**Specification for the Provision of research to produce scenarios for deployment of hydrogen technologies and infrastructure in contributing to meeting carbon budget and the 2050 target**

Tender Reference Number: DJ/0415

**Specification of Requirements**

Invitation to Tender for the **invitation to tender for Provision of research to produce scenarios for deployment of hydrogen technologies and infrastructure in contributing to meeting carbon budget and the 2050 target**

Tender Reference Number: DJ/0415

Deadline for Tender Responses: ………………

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# Introduction and summary of requirements / Preamble

The Committee on Climate Change (CCC) was set up as part of the Climate Change Act. The Committee is an independent body tasked with providing advice to government on climate change issues, and particularly the setting of carbon budgets for the UK.

The CCC will recommend the level of the 5th carbon budget, covering the period 2028-32, by the end of 2015.

# Background

***The CCC approach to developing scenarios***

The CCC’s advice on carbon budgets is based on detailed analysis of a range of technologies and behaviours that could reduce UK emissions. Using that analysis, CCC has developed scenarios for deployment of technologies to reduce greenhouse gas emissions to 2020[[1]](#footnote-1), 2030[[2]](#footnote-2) and to 2050[[3]](#footnote-3). These are intended to demonstrate possible ways in which carbon budgets and the 2050 target could be met, estimate the economic cost of doing so, and identify barriers to delivery and consider how these could be overcome.

Our central scenarios include:

* Decarbonisation of the power sector through deployment of renewables, nuclear and carbon capture and storage (CCS), with the sector largely decarbonised by 2030 (e.g. to around 50-100 gCO2/kWh). Power sector emissions are further reduced through improved efficiency (e.g. for lights and appliances).
* Deployment of electric and plug-in hybrid cars and vans reaches around 60% of new vehicle sales by 2030 (30% of the stock), with some deployment of hydrogen-fuelled heavy-duty vehicles in the 2020s.
* Decarbonisation of heat via heat networks and deployment of heat pumps in homes. Heat pump deployment reaches a cumulative 4 million installations by 2030, covering 13% of homes, with additional deployment in non-residential buildings, while heat networks meet 6% of demand by the same date.
* Improvement of energy efficiency in industrial sectors, together with decarbonisation via use of biomass and biogas and the application of CCS.
* Other measures to reduce GHG emissions across the transport, buildings, industry, agriculture, waste and other non-CO2 sectors.

Our medium-term scenarios (e.g. to 2030) are designed to represent the CCC’s assessment of the least-cost way of reducing emissions on the path to meeting the 2050 target to reduce emissions by at least 80% by 2050. As such, they contain both measures that are cost-effective against projected carbon prices and those required on the path to 2050.

* Examples of cost-effective measures are efficiency improvements across a range of sectors (e.g. appliances, lighting, vehicles) or deployment of mature low-carbon power generation (e.g. onshore wind, nuclear).
* There are measures included in our scenarios are required to be on track for 2050, but that are not necessarily cost-effective at prevailing carbon prices during the 2020s. These are included at the minimum level consistent with required cost reductions and feasible paths for deployment to the level that may be needed by 2050 (the ‘critical path’ level). Examples of such technologies are offshore wind and carbon capture and storage.
* Some technologies become cost-effective during the 2020s, such as electric vehicles and heat pumps. The level of deployment in our scenarios is the greater of the cost-effective and critical path levels of deployment (e.g. for heat pumps, the critical path level of cumulative deployment by 2030 is 2.5 million, while the cost-effective level is 4 million – the latter is the built into our central scenario).

When considering the level of technology deployment that may be required by 2050, we consider a range of 2050 scenarios rather than a single one. This keeps in play a range of ways to meet the 2050 target, thus avoiding being overly prescriptive while also managing risks, given the range of uncertainties regarding the appropriate path to 2050.

The range of 2050 scenarios tends to be based on those set out in our report *The 2050 Target*[[4]](#footnote-4), which accompanied our 2012 advice on inclusion of international aviation and shipping in carbon budgets. However, we keep these under review, and are happy to use alternative scenarios where this is appropriate.

***How hydrogen has featured in our published scenarios to 2030 and 2050***

**Transport**

In our 4th Carbon Budget Review, we assessed the potential future costs and possible uptake of hydrogen fuel cell light duty vehicles (LDVs - cars and vans) and heavy duty vehicles (HDVs - buses and HGVs) to 2030.

A number of studies have suggested that hydrogen could feasibly make up around 10% of car and van sales by 2030[[5]](#footnote-5),[[6]](#footnote-6),[[7]](#footnote-7), as part of a wider target of 60% of new car and van sales being Ultra-Low Emission Vehicles (ULEVs). However, in the near term, hydrogen LDVs do not appear to be as promising a mass market proposition as plug-in electric vehicles, partly due to higher purchase prices and also because of the challenges relating to development of fuelling infrastructure and of a full-scale supply infrastructure for low-carbon hydrogen.

We therefore chose not to include hydrogen fuel cell LDVs in our central scenario but noted that it could be important to keep the option open for the longer term, both for more demanding duty cycles where even longer-range electric vehicles may not be suitable and for new car buyers without access to off-street parking and hence readily available overnight charging. More generally, if plug-in vehicles do not turn out to be accepted by consumers, hydrogen offers an alternative for mass-market deployment.

The 4th Carbon Budget Review also recognised the potential in the longer term for hydrogen to reduce emissions from buses and HGVs, where battery electric vehicles may be unsuitable (e.g. due to size, weight and cost of the battery required), and if current challenges can be overcome (e.g. around hydrogen storage technology). To meet the 2050 decarbonisation target, our central scenario assumed that 50% of new bus sales would by hydrogen fuelled by 2030, rising to 100% by 2040. For HGVs we assumed that the share of hydrogen fuel cell vehicles would begin to grow in 2030, increasing rapidly to 100% of new sales by 2040.

**Power**

Our scenarios for power sector decarbonisation to 2030 each include at least 6 GW of carbon capture and storage (CCS) stations, in order to drive the commercialisation of that set of technologies. While we are not explicit about the balance within this of technology types (i.e. pre-combustion vs. post-combustion vs. oxy-fuel), we have recognised the value of pre-combustion CCS in assisting in development of hydrogen options.

On the 2050 timescale, our 2012 scenarios included the potential for hydrogen turbines to provide a low-carbon option to displace high-carbon peaking plants. We also recognise the potential for hydrogen to provide seasonal storage in order to manage the seasonality of UK energy demand, although we have not included this in our scenarios to date.

**Industry**

Our scenarios to 2030 do not contain any use of hydrogen to decarbonise industry, but various pieces of analysis have identified a potentially significant contribution it could make to meeting the 2050 target[[8]](#footnote-8),[[9]](#footnote-9),[[10]](#footnote-10).

The extent to which it can contribute to decarbonisation of industry depends on the supply of relatively low-cost hydrogen to industrial installations. We have hitherto assumed that this would necessitate the use of pre-combustion CCS, located relatively close to industrial clusters.

Our economy-wide scenarios include the development of CCS plants in the power sector, together with some capture on industrial installations to 2030. However, they do not explicitly involve hydrogen production on the back of these developments, though clearly this would be possible.

**Heat for buildings**

Our scenarios for 2030 and 2050 do not contain any contribution from hydrogen in supplying heat for buildings.

***Development of scenarios for the 5th carbon budget analysis***

For the 5th carbon budget analysis, our detailed scenarios will now go to 2035 (c.f. 2030 for the 4th carbon budget and 4th carbon budget review). The process for their development will include reviewing the existing central sectoral scenarios to 2030 as well as extending an additional five years.

We are also introducing ‘alternative’ sectoral scenarios, which get to the same level of emissions reduction as our central scenario, but using a different set of measures. Given its potential to contribute to emissions reductions across a wide range of sectors, together with its relatively small contribution in our medium-term analysis to date, this approach provides an opportunity for hydrogen to play a much larger role in our decarbonisation scenarios.

This approach aims to set out the different ways in which carbon budgets can be met, while also highlighting the nature and timing of the strategic choices that will be required on the path to meeting the 80% target.

# Aims and Objectives

The aims of the project are:

* To provide an overview of the prospects and potential roles for hydrogen technologies to play a role in reducing emissions in the transport, power, industry sectors, and in heat supply for buildings, including the synergies and conflicts between these applications, and the full chain from production through distribution to use.
* To develop two scenarios for hydrogen deployment
  + **Critical Path**: this scenario has a background role for hydrogen in the medium term, concentrating on developing markets and infrastructure in such a way that hydrogen technologies could still play an important role in 2050
  + **Full Contribution**: in this scenario, hydrogen technologies grow rapidly and play an important part in reducing emissions over the period to 2035, across multiple sectors, on the way to potentially playing a dominant role in the energy system by 2050
* To pull out the strategic considerations for the roll-out of hydrogen technologies over time in the UK, taking into account the need for development of infrastructure and markets together with interactions between hydrogen deployment across sectors. This should lead to timelines for decisions and deployment, and the identification of key uncertainties and choices between hydrogen pathways vs. alternative decarbonisation pathways
* Potentially, to provide a costing of the Full Contribution and Critical Path scenarios

# Description of Work for consultants

The core part of this project contains four components:

* Task 1: Overview of hydrogen technologies status / prospects
* Task 2: Characterise Critical Path hydrogen scenario
* Task 3: Characterise Full Contribution hydrogen scenario
* Task 4: Strategic consideration of hydrogen pathways

A fifth task is potentially desirable, if the consultants are able to provide it (in which case it should be provided as an optional extra part of the proposal, costed separately):

* Task 5: Costing of the Full Contribution and Critical Path hydrogen scenarios

Consultants should set out in their bid their proposed method for accomplishing tasks 1-4 and also, if relevant, Task 5.

**Task 1: Overview of hydrogen technologies status / prospects**

This task would set out the range of hydrogen technologies that could help to reduce emissions over the period to 2050, their current status and costs, their prospects and barriers to deployment.

The range of technologies should include, but not necessarily be limited to:

* **Transport**. Hydrogen fuel cell vehicles for light-duty (e.g. cars, vans) and heavy-duty (e.g. buses, HGVs), and also hydrogen internal combustion engine vehicles if these have a reasonable prospect of being deployed successfully.
* **Power sector**. Electricity generation via both hydrogen turbines and large-scale fuels cells; smaller-scale distributed fuel cells for power generation/CHP.
* **Industry**. Hydrogen options for displacing fossil fuels in high-temperature heat applications.
* **Heat in buildings**. This should include both piping hydrogen into buildings and use at the district scale in conjunction with heat networks.
* **Hydrogen supply**. Pre-combustion CCS (both steam methane reforming and biomass/coal gasification), small scale SMR without CCS, electrolysis.
* **Storage**. Viable storage options in relation to the other hydrogen technologies considered, including seasonal storage in salt caverns.
* **Distribution infrastructure**. This should cover the UK-relevant considerations around the use of dedicated hydrogen pipelines, liquid hydrogen tankers and repurposing of the natural gas grid.

We would expect this task to be high-level and based on existing work alongside an understanding of current activity and prospects within the sector.

Consideration of the barriers to deployment should focus on the fundamental challenges, rather than any present weaknesses in the policy framework (although these can also be considered).

**Task 2: Critical Path hydrogen scenario**

The role of the Critical Path scenario to 2035 is to set out the key measures needed in this period in order to keep open the option of hydrogen playing a substantial role in a low-carbon energy system in 2050.

The intention is that these measures could be included in our Central sectoral scenarios, in order to keep open the hydrogen option even if it’s not one of the main contributions to medium-term emissions reduction.

As the scenario is defined by keeping open a level of deployment in the long-term, it may first be necessary to set out the potential role for hydrogen in 2050. It would then be necessary to work back from this long-term picture in order to set out the profile for the minimum amount of market development, hydrogen infrastructure development and roll-out of hydrogen technologies over the intervening period.

The consultants will need to agree this 2050 picture with the CCC, in order to ensure that this is consistent with our wider analysis. It may be useful to use our existing 2050 scenarios as a starting point for this[[11]](#footnote-11), although if improvements can be made to the characterisation of the role for hydrogen in these we are open to changes.

The key outputs of these tasks are a quantified timeline to 2035 for deployment of hydrogen technologies by sector, and associated infrastructure, including setting out the emissions savings and effect on consumption of other energy vectors (fossil fuels, electricity) over time.

This should be accompanied by a narrative that sets out how this keeps the option open for the longer term, the rationale for why this is the appropriate degree of action to do so, and identified interactions and synergies between deployment in different sectors (e.g. due to shared infrastructure).

It should also outline how it interacts with other potential abatement measures (e.g. displacing or facilitating other low-carbon technologies, impact on demand etc.), and give an indication of geographical deployment (e.g. concentration close to particular energy sources or types of demands).

The components of the scenario need not be generated from scratch – the consultants are free to build on existing analysis, where this helps to provide a robust contribution to scenario development.

**Task 3: Full Contribution hydrogen scenario**

The role of this scenario is to present a case in which hydrogen technologies make a substantial contribution to decarbonisation over the period to 2035.

We would not expect the sectoral emissions reductions from hydrogen technologies in this scenario to go beyond those in our Central scenario, which is expected to be similar to scenarios to 2030 in our previous carbon budget reports in 2010 and 2013[[12]](#footnote-12). It may be that it is not feasible, at least in some sectors, for emissions reductions to match those in our other scenarios – in this case the scenario should go as far as feasible, which can then be supplemented by non-hydrogen measures.

A key issue in the development of this scenario surrounds the future of the gas grid. Consultants should take a view on whether and how the gas grid can be used to support deployment of hydrogen within this scenario. As this is an important determinant of the pattern of hydrogen deployment within the scenario, this assumption should be agreed with CCC early in the scenario development process.

While this Task is more focused on the period to 2035 than to 2050, it should also consider the period post-2035 and, at a high level, what the overall contribution of hydrogen could be by 2050.

The key outputs of this Task are a quantified timeline to 2035 for deployment of hydrogen technologies by sector, and associated infrastructure, including setting out the emissions savings and effect on consumption of other energy vectors (fossil fuels, electricity) over time.

This should include a justification for why this level of deployment is feasible and potentially a cost-effective approach to decarbonisation. This should also be accompanied by a narrative that identifies interactions and synergies between deployment in different sectors (e.g. due to shared infrastructure).

It should also outline how it interacts with other potential abatement measures (e.g. displacing or facilitating other low-carbon technologies, impact on demand etc.), and give an indication of geographical deployment (e.g. concentration close to particular energy sources or types of demands).

Again, the components of the scenario need not be generated from scratch – the consultants are free to build on existing analysis, where this helps to provide a robust contribution to scenario development.

**Task 4: Strategic consideration of hydrogen pathways**

This task builds on the Full Contribution and Critical Path scenarios, to pull out the strategic considerations around how to approach the roles for hydrogen over the period to 2035.

It should identify any no-regrets actions, together with the key factors on which more ambitious action depend (e.g. costs, technology performance, infrastructure and consumer acceptability, both for hydrogen technologies and competing alternatives).

This should take into account:

* the interactions between hydrogen deployment across sectors identified in Tasks 2 and 3;
* the expectation that information will gradually emerge over the prospects of options for decarbonisation, both hydrogen technologies and alternatives
* lead-times for hydrogen market development and infrastructure development

In particular this task should identify decision points over the roles and level of ambition for hydrogen technologies, together with the relevant considerations in making these decisions. It should assess which aspects of the potential roles for hydrogen should be regarded as part of ‘Plan A’ for decarbonisation, should be ‘Plan B’ (triggered under what circumstances) or part of a portfolio approach to decarbonisation.

**Task 5: Costing of the Full Contribution and Critical Path scenarios**

This optional, additional Task (which should be priced separately), provides costings to 2035 for the Critical Path and Full Contribution scenarios developed in Tasks 2 and 3.

This costing should cover the costs of deploying hydrogen technologies and accompanying infrastructure at the levels specified in the these scenarios, including anticipated cost reductions over time. These costs will need to be calculated relative to a counterfactual technology (which will generally be higher carbon, e.g. a petrol car or a gas boiler) – the CCC will provide assumptions on the identities and costs of these counterfactual technologies.

A spreadsheet should be provided, including:

* Overall scenario costs relative to a scenario without hydrogen
* Costs of individual technologies separated into capital costs, operation and maintenance and energy costs, with hydrogen supply and end-use presented separately
* Technology performance parameters – lifetimes, efficiencies and other relevant characteristics (e.g. CO2 capture rate for CCS)

Where infrastructure is deployed in the period to 2035 in order to support deployment later on, the full cost should be included in the calculations, together with an indication of the utilisation of this capacity over the period to 2035.

# Outputs Required

The deliverables from this assignment will be:

* A report setting out the findings of all Tasks, i.e.:
  + An overview of the status of hydrogen technologies, current costs and barriers to deployment
  + Characterisation of the Full Contribution and Critical Path hydrogen scenarios, including quantified levels of technology and infrastructure deployment to 2050
  + A discussion of strategic considerations relating to these hydrogen scenarios, including uncertainties, key actions and decision points
* A set of Excel spreadsheets containing all quantitative data produced in all Tasks, and any detailed analysis used to calculate the outputs.

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 take lead responsibility for ensuring quality assurance and ensure that this responsibility rests with an individual not directly involved in the research, analysis or model development,
* Provide 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 will run as follows.

|  |  |
| --- | --- |
| **Date** | **Action** |
| 13 May 2015 | Deadline for response to ITT |
| 18/19 May | Interviews |
| 21/22 May | Kick-off meeting |
| w/c 22 June | 1st interim meeting (present and discuss initial findings for Tasks 1-3) |
| 3 July | Finalise scenario definition for Task 2, and provide spreadsheet |
| 15 July | Finalise scenario definition for Task 3, with spreadsheet, and provide draft of Task 4 |
| w/c 18 July | Final project meeting (present and discuss results and findings) |
| 19 August | Full draft report |
| 26 August | Comments from CCC on draft report |
| September 2015 | Final report |

If the optional Task 5 is also being undertaken, we would anticipate this being done alongside scenario definition, but potentially with final cost outputs lagging the other outputs slightly.

In addition to these formal reporting points, the CCC would expect to have regular discussions to ensure the work is progressing as expected and focuses on key issues of interest to the Committee.

# 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 £42,000 to £58,000 excluding VAT, for the core Tasks 1-4. Bids including the optional Task 5 are subject to an overall maximum budget of £71,000.

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 CCC 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 40 pages, excluding 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** | 10% |
| 2 | **MANAGING YOUR RELATIONSHIP WITH THE CCC** | 10% |
| 3 | **QUALITY ASSURING THE SERVICES YOU PROVIDE** | 10% |
| 4 | **MANAGEMENT STRUCTURE** | 10% |
| 5 | **PROJECT TEAM – SKILLS AND KNOWLEDGE** | 10% |
| 6 | **METHOD, ABILITY AND TECHNICAL CAPACITY** | 20% |
| 7 | **UNDERSTANDING OF REQUIREMENTS** | 20% |
| 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 18/19 May 2015 If this date changes, 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. See CCC (2008), *Building a low-carbon economy* (<http://www.theccc.org.uk/publication/building-a-low-carbon-economy-the-uks-contribution-to-tackling-climate-change-2/>), and CCC’s annual progress reports. [↑](#footnote-ref-1)
2. See CCC (2010), *The Fourth Carbon Budget* and CCC (2013), *Fourth Carbon Budget Review*. Available from <http://www.theccc.org.uk/publication/the-fourth-carbon-budget-reducing-emissions-through-the-2020s-2/> and <http://www.theccc.org.uk/publication/fourth-carbon-budget-review/> [↑](#footnote-ref-2)
3. See CCC (2012), *The 2050 target*. Available from <http://www.theccc.org.uk/publication/international-aviation-shipping-review/> [↑](#footnote-ref-3)
4. CCC (2012), *The 2050 target*. [↑](#footnote-ref-4)
5. AEA Technology (2012) *A Review of the Efficiency and Cost Assumptions for Road Transport Vehicles to 2050*. Available from <http://archive.theccc.org.uk/aws/ED57444%20-%20CCC%20RoadV%20Cost-Eff%20to%202050%20FINAL%2025Apr12.pdf> [↑](#footnote-ref-5)
6. UK H2 Mobility (2013) *Phase I results*. Available from <http://www.ukh2mobility.co.uk/wp-content/uploads/2013/08/UKH2-Mobility-Phase-1-Results-April-2013.pdf> [↑](#footnote-ref-6)
7. Element Energy et al (2013) *Pathways to high penetration of electric vehicles*. Available from <http://www.theccc.org.uk/wp-content/uploads/2013/12/CCC-EV-pathways_FINAL-REPORT_17-12-13-Final.pdf> [↑](#footnote-ref-7)
8. AEA (2012) *Potential for Post-2030 Emissions Reduction from Industry*. Available from <http://archive.theccc.org.uk/aws/IA&S/AEA%20-%20Potential%20for%20post-2030%20emissions%20reduction%20from%20industry%20-%20Report.pdf> [↑](#footnote-ref-8)
9. Ricardo-AEA (2014), *RHI Evidence Report: Direct Application of Renewable Heat*. Available from <https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/372992/RHI_Evidence_Report_-_Direct_Applications_of_Renewable_Heat.pdf> [↑](#footnote-ref-9)
10. DECC and BIS (2015), *Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050*. Available from <https://www.gov.uk/government/publications/industrial-decarbonisation-and-energy-efficiency-roadmaps-to-2050> [↑](#footnote-ref-10)
11. CCC (2012), *The 2050 target*. [↑](#footnote-ref-11)
12. See CCC (2010), *The Fourth Carbon Budget* and CCC (2013), *Fourth Carbon Budget Review*. Available from <http://www.theccc.org.uk/publication/the-fourth-carbon-budget-reducing-emissions-through-the-2020s-2/> and <http://www.theccc.org.uk/publication/fourth-carbon-budget-review/> [↑](#footnote-ref-12)