalgrid.com/uk/gas-transmission/document/133851/download

261 http://www.gasinfo.uk.com/Distribution_page.htm

Simply switching large sectors of the economy to electricity means that the capacity of the electricity network must increase, and the amount of generation capacity must grow as sectors transition across. The advantage of keeping live the gas network is that the asset already exists and some of the costs of expansion of the electricity network can be avoided as the capacity increase will not have to be equivalent to the total energy in the gas network.

Should the demand on the gas network reduce considerably such that sections of the network become stranded the costs of making safe and ultimately removing it would be substantial. The environmental and ecological disruption caused by having to remove and decommission the gas network would be considerable.

There are also practical advantages in retaining both an electricity and gas network connection to residential property, such as during a power cut cooking can usually still take place on the gas hob (assuming one is installed). Additionally, if a gas fire as well as central heating is installed this can provide a certain amount of heat during the power outage.

4.3 Review of the impact of the transition period

4.3.1 Transitional arrangements in the Future Homes Standard consultation

One of the major objectives of the transitional arrangement is to provide clarity for all developers who are affected by the changes made in Building Regulations, especially as to which standards a development site will need to comply with, considering that many housebuilding sites are built over a number of years and require planning in advance.

> “The Government must develop a transition policy as a matter of urgency.
>
> **Clive Linsdell**
> **CEO of BUUK**

> “The transition uncertainty is holding housing development back; we’ve seen connections delayed.
>
> **Mike Pearce**
> **CEO of Last Mile**

As noted in Appendix C an interim uplift of the Buildings Regulations (Part L and Part F) will occur in 2021. A transitional arrangement will apply for this 2021 change such that for homes where work has commenced within 12 months of the submission of a notice or plan the Regulations in place at the time the planning permission was granted can still apply.[262] However, no such transitional arrangement is proposed for the Future Homes Standard’s implementation in 2025. Further, following the Government’s decision not to amend the Planning and Energy Act 2008, this means that local authorities will retain powers to set local energy efficiency standards for new homes.[263]

262 Op.cit. 1 p.100
263 Ibid. p.4

Some larger housing developments will have been granted planning permission already, but will not complete until after 2025. The currently stated implementation arrangements mean that some houses on these developments will be designed to current Building Regulations, whereas those to be built after 2025 will have to comply with the Future Homes Standard.[264] Those houses designed to be compliant with the Future Homes Standard will require a change in building design and utility connection potentially mid-way through a housing project.[265] This arrangement imposes a discontinuity in house design across the development. It should be noted that the detailed technical specification related to the Future Homes Standard will not be available until 2023 and will be subject to consultation at that time, hence the final 'recipe' for building fabric may not be known until 2024. This only leaves circa 12 months to confirm supply chains, test fabric elements (including flame retardant testing of insulation and other materials) and mobilise to site. On the other hand, the Scottish Government has confirmed that all planning permissions granted before 2024 can continue to apply the buildings standard that applied at the time the planning permission was granted.[266]

The implication is that the lack of clarity surrounding the transitional arrangement have not only caused uncertainty in the market, but also caused some house builders to consider deferring certain developments. This places at risk the target to build 300,000 new homes per year by mid-2020s.

4.3.2 Feasibility of 2025 as an implementation date

As stated in the Future Homes Standard consultation paper, there is no doubt that changing away from gas boilers to heat pumps will play an integral role in delivering the objective of building homes that are zero carbon ready.

This will help the Government achieve its net zero ambitions by 2050 as well as its recently announced reduction in carbon emissions by 78% by 2035.[267] The Future Homes Standard must dovetail with the Government's other policies and targets, such as the installation of 600,000 heat pumps per year by 2028.[268]

However, the key findings of this report indicate the current level of preparedness within the supply chain for heat pumps and installers are such that the UK may not be ready by 2025. Thus, putting at risk the target to deliver 300,000 new homes per year by 2025[269] based on a UK manufacturing base, with the implications this will have on the delivery of the levelling up and jobs agenda ambitions.

Also, the availability of electricity network connections in certain areas is reported to be delaying housing developments.

In order to facilitate the development of a UK manufacturing sector a targeted Government support scheme such as start-up grants and innovation funding should be considered.

Additionally, this study found the most significant challenge to achieving the 2025 target is a shortage of qualified installers and repair engineers for heat pumps. To meet the 300,000 new homes per annum target it is expected at least 10,000 technicians should be trained and certified,[270] compared to the current level of approximately 1,200 trained heat pump installers.[271] Indicative information on the timeline to develop a technically robust national training scheme is, between 12 to 18 months to write and consult on the content of an installer qualification such as a NVQ and four months for the City and Guilds Institute to validate the course, with a further six months to develop consistent course materials that could be used nationally by technical colleges and other training providers. To address this skills gap, and be ready for 2025, a training support and certification scheme should be developed urgently.

264 https://www.london.gov.uk/sites/default/files/fhs_consultation_response.pdf
265 Op.cit. 1p.103
266 https://www.gov.scot/news/setting-housing-standards-to-cut-climate-change-emissions/
267 https://www.gov.uk/government/news/uk-enshrines-new-target-in-law-to-slash-emissions-by-78-by-2035
268 Op.cit. 19
269 Op.cit. 3
270 Op.cit. 27
271 Ibid.

5. Our recommendations

Considering the findings set out above the following recommendations are made.

Recommendations

Recommendation 1 — Undertake an impact assessment for the Future Homes Standard

Undertake an impact assessment for the Future Homes Standard, so that any decisions made in relation to the Standard are robustly based on the assessment.

Recommendation 2 — Bring forward the consultation on building fabric and legislation for the Future Homes Standard

Bring forward the consultation on the building specification/ fabric elements of the Future Homes Standard planned for 2023 and legislation planned for 2024.

Recommendation 3 — Provide planning continuity for house builders

Consider a phased implementation of the Future Homes Standard to allow committed developments to proceed based on the planning permission already granted to prevent delays to housebuilding that may lead to Government homebuilding targets not being met.

Recommendation 4 — Coordinate the implementation of the Future Homes Standard with electricity and gas network planning and regulatory milestones

Coordinate the implementation of the Future Homes Standard with the network load planning guidance on heat and electric vehicle load, the report back from the hydrogen network trials that are in progress and the electricity price control period in 2028 (ED3).

Recommendation 5 — Hydrogen integration

Implement the Future Homes Standard such that it is coordinated with the availability of data from the hydrogen pilot projects currently ongoing to reduce emissions from across the economy.

Recommendation 6 — Improve clarity on regulatory reforms

Providing more clarity around network charging and other reforms would help housebuilders and others to plan more effectively for the planned ramp-up of heat pumps. Without this clarity, the risks of delays to housebuilding and the necessary network reinforcement will increase.

Recommendation 7 — Provide support for the supply chain to increase UK heat pump manufacturing capacity

With limited UK heat pump manufacturing capacity available, if the implementation of the Future Homes Standard is to be based on UK manufactured heat pumps, a support scheme (including start-up grants and innovation funding) should be put in place as soon as possible.

The support scheme's design will need to consider applicable State Aid and competition implications.

Recommendation 8 — Provide support for heat pump installer training

To address the potential qualified installer skills shortage, a training support and installer certification scheme should be put in place.

Recommendation 9 — Undertake public communications to increase consumer acceptance

A public communications programme, coinciding with COP26 and continuing thereafter, would help to increase awareness of the significant carbon emissions from homes and increase acceptance of low-carbon heat technologies.

Appendix A

Glossary

ASHP	An air source heat pump is a system that transfers heat from outside to inside a building, or vice versa. Under the principles of vapour compression refrigeration, an ASHP uses a refrigerant system involving a compressor and a condenser to absorb heat at one place and release it at another.
BEIS	Department for Business, Energy & Industrial Strategy is United Kingdom ministerial department. The department is responsible for developing and delivering a comprehensive industrial strategy and leading the Government's relationship with business; ensuring that the country has secure energy supplies that are reliable, affordable and clean; ensuring the UK remains at the leading edge of science, research and innovation; tackling climate change.
Capex	Capital expenditure
Diversity Maximum Demand	In recognition that not all demand sources within a home are switched on at once the connection capacity required utilises a diversity factor. In the case of heat pumps this is 50% of unit demand (circa 7kW) plus 1.8kW giving a total of 5.3kW on a diversified basis.
DNO	A Distribution Network Operator is a company licensed to distribute electricity in the UK. These companies own and operate the system of cables and towers that bring electricity from the national transmission network to end users. In England the network associated with an operating voltage of 132kV and below. In Scotland distribution networks are below 132kV (132kV is a transmission voltage).
EPC Rating	Energy Performance Certificate is a review of a property's energy efficiency.
GSHP	A Ground Source Heat Pump transfers heat from the ground into buildings. Radiation from the sun heats the earth. The earth then stores the heat and maintains, just two metres or so down, a temperature of around 10°C even throughout the winter. A ground source heat pump uses a ground heat exchange loop to tap into this constantly replenished heat store to heat buildings and provide hot water.
Greenhouse gases	The major greenhouse gases are water vapour, carbon dioxide, nitrous oxide, methane, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride, they are transparent to solar (short-wave) radiation but opaque to long-wave (infrared) radiation, preventing long-wave radiant energy from leaving the earth's atmosphere. The net effect is a trapping of absorbed radiation and a tendency to warm the planet's surface.
GW	Watts $x10^9$
IDNO	An Independent Distribution Network Operator. These companies own and operate smaller distribution networks that are located within the areas that DNOs serve. IDNOs are licensed by energy regulator Ofgem.
INA	Independent Networks Association
kWh	Kilowatt-hour is an energy unit. One kilowatt-hour is defined as the energy consumed by power consumption of 1kW during 1 hour: 1 kWh = 1kW · 1h. One kilowatt-hour is equal to 3.6 · 10 6 joules: 1 kWh = $3.6 \cdot 10^6$ J. The energy E in kilowatt-hour (kWh) is equal to the power P in kilowatts (kW), times the time t in hours (h).

MCS Accreditation	Microgeneration certification Scheme (MCS) certifies low-carbon products and installations used to produce electricity and heat from renewable sources. MCS certification is a mark of quality and demonstrates your adherence to recognised industry standards, highlighting quality, competency, and compliance.
Net-zero	Net-zero refers to achieving a balance between the amount of greenhouse gas emissions produced and the amount removed from the atmosphere. There are two different routes to achieving net zero, which work in tandem: reducing existing emissions and actively removing greenhouse gases. See https://www.instituteforgovernment.org.uk/explainers/net-zero-target.
NOx	NOx is a generic term for the nitrogen oxides that are most relevant for air pollution, namely nitric oxide (NO) and nitrogen dioxide (NO_2). These gases contribute to the formation of smog and acid rain, as well as affecting tropospheric ozone.
Ofgem	Ofgem is the Office of Gas and Electricity Markets. It is a non-ministerial Government department and an independent National Regulatory Authority. A mandated role is to protect consumers now and in the future by working to deliver a greener, fairer energy system.
Renewable Heat Incentive	Introduced in April 2014, the Renewable Heat Incentive (RHI) is a Government financial scheme to encourage the use of renewable heat. Whilst Ofgem implements and administers the scheme, the Department for Business, Energy & Industrial Strategy (BEIS) develops and reviews the scheme policy and rules. Applicants who join the scheme by switching to heating systems that use eligible energy sources and stick to the rules receive quarterly payments for seven years for clean renewable heat. There are only four eligible renewable heating systems for the domestic RHI scheme, which include Ground Source Heat Pumps (GSHP), Air Source Heat Pumps (ASHP), Biomass boilers and solar thermal, and recent changes require renewable heating equipment must be installed in accordance with certain standards to be considered eligible for the domestic RHI.
RIIO2-ED2	Revenues = Incentives + Innovation + Outputs RIIO-2 challenges network company customer engagement and user groups submitted independent reports on the proposed network company business plans. The aim of these independent groups is to ensure consumers have a stronger voice in challenging each network company on how their needs and views are accounted for in the plans. The RIIO-ED2 price control starts in 2023, setting the revenue monopoly network owners can earn from charges on consumer energy bills. The framework will drive electricity distribution companies to go further to decarbonise power, transport and heating to help deliver net zero.
SOx	Sulphur oxide (SOx) emissions are mainly due to the presence of sulphur compound in the fuel. Smoke containing sulphur oxides emitted by the combustion of marine fuel will often oxidize further, forming sulphuric acid which is a major contributor to acid rain.
U-Values	A U-value is a sum of the thermal resistances of the layers that make up an entire building element — for example, a roof, wall or floor. It also includes adjustments for any fixings or air gaps. A U-value value shows, in units of $W/m^2 \cdot K$, the ability of an element to transmit heat from a warm space to a cold space in a building, and vice versa.

Appendix B

List of interviews

This Appendix provides the list of the interviews held with key stakeholders affected by the Future Homes Standard including a summary of the key topics discussed.

Table B1: The list of interviews

Interview	Date	Key topics
Barratt Homes Major UK housebuilder	8 April 2021	▸ Future Homes Standard – Barratt Homes' response ▸ Barriers to achieve the Government's 300K new homes objective ▸ Barratt Homes' design experience in compliance with the various standards and regulations ▸ A fabric first approach as a first step towards a zero-carbon home ▸ Mobilisation has not occurred in the heat pump supply chain due to the uncertainty of the roadmap to zero carbon ▸ A major public education campaign may be required ▸ Any works/planning done on jobs, skills and trades ▸ Any involvement in other Government policies and agendas ▸ Fair and just transition
BUUK Independent provider of last-mile utility networks	9 April 2021	▸ Response to the Future Homes Standard ▸ Considering EVs, lighting, heating – DNO do not have the capacity available ▸ Hybrid boilers or using biogas or hydrogen as a solution for retrofitting existing homes ▸ A proper utility infrastructure plan required to increase the electricity network capacity ▸ A roadmap on the risk of transition required ▸ Any need for different skills or trades post 2025 ▸ Other Government policies and agendas affecting BUUK's strategy ▸ FHS potential to disrupt the housebuilding market
UK Power Networks Distribution Network Operator	14 April 2021	▸ Response to the Future Homes standard ▸ Implications for UKPN's network capacity in response to the Future Homes Standard (electric heating) ▸ UKPN's 2028 projection for total heating load ▸ Supplier relations ▸ Feedback from stakeholders (developers) regarding the FHS
ESP Utility Group Independent provider of last-mile utility networks	15 April 2021	▸ Response to the Future Homes Standard ▸ A hydrogen backbone would diversify network risk ▸ Some electricity distribution networks have capacity constraints ▸ Clarity around the transition to the Future Homes Standard is needed
Cadent Gas Owner and operator of a gas distribution network	16 April 2021	▸ Response to the Future Homes Standard ▸ Hydrogen as a true alternative gas and its production capacity of 5GW by 2030 likely be too low ▸ 1.6mn boilers get replaced each year, which indicates a potential market for hydrogen or natural gas/hydrogen blend ▸ The FTS turning its back on gas and potentially hydrogen. By 2035, 3mn homes could be off gas grid. ▸ Gas network becoming a stranded asset and high decommissioning cost ▸ 23mn existing housing stock is a real challenge
Lastmile Independent provider of last-mile utility networks	20 April 2021	▸ Specific advice on how local authorities use the FHS required ▸ The transition uncertainty is causing housing development delayed ▸ The transition uncertainty may jeopardise the UK Government's target to build 300,000 properties per annum by the mid-2020s. ▸ Need for a real-life measurement on demand on networks where there are high levels of EVs. and electric heat penetrations.

Interview	Date	Key topics
Dyanamis Heat pump installer and developer of heat pump control software	21 April 2021	▸ Upskilling the heat pump installer is the greatest threat in supply chain ▸ Consumers are used to using gas boilers. Automated systems and consumer education are essential to increase heat pump installations in the UK
Ofgem UK energy regulator	22 April 2021	▸ Response to the Future Homes Standard ▸ Ofgem's role in investment ▸ Changes in demand patterns for the gas and electricity networks during ED2 period ▸ Length of the proposed transition timetable ▸ Implication for Government's policies to facilitate the construction of 300,000 new homes per year ▸ Pathway implications for the use of hydrogen as fuel as part of the drive toward net zero target
Persimmon Homes Major UK housebuilder	22 April 2021	▸ Response to the Future Homes Standard ▸ Potential delay issue in housing development due to a bottleneck issue of land supply ▸ Issues in jobs, skills and trades ▸ FHS implications on local authorities setting their own standards
Independent industry expert (Heat pump)	26 April 2021	▸ Heat pumps production, installation process and time ▸ Major challenges exist in current heat pump industry – qualified installers and repair engineers ▸ Heat pump manufacturing capacity (globally) not an issue ▸ Consumer acceptance issue especially in air source heat pumps due to familiarity ▸ Other challenges such as noise and physical footprint of heat pumps ▸ Hydrogen boilers manufacturing capacity exists, market demand is required
Electricity North West Electricity distribution network operator	27 April 2021	▸ Response to the Future Homes Standard ▸ 94% of ENW customers connected and using gas for heat. Household unlikely to adopt heat pumps due to the upfront cost ▸ Electric network issue when combining heat pumps and EV demand ▸ Longevity of heat pump demand
Vaillant Gas boiler and heat pump manufacturer	30 April 2021	▸ Response to the Future Homes Standard ▸ Heat pump installation as one of the biggest constraints ▸ Energy efficiency issue of the UK housing stock ▸ Manufacturing heat pumps in the UK has a great potential ▸ An opportunity for hybrid system to be used in the retrofit market ▸ New products launched post-2025 will be all hydrogen ready ▸ Future of hydrogen boiler especially in the retrofit market ▸ Consumer behaviour as a very important factor
National Grid (ESO) Transmission system operator	10 May 2021	▸ NGC (ESO) are working on the network implications of the pathway to net zero, with the network responding to changes in peak demand and demand pattern ▸ Looking to align gas and electricity networks in response to decarbonisation of heat and transport ▸ Gas transmission is likely to have a hydrogen/hydrogen blended future ▸ As an ESO the future is likely to be one where both generation and flexible demand are dispatched ▸ More storage is likely – batteries, hydrogen etc.

Appendix C

Background and basis of the Future Homes Standard consultation

This Appendix C sets out the background and basis of the consultations and associated responses that have led to the Future Homes Standard. The process of consultation started in 2019 and will continue until at least 2023.

Each of the consultation documents is summarised together with Government's key responses and decisions.

C.1 Overview and vision of the 2019 consultation

Heating and powering buildings accounts for 40% of the total energy usage in the UK,[272] amounting to 22% of the UK's greenhouse gas emissions.[273] Accordingly, reducing carbon emissions from homes is essential to meeting the net zero emission target set by Government.

The UK Government's 2017 Clean Growth Strategy[274] set out the wider policy agenda to decrease carbon emissions[275] whilst maintaining economic growth, a key element of which is to roll out low-carbon heating in new homes.[276]

In the 2019 Spring Statement, the Government made an announcement that it would introduce a Future Homes Standard, to future-proof the housing sector by introducing low-carbon heating and world-leading levels of energy efficiency.[277] The underlying target was to reduce carbon emissions from new homes by at least 75% compared to homes built under the then current Building Regulations.[278] 2019 Spring Statement led to a consultation[279] on proposed changes to the Building Regulations Part L (conservation of fuel and power), Part F (ventilation) and the Future Homes Standard.

The 2019 consultation suggested an interim uplift in insulation and ventilation standards contained in the Building Regulations in 2021 which would result in a 31% reduction in carbon emissions[280] compared to previous standards. Responses to the consultation were generally positive, despite concerns around the ongoing focus on new homes rather than existing homes and the proposed timing for the Future Homes Standard.

In January 2021, the Government published its response and confirmed that all new homes will be required to be equipped with low-carbon heating by 2025, effectively prohibiting fossil fuel heating such as gas boilers.[281]

In April 2021, the UK Government announced its acceptance of the Climate Change Committee's recommendation to adopt the proposal that greenhouse gas emissions should be cut by 78% by 2035 compared to 1990 levels. This announcement accepted the Sixth Carbon Budget,[282] which seeks to limit carbon emissions in the period 2033 to 2037 and will take the UK more than three-quarters of the way to reaching net zero by 2050.[283]

A further consultation will be conducted on airtightness standards for homes in 2023, together with the technical specification associated with the Future Homes Standard.

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272 Department for Business, Energy & Industrial Strategy, 'The Grand Challenge missions' (26 Jan 2021). Available online: https://www.gov.uk/government/publications/industrial-strategy-the-grand-challenges/missions

273 Op.cit 1.

274 BEIS, 'The Clean Growth Strategy: Leading the way to a low-carbon future' (2017) https://www.gov.uk/government/publications/clean-growth-strategy

275 Department for Business, Energy & Industrial Strategy, ' Clean Growth Strategy-executive summary' (16 Apr 2018) Available online: https://www.gov.uk/government/publications/clean-growth-strategy/clean-growth-strategy-executive-summary#our-clean-growth-strategy

276 Ibid.

277 Op.cit. 79

278 Op.cit 1.

279 The Consultation ran from 1 October 2019 to 7 February 2020. A total of 3,310 individual responses to the consultation from a wide range of stakeholders including Designer/Engineer/Surveyor (1,449 responses), Local authorities (247 responses), Builder/Developer(134 response), Manufacturer/Supply chain (88 responses), Energy sector (83 responses), Professional body or institution (56 responses), Installer/Specialist sub-contractor (51 responses), National representative or trade body (48 responses), Property management (37 responses), Building control approved inspector (15 responses) and Competent persons scheme operator (7 responses).

280 Government's preferred option was targeting 31% reduction in emissions, mainly delivered through "carbon-saving technology", as well as enhanced building fabric standards, but not to the same extent as the first option.

281 Op.cit 1.

282 Department for Business, Energy & Industrial Strategy, Prime Minister's Office, 10 Downing Street, The Rt Hon Kwasi Kwarteng MP, The Rt Hon Alok Sharma MP, and The Rt Hon Boris Johnson MP, Press release- UK enshrines new target in law to slash emissions by 78% by 2035, (20 April 2021) Available online: https://www.gov.uk/government/news/uk-enshrines-new-target-in-law-to-slash-emissions-by-78-by-2035

283 Department for Business, Energy & Industrial Strategy and the Rt Hon Chris Skidmore MP, 'UK becomes first major economy to pass net zero emissions law' (27 June 2019) Available online: https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law

C.2 Timeline for implementation

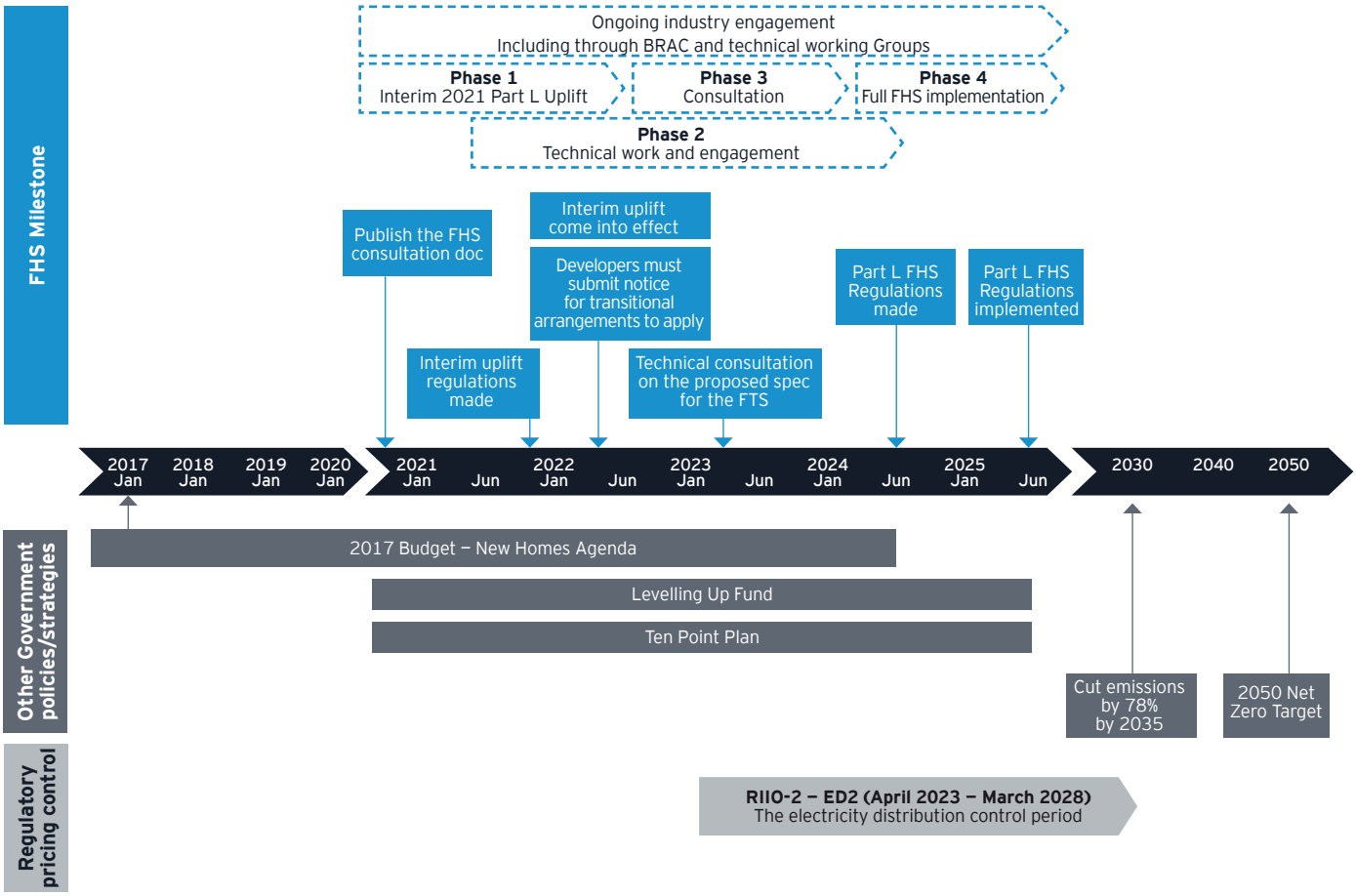
In accordance with the Prime Minister's Ten-Point Plan for a Green Industrial Revolution, the Government is committed to the implementation of the Future Homes Standard in the shortest possible timescale.[284] The Government has stated that it intends to provide the industry with enough time to develop the supply chains and skills necessary to deliver the Future Homes Standard. The standard will come into force by 2025 by progressing through four phases (see diagram C1). The proposed implementation timetable is designed to provide industry with early certainty and support to successfully implement the standard in order to meet the 2050 net zero carbon emissions target.[285]

In January 2021, via a consultation document, the interim 2021 Part L[286] (an uplift to insulation levels for new homes and non-domestic buildings) was confirmed. The Government states this 2021 step will act as a key steppingstone to the Future Homes Standard. From Autumn 2021 the Government will conduct research and analysis to develop the proposed technical specification (Phase 2). The consultation on the technical detail of the Future Homes Standard will take place during 2023 (Phase 3). Lastly, necessary legislation will be introduced in 2024 ahead of the full implementation in 2025 (Phase 4).

The 2019 consultation[287] considered the roadmap to the Future Homes Standard. There was a large divergence of opinion among stakeholder groups[288] regarding the readiness of the necessary supply chains, technologies and skills to deliver the Future Homes Standard[289]. Whilst 69% of the respondents indicated that the proposed 2025 timeline is not ambitious enough to meet the 2050 net zero target, various industry respondents argued that the proposed timeline was too ambitious. This view was based on the lack of availability of the necessary skills and supply chains capacity for low-carbon heat and related fabric construction, which would be a constraint on implementation.[290]

The concerns related to the readiness of the supply chain were echoed during the interviews undertaken.

Diagram C1 Future Homes Standard Timeline



284 Op.cit.29
285 Op.cit 1.
286 Conservation of fuel and power – in effect the insulation levels of new homes
287 Question 5 was Do you agree with the proposed timings to the Future Homes Standard Op.cit. 1
288 designers/engineers/surveyors; builders/developers; local authorities and research/academic organisations)
289 Op.cit. 1
290 Ibid.

> The expected mobilisation has not occurred in the heat pump supply chain, which many believe is due to the lack of certainty of what the overall national roadmap to zero carbon looks like.
>
> **David Thomas**
> **CEO of Barratt Homes**

Putting in place a robust transition plan related to the Future Homes Standard based on a full technical consultation on the Future Homes Standard is required promptly to maintain the 2025 implementation. As the consultation on the technical specification is not scheduled until spring 2023,[291] this may not leave the industry with enough time to react. For example, to put in place manufacturing capacity for heat pumps will take circa 24 to 36 months. Therefore, if a world ranking position is to be obtained in heat pump manufacture an applicable support scheme is required within the next 12 months.

C.3 Description of the steps to implement the Future Homes Standard

Major changes in Building Regulations for interim uplift in 2021

The most notable changes relating to Part L of Building Regulations are:

- A considerable step-up in insulation compared to the level required by the current Building Regulations as a steppingstone to the Future Homes Standard.[292]
- Having decided to retain the Fabric Energy Efficiency Standard (FEES), the interim 2021 Part L uses four new performance metrics,[293] based on a 'fabric-first approach' and the belief that such an approach will provide a smoother transition to the Future Homes Standard and the introduction of heat pumps in new homes.[294]
- The Government also stated that there would be no amendment to the Planning and Energy Act 2008, which enables local planning authorities to retain powers to set local energy efficiency standards for new homes on the basis that they are best placed to assess local needs and viability.[295]This means that different local authorities are applying different standards across the UK. Hence house builders must have different designs for different parts of the country or design for the highest standards and apply those even when they are not required by local authorities. This differentiated approach brings additional costs into the house building sector and thus removes some of the economies of scale that could be employed. The Government confirmed this position based on the responses it received to its consultation document.[296]

2nd stage of the consultation

In January 2021, in parallel with releasing the Government's response to the Future Homes Standard, the Government published the second part of its consultation, which sets out energy and ventilation standards for non-domestic buildings, existing homes and includes proposals to mitigate against overheating in residential buildings.[297]

This consultation is important as it seeks to consider how to mitigate against summer overheating issues in new homes so that air conditioning does not become the norm in new homes as this is seen as a retrograde step in achieving net zero.[298] As has been outlined above, insulation levels are set at a high standard to allow for efficient use of a heat pump in the UK in winter. This being especially important as below -5^{0}C heat pumps are likely to switch to resistive heating mechanisms (in simple terms a form of immersion heater). Therefore, the insulation standards must be such that homes can withstand the external temperature drop without having to rely on resistive heating mechanisms.

For information this consultation closed on 13 April 2021.[299]

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291 Ibid.
292 Ibid. p.27
293 i) primary energy target; ii) carbon dioxide emissions target; iii) fabric energy efficiency target and iv) minimum standards for fabric and fixed building surfaces. Op.cit1 p.30
294 Ibid. p.38
295 Ibid. p.20
296 Question 4: When, if at all, should the Government commence the amendment to the Planning and Energy Act 2008 to restrict local planning authorities from setting higher energy efficiency standards for dwellings? Source: Op.cit 1 p.19
297 Op.cit.1
298 Ibid.
299 Ibid.

C.4 Government impact assessment and policy options for the Part L and Part F 2021 interim uplift

The 2019 impact assessment provides analysis and evidence to support the options presented in relation to the uplift of part L and F of the Building Regulation.[300] It considered two potential options for an interim uplift for 2021, whether to target a 20% carbon emissions reductions 'Future Homes Fabric' (option 1) or whether to target 31% reduction through both 'Fabric Plus Technology' (option 2).[301] Table C1 summarises the two options set out in the consultation paper as well as the impact analysis.

It should be clarified that the impact analysis published does not consider the impact of the Future Homes Standard and the installation of low-carbon heating (e.g., heat pumps). The impact analysis related to the Future Homes Standard will not take place until 2023 when the detailed technical specification will be available. The lack of an impact analysis for the Future Homes Standard is discussed in more detail in Section 4.1.

Overall, the impact assessment[302] shows that both the costs and benefits are greater for Option 2 due to greater upfront capital costs from the installation of renewable technologies as well as greater energy saving from the photovoltaic (PV) generated energy.[303]

The Government confirmed that Option 2 is the Government's preferred option as it not only delivers higher carbon savings of 31% without relying on additional carbon offsetting measures, but also results in an overall net national economic benefit of £585mn compared to a net cost of £1,800mn for Option 1.[304]

The Government considered Option 2 to have a number of advantages, principally that it provided a steppingstone to the Future Homes Standard. The other benefit put forward by Government was the potential for this initial step to increase the capacity of supply chains and readying skills prior to the introduction of the Future Homes Standard.

It should be noted that within the responses to the Future Homes Standard consultation,[305] respondents were in favour of a higher uplift in fabric standard (insulation, glazing etc) than either of the two options outlined above to make a greater contribution to net zero.[306] There were also specific concerns about the need to retrofit insulation to achieve higher energy efficiency in the future after the implementation of the Future Homes Standard. This would be needed if these homeowners wish to install a low-carbon heating system (e.g., heat pump).[307]

Table C1 Summary of policy options[308]

	Option 1 – 'Future Homes Fabric'	Option 2 – 'Fabric Plus Technology'
Carbon emission reduction target[309]	20%	31%
Performance standards[310] (based on the energy and carbon performance of a home with the following items):	i. Very high fabric standards to minimise heat loss from windows, walls, floors and roofs (typically with triple glazing). This would be the same fabric requirement as we currently anticipate for the Future Homes Standard ii. A gas boiler iii. A wastewater heat recovery system.	i. An increase in fabric standards (but not as high an increase as in Option 1, likely to have double rather than triple glazing) ii. A gas boiler iii. A wastewater heat recovery system iv. Photovoltaic (solar) panels
Cost (addition to the build cost of a new home)[311]	£2,560	£4,850
Benefit (Annual energy bill saving)[312]	£60 p.a.	£260 p.a

300 Op.cit., 14
301 Op.cit. 1 Section 3.10
302 This assessment does not consider the costs and benefits of the Future Homes Standard and the Government will publish an associated impact assessment upon consultation on the full technical details prior to introduction of the standard in 2025.
303 Op.cit., 14
304 Ibid.
305 Question 6: "What level of uplift to the energy efficiency standards in the Building Regulations should be introduced in 2020?"
306 Op.cit. 1
307 ibid. section3.8
308 Op.cit., 14
309 Ibid.
310 Ibid.
311 Op.cit., 14 Pg.11-12
312 Ibid.

Appendix D

Gas transition projects

D.1 NyNet

HyNet North West is a significant clean growth opportunity for the UK. It is a low cost, deliverable project which meets the major challenges of reducing carbon emissions from industry, domestic heat and transport.

HyNet North West is based on the production of hydrogen from natural gas. It includes the development of a new hydrogen pipeline and the creation of the UK's first carbon capture, and storage (CCS) infrastructure. CCS could be a vital technology to achieve the widespread emissions savings needed to meet the 2050 carbon reduction targets.

Accelerating the development and deployment of hydrogen technologies and CCS through HyNet North West positions the UK strongly for skills export in a global low-carbon economy.

The new infrastructure built by HyNet could be readily extendable beyond the initial project and would provide a replicable model for similar programmes across the UK.

It is believed that the UK Government supports HyNet with over £33mn of funding. The funding covers around 50% of the investment necessary to finalise ongoing planning studies with the aim of the site becoming operational by 2025.

D.2 The Gas Markets Plan (GMaP)

To continue to deliver safe, reliable gas supplies at the best value for consumers, a process is needed to proactively and strategically consider how market frameworks need to change across all potential future scenarios. To achieve this, National Grid Gas Transmission, in collaboration with industry, policymakers and stakeholders have launched the Gas Markets Plan (GMaP).

The GMaP brings together a broad range of stakeholders to prepare for future gas market frameworks.

The GMaP report outlines the areas of change are to be explored with the industry over the next year, as well as what industry should be proactively preparing for in the next 2–10 years.

D.3 Aberdeen Vision

The Aberdeen Vision Project takes advantage of the Acorn Hydrogen plans which involve hydrogen production from natural gas at the St Fergus Gas Terminal, where around 35% of all UK natural gas comes onshore. This area of the north east provides a promising location for hydrogen production because of the volumes of natural gas, and because the area is currently investigating opportunities for developing carbon capture and storage infrastructure that is more than capable of dealing with the Acorn Hydrogen emissions.

The Aberdeen Vision project will evaluate co-mingling hydrogen into the gas grid and consider potential regional applications for hydrogen in heat and transport.

Appendix E

Hydrogen policies

Examples of wider hydrogen strategies

Japan

Japan set out a basic hydrogen strategy[313] in 2017, and it has since set out specific plans to become a 'hydrogen society.' The strategy seeks cost parity with competing fuels, such as liquefied natural gas (LNG) for power generation. Japan's policy has cost and efficiency targets per application, targeting electrolyser costs of $475/kW, efficiency of 70% or 4.3 kWh/Nm^3, and a production cost of $3.30/kg by 2030.

Japan has a series of projects underway looking to set up an international hydrogen supply chain. The Hydrogen Energy Supply Chain, for example, is committed to delivering hydrogen converted from coal gasification from Victoria's Latrobe Valley in Australia. The first liquid hydrogen ship was delivered in December 2019, and the first blue ammonia (ammonia from gas reforming with carbon capture) shipment arrived in September 2020.

Australia

Australia's hydrogen strategy 'H2 under 2',[314] sets a hydrogen production cost target of below AU$2/kg. The strategy sets out an AU$370mn Government support scheme linked to Australia's Technology Investment Roadmap.

Germany

In June 2020, Germany rolled out a national hydrogen strategy[315] that targets an electrolyser capacity of up to 5 GW by 2030. The strategy states the target corresponds to 14 TWh of green hydrogen production, requiring 20 TWh of renewables-based electricity. An additional 5 GW of capacity may be added by 2035 and no later than 2040.

European Union

The EU's hydrogen strategy[316] contains an electrolyser capacity target of 6 GW by 2024 and 40 GW by 2030, as well as production targets of 1mn and 10mn tonnes of renewable hydrogen per year for those two milestone years.

France

France's hydrogen strategy[317] provides an investment of €7.2bn by 2030 and a hydrogen production capacity target of 6.5 GW by 2030. About €1.5bn will be spent on construction of electrolysis plants.

Spain

Spain's hydrogen strategy[318] target's 4 GW of electrolyser capacity by 2030, with near term goals of at least 300 MW to 600 MW by 2024.

Canada

Canada's hydrogen strategy[319] outlines that by 2050 hydrogen will deliver circa 30% of Canada's end-use energy. The strategy contains provisions for a hydrogen supply network that could include both large-scale centralised plants in its natural gas–rich provinces or regions with high penetration of low-cost renewables, as well as smaller-scale distributed electrolytic production near demand centres. The strategy has a delivered hydrogen cost target of CA$1.50–3.50/kg.

313 Basic Hydrogen Strategy Determined (METI)
314 Australia's National Hydrogen Strategy | Department of Industry, Science, Energy and Resources
315 BMW – Federal Ministry for Economic Affairs and Energy – The National Hydrogen Strategy
316 https://ec.europa.eu/energy/topics/energy-system-integration/hydrogen_en
317 https://www.fch.europa.eu/sites/default/files/file_attach/Brochure%20FCH%20France%20%28ID%209473038%29.pdf
318 https://www.hylaw.eu/sites/default/files/2019-02/HyLAW_%20National%20policy%20Paper_ENG_Final.pdf
319 The Hydrogen Strategy (nrcan.gc.ca)

Appendix F

Hydrogen generation implications and costs

F.1 Introduction

This appendix sets out the cost and other practical issues derived from the production of hydrogen at a quantity equal to the Climate Change Committee's Balanced Scenario.

F.2 Gas volumes

During 2019 the UK consumed 858TWh of gas,[320] however, gas demand is decreasing overtime as appliances (mostly boilers) become more efficient. The Climate Change Committee considers that in its Balanced Scenario a hydrogen production capacity of 225TWh would be needed by 2050.

F.3 Electrolyser technology

Electrolysers are increasing in size and can be combined to form larger installations and thus capture economies of scale and efficiency. Current electricity consumption of ~45kWh/kg_{H2} is required to produce hydrogen.[321] It should be noted that electrolysers are likely to become more efficient overtime and thus this number will fall, so the calculations below are purely illustrative.

F.4 Hydrogen demand

Using a factor of 37.3 kWh/kg for hydrogen production on a higher heating value basis (recognising some water vapour in the hydrogen flow), the Balanced Scenario will lead to the production of approximately 6mn Tonnes of hydrogen.

F.5 Electricity demand

Using the electrolyser electricity demand of ~45kWh/kg_{H2} this gives an electricity requirement of 270TWh_e.

Assuming a 40% load factor this would be circa 77GW of renewables (twice the current UK renewables capacity ~38.2GW[322] or another 12 projects the size of the 6GW Hornsea 1, 2, 3 and 4).[323]

F.6 Electrolyser footprint & water needs

The electrolysers would have an estimated footprint of 746ha (~1,120 football pitches) and water consumption of 0.5L/kWh, which would be equivalent to the annual consumption of 690,000 households.[324]

F.7 Technology advances

By 2030 or 2050 it is likely that general efficiencies in energy requirements will reduce the need for hydrogen, electrolyser technology will become more efficient, also these figures should be regarded as purely illustrative as to the scale of production, as outturn demand would account for other factors such as storage, demand variability and spatial factors.

F.8 Investment needed

Putting in place a hydrogen production capability of this magnitude is a significant project.

Within the Climate Change Committee's Sixth Carbon Budget it suggests the Balanced Scenario needs to supply 225TWh of hydrogen by 2050, with a cumulative capital spend of £72.5 bn.[325] Hence this is a project of considerable scale and will make a significant contribution to both the jobs and the levelling-up agendas.

320 Department for Business, Energy and Industrial Strategy UK Energy Trends March 2021 (Chapter 4 – Gas) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/972773/Energy_Trends_March_2021.pf

321 https://ucpcdn.thyssenkrupp.com/_legacy/UCPthyssenkruppBAISUhdeChlorineEngineers/assets.files/products/water_electrolysis/tk_19_0820_hydrogen_broschuere_2019_03.pdf

322 Department for Business, Energy and Industrial Strategy UK Energy Trends March 2021 (Chapter 6 – Renewables) – 14.3GW of onshore, 10,4GW offshore and 13.5GW solar; https://www.gov.uk/government/statistics/energy-trends-section-6-renewables

323 www.orsted.co.uk/en/Generating-energy/Offshore-wind/Our-wind-farms

324 Department for Business, Energy and Industrial Strategy (2018) Hydrogen supply chain evidence base

325 https://www.theccc.org.uk/publication/sixth-carbon-budget/Section 6 – Fuel Supply

Hydrogen and the levelling-up agenda

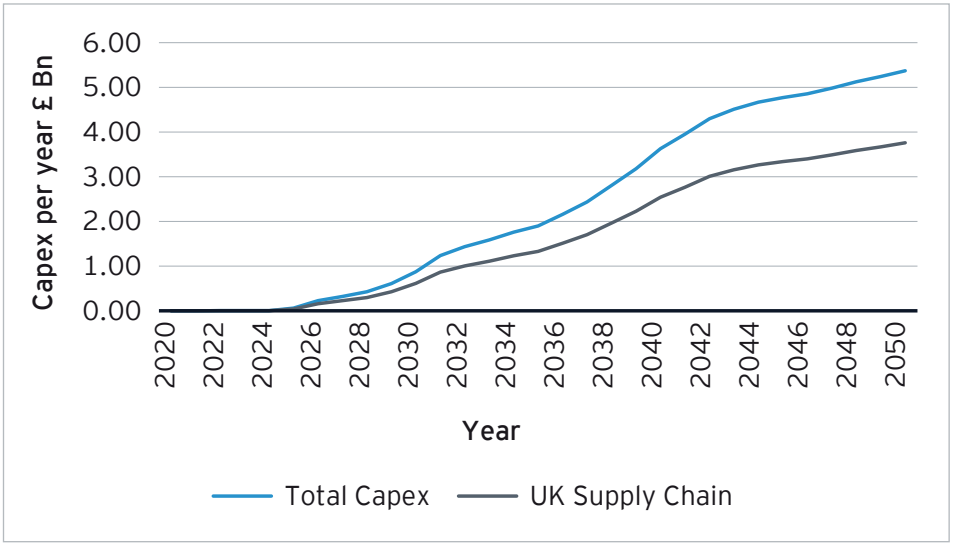
The levelling-up agenda is addressed as the hydrogen production facilities should be located at some or all or the current gas landing terminals – St Fergus (Aberdeenshire); Bacton (Norfolk); Teesside; Theddlethorpe (Lincolnshire) and Rampside (Cumbria).

Hydrogen and the jobs agenda

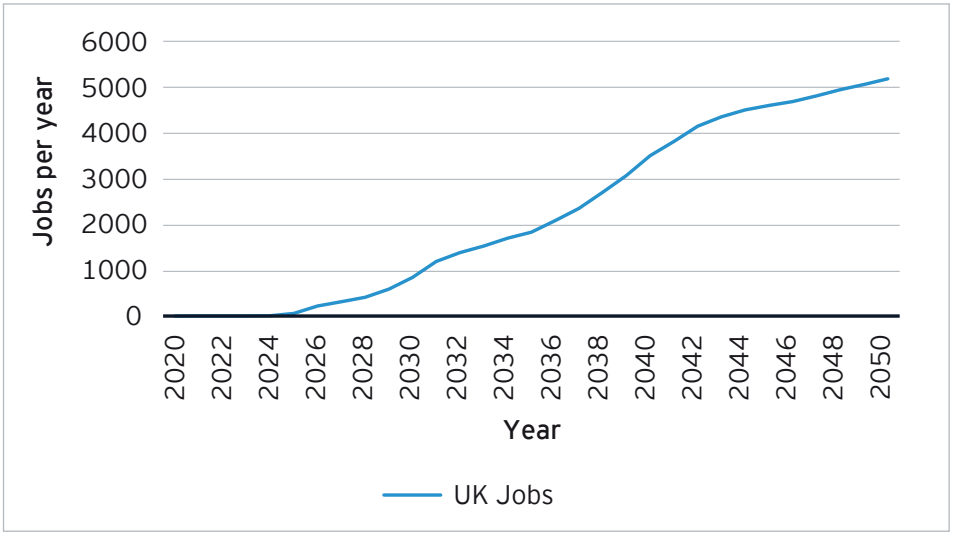
Taking the Hinckley Point C[326] and Sizewell C[327] projects as the nearest energy project comparators they have 64% and 70% respectively of their capital spend formed from UK supply chain. The UK based annual jobs associated with the projects are approximately 1,383 jobs per £1bn of capex.

Our illustrative analysis shows that by 2050 there will be 5,000 jobs directly associated with the construction of hydrogen production assets. The charts show that many of these jobs will have been in place for 20 to 30 years.

Illustrative hydrogen capex for the Balanced Scenario



Illustrative UK construction jobs based on the Balanced Scenario



326 https://www.edfenergy.com/energy/nuclear-new-build-projects/hinkley-point-c/about,
327 https://www.edfenergy.com/media-centre/news-releases/sizewell-c-dco.

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EY-Parthenon teams work with clients to navigate complexity by helping them to reimagine their eco-systems, reshape their portfolios and reinvent themselves for a better future. With global connectivity and scale, EY-Parthenon teams focus on Strategy Realized — helping CEOs design and deliver strategies to better manage challenges while maximizing opportunities as they look to transform their businesses. From idea to implementation, EY-Parthenon teams help organizations to build a better working world by fostering long-term value. EY-Parthenon is a brand under which a number of EY member firms across the globe provide strategy consulting services. For more information, please visit ey.com/parthenon.

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