**Specification for the provision of analysis on abating direct emissions from ‘hard to decarbonise’ homes, with a view to informing the UK’s long-term targets**

Tender Reference Number: RH/1118

**Specification of Requirements**

Invitation to Tender for the provision of analysis on abating direct emissions from ‘hard to decarbonise’ homes, with a view to informing the UK’s long-term targets

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Deadline for Tender Responses: 11th December, 5pm

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# Preamble

The Committee on Climate Change (CCC) was set up as part of the Climate Change Act. The CCC is an independent body tasked with providing advice to Government on climate change issues, and particularly the setting of carbon budgets, and the monitoring of progress towards meeting those budgets. The CCC’s past reports are available here: <http://www.theccc.org.uk/reports/>.

# Background

In 2015, at the 21st yearly session of the Conference of Parties, parties to the United Nations Framework Convention on Climate Change (UNFCCC) reached a landmark agreement to strengthen the global response to the threat of climate change. Parties committed to keeping global temperature rise this century well below 2 degrees Celsius above pre-industrial levels, and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.

In October of this year, the Intergovernmental Panel on Climate Change (IPCC) released a report on the impacts of global warming of 1.5 degrees above pre-industrial levels, alongside a series of related global emissions pathways.[[1]](#footnote-1)

This was followed by a formal request from UK and devolved Governments for the CCC to update its advice on UK climate action following the Paris Agreement.[[2]](#footnote-2) The Government has sought advice on the date by which the UK should achieve a net zero greenhouse gas or carbon target, and advice on how reductions in line with recommendations might be delivered in key sectors of the economy and at what cost.

The CCC is now in the process of updating its analysis on how ambitious long-term targets can be met. In the area of buildings decarbonisation, the focus of our update will be on those homes considered ‘hard to decarbonise’. We are seeking further analysis on the distribution and characteristics of these homes, on treatment packages and on trajectories for decarbonisation based on the latest available evidence.

#### Work to date on meeting long-term targets

Currently, the Climate Change Act 2008 sets out a legally binding target for the net UK carbon account for 2050 to be at least 80% lower than the 1990 baseline.[[3]](#footnote-3) A range of previous work has considered the contribution that must be made from buildings to achieve this.

Our 2012 report, ‘**The 2050 target – achieving an 80% reduction including emissions from international aviation and shipping**’, identified that meeting the current 2050 target will require a near complete decarbonisation of heat, due to the limited cost-effective options for reducing emissions from industry, agriculture and international aviation (Figure 1[[4]](#footnote-4)).

| Figure 1.Hard-to-reduce sectors and the 2050 target |
| --- |
|  |
| Source: CCC fifth carbon budget analysis.  Notes: 2015 provisional numbers presented here for waste & F-gases and international aviation and shipping are 2014 actual figures. The right hand column shows our assessment of residual emissions in 2050 from International Aviation and Shipping, Agriculture and Industry after cost-effective abatement opportunities have been taken up (our Central Scenario). |

Following this, analysis was undertaken both for the **fourth carbon budget review**, and for our **fifth carbon budget** report, in order to refine scenarios for meeting the current 2050 targets.

Our carbon budget advice is underpinned by scenarios for how carbon abatement can be achieved in each sector. Our scenarios are based on bottom up modelling of what is required on the cost-effective path to the current 2050 target (an 80% reduction on 1990 levels). They consider the relative cost-effectiveness of different approaches to meeting the 2050 target, in the context of expectations for emissions in the absence of further effort (the ‘baseline’). Specifically the scenarios include measures that are available at lower cost than the Government’s published carbon values.

In developing scenarios we also consider:

* The wider criteria set out in the Act, including impacts on affordability and competitiveness
* The need to ensure that measures required to meet the 2050 target are available to be deployed when needed, through demonstration and deployment of key technologies, development of markets, and deployment of supporting infrastructure
* The feasibility of deploying particular solutions
* Actions to which the Government is already committed

We develop four types of scenario, a ‘central’ scenario (representing our best assessment of the technologies and behaviours required to meet the 2050 target cost-effectively), a ‘max’ scenario (representing high deployment of carbon abatement measure towards the maximum limits that are likely to be feasible), a ‘barriers’ scenario (representing unfavourable conditions for key measures), and ‘alternative’ scenarios (representing deployment of different measures to those available in the other scenarios).

The buildings scenarios for the fifth carbon budget were developed by first modelling cost-effective energy efficiency measures.[[5]](#footnote-5) For low-carbon heat, modelling was undertaken to develop scenarios for deployment of district heating.[[6]](#footnote-6) We then assumed a cost-effective profile of uptake for energy efficiency and district heating. We used the National Household Model (NHM) to look at remaining cost-effective uptake of other technologies, namely heat pumps and biomass boilers (reflecting constraints driven by our assessment of biomass best-use).[[7]](#footnote-7) The NHM was not used to model hybrid heat pumps or resistive heating.

For the purposes of modelling our Max Scenario in the NHM, DECC’s high carbon value assumptions were used to inform cost-effective rollout of measures. Additionally, we made a simplifying assumption that remaining ‘on-gas’ properties would be fitted with hybrid heat pumps (in the case of larger properties) or storage heaters (for smaller flats). Our Max Scenario for buildings left 4MtCO2e of residual emissions in 2050, 16MtCO2e lower than the emissions associated with the CCC’s Central Scenario (Table 1).

| Table 1. Summary of CCC Barriers, Central and Max Scenarios and resulting annual emissions of greenhouse gases in 2050 forheat in buildings | | |
| --- | --- | --- |
| Max | Central | Barriers |
| Domestic: demand met by heat pumps or H2 (70%), heat networks (10%), electric heating (5%) and gas (10%). Non-domestic: demand met by heat pumps (50%), heat networks (45%) and gas (5%).  **4 MtCO2e** | Domestic: demand met by heat pumps or H2 (60%), heat networks (10%), electric heating (5%) and gas (25%). Non-domestic: demand met by heat pumps (35%), heat networks (25%) and gas (40%)  **19MtCO2e** | Domestic: demand met by heat pumps or H2 (20%), heat networks (5%), electric heating (5%) and gas (75%). Non-domestic: demand met by heat pumps (35%, heat networks (55%) and gas (5%).  **67 MtCO2e** |

In 2016 the CCC published a report on ‘**UK climate action following** **the Paris Agreement’.** This included an assessment of how far existing CCC Max Scenarios go in reducing emissions (Figure 2).

| Figure 2.Residual UK greenhouse gas emissions in 2050 under Max deployment across all sectors |
| --- |
|  |
| Source: CCC calculations. |

Most recently, a package of analysis by Imperial College London was launched earlier this year examining **alternative UK heat decarbonisation pathways**.[[8]](#footnote-8) This work has examined the costs of different heat decarbonisation pathways for buildings on the gas grid. Amongst other things, the analysis suggests that deep decarbonisation is possible for these buildings, but that reaching zero emissions from heat by 2050 may be expensive.

#### The need for further analysis on ‘hard to decarbonise’ homes

There is now a need to update existing advice, both to ensure that it reflects the latest evidence, and to illustrate in more detail a range of pathways to reducing carbon emissions from ‘hard to decarbonise’ homes. This includes those homes not decarbonised in our Central Scenario - typically homes that are particularly expensive/difficult to retrofit with energy efficiency measures, and therefore also with low-carbon heat (this group will also be a product of our suitability assumptions, modelling approach etc.). It will also include some homes in our Central Scenario that have ‘hard to decarbonise’ features, including those with solid walls and non-standard cavity walls. It could additionally include homes where the occupiers may prove resistive to making even cost-effective changes like improved efficiency and installing heat pumps or joining a heat network.

*Defining ‘hard to decarbonise’ homes*

Traditionally the CCC has undertaken distinct analysis on ‘hard to treat’ homes, namely those considered difficult to insulate (and subsequently less suitable for cost-effective low-carbon heating options). We are now classifying the group of homes of interest as ‘hard to decarbonise’, given the value of placing an equal focus on the suitability of cost-effective insulation andlow-carbon heat options. Our principle interest is in those homes for which the costs of decarbonising will be higher, barriers will be harder to overcome, or for which the decarbonisation solutions are likely to be more complex.

The 2013 Element Energy and Energy Saving Trust report, ‘Review of potential for carbon savings from residential energy efficiency’, sets out the classifications on which our fourth and fifth carbon budget analysis were based:

* All homes with uninsulated solid walls are typically considered ‘hard to treat’ due to the costs and other challenges associated with insulating them
* A range of non-standard cavity walls were classified as ‘hard to treat’ based on the definitions described in the Inbuilt 2012 report on hard to treat cavity walls (also used as the source of the DECC estimates of ‘hard to treat’ cavity wall numbers)
* ‘Hard to treat’ lofts were also identified based on the DECC definition, ‘properties that contain lofts which are hard to insulate. For example properties with a flat roof or very shallow pitch (to make the loft space inaccessible)’.[[9]](#footnote-9)

The definitions were based around the technical challenges associated with insulating properties with certain physical features.

However, in reality a wider range of factors is expected to influence how difficult and costly it is to decarbonise a home. These include factors such as the heritage or conservation value of a home, smaller homes where ‘space-take’ associated with internal solid wall insulation is likely to be a significant concern, and also other aesthetic or practical considerations which drive non-standard or higher-cost decarbonisation approaches (e.g. sash and bay windows).

On the other hand, there may also be cases where homes traditionally considered ‘hard to treat’, are not hard to decarbonise – i.e. where low-carbon heat solutions (e.g. heat pumps, heat networks or a switch to hydrogen fuel) can still be deployed at comparable cost and hassle to other properties, despite insulation challenges.

*Updating the evidence base*

The evidence base has evolved since the analysis undertaken for the fifth carbon budget. There is a need for updated analysis to make use of this new evidence, and to build on it by bringing information together to generate new insights.

There is a range of evidence available on the **demographics** of hard to treat homes, including technical potential, dwelling type, tenure, and household composition.[[10]](#footnote-10) However, there are gaps in understanding the demographics of ‘hard to decarbonise’ homes (where more broadly defined), and in understanding other key characteristics which will influence decarbonisation measures. These include:

* The incidence of ‘hard to decarbonise’ homes across England, Scotland, Wales and Northern Ireland, given the associated implications for devolved policy making.
* The geographic location of these homes, and the associated suitability of different low-carbon heating options. Some homes will be in areas that are likely to be suitable for district heating solutions, some may be on the gas grid, and those off the gas grid will have varying potential for gas connection depending on proximity. There could also be interactions between grid congestion and suitability for electric heating systems.
* The coincidence of factors driving segments of homes to be ‘hard to decarbonise’. For instance, some homes may require more than one insulation measure to deliver material carbon savings, or may require more complex decarbonisation approaches due to the coincidence of technical challenges and other features such as heritage (e.g. whether the home is in a conservation area).
* The extent to which ‘hard to decarbonise’ homes occur in areas with a high incidence of fuel poverty.

A number of gaps in the evidence base on **measure costs** were identified during the analysis for the fifth carbon budget assessment, including the absence of cost data for internal solid wall insulation, and uncertainty over the ranges associated with the costs for external solid wall insulation and cavity wall insulation given large variances across property types.[[11]](#footnote-11) New evidence has since been gathered as part of the Buildings Energy Efficiency Technical Research Programme undertaken by the Department for Business, Energy and Industrial Strategy (BEIS).[[12]](#footnote-12) There will be a need for the latest evidence to be reviewed, consolidated and integrated into the analysis. As part of this, there is also value in considering how costs vary as a function of retrofit approach (for instance whether as part of a local scheme, or whether done on a whole house retrofit basis), and location.

Analysis relies on an accurate understanding of the **energy and carbon savings that can be delivered by measures**. There is evidence that there is often a gap between the actual in-situ performance and the theoretical performance we can expect from decarbonisation measures. This may be attributed to factors such as consumer behaviour (e.g. comfort taking), quality of installation and assumptions around the specification prior to the installation of measures. The difference is often represented as an ‘in-use’ factor.

Our work for the fifth carbon budget identified evidence gaps around the heat loss associated with solid walled homes, impacting the energy savings associated with insulation. A project launched by DECC and BRE in 2013 sought to improve evidence on heat losses from solid wall properties and the performance of measures to insulate them.[[13]](#footnote-13) BEIS are in the process of updating wider evidence on in-use factors across measures which may become available over the course of this work. It is also important to note that whilst individual measures will have ‘in-use’ factors associated with them, these are likely to vary according to the other thermal properties of the home.[[14]](#footnote-14) We are interested in advancing our understanding in this area, and in advice which can reflect the value of ‘whole house’ approaches.

Finally, there are gaps in our understanding of how **packages of energy efficiency and low-carbon heating measures** can be applied to different segments of the ‘hard to decarbonise’ building stock. Whilst there is an evidence base on individual measures, there is more limited evidence on those packages of measures which could most cost-effectively decarbonise these homes, including limited understanding of the best balance between insulation measures and low-carbon heat.[[15]](#footnote-15)

*Updating the scenarios*

**The focus of this work will be on determining the most cost-effective and appropriate packages of decarbonisation measures for each segment of the ‘hard to decarbonise’ stock, and subsequently developing a profile of measure deployment which can be used to update our Max Scenario to 2050. A discrete number of additional scenarios will also be needed.**

To 2050, our Max Scenario for domestic buildings, developed as part of our analysis for the fifth carbon budget, currently includes: 70% of domestic demand met by heat pumps or H2, 10% met by heat networks, 5% by electric heating and 10% by gas. Low-carbon heat provision is in the wider context of energy efficiency measures including insulating 6.5 million solid walls (of which 4.5m are for wider fuel poverty benefits), 6.7 million cavity walls (including those cavity walls which require solid wall insulation) and 9 million lofts in homes by 2050.

In relation to hard to treat homes (as previously defined), our Max Scenario in 2050 includes:

* The insulation of 6.5 million solid walls (around 90% of the technical potential)
* The insulation of 2.5 million ‘hard to treat’ cavity walls (around 90% of the technical potential)
* 2 million hybrid heat pumps and 0.7m storage heaters, leaving 10% of demand met by gas heating

The current allocation of low-carbon heating technologies in our scenarios is not disaggregated by homes which are ‘hard to treat’ vs ‘easy to treat’ for insulation. As described above, levels of deployment were instead determined through use of the National Household Model (Box 1), and based on ‘cost-effective’ deployment of low-carbon heating options given our scenarios for energy efficiency and heat network deployment.[[16]](#footnote-16) For those homes in the Max Scenario not allocated a low-carbon heating system (assumed to be those homes where costs are too high), additional CCC modelling was undertaken to allocate hybrid heat pumps to homes and storage heaters to flats. Some residual residential fossil fuel use remains in our Max Scenario, including gas use associated with hybrid heat pumps and gas peaking plant in district heating systems.

| Box 1. National Household Model scenarios |
| --- |
| The National Household Model is a micro-simulation model developed for DECC, which draws on detailed English, Scottish and Welsh housing surveys. This enables a more accurate and detailed analysis across the stock. Input assumptions can be reviewed and amended within the model code (including the Standard Assessment Procedure buildings physics assumptions, technology costs and performance, and energy costs).  We developed detailed scenarios to 2050 for decarbonising heating in the existing housing stock, with support from the Centre for Sustainable Energy, assessing cost-effective rollout of building-scale technologies.  **Approach**  We assess cost-effectiveness on a social basis, using the HM Treasury Green Book social discount rate of 3.5% real, and factoring in a set of projections of carbon values to 2050, along with energy cost projections.  The scenarios on the National Household Model contain the following steps:   1. We include a range of scenarios for the rollout of heat networks and energy efficiency measures to 2050, along with projections for heat pumps and biomass boilers uptake under the Renewable Heat Incentive to 2021; 2. In each year, existing technology fails based on a probability distribution, with the probability of failure increasing with age. New heat pumps and biomass boilers are replaced after 15-20 years. 3. Consumers choose between a like-for-like replacement and low-carbon technology, based on the discounted lifetime costs including carbon. Technology is sized based on the peak heating load, with an oversizing factor for gas boilers, based on market intelligence. 4. Levels of low-carbon technology are constrained by an assumed supply-chain constraint of 30% annual growth in sales, along with a constraint on the total bioenergy available. Allocation is optimised so that consumers with the greatest cost savings are prioritised over the more marginal cases.   The modelling assumes decreases in capital costs between 2020 and 2030 of 20%, along with improvements in heat pump performance. |
|  |

We are keen to now build on the simplified approach for developing the Max Scenario for the fifth carbon budget, and to refine our understanding of the steps that can be taken to address emissions from ‘hard to decarbonise’ homes.

Following the development of scenarios for ‘hard to decarbonise’ homes, there will be a need to establish how they relate to levels of deployment of energy efficiency measures and low-carbon heating measures in the current Max (and potentially also Central) Scenario(s), such that double counting of measures can be avoided.

#### Research undertaken to date

* Work published by the CCC
  + CCC (2012), *The 2050 target – achieving and 80% reduction including emissions from international aviation and shipping*, <https://www.theccc.org.uk/wp-content/uploads/2012/04/CCC_IAS_Tech-Rep_2050Target_April2012.pdf>
  + Element Energy (2013), *Review of potential for carbon savings from residential energy efficiency*, <https://www.theccc.org.uk/wp-content/uploads/2013/12/Review-of-potential-for-carbon-savings-from-residential-energy-efficiency-Final-report-A-160114.pdf>
  + CCC (2015), *Sectoral scenarios for the Fifth Carbon Budget*, <https://www.theccc.org.uk/wp-content/uploads/2015/11/Sectoral-scenarios-for-the-fifth-carbon-budget-Committee-on-Climate-Change.pdf>
  + CCC (2016), *UK climate action following the Paris Agreement*, <https://www.theccc.org.uk/wp-content/uploads/2016/10/UK-climate-action-following-the-Paris-Agreement-Committee-on-Climate-Change-October-2016.pdf>
  + CCC (2016), *Next steps for UK heat policy*, <https://www.theccc.org.uk/wp-content/uploads/2016/10/Next-steps-for-UK-heat-policy-Committee-on-Climate-Change-October-2016.pdf>
  + CCC (2016), *Heat in UK buildings today*, <https://www.theccc.org.uk/wp-content/uploads/2017/01/Annex-2-Heat-in-UK-Buildings-Today-Committee-on-Climate-Change-October-2016.pdf>
  + Imperial College London (2018), *Analysis of alternative UK heat decarbonisation pathways*, <https://www.theccc.org.uk/publication/analysis-of-alternative-uk-heat-decarbonisation-pathways/>
* Wider evidence relevant to ‘hard to decarbonise’ homes
  + BRE, Defra, EST, (2008), *A study of Hard to Treat Homes using the English House Condition Survey, Part I: Dwelling and Household Characteristics of Hard to Treat Homes*, <https://www.bre.co.uk/filelibrary/pdf/rpts/Hard_to_Treat_Homes_Part_I.pdf>
  + BRE, Defra, EST, (2008), *A study of Hard to Treat Homes using the English House Condition Survey, Part II: Investigating improvement scenarios for Hard to Treat Homes*, <https://www.bre.co.uk/filelibrary/pdf/rpts/HTT_part_II_Final.pdf>
  + Changeworks (2008), *Energy Heritage: A guide to improving energy efficiency in traditional and historic homes,* <https://www.changeworks.org.uk/sites/default/files/Energy_Heritage.pdf>
  + ACE for the Energy Efficiency Partnership for homes (2010), *A review of the deliver tools used to improve hard-to-treat homes*, <https://www.ukace.org/wp-content/uploads/2012/11/77948-EEPH-DELIVERY-TOOLS-Revised-for-web.pdf>
  + DECC (2012), *Improving Energy Efficiency in Buildings: Resources Guide for Local Authorities*, <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/445440/EHS_Energy_efficiency_of_English_housing_2013.pdf>
  + Climate Xchange (2014), *Home energy efficiency – review of evidence on attitudes and behaviours*, <https://www.climatexchange.org.uk/media/1844/cxc_brief_home_energy_efficiency_review_-_full_report.pdf>
  + DCLG (2015), *English Housing Survey, Energy Efficiency of English Housing 2013*, <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/445440/EHS_Energy_efficiency_of_English_housing_2013.pdf>
  + BEIS (2017), *What does it cost to retrofit homes?* <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/656866/BEIS_Update_of_Domestic_Cost_Assumptions_031017.pdf> and <https://www.gov.uk/government/collections/buildings-energy-efficiency-technical-research>

# Aims and Objectives

The overarching aim of this work is to **develop a view on the most cost-effective and appropriate package of decarbonisation measures for each segment of the ‘hard to decarbonise’ stock, and to use this to provide a profile of measure deployment for ‘hard to decarbonise’ homes which can be used to update the Max Scenario to 2050. A discrete number of additional scenarios will also be needed.** The assessment should make use of the latest available evidence.

Alongside the core analysis, the outputs will need to include a qualitative assessment of the policy measures necessary to decarbonise these homes.

#### Scope of interest

As discussed above, this analysis is intended to feed into advice on future ‘net zero’ targets. We are interested in understanding both how packages of measures could be combined to achieve very low levels of direct emissions by 2050, and in determining how direct emissions from these homes can be fully abated.[[17]](#footnote-17)

We are interested in modelling the rollout of measures over time, following a trajectory which is realistic and aims to minimise costs overall. Scenarios for ‘hard to decarbonise’ homes should aim to decarbonise these homes by 2050 at the latest, with an associated view on whether certain measures could be deployed more quickly and under what circumstances.

The analysis will need to be developed on a UK-wide basis, with results separated out by country.[[18]](#footnote-18)

We expect the following tasks to form the basis of the work.

1. **To define ‘hard to decarbonise’ homes**

The necessary first step to frame and bound the subsequent analysis is to identify the set of characteristics that identify a home as being ‘hard to decarbonise’. As set out above, our primary interest is in those homes which are costly or difficult to decarbonise, as a result of one or more features.

* Regarding those homes which are costly to decarbonise, as a first step we are interested in those homes not decarbonised in our Central Scenario for the fifth carbon budget, where insulation measures did not prove to be socially cost-effective using the CCC’s central carbon price assumptions.[[19]](#footnote-19)
* However, we are also interested in those homes which may be difficult or complex to decarbonise for a range of reasons. This could include factors such as wall type, heritage value, suitability for low-carbon heating (e.g. off-gas grid, lack of district heating availability etc.). This group is expected to include some of those homes which are decarbonised in our Central Scenario, including solid walled homes.[[20]](#footnote-20)
* The definition could also include the type of occupier (e.g. some occupiers may be unwilling to take up any low-carbon heating solutions).

In particular, we are interested in those characteristics which could necessitate bespoke decarbonisation approaches. We acknowledge that there will be some characteristics which make homes difficult to decarbonise, but which would need to be addressed through the use of other policy levers. For instance, the misalignment of interests that can arise between landlord and tenant in rented homes, or additional challenges associated with vulnerable occupants. Whilst we are interested in qualitative discussion of these challenges and possible solutions, the focus of the quantitative analysis should be on issues that can be addressed through alterations to the packages of measures applied.

1. **To consolidate and extend the existing evidence on the distribution and characteristics of ‘hard to decarbonise’ homes**

This task is intended to be the basis for the modelling undertaken in tasks C and D.

A range of new evidence has emerged since the fifth Carbon Budget. There is now an opportunity to make use of this new evidence, and to extend it by bringing information together to generate new insights about the distribution and characteristics of ‘hard to decarbonise’ homes.

We are primarily interested in understanding:

1. The incidence of ‘hard to decarbonise’ homes across England, Scotland, Wales and Northern Ireland.
2. The coincidence of ‘hard to decarbonise’ homes with potential for locationally-specific low-carbon heating solutions. This includes proximity to areas suitable for low-carbon district heat networks, and/or proximity to the gas grid (for use with hydrogen or hybrid heat pumps). It could also include information on the scale of grid congestion where this data is available.
3. The coincidence of characteristics which make homes ‘hard to decarbonise’, including multiple technical barriers (i.e. a need for both wall insulation and loft insulation), and the coincidence of technical barriers with other challenges.
4. The extent to which hard to decarbonise homes occur in areas with a high incidence of fuel poverty. This will help inform scenarios and policy development.

This task should aim to generate a detailed segmentation of the ‘hard to decarbonise’ stock which incorporates the latest evidence on technical potential for measures. In the case of some measures (such as solid wall insulation) the costs are expected to vary materially between different types of home. As far as possible, this should also be represented and mapped geographically. The segmentation should seek to break down the different factors which make homes across the UK ‘hard to decarbonise’ and which could therefore require a variety of approaches to address. This detailed segmentation should be used to develop a simplified segmentation of the stock based around a defined number of ‘hard to decarbonise’ archetypes. These are envisaged to be the basis of analysis for task C.

A counterfactual will also need to be developed as part of task B, modelling expected energy use and emissions in the event of no further action/business as usual.

1. **To assess packages of treatment options for the different segments of the ‘hard to decarbonise’ stock, and the costs and carbon savings associated with them**

For each of the ‘hard to decarbonise’ archetypes, it will be necessary to determine the potential treatment options, and packages of measures which offer best decarbonisation potential (taking practical considerations into account), at least cost.  
  
Whilst the £/tonne abatement costs associated with packages of measures are expected to be an input into the selection of ‘lead options’ for decarbonisation of each archetype, in some cases the most cost-effective package of measures for an archetype may be associated with material practical challenges (for instance related to heritage value, space-take, peak impact, or very high upfront costs/bills). This will need to be assessed as part of the work, with potential alternative decarbonisation approaches identified. This will help ensure robust decarbonisation options can be identified for each archetype as well as informing our understanding of knock-on impacts where practical challenges cannot be overcome.

Whilst at least one ‘lead’ option is expected to be needed for each archetype, in some cases alternative options will also need to be identified to support the development of alternative deployment scenarios and qualitative discussion of variants.

* For example, for homes with uninsulated solid walls, a package which does not involve the use of conventional solid wall insulation will need to be examined.[[21]](#footnote-21)
* For homes on the gas grid, the challenges may be very different for a scenario where the gas supply is shifted to low-carbon hydrogen compared to a scenario based on electrification.

1. **To develop scenarios for measure deployment which abate direct emissions from the ‘hard to decarbonise’ stock , alongside advice on associated policy**

Task D aims to take the outputs of task C and translate them into scenarios for integration into the CCC’s Max Scenario for buildings.

A ‘core’ scenario will be needed which represents a best view of how the ‘hard to decarbonise’ stock can be decarbonised. We are also seeking the development of a discrete number of additional scenarios. To the extent some of our areas of interest are not addressed through additional scenarios, we would expect qualitative assessment to be undertaken.

Whilst the primary role of the successful bidder will be to develop discrete scenarios for the ‘hard to decarbonise’ stock, it is expected that additional discussions will need to take place with the CCC to ensure that the ‘hard to decarbonise’ scenarios can be integrated effectively with the rest of the CCC’s Max (and potentially also Central) scenario(s). We welcome research methodologies which are designed to support this process.

The scenarios should be accompanied by qualitative discussion on the policy measures which are expected to be needed to facilitate delivery.

# Methodology

Below we set out an illustration of how the work package might be taken forward.

**However bidders are invited to propose their recommended approach. This includes setting out amendments to tasks where alternative approaches are considered better able to deliver the project objectives within the required timescales and budget. Bids should make clear where simplifying assumptions or simplified methodological approaches are expected to be necessary.**

**We are conscious that this specification sets out a comprehensive work package, for delivery in limited timeframes. We envisage that bidders will need to make use of pre-existing modelling capability to enable delivery. Consortium approaches are particularly encouraged where this enables best use of pre-existing models and data.**

Bids should set out separate pricing for each task.

Bids should make clear the proposed approach to any stakeholder engagement planned as part of the work.

Bids should also make clear where a specific need for CCC input is anticipated, for instance to provide or develop assumptions.

1. **To define ‘hard to decarbonise’ homes**

We welcome proposals on the definition and scope of ‘hard to decarbonise’ homes as part of the tender proposal.

It is envisaged that the final definition will be agreed as early as possible in the research process.

1. **To consolidate and extend the existing evidence on the distribution and characteristics of ‘hard to decarbonise’ homes**

We envisage that this task will be based around the use of models of the UK housing stock with good locational granularity, which can be effectively combined with key datasets and analytical outputs. Some bidders may already have models and datasets which can serve this purpose. Where bidders have some components (such as models of the UK housing stock) but lack others (such as detail on the locational potential for district heating systems) we encourage the use of collaborative partnerships to maximise the use of readily available analysis. In the absence of this, the missing components will need to be developed as part of the work.

The first step is anticipated to involve integration of the relevant datasets into a housing stock model, such that ‘hard to decarbonise’ characteristics can be mapped against one another, and against potential for locationally specific decarbonisation solutions. We are also interested in the incidence of fuel poverty across this subset of the UK housing stock.

A counterfactual will need to be generated, determining the expected energy use and emissions of the ‘hard to decarbonise’ stock in the event of no further action.

We envisage the need for a detailed segmentation of the stock to be developed which can be of standalone analytical use for future work. This should then be used to develop a simplified segmentation which will be the basis of analysis for task C.

Generally, the choice of archetypes will need to be informed by the prevalence of homes that fit each description, and by the nature of the expected packages of solutions. Where one package of solutions is expected to be viable for more than one archetype for instance, there could be potential to combine them. It will be necessary to understand how the archetypes developed for this work relate to the ‘hard to treat’ segmentation developed for past CCC modelling.

1. **To assess packages of treatment options for the different segments of the ‘hard to decarbonise’ stock, and the costs and carbon savings associated with them**

For each of the ‘hard to decarbonise’ archetypes, it will be necessary to determine the range of potential treatment options, and subsequently the treatment options which offer best decarbonisation potential (taking practical considerations into account), at least cost.

**Determining the range of individual measures that could support decarbonisation:** CCC analysis has historically been based around a range of energy efficiency measures which could be integrated in homes,[[22]](#footnote-22) and a discrete list of low-carbon heating options including air source and ground source heat pumps, district heating systems,[[23]](#footnote-23) biomass boilers, storage heating and hybrid heat pumps. We are interested in refining analysis around the above measures (in particular for hybrid heat pumps and solid wall insulation) and extending the list of potential measures examined. Provisional proposals of measures to be examined are welcomed as part of the tender. We are keen that the list of potential measures is extended to include:

* Thin internal solid wall insulation
* Airtightness and ventilation
* Household level flexibility measures (such as batteries and thermal stores)
* Resistive heating[[24]](#footnote-24)
* Demolition and rebuilding of homes[[25]](#footnote-25)

We may wish to include solar thermal, to the extent this can contribute meaningfully to full decarbonisation, in a way that is additional to what can be offered by other solutions and at reasonable cost. We are also interested in understanding how packages of measures interact with hydrogen uptake at grid scale, as well as any role for bottled hydrogen.

For each of the measures, it will be necessary to establish techno-economic assumptions on the basis of the latest available evidence (including internationally where relevant). There is potential for new evidence to emerge during the course of the project (for instance any updated in-use factors that BEIS are able to provide). The modelling should be designed to enable these to be easily integrated when available. It is expected that some of the techno-economic assumptions (e.g. costs) will vary across archetypes for each measure. Where possible, assessment of the potential to bring costs down should also be included, e.g. how costs can be expected to change over time with learning, and in the case of whole house retrofit approaches and bulk installations.

**Determining packages of measures which can successfully decarbonise these homes:** We wish to understand how individual measures can be effectively combined to deliver holistic solutions to decarbonisation at a building-level. In particular, we are interested in the optimal balance between energy efficiency and low-carbon heat for the different archetypes, and in understanding how different low-carbon heating options can be effectively combined to deliver the best outcome.

We anticipate that a number of potential measure packages will need to be developed for each archetype. For homes with uninsulated solid walls, this will need to include one package which does not include the use of conventional solid wall insulation.

We are particularly interested in analytical approaches which extend beyond the core capabilities of the National Household Model, for instance through incorporating detailed building physics modelling or the use of real-life case studies. The proposed approach and inputs, including planned stakeholder engagement, should be set out as part of the tender.

**Determining the relative cost-effectiveness of these packages of measures, to inform identification of lead options:** We anticipate the need to determine the £/tonne abatement costs for each of the packages over the lifetime, to inform a view of which packages of measures are suitable for decarbonising each archetype at least cost. We expect costs to be bounded by the costs of demolishing and rebuilding homes, with low-carbon heating systems added. As discussed above, whilst the £/tonne abatement costs associated with measures are expected to be an input into the selection of ‘lead options’ for decarbonisation of these homes, there will also be a need to take other factors into account.

The analytical outputs will need to include a full and clear assumptions log setting out all techno-economic assumptions, and listing evidence sources to support them.

1. **To develop scenarios for measure deployment which abate direct emissions from the ‘hard to decarbonise’ stock, alongside advice on associated policy**

The lead options should be used to develop scenarios for measure deployment which abate direct emissions from the ‘hard to decarbonise’ stock.

Scenarios should reflect appropriate constraints on supply,[[26]](#footnote-26) rates of progress, and supporting infrastructure, with assumptions evidenced and set out in the assumptions log.

As noted above, insulating one component of a property, whilst leaving others uninsulated, may in reality lead to higher levels of heat loss through uninsulated areas, limiting the overall benefits of the individual insulation measure. Scenarios (and associated in-use factors) should reflect this, setting out a realistic retrofit approach which maximises the delivery of savings.

A ‘core’ scenario will be needed which represents a best view of how the ‘hard to decarbonise’ stock can be decarbonised by 2050. This includes understanding the measures necessary to reduce direct emissions to very low levels, and what further action would be necessary to abate them fully.

We are also seeking the development of a discrete number of additional scenarios. Through these we would like to understand the measures and costs associated with:

* Decarbonising at a faster rate
* Decarbonising without use of conventional solid wall insulation[[27]](#footnote-27)
* Different technology pathways (including hydrogen)

We welcome a view from bidders on how many scenarios they intend to develop. To the extent the above areas of interest are not addressed through alternative scenarios, we would expect qualitative assessment to be undertaken.

The outputs will need to set out how emissions in ‘hard to decarbonise’ homes can be abated on a year-by-year basis, including:

* Deployment levels
* Direct abatement (MtCO2e)
* Indirect abatement (MtCO2e)
* Unit abatement cost (£/tCO2e) including sensitivities on fossil fuel price and technology cost (split into capex, opex, fuel costs and costs of capital etc.)
* Change in energy demand for all relevant energy sources (including increases and decreases in electricity use, rather than just the net impact)

In order to do so, comparison against the counterfactual developed in task B will be necessary.

For an example of the template format that will need to be followed, please see the Fifth Carbon Budget Central Scenario Dataset.[[28]](#footnote-28) The data will need to be presented on both an aggregate basis and separated out by Devolved Administration.

Alongside the scenarios, the final report will need to include discussion of the policy measures which would be necessary to support these scenarios, including what policy measures could be instigated to achieve decarbonisation at a faster rate.

All analysis will need to be fully quality assured by an independent person not directly involved in the work, with quality assurance fully documented. See section 6 for further discussion.

# Outputs Required

The outputs of the work should include:

* **An excel workbook**, containing the scenarios, a detailed assumptions log (including ranges on key data items where required to test sensitivities and deliver robust conclusions), and detailed modelling outputs that underpin the scenarios. This should be clearly set out and formatted, maximising ease of future use and reference for users not directly involved in the work. Cells should be linked and spreadsheets should be unlocked.
* **Associated models.** Where excel models are used these should be shared, fully unlocked and linked to rest of the excel workbook deliverable above, allowing future capability to update assumptions and re-run outputs. Where alternative modelling software is used (e.g. the NHM, building physics packages) any relevant inputs such as scripts, stock and model version should be shared. In the event of any limitations on sharing, these should be specified as part of the tender.
* **A report,** setting out the scope of work, methodology and findings. This report should also include discussion of the policy measures needed to support the delivery of the scenarios.

# Ownership and Publication

The key deliverables will be handed over to the CCC, who may choose to publish these as supporting evidence on their website. Spreadsheets should be open access and unrestricted, to enable full QA of results and assumptions.

# Quality Assurance

This project must comply with the ‘CCC – Quality Assurance of Evidence and Analysis’ guidance and bidders must set out their approach to quality assurance in their response to this ITT.

All research tasks and modelling must be quality assured and documented. Contractors should:

* Include a quality assurance (QA) plan that they will apply to all of the research tasks and modelling,
* Specify who will be responsible for quality assurance and ensure that this is done by individuals who were not directly involved in the research, analysis or model development,
* Provide a QA log to demonstrate the QA undertaken, including who undertook the QA and the scope, type and level of QA that has been undertaken (e.g. a log entry only stating ‘the data was checked’ will not be sufficient)

Sign-off for the quality assurance must be done by someone of sufficient seniority within the contractor organisation to be able take responsibility for the work done. Acceptance of the work by the CCC will take this into consideration. The CCC reserves the right to refuse to sign off outputs which do not meet the required standard specified in this invitation to tender.

The successful bidder will be responsible for any work supplied by sub-contractors and should therefore provide assurance that all work in the contract is undertaken in accordance with the quality assurance expectation agreed at the beginning of the project.

For primary research, contractors should be willing to facilitate CCC research staff to attend interviews or listen in to telephone surveys as part of the quality assurance process.

# Timetable

The proposed timetable for the project is set out in the following table.

In addition to the formal reporting points, the CCC would expect to have regular scheduled discussions (weekly meetings or calls) to ensure the work is progressing as expected.

|  |  |
| --- | --- |
| **Date** | **Action** |
| 20th Nov 2018 | Publication of ITT |
| 11th Dec 2018, 5 pm | Deadline for response to ITT |
| 17th, 18th (morning), 19th Dec | Interviews |
| w/c 31st Dec | Kick-off meeting (identify key sources of information, agree methodology & timelines) |
| 11th Feb | Interim summary of emerging findings |
| 1st March | Final excel workbook, and summary of recommendations |
| 8th March | Final report and associated models |

# Challenges

The specific challenges that the CCC envisage with this project include:

* Gaps in the evidence base, particularly for newer technologies
* Establishing a methodology and approach which enable high quality insights to be delivered in short timeframes
* Ensuring that the project findings can be integrated effectively and coherently with the CCC’s existing scenarios

Bids should set out how these risks will be managed alongside any other risks and challenges to successfully undertaking this work.

# Ethics

All applicants will need to identify and propose arrangements for initial scrutiny and on-going monitoring of ethical issues. The appropriate handling of ethical issues is part of the tender assessment exercise and proposals will be evaluated on this as part of the ‘addressing challenges and risks’ criterion.

We expect contractors to adhere to the following GSR Principals:

1. Sound application and conduct of social research methods and appropriate dissemination and utilisation of findings
2. Participation based on valid consent
3. Enabling participation
4. Avoidance of personal harm
5. Non-disclosure of identity and personal information

# Working Arrangements

The successful contractor will be expected to identify one named point of contract through whom all enquiries can be filtered. A CCC project manager will be assigned to the project and will be the central point of contact.

# Skills and experience

CCC would like you to demonstrate that you have the experience and capabilities to undertake the project. Your tender response should include a summary of each proposed team members experience and capabilities.

Contractors should propose named members of the project team, and include the tasks and responsibilities of each team member. This should be clearly linked to the work programme, indicating the grade/ seniority of staff and number of days allocated to specific tasks.

Contractors should identify the individual(s) who will be responsible for managing the project.

# Consortium Bids

In the case of a consortium tender, only one submission covering all of the partners is required but consortia are advised to make clear the proposed role that each partner will play in performing the contract as per the requirements of the technical specification. We expect the bidder to indicate who in the consortium will be the lead contact for this project, and the organisation and governance associated with the consortia.

Contractors must provide details as to how they will manage any sub-contractors and what percentage of the tendered activity (in terms of monetary value) will be sub-contracted.

If a consortium is not proposing to form a corporate entity, full details of alternative proposed arrangements should be provided. However, please note CCC reserves the right to require a successful consortium to form a single legal entity in accordance with Regulation 28 of the Public Contracts Regulations 2006.

CCC recognises that arrangements in relation to consortia may (within limits) be subject to future change. Potential Providers should therefore respond in the light of the arrangements as currently envisaged. Potential Providers are reminded that any future proposed change in relation to consortia must be notified to CCC so that it can make a further assessment by applying the selection criteria to the new information provided.

# Budget

The budget for this project is £60,000 to £75,000 excluding VAT.

Contractors should provide a full and detailed breakdown of costs (including options where appropriate). This should include staff (and day rate) allocated to specific tasks.

Cost will be a criterion against which bids which will be assessed.

Payments will be linked to delivery of key milestones. The indicative milestones and phasing of payments can be adjusted and agreed with the contractor and Project Manager. Please advise in your tender response how this breakdown reflects your usual payment processes:

In submitting full tenders, contractors confirm in writing that the price offered will be held for a minimum of 60 calendar days from the date of submission. Any payment conditions applicable to the prime contractor must also be replicated with sub-contractors.

The Committee on Climate Change aims to pay all correctly submitted invoices as soon as possible with a target of 10 days from the date of receipt and within 30 days at the latest in line with standard terms and conditions of contract.

# Evaluation of Tenders

Contractors are invited to submit full tenders of no more than 35 pages, excluding CVs and declarations. Tenders will be evaluated by at least three CCC staff.

CCC will select the bidder that scores highest against the criteria and weighting listed below, see the ITT for further information.

**EVALUATION CRITERIA AND SCORING METHODOLOGY**

|  |  |  |
| --- | --- | --- |
| Criterion | Description | Weighting |
| 1 | **RELEVANT EXPERIENCE / DEMONSTRATION OF CABABILITY** | 20% |
| 2 | **MANAGING YOUR RELATIONSHIP WITH THE CCC** | 5% |
| 3 | **QUALITY ASSURING THE SERVICES YOU PROVIDE** | 10% |
| 4 | **MANAGEMENT STRUCTURE** | 5% |
| 5 | **PROJECT TEAM – SKILLS AND KNOWLEDGE** | 20% |
| 6 | **METHOD, ABILITY AND TECHNICAL CAPACITY** | 20% |
| 7 | **UNDERSTANDING OF REQUIREMENTS** | 10% |
| 8 | **RISK AND CHALLENGES** | 10% |
|  |  |  |
|  | | 100% |

**Scoring Method**

Tenders will be scored against each of the criteria above, according to the extent to which they meet the requirements of the tender. The meaning of each score is outlined in the table below.

The total score will be calculated by applying the weighting set against each criterion, outlined above; the maximum number of marks possible will be 100. Should any contractor score 1 in any of the criteria, they will be excluded from the tender competition.

|  |  |
| --- | --- |
| **Score** | **Description** |
| 1 | Not Satisfactory: Proposal contains significant shortcomings and does not meet the required standard |
| 2 | Partially Satisfactory: Proposal partially meets the required standard, with one or more moderate weaknesses or gaps |
| 3 | Satisfactory: Proposal mostly meets the required standard, with one or more minor weaknesses or gaps. |
| 4 | Good: Proposal meets the required standard, with moderate levels of assurance |
| 5 | Excellent: Proposal fully meets the required standard with high levels of assurance |

**Structure of Tenders**

Contractors are strongly advised to structure their tender submissions to cover each of the criteria above and supply a price schedule specifying the daily rates (ex-VAT) you will charge for each level of your staff.

**Evaluation for Interviews, if held**

CCC reserves the right to award the contract based on applicants’ written evaluation only if one candidate emerges from the evaluation stage as significantly stronger than the others.

Should interviews go ahead, CCC will shortlist the top three suppliers with the highest marks from the written proposals. Interviews are provisionally expected to be held on the 17th, 18th (morning) or 19th December. If these dates change, the CCC will notify applicants.

The areas to be covered in the interview, and markings allocated to each topic area will be sent to the shortlisted supplier prior to interview.

Further details of interviews will be sent to successful applicants on selection.

**Feedback**

Feedback will be given in the unsuccessful letters or emails.

1. IPCC (2018), *Global Warming of 1.5oC*, <http://www.ipcc.ch/report/sr15/> [↑](#footnote-ref-1)
2. For a copy of the letter, please see: <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/748489/CCC_commission_for_Paris_Advice_-_Scot__UK.pdf> [↑](#footnote-ref-2)
3. Climate Change Act 2008, Section 1, <https://www.legislation.gov.uk/ukpga/2008/27/section/1> [↑](#footnote-ref-3)
4. Figure drawn from our more recent report: CCC (2016), *Next steps for UK heat policy,* <https://www.theccc.org.uk/wp-content/uploads/2016/10/Next-steps-for-UK-heat-policy-Committee-on-Climate-Change-October-2016.pdf> [↑](#footnote-ref-4)
5. For further detail on the original approach taken, later updated for the 5th carbon budget, see Element Energy and Energy Saving Trust (2013), *Review of potential for carbon savings from residential energy efficiency*, <https://www.theccc.org.uk/wp-content/uploads/2013/12/Review-of-potential-for-carbon-savings-from-residential-energy-efficiency-Final-report-A-160114.pdf> [↑](#footnote-ref-5)
6. For further detail see Element Energy, Frontier Economics and Imperial College London (2015), *Research on district heating and local approaches to heat decarbonisation*, <https://www.theccc.org.uk/wp-content/uploads/2015/11/Element-Energy-for-CCC-Research-on-district-heating-and-local-approaches-to-heat-decarbonisation.pdf> [↑](#footnote-ref-6)
7. In our Central Scenario we include 5-15 TWh of biomass used in building-scale boilers in 2030 (including biomass boilers in around 0.3m homes), and 11-27 TWh including biomass used in heat networks. To 2050, we include 13 TWh of local bioenergy sources for use in heat networks in our Central Scenario, with a high end estimate of 59 TWh. Use of biomass boilers in 2050 in our Central Scenario is significantly reduced to around 25,000 homes, assuming the need to divert bioenergy to other uses such as bio-CCS. [↑](#footnote-ref-7)
8. Imperial College London (2016), *Analysis of alternative UK heat decarbonisation Pathways*, <https://www.theccc.org.uk/publication/analysis-of-alternative-uk-heat-decarbonisation-pathways/> [↑](#footnote-ref-8)
9. Updated classifications of non-standard cavity walls and lofts are included in Energy Saving Trust (2016), *Quantification of non-standard cavity walls and lofts in Great Britain*, <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/656865/160628_Non-standard_cavity_walls_and_lofts.pdf> [↑](#footnote-ref-9)
10. Including: BRE, Defra and EST (2008), *A study of Hard to Treat Homes using the English House Condition Survey, Part I: Dwelling and Household Characteristics of Hard to Treat Homes*, <https://www.bre.co.uk/filelibrary/pdf/rpts/Hard_to_Treat_Homes_Part_I.pdf>; DCLG (2015), *English Housing Survey, Energy Efficiency of English Housing 2013*, ch 3: <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/445440/EHS_Energy_efficiency_of_English_housing_2013.pdf>; Climate Xchange (2014), *Home energy efficiency – review of evidence on attitudes and behaviours*, <https://www.climatexchange.org.uk/media/1844/cxc_brief_home_energy_efficiency_review_-_full_report.pdf> [↑](#footnote-ref-10)
11. CCC (2015) *Sectoral scenarios for the Fifth Carbon Budget, Technical report*, and Element Energy and Energy Saving Trust (2013), *Review of potential for carbon savings from residential energy efficiency* [↑](#footnote-ref-11)
12. See: <https://www.gov.uk/government/collections/buildings-energy-efficiency-technical-research> [↑](#footnote-ref-12)
13. See: <https://www.gov.uk/government/collections/buildings-energy-efficiency-technical-research> [↑](#footnote-ref-13)
14. For instance, insulating one component of a property, whilst leaving other areas uninsulated, may lead to higher levels of heat loss through uninsulated areas, limiting the overall benefits of the individual insulation measure. [↑](#footnote-ref-14)
15. For instance, EPC band C is frequently quoted as being consistent with the insulation level necessary to support heat pump deployment. However, there appears to be limited detailed evidence to support this. [↑](#footnote-ref-15)
16. CCC (2015), *Sectoral scenarios for the Fifth Carbon Budget*, <https://www.theccc.org.uk/wp-content/uploads/2015/11/Sectoral-scenarios-for-the-fifth-carbon-budget-Committee-on-Climate-Change.pdf> [↑](#footnote-ref-16)
17. This approach is intended to acknowledge the potential role of Greenhouse Gas Removal technologies, to the extent they represent a cost-effective alternative to abating a small volume of residual emissions from ‘hard to decarbonise’ homes. [↑](#footnote-ref-17)
18. In some cases data gaps may require analysis to be extrapolated for some regions of the UK. [↑](#footnote-ref-18)
19. For the fifth carbon budget analysis, central assumptions in this area used carbon prices of £46/tCO2 in 2015, rising to £78/tCO2 by 2030, and £333/tCO2 by 2050. Further information on the analysis can be provided. NB The number of insulation measures deemed socially cost-effective against these carbon prices is expected to change with any updates to techno-economic assumptions associated with measures. Some associated updates to the central scenario may therefore be required. [↑](#footnote-ref-19)
20. In addition to the one million solid walled homes which were found to be cost-effective to insulate by 2030, our central scenario to 2030 also included solid wall insulation for a further one million homes in fuel poverty. Even where cost-effective, solid wall homes can pose challenges due to other practical considerations. e.g. ‘space-take’ associated with internal solid wall insulation, or heritage considerations inhibiting use of external insulation. [↑](#footnote-ref-20)
21. For this variant, it is envisaged other measures would be relied upon to drive decarbonisation. This may include the use of thin solid wall insulation for instance. [↑](#footnote-ref-21)
22. Element Energy and Energy Saving Trust (2013), *Review of potential for carbon savings from residential energy efficiency*  [↑](#footnote-ref-22)
23. Element Energy, Frontier Economics and Imperial College London (2015), *Research on district heating and local approaches to heat decarbonisation*  [↑](#footnote-ref-23)
24. Our analysis indicates that resistive heating generally represents a more costly route to decarbonising relative to heat pumps. This is due to the lower efficiency of the technology, resulting in greater energy use, higher bills and higher system costs. However, we are interested in understanding the extent to which there could be niche roles, for instance in combination with other technologies for some homes. [↑](#footnote-ref-24)
25. We expect to be able to provide rebuild costs for new homes built to current, or more ambitious standards. [↑](#footnote-ref-25)
26. Including limitations on the use of biomass heating in homes [↑](#footnote-ref-26)
27. For this variant, it is envisaged other measures would be relied upon to drive decarbonisation. This may include the use of thin solid wall insulation. [↑](#footnote-ref-27)
28. CCC (2016), Fifth Carbon Budget Dataset, <https://www.theccc.org.uk/publication/fifth-carbon-budget-dataset/> [↑](#footnote-ref-28)