Meeting net zero with decarbonised gas

We can't achieve net zero without decarbonised gas

Although the UK has done a great job of decarbonising electricity generation, to get to net zero we need to tackle harder-to-decarbonise sectors like heat, transport and industry. Decarbonised gas – biogases, hydrogen and the deployment of carbon capture, usage and storage (CCUS) – can make our manufacturing more sustainable, minimise disruption to families and deliver negative emissions.

To achieve net zero, we need to:

- **Decarbonise heating in 1 million homes a year:** There are 27 million homes in the UK, and we have 30 years until 2050. So this is a mammoth challenge, but converting homes to hydrogen and using biogases is cheaper and easier than changing entire central heating systems for heat pumps.
- **Decarbonise heavy transport:** Trucks, trains and ships are less suited to batteries, and a mix of biogases and hydrogen can decarbonise these transport modes effectively and improve air quality.
- **Decarbonise heavy industry, without offshoring of factories:** Energy intensive industries employ over 1 million people and are at the heart of communities. CCUS and fuel switching to hydrogen can clean up our manufacturing and open export opportunities, creating good jobs.
- **Deliver negative emissions:** Negative emissions will be needed to offset remaining emissions that are impossible to eliminate. To achieve negative emissions, we need bioenergy with CCUS, and to develop this, we need CO_2 transport and storage networks in key clusters.
- **Couple the gas and electricity sectors:** To make best use of our growing renewable resources, and to accommodate more renewables on the grid, excess renewable electricity can be used to produce hydrogen, which can be used in transport, blended in the gas grid, and even exported.

We have the solutions and are ready to implement them

Technologies for producing biomethane and hydrogen and capturing and storing CO_2 are well established, and deployment will see efficiency improvements and cost reductions. Industry is developing over 30 decarbonised gas projects across the UK to lay the foundations for a wider roll-out. These include biomethane and other biogases, power-to-gas, hydrogen blending in the gas grid, 100% hydrogen, industrial CCUS, decarbonised power generation, and decarbonised transport.

We need strong action from Government

1. An increase in the permitted hydrogen limit in the gas grid from 0.1% to 2-3% as a first step, and then a further increase to 20%.
2. Industrial decarbonisation projects funded through the Industrial Strategy Challenge Fund (ISCF) and Industrial Energy Transformation Fund (IETF).
3. Investible mechanisms to fund hydrogen production, CCUS and injecting more low carbon gases into the gas grid. This includes acting on the current CCUS business models consultation.

Offshore wind provides a positive example of consistent policy that has delivered large-scale investment, deployment and cost-reduction. There is no reason why the same cannot happen for decarbonised gas – for example, biomethane tariff costs have fallen by 40% in just five years.

We need decarbonised gas to achieve net zero

DECARBONISED GAS IN A NUTSHELL

Decarbonised Gas Alliance

What?

Decarbonised gas is a great solution to a growing problem: how do we efficiently and cost-effectively decarbonise the UK's energy system?
By harnessing the potential of our existing immense gas system, re-purposing it rather than decommissioning it, the UK can cut the cost of decarbonising in half.

How?

By using a range of low carbon and renewable gases such as hydrogen and biomethane, alongside carbon-capture technology.

It's not about one magic bullet – decarbonised gas and electrification would work alongside one another.

Why?

Since 1990, the UK has done a good job of decarbonising electricity, but it has done a poor job of decarbonising heat, transport and industry.

Decarbonising the gas system can hep us to tackle these harder areas, safely and cost-effectively.

How can we do it?

Biomethane, bio-SNG (synthetic natural gas) and bio-LPG (liquified petroleum gas) are produced from waste products and are therefore naturally low carbon and renewable. They can be used directly in place of natural gas in the grid or LPG. John Lewis & Partners are already converting their entire HGV fleet to biomethane.

H_2

Hydrogen can be produced from water using low carbon electricity, or from natural gas with CCUS at scale. The only emission when used is water.
Hydrogen can be used in place of gas in the home, for transport and in industry. It can also be blended in the gas grid up to 20% without needing to change appliances.

CO_2

Using carbon capture, utilisation and storage (CCUS) technology will halve the cost of meeting the UK's 2050 carbon reduction targets.
CCUS could also be used to decarbonise heavy emitting industrial clusters such as the North West and Teesside, enabling these sites to remain a part of their community and benefit the economy.

Hydrogen and gas with CCUS can provide flexible electricity generation to complement renewables

The gas system provides most of our energy in the winter

Bioenergy with CCUS provides negative emissions

You are 50% more likely to be in fuel poverty off the gas grid

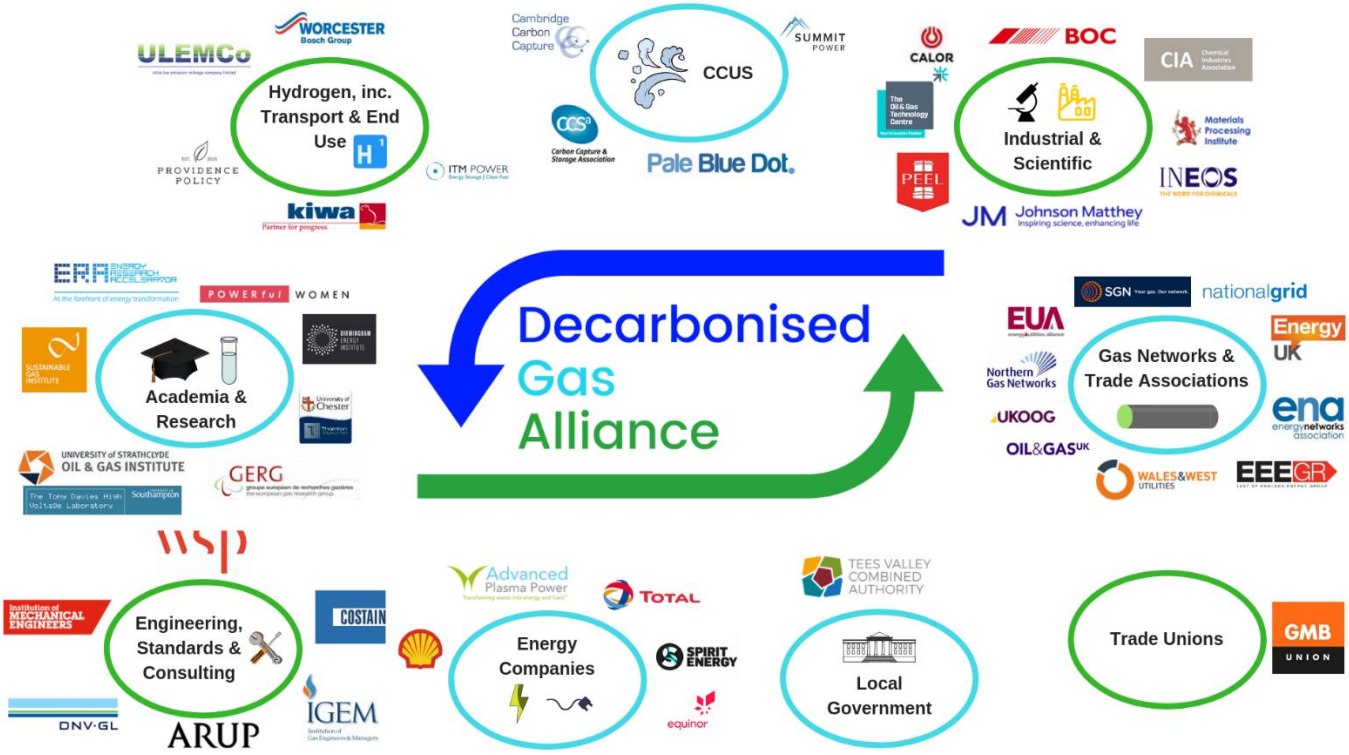
20+ ongoing projects trialling these technologies

About the Decarbonised Gas Alliance

The Decarbonised Gas Alliance is a diverse group of almost 50 expert organisations, shown in the diagram below, who have come together to help decarbonise the gas system and meet the UK's target of net zero climate emissions.

We believe that decarbonised gas – biogases, hydrogen and the deployment of carbon capture, usage and storage (CCUS) – can help us meet this goal while keeping industry in the UK, providing good jobs for communities and minimising disruption to families.

We can't achieve net zero without it.



Appendix A: Why we need decarbonised gas

1. **We have an excellent gas system in the UK that delivers considerable amounts of energy at low cost to households and industry, and keeps us warm in winter.**

    - **Large capacity:** The gas system supplies 2½ times more energy than the electricity system throughout the year,[1] and around four times more at peak periods, like cold winter evenings.[2]
    - **Low cost:** Natural gas is around a quarter the unit price of electricity for both households and industry,[3] so it is vital to maintaining industrial competitiveness and limiting fuel poverty. A household in England is 50% more likely to be in fuel poverty without a gas grid connection.[4]
    - **The bulk of household usage:** Over the year, for a typical home connected to the gas grid, 87.5% of the heat and power used by that home will be delivered by the gas system, including the gas delivered to power stations. Even if there was no gas used for electricity generation, the gas system would still be delivering 79.5% of that home's heat and power.[5]
    - **Vital to manufacturing:** Gas is a crucial raw material in the manufacturing of everyday products from toothpaste to mobile phones and fertilisers to help grow food. Some industrial processes also require a flame to come into direct contact with the material or product being produced, for example in furnaces or kilns.
    - **Considerable storage:** We estimate that the gas system can withdraw 1,400 GWh of energy per day from storage, compared with under 15 GWh a day for electricity storage.[6]

2. **We can decarbonise the gas system through using biogases, hydrogen and carbon capture, usage and storage (CCUS), including delivering negative emissions.**

    - **Biogases:** Biogases can be produced in a variety of ways, mainly from anaerobic digestion to produce biomethane, or from gasification combined with methanation technology to produce a synthetic natural gas (SNG) from waste materials. Bio liquified petroleum gas (LPG) can also be produced from waste sources. The decarbonisation comes from the productive use of waste gases that would otherwise be vented. Biomethane and bio-SNG can be used as a direct substitute for natural gas, and can also be used to decarbonise buses and trucks, while bio-LPG can be used as a direct substitute for LPG in off-grid and transport applications.
    - **Hydrogen:** Hydrogen emits no greenhouse gases when combusted or used in a fuel cell. The range of potential applications is as broad as for natural gas, including heavy transport and power generation, although existing equipment will need to be replaced with hydrogen-compatible equipment. Hydrogen can be stored seasonally, and blended in the gas grid at low concentrations, without the need to change appliances. It can be produced in a low-carbon manner, by employing carbon capture and storage on production from natural gas, using low carbon electricity for electrolysis of water, or producing hydrogen from biomass.
    - **Carbon Capture, Usage and Storage (CCUS):** CCUS can be used to capture and permanently store, or utilise, carbon emissions from a wide variety of sources. These include power generation from gas, hydrogen production from gas, and directly from energy and emission intensive industry, such as ammonia, cement and steel production. When used with biomass sources, CCUS can produce negative emissions, which are critical to achieving any net zero target in practice.
    - **Integration with renewable electricity:** Decarbonising the gas system can support the growth of renewables. Via a sector coupling approach, excess renewable electricity, which will be low-cost, can be used to produce hydrogen by electrolysis, which can then be blended into the gas grid, used directly in transport and industrial applications, or stored to provide power generation when wind speeds or solar radiation are low.

3. Decarbonising the gas system will provide important benefits as we work towards net zero.

a. *Keep and grow industry in the UK by providing great opportunities to export expertise and low carbon industrial products.*

- At the heart of communities: In many parts of the country, energy intensive industries – including iron and steel, cement, chemicals, oil refining, food and drink, pulp and paper and ceramics – are the largest employers in the area and offer high quality jobs that pay above the median wage. Overall, energy intensive industry accounts for £140 billion in economic value added and employs over 1.1 million people.[7]
- Emissions offshoring: To date, we have seen far too much decarbonisation through offshoring of industry. Between 1997 and 2016, the UK's production of emissions fell by 35%, but the emissions embodied in the goods and services we *consume* in this country only fell by 9%,[8] as manufacturing declined dramatically.[9] To give one example, the closure of Redcar steelworks in late 2015 led to 2,000 job losses, but caused nearly half the fall in industrial emissions in 2016.[10] This is not a sustainable position for the UK, is not compatible with the Clean Growth Strategy, and may actually increase emissions globally as industry in many countries is far more dependent on coal.
- Decarbonising industry: We have an opportunity to turn this around and decarbonise industry here at home. The Committee on Climate Change's (CCC) net zero report found that industry can be effectively decarbonised through CCUS, hydrogen, bioenergy where CCUS is available, and some electrification.[11]
- New global opportunities: The global CCUS market could rise to £100 billion a year;[12] the global hydrogen market could reach £1.9 trillion a year by 2050;[13] the EU bio-economy is already worth £1.7 trillion today; and international electrolyser and fuel-cell combined heat and power (CHP) markets are growing. Decarbonising UK industry can help to retain and future-proof the UK's manufacturing base, preparing it to take commercial advantage of global marketplaces where customers will increasingly want to buy low carbon industrial goods and services.
- Export revenue: The UK will also have an opportunity to earn export revenue from manufacturing hydrogen technologies, including appliances, electrolysers and gas reformers; from storing CO_2 on behalf of other countries and/or through capturing and storing CO_2 from industrial processes and then exporting the low carbon products; and from exporting renewable hydrogen.

b. *Provide good jobs for communities in manufacturing, hydrogen installations and storing CO_2.*

- Industries in transition: A recent Summit Power report found that developing a network of CCUS projects along the East Coast of the UK, capturing 75 million tonnes of CO_2 per year, would provide £163 billion of economic benefits and 225,000 jobs, cumulatively, through to 2060.[14]
- Installing new heating appliances: The H21 North of England report showed that a widespread conversion of homes to hydrogen would require over 3,000 gas engineers for a number of years, with additional management staff.[15] Further jobs would be created in hydrogen production and transportation.

c. *Minimise disruption to families as using hydrogen and biogases in the home is easier and cheaper than changing the entire central heating system to electric.*

- 1 million homes a year: There are 27 million households in the UK[16] and we have 30 years to get to net zero. This means that we need to decarbonise the heating of around 1 million homes a year – a mammoth task.
- Previous examples: There are two examples of home heating interventions in the UK that have achieved at least 1 million homes a year – the town gas to natural gas switch in the 1970s, and the 2005 regulations mandating that all new boilers are energy efficient condensing models.[17] A requirement that all new boilers are hydrogen-ready could make a future switchover to hydrogen more straightforward.

- **Easier and cheaper:** Hydrogen boilers, micro combined heat and power units, and hybrid systems, where a heat pump is supplemented by a gas boiler (potentially running on biogases) when the weather is very cold, are easier and cheaper to install than electric-only solutions. This is because they do not need a full change to the entire central heating system. For most homes, an electric heat pump-only solution would require a new central heating system, including much larger radiators and hot water tanks, costing an estimated £10,000 per household.[18]

4. **We cannot achieve net zero without decarbonised gas because we need negative emissions, and the gas system can deliver negative emissions through bioenergy and direct air capture with CCUS.**

   - **Harder-to-decarbonise sectors:** Decarbonised gas can help to address the harder-to-decarbonise sectors. Since 1990, the UK has made major progress in reducing emissions from electricity (down 122 million tonnes, or 57%) and in certain non-CO_2 gases (down 111 million tonnes of CO_2-equivalent, or 56%). These two areas combined account for over 70% of the UK's total decarbonisation since 1990.[19] By contrast, transport emissions have fallen by just 0.7%, and residential emissions have fallen by less than 15%.[20] And as shown above, we have seen far too much industrial decarbonisation through offshoring. To give one example, hydrogen can be used to decarbonise heavy transport – trucks, trains and ships – where batteries are less feasible.
   - **Major effort required:** The CCC's net zero report found that hydrogen use would increase ten-fold to 270 TWh by 2050 and that up to 176 million tonnes of CO_2 would be captured and stored each year from a variety of sectors. Biogases would also play a role, including through bioenergy with carbon capture and storage (BECCS). The report also found that electricity use would double from 300 TWh to around 600 TWh.[21] A major effort is therefore required in both the gas and electricity sectors – it's not a case of one or the other.
   - **Negative emissions:** The CCC has concluded that reaching net zero will require removal of CO_2 from the atmosphere. Negative emissions can be delivered from bioenergy with CCS, or from direct air capture, but both options require a CO_2 transport and storage infrastructure.[22] As the CCC has concluded, "CCS is a necessity not an option for reaching net-zero GHG emissions".[23]
   - **Capacity and expertise:** The UK has more than 100 years' of CO_2 storage capacity,[24] and can make use of oil and gas industry expertise, and its supply chain and innovation system.

5. **Industry is developing many innovative projects around the country that are laying the foundations for decarbonising the gas system and integrating with decarbonised electricity.**

   - **Industry is ready:** There are over 30 projects taking place across the country to lay the foundations for a roll-out of decarbonised gas solutions – see Appendix B. These include projects to develop biomethane and other biogases, power-to-gas, hydrogen blending in the gas grid, 100% hydrogen, industrial CCUS, decarbonised power generation, and decarbonised transport.
   - **Cost reductions:** Where decarbonised gas has had support for widespread deployment, we have seen impressive cost reductions. Tariff payments for biomethane injected into the grid have fallen by over 40% in the last four years, from 8.2 pence per kWh before 2015, to 4.8 pence per kWh in 2019. Biomethane is now being injected into the grid at 89 sites nationwide.
   - **Bringing it all together:** Clusters of heavy industry offer a great opportunity for deep decarbonisation. CO_2 emissions can be captured directly from factories and stored offshore; hydrogen can be produced from natural gas, with the CO_2 stored in the same CCUS network, and deployed in heavy industry and blended in the gas grid; excess offshore wind electricity can be used to produce hydrogen that can be deployed in fuel cells for marine, rail and truck transport; and negative emissions can be generated from bioenergy with CCUS. Major projects are being studied in all these areas.

Appendix B: Summary of UK decarbonised gas projects

Although at present there are limited support mechanisms that can facilitate a wider roll-out of decarbonised gas, there is a wide range of decarbonised gas projects underway, demonstrating the desire of industry to find lasting solutions. The list below is not exhaustive, but provides a brief summary of many of the main projects in the UK.

Biogases[25]

- Biomethane: Injected at 89 sites; 6.7 TWh so far. Policy support through Renewable Heat Incentive.
- Bio SNG: New plant in Swindon would take in waste from the local area and produce BioSNG.
- Bio LPG: Potential to use bio LPG in off-gas-grid homes in place of oil or solid fuels. Bio LPG currently produced in Rotterdam.
- Transport – filling stations: Now 11 liquified natural gas (LNG) and 8 compressed natural gas (CNG) filling stations – 3 of the CNG filling stations are biomethane, allowing an 84% well to wheel CO_2 reduction. Policy support through Renewable Transport Fuel Obligation.
- Transport – vehicles: Increasing business interest in fleet conversion. John Lewis and Waitrose plan to convert their entire fleet of 500 diesel lorries to bio-methane vehicles by 2028, reducing fleet emissions by over 80% and saving more than 49,000 tonnes of CO_2 annually. Reading and Bristol using CNG buses.

Gas network flexibility[26]

- Future Billing Methodology: Ongoing project to create more flexible billing arrangements, meaning that biogases and hydrogen in parts of the network would not need pre-processing to meet average calorific value and other requirements.
- Freedom Project: Trial of hybrid heat pumps – a heat pump working alongside a gas boiler – in 75 residential properties in Bridgend, South Wales. Demonstrated the ability of the system to switch between gas and electric load.
- Real-Time Networks: An installation of sensors that will enable the measurement of the energy content of different gases within the network, rather than just the traditional flow and volume. This will allow more low carbon gases to be injected.

Hydrogen blending[27]

- 2-3% blend: Current UK limit is 0.1% hydrogen; gas distribution networks considering making safety case application to increase to 2-3% hydrogen blend – would allow first stages of a market in e.g. grid balancing of excess renewables via electrolysis.
- 2-3% blend – Aberdeen: Aberdeen Vision is led by SGN, with support from National Grid Gas Transmission, and runs until September 2019. Its aim is to study the potential of blending 2% hydrogen at the St Fergus reception terminal and the viability of building a hydrogen pipeline from St Fergus to Aberdeen.
- 20% blend – HyDeploy 1: Project currently underway, will inject up to 20% hydrogen in part of the Keele University private gas network in Summer 2019 to test performance of appliances – safety case already approved and currently constructing hydrogen production equipment. 2020 project finish.
- 20% blend – HyDeploy 2: Received funding and started earlier in 2019. Will blend up to 20% hydrogen in two public gas networks in North of England – 750 homes each. Needs safety case approval and positive results from HyDeploy 1 – would then blend in first area in 2020 and second area in 2021. NB: 20% blend chosen as gas appliances manufactured after 1993 have been

designed to operate with a hydrogen mix up to 23%. The HyNet scheme (see industry section) would blend hydrogen in the gas grid at up to 20%.

- National transmission assets: Gas Transmission ran a wide-ranging technical project with the Health and Safety Executive in early 2019 to better understand the potential impact of hydrogen on national transmission assets. Project HyNTS will look at the physical capabilities of the NTS, evaluate work that is taking place in the UK and Europe on hydrogen and conduct a gap analysis for the NTS.
- Project Cavendish: This project is focused on the Isle of Grain in Kent, which is home to the Grain LNG terminal. National Grid Gas Transmission, Cadent and SGN are working with Arup to examine whether existing infrastructure could be used to supply hydrogen to London and the South East of England, including design and modelling work to assess the potential CO_2 reductions that could be achieved and the business model options.

100% hydrogen[28]

- Trials: H100 programme would test 100% hydrogen in a small new build area, not reliant on existing grid issues – potentially the first demonstration of a 100% hydrogen network.
- Gas network upgrade: 30-year Iron Mains Risk Reduction Programme replacing distribution mains with polyethylene – suitable to transport 100% hydrogen – will be completed around 2030.
- Safety and appliance testing: Two parallel programmes to confirm safety:
  - H21 safety testing on gas distribution network to confirm 100% hydrogen suitability (completion 2020).
  - BEIS Hy4Heat programme testing appliances, safety in the home, and colorants/odorants for hydrogen etc (completion 2021).
- Feasibility studies: H21 Leeds City Gate (2016) and H21 North of England (2018) showed how North of England cities (3.7 million meter points) could be converted to 100% hydrogen. Hydrogen produced from methane via auto-thermal reforming and CCS for a 92% emissions reduction, and seasonal hydrogen storage in salt caverns, informed by HyUnder project.

Industry[29]

- Industrial decarbonisation "Mission" and funding: BEIS mission for one net-zero industrial cluster by 2040 and at least one low carbon cluster by 2030 – includes £315 million Industrial Energy Transformation Fund (subject to consultation) and £170 million Industrial Strategy Challenge Fund.
- Other low carbon industry R&D: BEIS portfolio of low carbon industry funding, including £20 million Carbon Capture and Utilisation demonstration, £15 million Call for CCUS Innovation, £20 million Hydrogen Supply Competition and £20 million Industrial Fuel Switching competition.
- Industrial decarbonisation projects: Numerous feasibility studies and early stage projects (would need funding to progress to practical construction) including:
  - Acorn – Phased full chain carbon capture, transport and offshore storage project to initiate CCS in the UK. PCI funded. CO_2 storage licence in place. Re-uses existing infrastructure. Linked to Acorn Hydrogen, with export via NTS blending and/or 100% applications in NE Scotland.
  - HyNet – Liverpool to Manchester HyNet project would capture and store existing CO_2 emissions from industry and then provide hydrogen to heavy industry in the region, saving several million tonnes of CO_2 a year, with residual hydrogen blended up to 20% in residential gas grid. Hydrogen production from methane with CCS. Final investment decision 2022.
  - Teesside Collective – CCS-equipped industrial zone.
  - Centurion – 100 MW power-to-gas storage feasibility study in Runcorn – largest electrolyser in world.
  - Humberside zero-carbon partnership – A partnership between Drax, Equinor, and National Grid Ventures to decarbonise the Humber industrial cluster and the wider Yorkshire region. The project would see CCUS technology applied to the biomass units at Drax Power Station

delivering negative emissions, along with the construction of a hydrogen production facility at the Drax site. These projects would in turn serve as the catalyst for the development of a CO_2 transport and storage network in the Humber Estuary. This would transform the UK's most carbon-intensive industrial cluster, protecting existing businesses and creating a new hydrogen economy in the region.

Hydrogen transport[30]

- Filling stations: Currently 16 hydrogen filling stations in operation; £23 million Hydrogen for Transport programme will fund 14 further filling stations and deployment of new vehicles.
- Buses: Hydrogen buses in London and Aberdeen, including refuse vehicles; new UK double-decker hydrogen fuel cell bus.
- Trains: Proposal to convert 100 older trains to hydrogen, to be running from 2022. Previous Government announcement of aim to phase out diesel-only trains by 2040.
- Ships: World's first hydrogen ferry to be built in Scotland; potential of hydrogen ferries to be used in Orkney and Western Isles.
- Integrated project: Big Hit project in Orkney to use renewable hydrogen for auxiliary power and heat for ferries in Kirkwall harbour, fuelling a fleet of hydrogen range-extended light vehicles, and heating for buildings in the Kirkwall area.

CCUS in electricity sector[31]

- Cost savings and flexibility: Committee on Climate Change concluded costs of meeting UK's previous 2050 targets could be twice as high without CCS, and that CCS is "a necessity not an option" for net zero. With recent setbacks in UK's new nuclear programme, CCS offers firm and dispatchable power.
- Offshore storage capacity: Energy Technologies Institute recent project to assess offshore storage capacity – over 100 years of CO_2 storage and fields ready for decommissioning or CCS are near to industrial clusters.
- Projects: Several potential CCS projects in power sector (all would require funding):
  - Clean Gas Project – Oil and Gas Climate Initiative-led project to create commercial full-chain CCUS facility in Teesside, combining CO_2 capture from power generation and local industrial emitters.
  - Caledonia Clean Energy project – 90% CO_2 capture on gas-fired power plant of up to 1.3 GW.
  - NetPower – Uses Allam Cycle with supercritical CO_2 instead of steam. UK invention; 50 MW pilot plant operating in Texas; potential to build 300 MW plant.
- Government action: BEIS CCUS action plan published in November 2018 – most important element is current Business Models consultation. US 45Q tax credit also one to watch.

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[22] There are other CO_2 removal techniques which do not require a CO_2 transport and storage network, for example reforestation, but they are unlikely to be sufficient.
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[24] The North Sea has 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. 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/
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