Written Evidence Submitted by E3G
(HNZ0043)

E3G is an independent, not-for-profit climate change think tank. E3G have been engaging on issues of energy system decarbonisation for over 15 years, and on the future role of gas and hydrogen for the past 6 years. E3G has technical, policy and financial expertise on decarbonising homes – with focus on zero emissions heat and energy efficiency. Our response to this consultation reflects these areas of specialism.

Summary

1. Zero emissions green hydrogen is a **scarce, premium commodity**. Used wisely, it can underpin a competitive zero-emissions industry, as well as freight and power sectors. To reap this opportunity, it must be **developed and deployed strategically, where it adds most value.** The focus must be on **"hard-to-abate" sectors** where, at present, no alternative is available for decarbonisation (e.g. high temperature heat and feedstock for certain industries, the power sector, shipping and aviation). By targeting resources behind its use in those sectors, we maximise chances for success and minimise costs to industry and end users.

2. We encourage the **UK to show leadership on green hydrogen,** in parallel to seeking rapid growth in renewable energy capacity, earning the title of the *'Saudi Arabia of wind power'*. This will allow the UK to play an international leadership role on climate action and innovation, as other countries race to develop sustainable hydrogen solutions.

3. Hydrogen from fossil gas in combination with Carbon Capture and Storage (CCS) **– blue hydrogen – is not zero emissions and should not be the focus of development.** Developing blue hydrogen does not accelerate development of green hydrogen on the supply side, since these are fundamentally different technologies. Furthermore, blue hydrogen will always lead to residual upstream and midstream emissions from **methane leakages** during the extraction and transport of natural gas. In the transition period, an overreliance on blue hydrogen could slow efforts to meet carbon budgets, **diverting resource from making fast gains** on efficiency and renewable energy, as well as the development of electrolyser technologies required for green hydrogen. Blue hydrogen is not an "easy" technology, and significant progress would be needed on CCS within the next decade if it is to play any meaningful role in the transition period – with **care taken to avoid a 'lock in'** of dependence on fossil hydrogen technology and infrastructure.

4. An overall efficient energy system that includes hydrogen will need to see **maximum progress on efficiency, electrification and renewables**.[1] The legitimacy of any public funding towards hydrogen hinges on a simultaneous **phase out of unabated fossil gas**.

5. For an efficient use of public resources, it is essential that the Government **clarifies its focus in terms of production and end-use in the forthcoming Hydrogen Strategy**, in line with a zero emissions pathway. We recommend that the Government articulate that it will focus on deployment of **green hydrogen within hard-to-abate sectors.**

6. The **decarbonisation of the power sector** should be a priority. Hydrogen-fired gas turbines currently provide the most promising route for firm back-up power supplies. Absent any major breakthrough innovation (e.g. cryogenics) it may prove the only credible route to provide long duration storage.

7. New, consolidated academic research by UKERC finds **energy efficiency, heat pumps and district heating** comprise the most effective investment pathway for heat decarbonisation for the next 10 years.[2] Green hydrogen for **heating is a highly inefficient option** for most of the UK. Government climate advisors have warned that the country would need **30 times as much offshore wind farm capacity to produce enough "green" hydrogen to** than electrification pathways with heat pumps.[3] As well as being an inefficient option, hydrogen for heating could not be delivered at scale at the pace needed to meet decarbonisation targets,[4] with initial trials and pilots not expected to deliver scalable results until the end of the decade. Besides the strongly limited supply of green hydrogen, retrofitting grids and household appliances for 100% hydrogen transport and usage would require costly investments. Furthermore, there are concerns that hydrogen gas would also, at present rates, be about twice as expensive as natural gas, leading to **higher bills for consumers** or taxpayer subsidies.[5]

8. In light of the evolving science on the potential of hydrogen and conflicts of interest of market players, **rigorous and independent analysis and systems governance** must be ensured. This is particularly important following recent academic research that **found 'incumbent' industry actors with interests in fossil fuel heat were overselling the idea** of converting the UK's existing gas infrastructure to run on hydrogen, to protect their interests and detract from the importance and value of electrification.[6] The Government must act to ensure a **more nuanced and evidence-based discussion on hydrogen**. For instance, the Government's Hydrogen Advisory Council is chaired by Shell and currently contains no members from civil society.[7]

Terminology:

9. '**Green hydrogen'** describes hydrogen produced via electrolysis from renewable electricity.

---

[1] CCC (2018), **Hydrogen in a low carbon economy**
[2] **https://d2e1qxpsswcpgz.cloudfront.net/uploads/2020/09/The_pathway_to_net_zero_heating_UKERC_briefing.pdf**
[3] **https://www.thetimes.co.uk/article/switching-all-boilers-to-hydrogen-is-impractical-zw00f3v9l**
[4] **https://www.theccc.org.uk/wp-content/uploads/2015/11/Committee-on-Climate-Change-Fifth-Carbon-Budget-Report.pdf**
[5] As quoted in **https://www.thetimes.co.uk/article/switching-all-boilers-to-hydrogen-is-impractical-zw00f3v9l**
[6] **https://www.sciencedirect.com/science/article/pii/S2210422420300964?via%3Dihub**
[7] **https://www.gov.uk/government/groups/hydrogen-advisory-council**

10. **'Grey hydrogen'** describes hydrogen produced from fossil gas through steam methane reformation (SMR), without carbon capture and storage (CCS).
11. **'Blue hydrogen'** describes hydrogen produced from fossil gas through steam methane reformation in combination with CCS. An alternative technology is pyrolysis, but this is at very low levels of maturity and encounters many of the same issues as SMR.

Questions

1. The suitability of the Government's announced plans for "Driving the Growth of Low Carbon Hydrogen", including:

- the focus, scale and timescales of the proposed measures;
- how the proposed measures—and any other recommended measures—could best be co-ordinated;
- the dependency of the Government's proposed plans on carbon capture and storage, any risks associated with this and how any risks should be mitigated; and
- potential business models that could attract private investment and stimulate widespread adoption of hydrogen as a Net Zero fuel;

Focus, scale and timescales

In the Ten Point Plan and other Government documents, reference to focussing on 'low carbon hydrogen' is made. However, it remains to be clarified if the Government will only support the development of **zero emissions hydrogen sourced from renewable energy** (known as **green hydrogen**) – currently a scarce, premium commodity. It needs to be focused on areas where it adds most value, i.e. in **sectors where no alternative is available** (e.g. providing high temperature heat and feedstock for some industries, shipping and aviation). Its success and scalability are closely tied to progress on **efficiency and renewables**,[8] and the legitimacy of any public funding for hydrogen hinges on a simultaneous phase out of unabated fossil gas.

Hydrogen from fossil gas (known as blue or grey hydrogen) is not zero emissions and cannot play a role in the long term. Even in the transition, an overreliance on it could slow efforts to meet carbon budgets, potentially diverting resource from making fast gains on efficiency and renewable energy. An only transient role of blue hydrogen requires an evaluation of whether the investment costs associated with it are warranted.

Developing blue hydrogen does not accelerate the development of green hydrogen on the supply side, since these are fundamentally different technologies. Furthermore, blue hydrogen will always lead to residual upstream and midstream emissions from **methane leakages** during the extraction and transport of natural gas. In the transition period, focus on blue hydrogen must not **divert resource from making fast gains** on efficiency and renewable energy, as well as the development of

[8] CCC (2018), **Hydrogen in a low carbon economy**

electrolyser technologies required for green hydrogen, and care taken to **prevent a lock-in of dependence** on fossil hydrogen technologies and infrastructure. Blue hydrogen is **not an "easy" technology**, and significant progress would be needed on CCS within the next decade if it is to play any meaningful role in the near-term transition period.

This picture on emissions of the individual processes should be complemented by a **systems perspective**:

- **The phase in of hydrogen only brings emissions benefits if it simultaneously contributes to the phaseout of fossil fuels, including in the transport sector**. Otherwise the legitimacy of any public investments will be low: a more costly, less efficient product, for little emissions benefits and the risk of increased gas import dependency as North Sea production declines. It is thus important that an unabated fossil gas phaseout trajectory accompanies measures to phase in hydrogen. Decarbonising hydrogen use in existing processes is already a challenge.[9]
- **Is a lower emission, more efficient alternative already available** (e.g. direct electrification, energy savings)?
- **Speed and the contribution towards 2030 targets**: For example, illustrative scenarios developed for the National Infrastructure Commission[10] show how, compared to business as usual (BAU)[11], heat pumps at scale could cut cumulative heat-related emissions from buildings to 2030 by 25%– broadly in line with what climate science requires. The illustrative scenario for hydrogen at scale – blue hydrogen – reaches cumulative emissions 11% lower than that.
- **Actions taken in the near-term need to be focussed strategically on scaling up green hydrogen where it is most needed in the long-term, within hard-to-abate sectors.** For instance, retrofitting homes with hydrogen boilers does not help prepare for hydrogen use in ships and industrial decarbonisation, since these are different processes.

The UK Government seeks to develop 5GW of "low carbon" hydrogen production capacity by 2030 that could see the UK benefit from around 8,000 jobs across industrial heartlands and beyond. The Government is yet to clarify what share of this target will be met through blue vs green hydrogen, as a definition of "low carbon" hydrogen is not articulated. **The Government should use the forthcoming Hydrogen Strategy to confirm that the focus on will be on green hydrogen, deployed in hard-to-abate sectors.**

This scale and timeline of is ambitious – if focused on green hydrogen – and comparable to European peers, with Germany targeting 5GW of installed hydrogen capacity by 2030, with €7bn support and a target for green hydrogen production – and aiming for another 5GW a decade later.[12]

---

[9] https://www.theccc.org.uk/wp-content/uploads/2018/11/Hydrogen-in-a-low-carbon-economy.pdf
[10] Element Energy & E4tech for NIC (2018) ***Cost analysis of future heat infrastructure options***
[11] Incremental improvements in energy efficiency and more efficient boilers.
[12] **https://www.spglobal.com/platts/en/market-insights/latest-news/electric-power/061020-german-cabinet-approves-hydrogen-strategy-sets-14-twh-target-by-2030**

In comparison, in recent Spending Review, the UK Government pledged just £240m to create a Net Zero Hydrogen Production fund to support the production of “low-carbon” hydrogen.[13] **There is a need for a finance strategy commensurate with meeting the new target**, considering how public, private and blended finance might play a role.

In addition to the overarching Government target and timescale, additional measures are being pursued in the near term, including that by 2023, it will work with industry to complete testing necessary to allow up to 20% blending of hydrogen into the gas distribution grid for all homes on the gas grid. We note that for green hydrogen to play any role in a zero-emissions heating scenario, this must further increase from 20% to 100%. By 2025 the Government has committed to support industry begin a large village hydrogen heating trial and set out plans for a possible pilot hydrogen town before the end of the decade. For perspective: by the end of the decade, many hundreds of towns will need to shift to clean heating and energy systems. While there’s a role for exploring future technologies, this must not distract from deployment of solutions available today. In question response to question 6, we set out that case that **hydrogen for heating is not a strategic or cost-effective near-term approach for heat decarbonisation.**

Instead of the current focus on heating, we encourage the government to focus innovation and deployment on hard-to-abate sectors, including power and freight. These are areas where globally, the **UK could take a leadership role** on the development and deployment of green hydrogen. To succeed, the Government must in parallel work to ensure rapid growth in renewable technologies, fulfilling the Prime Minister’s pledge to become the 'Saudi Arabia of wind power'.

Coordinating government plans on hydrogen

In order to deploy the green hydrogen available to maximise value in the UK**,** a **rigorous independent analysis of key decarbonisation outcomes is needed**. We describe this in more detail in our paper on the EU hydrogen strategy[14].

One can distinguish between two main types of outcomes:

- **Those where multiple solutions and technologies for decarbonisation already exist.** Here the focus is on enabling fair competition as far as possible, e.g. by reviewing fiscal and regulatory structures. An example is to ensure green hydrogen is not disadvantaged compared to fossil gas or blue hydrogen because of indirect fossil fuel subsidies or higher electricity taxation.
- **Those where few solutions exist and where the development and maturing of a specific and most promising technology is critical to delivering climate neutrality.** The development of green hydrogen for high temperature heat processes in industry may be an example for that criticality.

This needs to be reflected in **a whole system architecture process to clarify what needs to happen, where it needs to happen and when it needs to happen regarding markets and infrastructure**. This

[13] **https://www.gov.uk/government/news/beis-in-the-spending-review**
[14] E3G (2020), EU Hydrogen Strategy: **Harnessing momentum for a new regulatory approach**

may be done most effectively at local level. For example, in the Netherlands, the phaseout of gas in buildings is planned at local level using some clear guidance on outcome and science provided centrally, and then triaged at national level to ensure a feasible approach.[15] This could give sufficient guidance to regulators to make sure these happen as effectively and efficiently as possible.

The role of CCS, emissions and net-zero

Grey hydrogen has a worse carbon footprint than fossil gas, due to its conversion losses.

Blue hydrogen has significant residual emissions and cannot be considered zero emissions. While CCS may mitigate this effect, permanence of carbon storage is still an issue and varies by technology. A study from Hamburg University finds that blue hydrogen using SMR+CCS still emits 46g CO2eq/MJ.[16] Oil and gas production are associated with significant **methane emissions**, increasingly monitored through EU satellite data[17]. The true extent of leakage for all sources of EU gas and transport routes is still to be determined, but as methane is an extremely potent greenhouse gas, its role in particular in regards to climate tipping points over the next 10-15 years needs to be investigated thoroughly before making long-term infrastructure decisions. The **UK needs to plan legislative action on methane reductions** along the value chain, similar to the EU, following Brexit.

Green hydrogen can potentially be near zero-emissions, with residual emission stemming from manufacturing of renewables installation. Evidence from Europe suggest that co-planning hydrogen infrastructure layout and renewables locations reduces infrastructure needs and costs.[18] Electrolysis hydrogen could also be produced from grid electricity which would suggest a different infrastructure layout. In terms of emissions, with a progressive decarbonisation of the grid, the emissions footprint will converge.

The EU is currently developing a classification system for different types of hydrogen. All three EU institutions have expressed a preference for green hydrogen.[19] We recommend that the UK cooperates with the EU on establishing joint standards to avoid setting up unnecessary trade barriers.

Recommendations:

- The UK's forthcoming Hydrogen Strategy should clarify that the Government will focus on and show leadership on the development of green hydrogen for hard-to-abate sectors. Blue hydrogen produced using fossil fuels with CCS is not zero emissions, and this must be acknowledged.

---

[15] The Dutch **Climate Agreement** from 2019 describes the approach (C1.3). The approach of the city of Amsterdam: **https://www.amsterdam.nl/en/policy/sustainability/policy-phasing-out/**

[16] **https://www.sciencedirect.com/science/article/pii/S2590174520300155**

[17] European Space Agency (2020), **Detecting Methane at a Global Scale**

[18] **https://www.artelys.com/wp-content/uploads/2020/11/Artelys-2050EnergyInfrastructureNeeds.pdf** and **https://www.e3g.org/news/hydrogen-infrastructure-from-pipedream-to-progress/**

[19] **https://www.consilium.europa.eu/en/press/press-releases/2020/12/11/towards-a-hydrogen-market-for-europe-council-adopts-conclusions/**; **https://ec.europa.eu/commission/presscorner/detail/en/ip_20_1259**; **https://www.europarl.europa.eu/RegData/commissions/itre/projet_rapport/2020/658772/ITRE_PR(2020)658772_EN.pdf**

- Significantly more capital is likely to be required to meet the government's target, and a finance strategy considering public, private and blended funding will be required. This must be additional to public funding commitments for other decarbonisation priorities and not detract from other capital spending requirements (i.e. heat networks, home retrofits, etc).
- The introduction of green hydrogen must be coupled to plans and targets for a successful phase-out of unabated fossil gas and associated infrastructures.
- Cooperation with the EU should be sought over standards and guarantees of origin for hydrogen to avoid establishing trade barriers.
- A precautionary approach to decision-making, based on pilots, research and applying lessons from other countries should be advanced.
- Rigorous independent analysis of key decarbonisation outcomes is needed to inform how green hydrogen development and deployment can best be co-ordinated in the UK, reflected in a whole system architecture process to clarify what needs to happen, where it needs to happen and when it needs to happen regarding markets and infrastructure.

2. The progress of recent and ongoing trials of hydrogen in the UK and abroad, and the next steps to most effectively build on this progress;

We note key areas of importance for recent and ongoing trials of hydrogen around the world:

- **A focus on green hydrogen**: A number of hydrogen strategies have now focussed on renewable hydrogen for their public support: Germany, Portugal, Spain (in its recovery package).
- **A focus on hard-to-abate end use sectors**: The German Hydrogen Strategy puts a focus on hard-to-abate sectors to ensure high-cost hydrogen does not get used where it is not prudential, stating hydrogen use must focus on the *"fields in which the use of hydrogen is close to being economically viable in the short or medium term, in which no major path dependency is being created, or in which there are no alternative options for decarbonisation".*[20]
    - The Norwegian hydrogen strategy focusses on maritime and heavy-duty transport as well as industrial processes.[21]
    - The Portuguese hydrogen strategy, too, focusses on hydrogen use for transport and industry.[22]

The table below compiled by Aurora Energy Research provides a snapshot of activities.[23]

[20] **https://www.bmbf.de/files/bmwi_Nationale%20Wasserstoffstrategie_Eng_s01.pdf**
[21] https://www.regjeringen.no/en/aktuelt/the-norwegian-hydrogen-strategy/id2704774/
[22] https://www.portugal.gov.pt/download-ficheiros/ficheiro.aspx?v=93d054d7-f75d-496e-a95a-4d4d7f27251d
[23] **https://www.auroraer.com/wp-content/uploads/2020/11/HyMar-Presentation-November-2020_AG.pdf**

	Policy framework	Released	Focus areas
	Dutch strategy & SDE++ scheme	Jun 2019 & Apr 2020	▪ Government intends to play a key role in repurposing existing gas grid ▪ Targeting 500MW of electrolysers by 2025 rising to 3-4GW by 2030 ▪ SDE++ scheme focuses on technologies with lowest CO_2 abatement cost - includes blue H_2 with full-time CCS
	Portuguese strategy	May 2020	▪ Target for 2GW electrolysers by 2030, on the road to 5GW electrolysers by 2050 ▪ Reduced access fees and restrictions for H_2 injection into the gas grid ▪ Support mechanism for green H_2 production by 2021
	Norwegian strategy	Jun 2020	▪ In May the government proposed a NOK 3.6 billion ($380 million) green package which would, in part, support hydrogen projects, and offshore wind ▪ The hydrogen strategy released in June was high-level and light on targets
	Germany Hydrogen Strategy	Jun 2020	▪ Establishment of National Hydrogen Council ▪ Removing barriers for green H_2 production ▪ Developing a framework of 'hydrogen readiness' for international trade ▪ 5GW electrolyser target by 2030 rising to 10GW by 2040
	Spain Hydrogen Roadmap	Jun 2020	▪ Aims to develop 4GW electrolysers by 2030 with €8.9bn investment ▪ Adapting regulations to lift restrictions and create green H_2 guarantees of origin ▪ By 2024, 300-600MWs of electrolyser capacity
	EU strategy & European Green Deal	Jul 2020	▪ Climate-neutral energy system integration with renewable H_2 and electricity ▪ Europe-wide 40GW electrolysis target by 2030 plus additional 40GW in partner countries
	UK Hydrogen Advisory Council	Jul 2020	▪ No UK strategy for hydrogen at present ▪ Government formed UK Hydrogen Advisory Council in July 2020 ▪ Hydrogen policy is anticipated as part of Energy White Paper or Green Stimulus plan
	France Hydrogen Strategy	Sep 2020	▪ Pledges 6.5GW of electrolyser capacity by 2030 ▪ Outlines spending commitment of €7bn for scaling up low-carbon hydrogen between 2020-2030

3. The engineering and commercial challenges associated with using hydrogen as a fuel, including production, storage, distribution and metrology, and how the Government could best address these

Key challenges will include those surrounding **integration of hydrogen into the grid** – including the costs of building new hydrogen grids or switching existing gas grids. This is currently an area of huge uncertainty, with trials and pilots ongoing.

The Ten Point Plan states the Government will work with industry to complete testing necessary to allow up to 20% blending of hydrogen into the gas distribution grid, and support industry to begin hydrogen heating trials in a local neighbourhood. We note that for green hydrogen to play a role in a zero-emissions future, this must further increase to 100%.

Hydrogen will not be a replacement for making decisions about the future of gas infrastructure, as energy efficiency and electrification will reduce gas utilisation in many places. The hydrogen network will be much more focused compared to the gas network, likely to be around particular industrial clusters (see question 4).

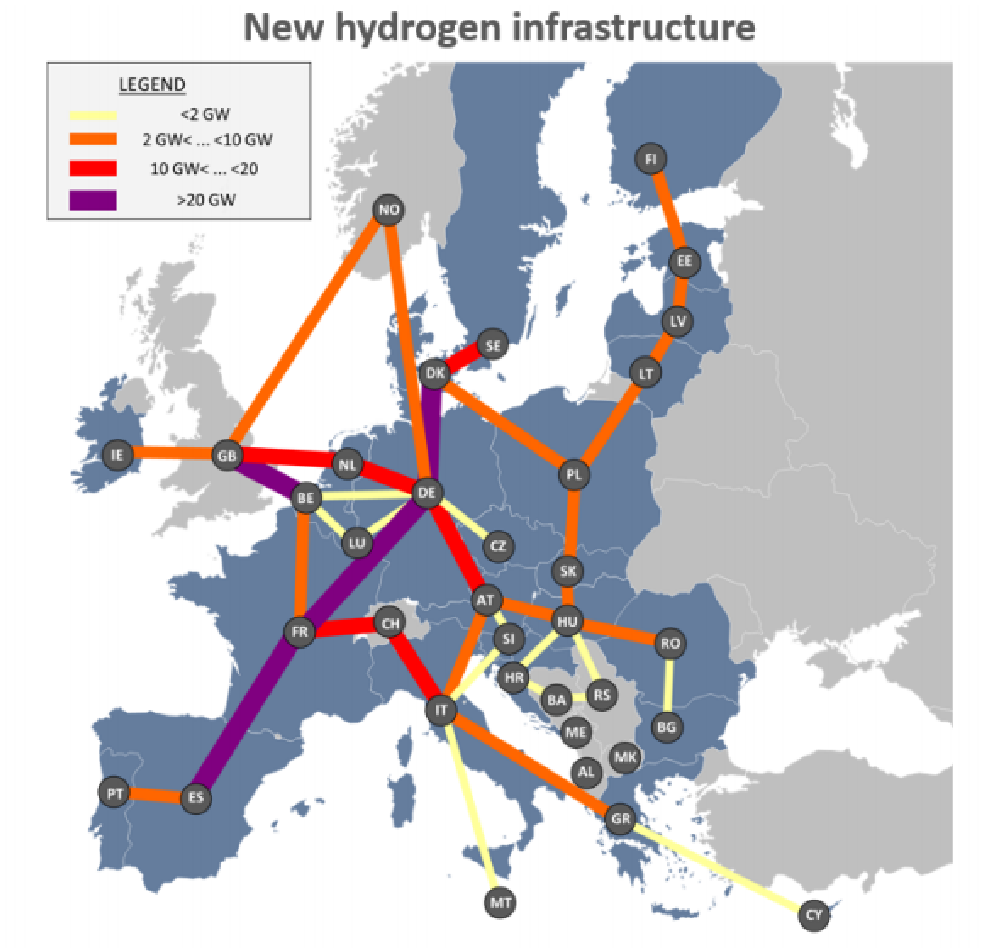
4. The infrastructure that hydrogen as a Net Zero fuel will require in the short- and longer-term, and any associated risks and opportunities

The deployment of hydrogen requires infrastructure transformation. While estimates of the costs for refurbishing the gas grid are uncertain, a study for Germany indicates a minimum of €45bn for a full conversion of the network.[24] Another study for the EU concludes that the costs of converting distribution networks and appliances for hydrogen use are prohibitive.[25] In addition, supply and demand patterns will look different compared to the current network, requiring a different network shape.

Hydrogen transport at global scale, i.e. via ship, is likely not to occur in its pure form and cannot be done with existing infrastructure. To liquify hydrogen, extremely low temperatures are needed.[26] Alternatives include further conversion to ammonia as a carrier, but this introduces further energetic inefficiencies and requires additional investments.

A report by Artelys, commissioned by the European Climate Foundation, finds that the Europe-wide costs for cross-border hydrogen infrastructure (including connections to the UK – see diagram below) will be €15-25bn, depending on demand.[27] It finds that a more localized production and use of hydrogen through "clustering" drives down the associated infrastructure costs, since less infrastructure is required overall.

[24] Marcogaz (2019), **Hydrogen Admission into existing natural gas infrastructure and end use**
[25] Gas for Climate (2020), **Gas Decarbonisation Pathways**
[26] **https://www.frontier-economics.com/media/4269/frontier-economics-role-of-lng-in-energy-transition-study-for-gle-members-october-2020.pdf**
[27] **https://www.artelys.com/wp-content/uploads/2020/11/Artelys-2050EnergyInfrastructureNeeds.pdf#page=1&zoom=auto,-82,842**



The most efficient way to produce and consume hydrogen is in "clusters" focused on industrial consumers.[28] Infrastructure should hence be developed "bottom up" around those clusters, rather than beginning "top down" by looking at the existing gas grid and how it can be converted. The industries in these clusters are heavy users of fossil fuels and account for some of the hardest-to-abate emissions in our economy. Today, industrial clusters represent around 20% of Europe's GHG emissions (excluding transport), but that share could rise to a majority of emissions as other sectors decarbonise earlier. In the UK, the Humber industrial cluster is an example of how a regional approach might be advanced.

We note that it is important that the development of clusters has **assurance of independent scientific rigour and robust governance protocols to protect against a potential conflict of interests** – particularly where companies operating in these clusters currently operate business models with links to fossil fuel investments and infrastructure. For instance, Humberside LEP is working closely with Drax, Phillips 66, Equinor, National Grid and Centrica to develop a Humber Cluster Plan for the region to achieve net zero carbon emissions by 2040.[29] While it is important to engage industry in the process of developing a plan, the evidence base it is formed upon should be

[28] https://www.weforum.org/agenda/2020/10/industrial-clusters-can-be-a-key-lever-for-decarbonization-heres-why/
[29] https://renews.biz/62439/sse-equinor-draw-up-net-zero-plan-for-the-humber/

independent of corporate interests and reflect scientific assessment – for instance, ensuring that hydrogen production is green.

5. Cost-benefit analysis of using hydrogen to meet Net Zero as well as the potential environmental impact of technologies required for its widespread use;

The efficiency of producing and using hydrogen is low, due to conversion losses.[30] From a system's efficiency perspective**, hydrogen is thus best deployed where electrification and efficiency or circular processes are not possible.** This is mainly applicable to high temperature heat in industry, shipping and aviation and potentially seasonal storage.

The end use potential of hydrogen is **determined by its relative cost compared to other technologies/solutions. In many sectors, alternative solutions are already available and mature/near maturity** – e.g. electrification of heat or transport - and often have the potential to reduce operating costs for the end user while hydrogen will increase costs for the consumer. The UK does not currently produce significant amounts of green hydrogen, nor does it have technologies in place that would provide a market for that hydrogen.[31] Under current economic conditions owing to COVID 19, it is vital that the government focuses on the most cost-effective route to decarbonisation.

Cost ranges vary significantly and depend on:

- **The scope**: beyond production, significant costs arise from refurbishment of networks and end use appliances, and, in the case of blue hydrogen, the costs of CCS. For boilers, a 2018 study by Element Energy estimated the lead time for developing the product and getting it to a comparable price to a gas boiler at around 6-8 years. At the earliest, hydrogen boilers would thus be available in the mid- to later 2020s, leaving little more than one investment cycle to 2050.[32]
- **The cost of input factors**: For green hydrogen, the bulk of the costs depend on the cost of electricity.[33] A higher share of renewables thus enables significant cost reductions. For blue hydrogen, cost reductions may arise from reduced costs in CCS; SMR itself is however a mature technology with low reduction potential.
- While cost developments are highly uncertain, some studies indicate that **green hydrogen could become competitive with grey hydrogen in the next decade**[34]. Blue hydrogen would incur additional cost for CCS infrastructure and methane abatement, consequently it could face competitive pressure even earlier. There is a risk that the additional investments would not amortise within this time period.

30 E3G (2018), **Renewable and decarbonised gas renewable gas – options for a zero emissions society.**
[31] CCC (2018), **Hydrogen in a low carbon economy**
[32] Element Energy (2018), **Hydrogen Supply Chain Evidence**
[33] **US government data** suggests it was around 70% of total LCOE in 2015 (Central Electrolysis).
[34] "Clean hydrogen derived from renewable energy will be cost-competitive with grey hydrogen within 5-10 years." (**McKinsey**); BNEF (2020), **Hydrogen Economy Outlook**

Consumer choice is often limited, e.g. through high upfront costs (e.g. investing in buildings insulation), unaligned incentives (e.g. Energy Systems Catapult Analysis shows the effective carbon price for gas in buildings is still lower than for electricity[35]) or dependence on larger infrastructure transformations (e.g. hydrogen). **This means anticipatory investment or clear policy guidance by the government is needed for the most cost-effective options to materialise and for green hydrogen to be steered into those sectors where it adds most value.**

Most industry studies do not include full costs or full emissions; this makes an independent, science-based review necessary to ensure better informed decisions. For example, the study commissioned by the Energy Networks Association does not include upstream methane emissions and thus cannot be considered fully compatible with net zero.[36]

6. The relative advantages and disadvantages of hydrogen compared to other low-carbon options (such as electrification or heat networks), the applications for which hydrogen should be prioritised and why, and how any uncertainty in the optimal technology should be managed.

Investments in green hydrogen are important to facilitate the decarbonisation of hard to-decarbonise sectors. However, its potential to contribute to economic growth and economic recovery, in particular in the short term, should be seen in perspective:

- IEA estimates that energy efficiency generates about 3x as many jobs as hydrogen per dollar invested, and solar energy about 2x as many.[37]
- Energy efficiency could create 40,000 jobs in 2 years with a long-term growth potential of 150,000[38]. It simultaneously increases people's and firms' disposable incomes by reducing energy bills.

Hydrogen for heating

In order to get on track for climate targets, the UK needs to rapidly scale up the deployment of zero carbon heating solutions which are already available. New, consolidated academic research by UKERC finds **energy efficiency, heat pumps and district heating** comprise the most effective investment pathway for heat decarbonisation for the next 10 years.[39] It is deployment of these measures that E3G recommends the government must scale within this Parliament, in order to get on track to meet climate targets and interim carbon budgets.

Green hydrogen for **heating will be a highly inefficient option** for most of the country. Government climate advisors have warned that the country would need **30 times as much offshore wind farm capacity to produce enough "green" hydrogen to replace all natural-gas boilers.[40]**

---

[35] Energy Systems Catapult (2019), **Rethinking Decarbonisation Incentives**
[36] It is also unclear whether it captures the costs of carbon transport and storage. ENA (2019), **Pathways to Net-Zero: Decarbonising the Gas Networks in Great Britain**
[37] IEA (2020), **World Energy Outlook Special report - Sustainable recovery**
[38] https://www.bbc.co.uk/news/business-52999337?intlink_from_url=https://www.bbc.co.uk/news/uk&link_location=live-reporting-story
[39] **https://d2e1qxpsswcpgz.cloudfront.net/uploads/2020/09/The_pathway_to_net_zero_heating_UKERC_briefing.pdf**

Claims of widespread applicability of hydrogen within the heating sector are unproven and potentially misleading. The Climate Change Committee (CCC) found that the sunk costs of having an extensive gas grid do not automatically mean that it will be lower cost to switch it over to hydrogen and use it in boilers. Their analysis found that the costs of a range of pathways for heat decarbonisation are similar including those in which the gas grid has a much-reduced role or is decommissioned.[41] Furthermore, the CCC found that full conversion of the UK's gas distribution networks to hydrogen would lead to a very high demand for hydrogen by 2050 (470 TWh even allowing for substantial improvements to buildings energy efficiency). On a per-KWH basis this will be more expensive for the consumer or taxpayer. There are concerns that hydrogen gas would also, at present rates, be about twice as expensive as natural gas.[42]

In addition**, health and safety risks** have been identified around the introduction of hydrogen into homes. The risks associated with the storage of hydrogen (under high pressure or cryogenically in liquid form) and its use in Fuel Cell applications, are well appreciated by HSE and a comprehensive Guidance Note (HSG 243) has already been issued on the subject. In addition, work is already underway on various aspects of the fire and explosion hazards at the Health and Safety Laboratory, including investigations into the perceived risk of spontaneous combustion.[43] These risks – as well as perceptions associated with different low carbon heating technologies – need to be considered to ensure that households are supported and protected during the transition to low carbon heat.

Exeter's Energy Policy Group found that those with **existing interests around fossil fuel heat were overselling the idea** of converting the UK's existing gas infrastructure to run on hydrogen to protect their interests and detract from the importance and value of electrification**.**[44] The research highlights a concern that if the political influence by incumbents affects the policy process and slows down the deployment of known low carbon heat options, the UK's climate change goals are at risk of being missed. For example, the UK Government's Hydrogen Advisory Council is chaired by Shell and contains no members from civil society.[45] This needs to change to ensure a more nuanced discussion on hydrogen, with more transparency on the mandate and selection criteria.

Hydrogen for power sector decarbonisation

The **decarbonisation of the power sector should be a priority**. Hydrogen-fired gas turbines currently provide the most promising route to provide long duration storage. Therefore, this service should currently be categorised as a hard to abate function.

We note that the power sector poses particular challenges for decarbonisation. Many argue there is the need **for 'firm' power**, and BEIS's recent Energy White Paper assumes that 40GW of this will still be needed by 2050.

---

[40] **https://www.thetimes.co.uk/article/switching-all-boilers-to-hydrogen-is-impractical-zw00f3v9l**
[41] **https://www.theccc.org.uk/wp-content/uploads/2018/11/Hydrogen-in-a-low-carbon-economy.pdf**
[42] As quoted in **https://www.thetimes.co.uk/article/switching-all-boilers-to-hydrogen-is-impractical-zw00f3v9l**
[43] **https://www.hse.gov.uk/horizons/current-issues/energy-topics/hydrogen.htm**
[44] **https://www.sciencedirect.com/science/article/pii/S2210422420300964?via%3Dihub**
[45] **https://www.gov.uk/government/groups/hydrogen-advisory-council**

We encourage the UK to be ambitious in its plans to scale up green hydrogen production and ensure robust upstream methane elimination management. Another avenue may be re-examining the wisdom around 'firm power', as well as taking efficiency measures to reduce overall power requirements and focus on breakthrough innovation.

Further references

- E3G (2018), **Renewable and decarbonised gas renewable gas – options for a zero emissions society**
- EU hydrogen strategy, **Harnessing momentum for a new regulatory approach**
- Euractiv, 12 June 2020, **Can Germany deliver on its green hydrogen premises?**

(January 2021)