Building a zero-carbon economy – Call for Evidence

Background

On 15 October 2018 the governments of the UK, Scotland and Wales asked the Committee on Climate Change (CCC) to provide advice on the UK and Devolved Administrations' long-term targets for greenhouse gas emissions and the UK's transition to a net zero-carbon economy. Specifically: when the UK should reach net zero emissions of carbon dioxide and/or greenhouse gases as a contribution to global ambition under the Paris Agreement; if that target should be set now; the implications for emissions in 2050; how such reductions can be achieved; and the costs and benefits involved in comparison to existing targets.

The advice has been requested by the end of March 2019.

The UK's long-term emissions target is currently for at least an 80% reduction in greenhouse gas emissions from 1990 to 2050. It covers all sectors, including international aviation and shipping and is measured on a 'territorial' basis (i.e. based on emissions arising in the UK). On a comparable basis, emissions in 2017 were estimated to be 38% below 1990 levels.

The current target was set in 2008 based on advice from the Committee. That advice considered that to avoid the worst impacts of climate change, the central expectation of global temperature rise should be limited "to, or close to, 2°C", while the probability of crossing "the extreme danger threshold of 4°C" should be reduced to an extremely low level. That meant global emissions would roughly have to halve by 2050. The 2008 advice made the assumption that the UK should not plan to have a higher level of per capita emissions in 2050 than the global average.

The long-term target guides the setting of carbon budgets (sequential five-year caps on emissions that currently extend to 2032 and require a reduction in emissions of 57% from 1990 to 2030). Both the 2050 target and the carbon budgets guide the setting of policies to cut emissions across the economy (for example as set out most recently in the 2017 Clean Growth Strategy).

Any change to the long-term targets would therefore be expected to have significant implications, not just in the long-term but on current policies to drive the transition.

The CCC will advise based on a thorough consideration of the relevant evidence. We expect that to cover:

- The latest climate science, including as contained in the IPCC Special Report on 1.5°C.
- The terms of the Paris Agreement.
- Global pathways (including those reported by the IPCC) consistent with limiting global average temperature rise in line with the goals of the Paris Agreement.
- International circumstances, including existing plans and commitments to cut emissions in other countries, actions to deliver on those plans and opportunities for going further.
- An updated assessment of the current and potential options for deep emissions reductions in the UK and emissions removals from the atmosphere, including options for going beyond the current 80% target towards net zero.
- An appraisal of the costs, risks and opportunities from setting a tighter long-term target.
- The actions needed in the near term that would be consistent with achieving the long-term targets.

This Call for Evidence will contribute to that advice.

Responding to the Call for Evidence
We encourage responses that are brief and to the point (i.e. a maximum of 400 words per question, plus links to supporting evidence, answering only those questions where you have particular expertise), and may follow up for more detail where appropriate.

You do not need to answer all the questions, please answer only those questions where you have specific expertise and evidence to share. It would be useful if you could use the question and response form below and then e-mail your response to: communications@theccc.gsi.gov.uk using the subject line: 'Zero carbon economy – Call for evidence'. Alternatively, you can complete the question and answer form on the CCC website, available here.

If you would prefer to post your response, please send it to:

The Committee on Climate Change – Call for Evidence
7 Holbein Place
London
SW1W 8NR

The deadline for responses is 12 noon on Friday 7 December 2018.

Confidentiality and data protection
Responses will be published on our website after the response deadline, along with a list of names or organisations that responded to the Call for Evidence.

If you want information that you provide to be treated as confidential (and not automatically published) please say so clearly in writing when you send your response to the consultation. It would be helpful if you could explain to us why you regard the information you have provided as confidential. If we receive a request for disclosure of the information we will take full account of your explanation, but we cannot give an assurance that confidentiality can be maintained in all circumstances. An automatic confidentiality disclaimer generated by your IT system will not, of itself, be regarded by us as a confidentiality request.

All information provided in response to this consultation, including personal information, may be subject to publication or disclosure in accordance with the access to information legislation (primarily the Freedom of Information Act 2000, the Data Protection Act 1998 and the Environmental Information Regulations 2004).

Question and response form

When responding, please provide answers that are as specific and evidence-based as possible, providing data and references to the extent possible. Please limit your response to a maximum of <u>400 words</u> per question.

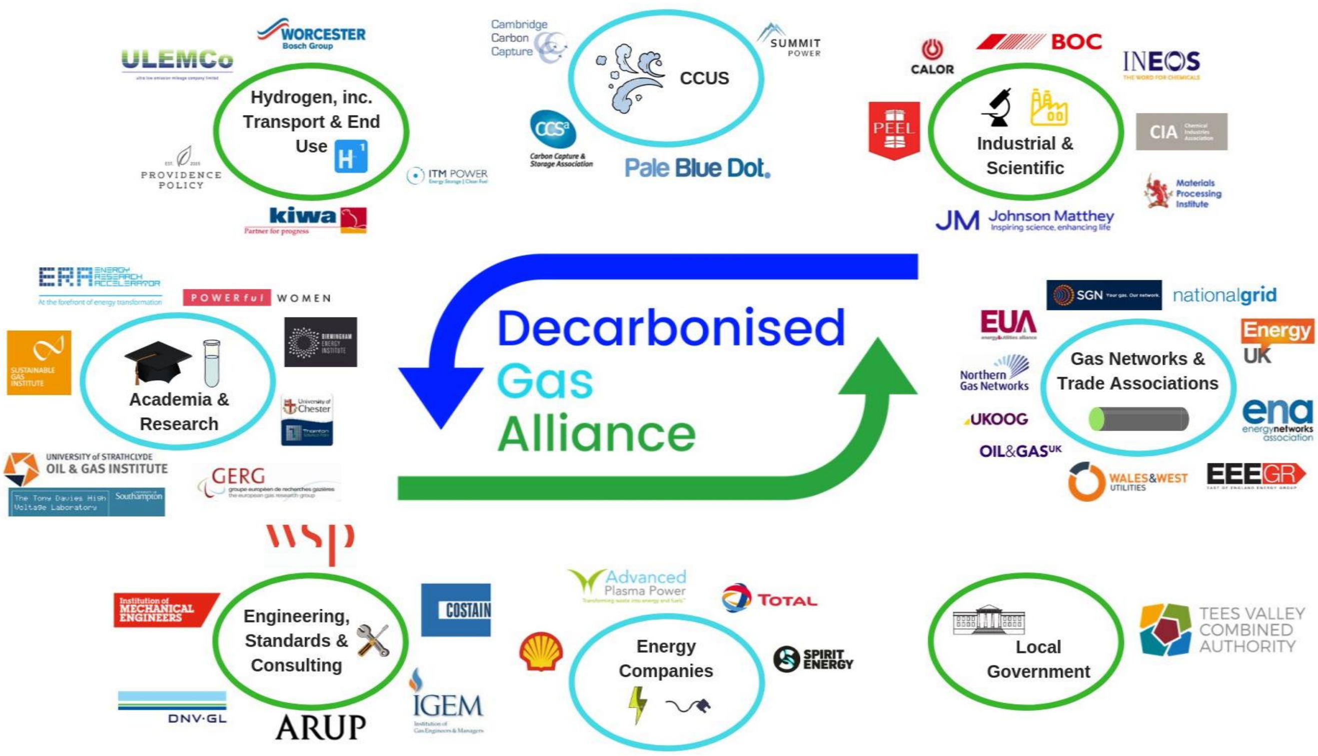
Introduction

1. The Decarbonised Gas Alliance (DGA) is an alliance of gas producers, transporters, suppliers and users, hydrogen and carbon capture experts, alongside R&D, supply chain and local government specialists whose knowledge and expertise will be vital in decarbonising the UK's gas system and improving poor air quality.

2. Our aim is to work with all levels of government and with other expert organisations to use the gas system as a whole to help deliver our emission reduction and air quality goals. We believe that decarbonising gas would make best use of our existing infrastructure and lower the overall costs of decarbonisation.

3. The DGA is a broad-based alliance, established in late 2016, and has now expanded to 45 signatory organisations, which are listed in full in the diagram below. The DGA secretariat is managed by DNV GL, a global specialist firm which provides certification and other technical assurance covering a range of energy sources.

4. We have provided answers to many of the questions in this call for evidence. For a couple of questions – in particular questions 6 and 8 – we felt there was a considerable amount of important evidence to include, which pushes the word count higher than suggested for those questions. We ask for the Committee's understanding on this.



Part 1: Climate Science

Question 1 (Climate Science): The IPCC's Fifth Assessment Report and the Special Report on 1.5°C will form an important part of the Committee's assessment of climate risks and global emissions pathways consistent with climate objectives. What further evidence should the Committee consider in this area?

ANSWER:

Question 2 (CO_2 and GHGs): Carbon dioxide and other greenhouse gas gases have different effects and lifetimes in the atmosphere, which may become more important as emissions approach net-zero. In setting a net-zero target, how should the different gases be treated?

ANSWER:

UK greenhouse gas emissions are broken down into the Kyoto basket of gases, with the internationally-used global warming potential over 100 years (GWP100) weightings applied to each one. We do not see any reason for the UK to adopt different GWP weightings – either in terms of the weightings themselves, or in terms of the number of years – to the international standards:

- The UK will reach net-zero before the world as a whole, and so even if the relative effects and lifetimes in the atmosphere become more important in the UK context, they will not impact the global context to anything like the same extent.

Indeed, to increase the GWP weightings for non-CO_2 gases, for example methane, could be damaging to the UK:

- Notwithstanding the CCC recommendations for less beef consumption, changing the treatment of methane would hit the UK agriculture sector, which in 2016 accounted for over 50% of the UK's emissions of methane, with methane emissions from cows (including enteric fermentation and waste) accounting for 79% of the agriculture total.[1]
- It would encourage food imports, particularly of beef and dairy products, from countries that adhered to the international GWP weightings, with emissions from those imports counted as zero in the UK. If the UK were to import all its beef and dairy products, the savings from methane emissions alone would account for 4.4% of the UK's entire GHG emissions in 2016[2] – and if methane was given a higher GWP weighting, the percentage would only increase. This would be a completely perverse outcome.
- More generally, it would take away a level playing field internationally, providing a

[1] BEIS, Final UK greenhouse gas emissions national statistics 1990-2016, Table 5 https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-2016

[2] BEIS, Final UK greenhouse gas emissions national statistics 1990-2016, Tables 1 and 5 https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-2016

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more general incentive to import from countries where methane was treated in line with international standards. This could include countries with lower controls on methane emissions than the UK, thereby increasing emissions globally.

As we will detail in subsequent answers, the UK should not reach net-zero through outsourcing emissions to other countries – we need to own the full basket of GHGs as we transition from the current energy system to a cleaner one.

Part 2: International Action

Question 3 (Effort share): What evidence should be considered in assessing the UK's appropriate contribution to global temperature goals? Within this, how should this contribution reflect the UK's broader carbon footprint (i.e. 'consumption' emissions accounting, including emissions embodied in imports to the UK) alongside 'territorial' emissions arising in the UK?

ANSWER:

The UK's record in reducing emissions to date is tempered by the fact that a great deal of emissions have moved overseas – industry provides a good example of this.

While business and industrial process emissions have fallen by 56 million tonnes, or 42%,[3] part of this fall has occurred due to offshoring of manufacturing, which may well increase global emissions, as manufacturing in many countries is less energy efficient and more dependent on coal than in the UK. Between 1997 and 2015, when comparable data is available:

- Manufacturing has fallen from 17% to just 10% of the UK's GVA.[4]
- Imports of carbon emissions, embedded in the goods and services that the UK consumes, have risen by 31%.[5]
- To give one example of this, the closure of Redcar steelworks in late 2015, with the loss of 2,000 jobs,[6] caused nearly half the fall in industrial emissions in 2016.[7]

Overall, the reduction in the UK's *consumption* of emissions is far less impressive than its record of *production* of emissions. Between 1997 and 2015, when comparable data is available, the UK's production of emissions fell by 33%, but its consumption of emissions only fell by 4%.[8] We do not believe that a viable Industrial Strategy or Clean Growth Strategy can continue to record a reduction in UK manufacturing as positive for emissions reduction.

Overall, there are serious flaws in the territorial system of global emissions accounting, as it

[3] BEIS, Final UK greenhouse gas emissions national statistics: 1990-2016 https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-2016

[4] Office for National Statistics, Blue Book, The industrial analysis https://www.ons.gov.uk/economy/grossdomesticproductgdp/compendium/unitedkingdomnationalaccountsthebluebook/2018/supplementarytables

[5] DEFRA, UK's Carbon Footprint 1997 – 2015, Figure 2 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/704607/Consumption_emissions_May18.pdf

[6] See https://www.gazettelive.co.uk/news/teesside-news/redcar-steelworks-closure-contributes-sharp-12696855

[7] Cooper SJG and Hammond GP, Decarbonising UK industry: towards a cleaner economy, Institution of Civil Engineers paper 1800007, May 2018, p.3

[8] DEFRA, UK's Carbon Footprint 1997 – 2015, Figure 2 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/704607/Consumption_emissions_May18.pdf

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provides a perverse incentive to encourage imports of electricity, fuels, other raw materials and goods, as the emissions associated with their production/generation and transportation are counted as zero in the UK's territorial emission boundary. It means that the UK could theoretically decarbonise by shifting economic activity overseas. We cannot emphasise strongly enough how counter-productive this would be.

To our knowledge, the most recent estimates of the UK's consumption emissions are those we highlighted above, produced by DEFRA for 2015. We believe that at a bare minimum, BEIS should publish annual estimates of consumption emissions alongside annual production emissions figures.

Question 4 (International collaboration): Beyond setting and meeting its own targets, how can the UK best support efforts to cut emissions elsewhere in the world through international collaboration (e.g. emissions trading schemes and other initiatives with partner countries, technology transfer, capacity building, climate finance)? What efforts are effective currently?

ANSWER:

The UK has a major opportunity to support international efforts to reduce greenhouse gas emissions and premature deaths from indoor air pollution at the same time:[9]

- Around 3 billion people still cook using solid fuels (wood, crop wastes, charcoal, coal and dung) and kerosene in open fires and inefficient stoves.
- 3.8 million people die prematurely each year from the household air pollution caused by the use of these fuels for cooking.
- The black carbon (sooty particles) and methane emitted by inefficient stove combustion are powerful greenhouse gases – black carbon is estimated to contribute the equivalent of 25-50% of carbon dioxide warming globally.
- Local deforestation caused by the need for firewood will reduce carbon sinks and worsen local ecosystems.
- Finally, there is a serious impact on education and equality, as fuel gathering takes up considerable time for women and children in particular.

By contrast, modern cookstoves reduce fuel use by 30-60% and black carbon emissions by 50-90%,[10] while improving household air quality, the prospects for women, and local

[9] World Health Organisation, Household air pollution and health, May 2018 http://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health; Climate and Clean Air Coalition http://ccacoalition.org/en/initiatives/household-energy

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ecosystems. They can form a key part of a low-cost, distributed energy system in developing countries. And in addition to reducing black carbon emissions, if fuelled by bio-LPG, they can be genuinely low-carbon solutions.

UK companies are currently leading the development of bio-LPG, with the first deliveries from UK sources arriving shortly,[11] and so a shift to clean cooking provides a major opportunity for UK technology exports to solve a pressing problem.

The UK also has the opportunity to export other leading technologies, provided that projects are approved in this country. This includes low-carbon hydrogen production from electrolysis and advanced methane reformation, carbon capture and storage, and industrial decarbonisation solutions, including CO_2 capture on cement plants.

Finally, we should not forget the importance of a skilled workforce in delivering low carbon solutions around the world. The UK's higher education sector is a major exporter for the country, and already provides training and CPD programmes in areas as diverse as nuclear, offshore wind and offshore oil and gas. As the UK develops further low-carbon solutions such as CCS, training programmes will be added, and these have the potential to be used to train students in other countries.

Question 5 (Carbon credits): Is an effective global market in carbon credits likely to develop that can support action in developing countries? Subject to these developments, should credit purchase be required/expected/allowed in the UK's long-term targets?

ANSWER:

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[10] Climate and Clean Air Coalition http://ccacoalition.org/en/initiatives/household-energy. Also see Global Alliance for Clean Cookstoves http://cleancookstoves.org/home/index.html

[11] Calor, Calor note for the Committee on Climate Change: Residential Heating and the Bioenergy Review 2018, September 2018, p.15

Part 3: Reducing emissions

Question 6 (Hard-to-reduce sectors): Previous CCC analysis has identified aviation, agriculture and industry as sectors where it will be particularly hard to reduce emissions to close to zero, potentially alongside some hard-to-treat buildings. Through both low-carbon technologies and behaviour change, how can emissions be reduced to close to zero in these sectors? What risks are there that broader technological developments or social trends act to increase emissions that are hard to eliminate?

ANSWER:

For **industry**, the industrial decarbonisation roadmaps to 2050 remain useful resources,[12] although the reality is that getting to zero is extremely challenging:

- For the lime and cement industry, direct separation calcining is near commissioning in a H2020 project in Belgium. This could capture over 95% of the process CO_2 emissions, which accounts for 60% of total CO_2 emissions.[13] CO_2 capture and use or storage would require appropriate policy support, but this has great global potential – cement production currently accounts for 6% of global CO_2 emissions.[14]
- For industry as a whole, a range of solutions, including hydrogen, biogases and BECCS are possible, and have particular potential in clusters. With shared infrastructure, direct CO_2 capture can be co-located with hydrogen production from natural gas with CCS, and hydrogen from electrolysis can be located close to the onshore terminals of offshore wind farms, allowing maximum use of curtailed wind electricity.

For **buildings on the gas grid**:

- The H21 North of England report showed how the main cities of the North of England could be converted to hydrogen by 2034.
- Hydrogen production from natural gas using auto-thermal reforming (ATR) would have a CO_2 capture rate of 94.2%,[15] and the overall reduction in scope 1 and 2 emissions would be 92.1%, compared with natural gas used for heating.[16] The savings implied by the H21 report are higher than the 60-85% assumed in the CCC's recent hydrogen report. The recent review of the hydrogen supply chain for BEIS also concluded that ATR would have a capture rate of 95%.[17]

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[12] BEIS, Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050, March 2015 https://www.gov.uk/government/publications/industrial-decarbonisation-and-energy-efficiency-roadmaps-to-2050

[13] See Project Leilac https://www.project-leilac.eu/the-leilac-pilot-plant

[14] See Carbon Disclosure Project https://www.cdp.net/en/articles/investor/cement-companies-must-more-than-double-efforts-to-meet-paris-climate-goals

[15] H21 North of England, November 2018, Table 4.3 https://northerngasnetworks.co.uk/h21-noe/H21-NoE-23Nov18-v1.0.pdf

[16] H21 North of England, November 2018, Table ES.4 https://northerngasnetworks.co.uk/h21-noe/H21-NoE-23Nov18-v1.0.pdf

[17] Hydrogen supply chain evidence base, Prepared by Element Energy Ltd for the Department for Business, Energy and Industrial Strategy, November 2018 https://www.gov.uk/government/publications/hydrogen-supply-chain-evidence-base

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- Emissions from production and combustion of the hydrogen would be 14.47g CO_2e/kWh.[18]
- In addition, the upstream natural gas supply chain emissions would need to be considered, although under the current flawed international carbon accounting rules, they may not be counted as part of the UK's carbon budgets. Pre-combustion emissions from the UK Continental Shelf and the Norwegian Continental Shelf are estimated to be 9-17g CO_2e/kWh,[19] although emissions from LNG and long-distance pipeline are higher.[20]
- New hydrogen boilers and fuel-cell CHP will be important technologies to develop, to ensure that a switch to a 100% hydrogen grid can be successful. Fuel cell CHP offers the potential for efficiency savings, with the aim of offsetting bill increases from a higher unit cost of energy. Fuel cell CHP units could be fuelled by natural gas and then modified to use hydrogen at a later date.
- If H21 goes ahead, using biomethane in the remaining methane parts of the gas grid will be particularly important.

For **buildings off the gas grid**, bio-LPG has the potential to allow major emissions reductions, at similar cost to current LPG heating and at an abatement cost of around £18 per tonne of CO_2:[21]

- An old oil boiler would emit 3.6 tonnes of CO_2 equivalent per annum;
- A new hybrid heat pump would emit 2.1 tonnes per annum;
- A new bio-LPG boiler would emit just 0.4 tonner per annum, a, 89% reduction.

It must be remembered that lifecycle emissions from **electricity** sources are not zero carbon either. There are numerous studies that provide differing figures, but all are above zero. One meta-analysis provided mean lifecycle emissions of:[22]

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[18] H21 North of England, November 2018, Table ES.4 https://northerngasnetworks.co.uk/h21-noe/H21-NoE-23Nov18-v1.0.pdf

[19] MacKay and Stone, Potential Greenhouse Gas Emissions Associated with Shale Gas Extraction and Use, report for DECC, September 2013, Table A5 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/237330/MacKay_Stone_shale_study_report_09092013.pdf

[20] MacKay and Stone, Potential Greenhouse Gas Emissions Associated with Shale Gas Extraction and Use, report for DECC, September 2013, Tables A4 and A6 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/237330/MacKay_Stone_shale_study_report_09092013.pdf

[21] Calor, March 2018 https://www.calor.co.uk/news/calor-introduces-biolpg-to-the-uk-market-and-sets-path-to-be-fully-renewable-by-2040/; Calor, Calor note for the Committee on Climate Change: Residential Heating and the Bioenergy Review 2018, September 2018, pp.13-15

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- 85g CO_2e/kWh for solar PV;
- 29g CO_2e/kWh for nuclear;
- 26g CO_2e/kWh for wind.

It is also worth noting that, for **Europe as a whole** to reduce emissions by 95%, a zero-carbon gas pathway, which includes biomethane, hydrogen from electrolysis and natural gas, and CCS (including BECCS) has been estimated by Poyry to cost €1.15 trillion less than an all-electric pathway.[23]

Finally, we also believe that fully decarbonising **transport** will also prove difficult in practice. Hydrogen can power more cars, buses and HGVs with a similar driving range to diesel and petrol, with no carbon dioxide or air pollutants at the point of use, and at the same time improve city air quality. There is an opportunity for hydrogen vehicles to operate alongside battery electric vehicles, reducing the extent of grid reinforcement needed for battery charging. At the same time, hydrogen powered trains are now starting to enter service,[24] and these offer a much cheaper alternative to rail electrification. Electrolysis may be particularly important for producing hydrogen at the right purity levels for fuel cells.

Question 7 (Greenhouse gas removals): Not all sources of emissions can be reduced to zero. How far can greenhouse gas removal from the atmosphere, in the UK or internationally, be used to offset any remaining emissions, both prior to 2050 and beyond?

ANSWER:

We share the view that bioenergy with CCS will need to be deployed for the UK to reach net-zero emissions overall. This will include hydrogen production from biomass gasification with CCS.

[22] World Nuclear Association, Comparison of Lifecycle Greenhouse Gas Emissions of Various Electricity Generation Sources http://www.world-nuclear.org/uploadedFiles/org/WNA/Publications/Working_Group_Reports/comparison_of_lifecycle.pdf
[23] Poyry, Fully decarbonising Europe's energy system by 2050, May 2018 http://www.poyry.com/sites/default/files/media/related_material/poyrypointofview_fullydecarbonisingeuropesenergysystemby2050_printerfriendly.pdf
[24] See https://www.theguardian.com/environment/2018/sep/17/germany-launches-worlds-first-hydrogen-powered-train

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The UK also has the potential to store CO_2 on behalf of other countries:

- UK offshore waters have ample CO_2 storage opportunities, estimated to be around 78 billion tonnes – simply utilising the top 15% of this storage capacity would be enough to meet entire UK needs for 100 years.[25]
- At the same time, the UK has a world class oil and gas industry with the expertise needed to deliver a CCS industry.
- Storing CO_2 on behalf of other countries would also generate revenue for the UK. For example, at a storage price of £5 a tonne, storing 50 million tonnes of CO_2 a year would generate £250 million for the UK economy. The value of the UK developing its own storage capability is estimated to boost the UK's balance of trade by £9 billion to 2060.[26]

Throughout our evidence, we do highlight economic issues. It is important not to forget the economic aspects to net-zero, particularly given the need to reduce emissions at lowest cost, and the need to create new employment opportunities as part of a "Just Transition".

Question 8 (Technology and Innovation): How will global deployment of low-carbon technologies drive innovation and cost reduction? Could a tighter long-term emissions target for the UK, supported by targeted innovation policies, drive significantly increased innovation in technologies to reduce or remove emissions?

ANSWER:

First, the **potential global market** in low carbon industrial goods and services could be very large indeed. For example:

- Globally, the Hydrogen Council roadmap presents a 2050 vision where the global annual sales of hydrogen technology and services reach £1.94 trillion and create jobs for 30 million people. The roadmap estimates that global demand for hydrogen could increase tenfold between 2015 and 2050, from 8 EJ (over 2,000 TWh) to almost 80 EJ (over 20,000 TWh).[27]

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[25] Energy Technologies Institute, Pale Blue Dot, Costain and Axis, Progressing Development of the UK's Strategic Carbon Dioxide Storage Reserve: A Summary of Results from the Strategic UK CO_2 Storage Appraisal Project, April 2016 http://www.eti.co.uk/project/strategic-uk-ccs-storage-appraisal/

[26] Summit Power, Clean Air – Clean Industry – Clean Growth: How Carbon Capture Will Boost the UK Economy, October 2017, p.5 http://www.ccsassociation.org/news-and-events/reports-and-publications/clean-air-clean-industry-clean-growth/

[27] Hydrogen Council, Hydrogen scaling up, November 2017, p.8 and p.20 http://hydrogencouncil.com/wp-content/uploads/2017/11/Hydrogen-Scaling-up_Hydrogen-Council_2017.compressed.pdf

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- The future global CCS market is estimated to be around £100bn/year,[28] with 11Gt CO2 needing to be permanently stored by 2060 to meet Paris Agreement emissions reduction targets.
- The estimated European electrolyser market (dependent on Brexit outcome) is £3.7 billion in 2017-2025, which could represent around £0.8 billion to the UK by 2025.[29]

Second, the UK has important **strengths**, which mean it stands to benefit from exports and tax revenues in these areas, including:

- World-leading universities and research institutions, together with existing partnerships such as HyNet and H21, that have developed detailed plans for deep decarbonisation.
- Leading UK electrolysis technology providers, including installing the world's largest electrolyser in Germany.
- A world-class oil and gas industry with the expertise to develop CO_2 storage at scale, and around 50% of the commercially viable CO_2 storage in the North Sea.
- One of the most substantial gas networks in the world, which supplies around 100TWh of gas each year to metals, paper, ceramics, food and drink and other industrial customers, alongside around 300TWh for domestic consumers and a similar level to power stations,[30] and which is already being upgraded through the Iron Mains Replacement Programme, which will make it more amenable to transporting hydrogen.

Third, **policies** to support innovation and deployment are essential to reduce costs and ensure that the UK is well placed to compete in these global markets. The Industrial Strategy Challenge Fund provides an excellent opportunity, and network innovation provides a good further example:[31]

- Regulated sectors such as energy networks need specific mechanisms to support and drive innovation, as economic regulation otherwise tends to focus on minimising short-term costs.
- The UK has a relatively good track record on supporting innovation in energy utilities, notably through Ofgem's "RIIO" regulatory framework, which features innovation as a core aim and supports projects at a variety of scales and Technology Readiness Levels.

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[28] HM Government, Clean Growth Strategy, October 2017, p.69 https://www.gov.uk/government/publications/clean-growth-strategy

[29] Tractebel and Hinicio, Study on early business cases for h2 in energy storage and more broadly power to h2 applications, June 2017, p.2 https://www.fch.europa.eu/sites/default/files/P2H_Full_Study_FCHJU.pdf

[30] BEIS, DUKES: Natural Gas, Table 4.1 https://www.gov.uk/government/statistics/natural-gas-chapter-4-digest-of-united-kingdom-energy-statistics-dukes

[31] See Energy Networks Association, Gas Network Innovation Strategy, March 2018 http://www.energynetworks.org/gas/futures/gas-network-innovation-strategy.html

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An assessment by Poyry found that Ofgem's previous Low Carbon Network Fund delivered £1.7bn of benefits,[32] and around £50m has been invested in projects around the future of the gas networks since new mechanisms were introduced in 2013. This has included support for flagship decarbonisation projects such as H21, Hydeploy, Freedom and H100, which are helping to provide policymakers with evidence around future options.

- Going forward, regulatory frameworks need to continue to encourage innovation and the role that networks can play in developing the technology and operational models of the future. Government and regulators should also consider how price controls incentivise larger scale transition using the learning from innovation projects, such as work to deliver a gas network capable of carrying a wider range of decarbonised gasses.

Question 9 (Behaviour change): How far can people's behaviours and decisions change over time in a way that will reduce emissions, within a supportive policy environment and sustained global effort to tackle climate change?

ANSWER:

It is vitally important to design policies that work for consumers, whether domestic or industrial, and there are several aspects to this:

- First, domestic consumers are choosing gas over electricity for heating. In 2017, 22,000 heat pumps were sold, but 1.6 million gas boilers were installed.[33] This suggests to us that consumers are comfortable with their existing gas heating systems, and that future low carbon heating systems will need to work with the grain of consumer behaviour.
- Second, fuel poverty is already too high, and a low-carbon transition should be looking to reduce, not increase it. Electricity costs consumers at least three times more per kWh than gas,[34] and households off the gas grid are far more likely to be in fuel poverty.[35]

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[32] Poyry, An independent evaluation of the LNCF: A report to Ofgem, October 2016 https://www.ofgem.gov.uk/system/files/docs/2016/11/evaluation_of_the_lcnf_0.pdf

[33] See University of Strathclyde, 20 September 2018 https://www.strath.ac.uk/research/internationalpublicpolicyinstitute/ourblog/september2018/wewerepromisedheatpumpsaviewontheelectrificationofheat/

[34] BEIS, Quarterly Energy Prices, September 2018, Tables 2.2.3 and 2.3.3 https://www.gov.uk/government/statistics/quarterly-energy-prices-september-2018

[35] BEIS, Annual fuel poverty statistics report: 2018, Figure 4.14 https://www.gov.uk/government/statistics/annual-fuel-poverty-statistics-report-2018

Question 9 (Behaviour change): How far can people's behaviours and decisions change over time in a way that will reduce emissions, within a supportive policy environment and sustained global effort to tackle climate change?

- Third, awareness of low-carbon heating system is low, as evidenced in recent opinion research carried out for the CCC[36], and so there is a need for sustained communication. The relative low uptake of the smart meter programme is an example of the scale of the challenge.
- Fourth, industrial consumers are also important. Industrial gas prices are less than one third of industrial electricity prices,[37] and many energy intensive industries operate in highly competitive global markets, with small margins.

Overall, we believe that small interventions will not be sufficient to achieve the required behaviour changes. For example:

- The domestic RHI, for example, has not been a success, with less than 18,000 properties on the gas grid making a switch in the four years of the scheme's operation.[38]
- At this rate, it would take around 5,000 years to switch all properties on the gas grid, and we also note that the two most recent sets of RHI deployment statistics do not seem to provide an on/off gas grid split any longer.

Schemes like the Industrial Strategy Challenge Fund are also essential, as they have the potential to invest significant sums of money in necessary industrial decarbonisation pilots, leveraging large-scale private sector investment.

Question 10 (Policy): Including the role for government policy, how can the required changes be delivered to meet a net-zero target (or tightened 2050 targets) in the UK?

ANSWER:

First, **sustained support for deployment** is essential to ensure that the required build rates are achieved in practice, and that costs reduce. Offshore wind is a good example of a technology where sustained support for deployment has reduced costs by more than half since 2011,[39] with direct employment in the sector rising to around 10,000.[40]

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[36] Madano and Element Energy, Public acceptability of the use of hydrogen for heating and cooking in the home: Results from qualitative and quantitative research in UK, November 2018 https://www.theccc.org.uk/publication/public-acceptability-of-hydrogen-in-the-home-madano-and-element-energy/

[37] BEIS, Quarterly Energy Prices, September 2018, Table 3.1.1 https://www.gov.uk/government/statistics/quarterly-energy-prices-september-2018

[38] BEIS, RHI deployment data, August 2018, Table 2.7 https://www.gov.uk/government/statistics/rhi-deployment-data-august-2018

[39] See https://www.ft.com/content/2ce7ac15-ee6e-3f9a-b427-6d34dac99ba2

[40] Aura, Future UK Employment in the Offshore Wind Industry, June 2017, p.13 https://aurawindenergy.com/uploads/files/Cambride-Econometrics-Future-UK-Employment-in-Offshore-Wind-June-2017.pdf

Question 10 (Policy): Including the role for government policy, how can the required changes be delivered to meet a net-zero target (or tightened 2050 targets) in the UK?

This needs to include the full range of decarbonised gases, including biomethane and bio-LPG, hydrogen from natural gas and hydrogen from electrolysis, and bioenergy with CCS. In particular we would note that CCUS will be vital to meeting even the 80% emission reduction target at least cost, and therefore it would be a false economy not to provide long-term support for its deployment.

Second, focusing on **industrial clusters**, that can benefit from economies of scale and shared infrastructure, but where current dispersed ownership makes co-ordination and allocation of risk difficult, will be essential. Support for innovation and pilot development, for example from the Industrial Strategy Challenge Fund, will need to be accompanied by policy development in parallel – otherwise the needed industry investment will not take place.

Third, establishing a **price on carbon or its removal** could be helpful to incentivising deployment:

- The Energy Transitions Commission has concluded that industrial decarbonisation requires strong incentives for long-term change, established well in advance, whether via carbon pricing, regulations, or financial support.[41] Carbon prices should be:
    - Defined in advance, setting a long-term signal;
    - Differentiated by sector, because higher pieces are needed in some sectors (e.g. cement may need a carbon price of $110-130 per tonne, compared with $25-60 per tonne for steel);
    - Domestic, in the absence of global agreements, on products that are not generally traded internationally;
    - Downstream, on the lifecycle emissions of consumer products.
- Tax credits are another option to incentivise deployment. The US 45Q tax credit will rise to $50 a tonne for dedicated geological storage of captured CO_2, which the International Energy Agency believes is high enough to spur CCS deployment for natural gas processing, ammonia, ethanol and hydrogen production.[42]

Fourth, the **duties of economic regulators** need to cover emissions reduction. For example, the Oil and Gas Authority should take account of the need to facilitate economic storage of CO_2 in exercising its statutory duty of maximising economic recovery of offshore oil and gas.

Fifth, **alignment of funding, planning and decision-making** needs to take place. We welcome the establishment of the BEIS Hydrogen Economy Team to help join up

[41] Energy Transitions Commission, Mission Possible: Reaching net-zero emissions from harder-to-abate sectors by mid-century, November 2018 http://www.energy-transitions.org/sites/default/files/ETC_MissionPossible_FullReport.pdf

[42] International Energy Agency, March 2018 https://www.iea.org/newsroom/news/2018/march/commentary-us-budget-bill-may-help-carbon-capture-get-back-on-track.html

Question 10 (Policy): Including the role for government policy, how can the required changes be delivered to meet a net-zero target (or tightened 2050 targets) in the UK?

policymaking, but there needs to be greater co-ordination between BEIS and the DfT to reduce transport emissions, and the Ofgem RIIO price-control periods need to align with forthcoming decisions on heat decarbonisation. Otherwise, we would risk unnecessary delay to implementation.

Part 4: Costs, risks and opportunities

Question 11 (Costs, risks and opportunities): How would the costs, risks and economic opportunities associated with cutting emissions change should tighter UK targets be set, especially where these are set at the limits of known technological achievability?
ANSWER: There are risks if the UK becomes an international outlier on greenhouse gas reduction – reducing greenhouse gases does come at a cost. There are, on the other hand, opportunities from being a first-mover, as Denmark has shown with respect to wind energy. As we have shown above, the UK has strengths in a number of aspects of decarbonisation and has developed ambitious proposals in several regions (for example, H21, HyNet and Acorn) that could provide a template for other countries. We have also shown that global markets for technologies such as hydrogen and CCS could become very large indeed, and the UK would be well placed to compete. If other countries follow the UK's lead, then we believe that a tighter target, together with policies to back it up, can provide a spur to technological development and exports, including skills and training development. However, with the current flawed international carbon accounting regime, there is also a risk that policies to meet a tighter UK target incentivise imports of raw materials, energy and industrial and agricultural goods, where emissions are counted as zero in the UK. As we have stated elsewhere, this would be a highly perverse outcome, which would risk increasing emissions globally. It is therefore essential that measures are taken to ensure that the UK's consumption of CO_2 emissions falls alongside its production of greenhouse gases.

Question 12 (Avoided climate costs): What evidence is there of differences in climate impacts in the UK from holding the increase in global average temperature to well below 2°C or to 1.5°C?
ANSWER:

Part 5: Devolved Administrations

Question 13 (Devolved Administrations): What differences in circumstances between England, Wales, Scotland and Northern Ireland should be reflected in the Committee's advice on long-term targets for the Devolved Administrations?

ANSWER:

We would note that circumstances vary widely between the various nations of the UK, and any targets for the Devolved Administrations need to take these into account. For example:

- The Port Talbot industrial cluster accounted for nearly 50% of all industrial emissions in Wales in 2016,[43] but a far lower proportion of all industrial emissions for the UK as a whole. Work to decarbonise Port Talbot should take place, whilst ensuring it can remain competitive and support skilled employment. But it would be completely perverse if a Welsh target could only be met through the closure of Port Talbot, with offsetting negative emissions in England prohibited from being counted. In essence, setting the wrong targets for the Devolved Administrations could make the international carbon accounting problem worse, by devolving it down to the level of the individual nations of the UK.
- Scotland has a far larger per capita renewable resource than England, as it enjoys higher average wind speeds and is far less densely populated. Therefore, it is "easier" to meet a net-zero target in Scotland, but it may be more cost-effective for the UK if the marginal kWh of renewable power is used to help decarbonise electricity generation in England.

The target that is of most importance is the one for the UK as a whole. And we should not forget the importance of communities across all the four nations:

- Industrial clusters, such as those containing high energy use industries (e.g. iron and steel, cement, chemicals, oil refining, food and drink, pulp and paper, ceramics) are vital to the UK. They contribute around £140 billion in GVA (8% of the UK economy); employ around 1.1m workers and 70% of businesses are exporters.[44]
- They are at the heart of communities, tending to be in areas of economic disadvantage, often being the largest employer in the area, offering high quality jobs that tend to pay above the UK median wage.

[43] Committee on Climate Change, Reducing UK emissions: 2018 Progress Report to Parliament, June 2018, p.257 https://www.theccc.org.uk/wp-content/uploads/2018/06/CCC-2018-Progress-Report-to-Parliament.pdf

[44] BEIS analysis using the ONS Annual Business Survey

Part 6: CCC Work Plan

Question 14 (Work plan): The areas of evidence the Committee intend to cover are included in the 'Background' section. Are there any other important aspects that should be covered in the Committee's work plan?
ANSWER: