Mythbusting the "Hydrogen Economy"

Hydrogen production is being promoted by the Government and the Solent Cluster. Many believe this is a dangerous distraction from attempts to truly combat the climate emergency. The science does not support the route proposed and risks the fossil fuel industry continuing their damaging emissions.

To summarise the science and technology:

A fast ramp up of Hydrogen production <u>especially from fossil fuel</u> would accelerate climate destruction rather than mitigate it:

- ***Grey Hydrogen:*** *is made from methane, releasing prodigious quantities of Greenhouse Gases. Nearly all hydrogen is made this way today and globally its climate impact is more than that from aviation.*
- ***Blue Hydrogen:*** *is when Carbon Capture & Storage (CCS) is added to trap the carbon dioxide from Grey Hydrogen. The capture is partial and overall rather ineffective when methane leakages are included. Despite industry claims, the process in reality is only marginally less damaging than the Grey.*
- ***Green Hydrogen:*** *is made by electrolysing water from wind or solar electricity and is the net zero goal for hydrogen. It could replace current Grey Hydrogen as a chemical feedstock and also decarbonise steel. Other potential, sensible, uses could be for some heavy transport and storage of surplus renewable energy (RE). However, the whole process of storing and converting back to* **work**[1] *is rather inefficient, losing 60-70% of the energy. Talked-up general uses, such as heating homes and powering vehicles by hydrogen, are vastly less efficient than renewable energy used directly as electricity. At present, Green Hydrogen represents 0.04% of total production and is not expected to exceed 1% of RE needs by 2030.*

Expanding on the concerning facts

- **How bad Grey and Blue Hydrogen are for the Climate.** The Grey Hydrogen conversion process with methane and steam releases carbon dioxide. In addition it has a similar sized climate impact from the leakage and flaring of methane all the way from well to refinery. It is made only 10-20% less damaging with CCS as Blue Hydrogen, because the capture is only partial and methane leakage still doubles the impact[2]. Also, CCS does not exist at scale at present, a ramp up would take decades, hardly help net zero by 2050 and would quickly become a zombie asset and uneconomic over a typical 30 year life of a plant. To reduce climate impact we'd be better off burning the methane directly than either Grey or Blue Hydrogen. Even coal is better!
- **How efficient is the Green Hydrogen route?** It is nearly always far more efficient to use renewable energy (RE) directly as electrical energy. It arises from fundamental chemistry and physics. For example, hydrogen domestic boilers would require <u>six times</u> RE compared with domestic electric heat pumps. For transport, the factor is <u>three times</u>. When this is properly and

[1] For an explanation of Work and Chemical or Heat energy see p6

[2] Oil may be used as a precursor on some sites but generally it's methane

widely understood it will be seen as 'no contest'. There are already 1000 times as many battery cars as hydrogen powered.

- **Hydrogen as energy storage loses much energy.** 30-40% energy is lost in electrolysis of water. Then energy is needed for compressing the gas, and finally it is no better than 50% converting back to useful work. So there's a cycle efficiency of say 30% (70% lost). We will need long term storage of wind and solar for seasonal intermittency but other means would be much more efficient. Given the energy losses, the use of green hydrogen for RE storage will require green hydrogen to be made at very low cost, for example from surplus electricity of RE generating assets, which would need to be far larger than available today.
- **Green hydrogen & water stress.** This presents serious competition with scarce supplies of fresh water. This and the low efficiency mean that Green Hydrogen is probably the last of the uses of RE electricity.
- **Hydrogen is needed as a chemical feedstock,** vitally for making ammonia for fertiliser, but why is the industry not cleaning that up now? That should be the focus of the industry, not the use of hydrogen as an energy vector. If we follow the path proposed by the fossil fuel industry of massively increased hydrogen production (Grey, Blue and Green), we will have significantly added to destructive emissions well before 'net zero'**.**
- **There are many other fundamental technical barriers.** To name a few of these:-
    - Hydrogen is not energy dense and so difficult to transport that it is nearly always generated on site where needed (as feedstock). It's easier to transport electrons than atoms.
    - By road, 18 Trucks carrying hydrogen at 700 bar would be needed to carry the same energy as one truck carrying diesel.
    - In aeroplanes, hydrogen cannot be carried in the wings, it occupies half the volume of the passenger space.
    - To feed airports, the scale required is simply not feasible - to generate enough green hydrogen to replace all current flights from Heathrow alone would require 1.5 times current total UK electricity consumption. Or 15 Hinkley Point Cs.
    - The current methane gas grid is far from 'hydrogen ready' and would need an estimated £32 billion upgrade and crucially many years of installation.
    - The gas is much more explosive than methane and, because it has the smallest molecule, tends to leak and embrittle normal steels.
    - The NOx emissions from combusting hydrogen are much higher than from natural gas, so this alone should rule out domestic hydrogen boilers from the outset - only fuel cells should be considered

Why the focus on the hydrogen economy right now?

The Government, previously via BEIS (presume now via Department for Energy Security and Net Zero), is promoting hydrogen production across the UK, for industry, transport and heating, especially stimulating investment in it. UK hydrogen strategy - GOV.UK (www.gov.uk) Government has been heavily lobbied by the fossil fuel industry to do this.

However, the House of Commons Science and Technology Committee published its own enquiry last December: The role of hydrogen in achieving Net Zero - Science and Technology Committee (parliament.uk). The short answer is "no it won't have a role" with a few exceptions:

"It seems likely that any future use of hydrogen will be limited rather than universal. It is likely to be best suited to applications or places which are:

- *Hard to electrify—such as some parts of the rail network;*
- *Uses that do not require the creation of an extensive refuelling network—such as local bus services operating out of a fixed number of depots; and*
- *Users who are adjacent to, or accessible to, places where hydrogen is produced, such as industrial clusters.*

In addition, hydrogen has important potential uses as:

- *a means of energy storage; and*
- *a source power for energy intensive industries like steel, glass and mineral production.*

This limited—rather than universal—use of hydrogen should inform Government decisions. For example, we disagree with the Climate Change Committee's recommendation that the Government should mandate new domestic boilers to be hydrogen-ready from 2025."

The current promotion of hydrogen as a solution to decarbonisation is not founded on science and is given a thorough demolition by Professor David Cebon, of University of Cambridge, and the Hydrogen Science Coalition. They say:

"There is some confusion about which kind of hydrogen should be prioritised and for which end use sectors. Many governments are considering widespread use of hydrogen in sectors where there are already cheaper, more efficient solutions available today. This is despite the Intergovernmental Panel on Climate Change recognising that hydrogen will represent, at best, 2 percent of total energy consumption in 2050."

Read the full arguments here: Hydrogen Science Coalition | Principles - Hydrogen Science Coalition (h2sciencecoalition.com) and especially the five recommendations made by the Coalition.

The impact of Government strategy in the Solent area

The Solent Cluster was launched in November 2022 and promises:

Together we will create a hub of expertise and innovation that will enable the development of a new hydrogen and lower carbon fuel facility creating sustainable fuels for marine, aviation and transport as well as providing low carbon energy to heat homes, businesses, and public buildings in our region and beyond.

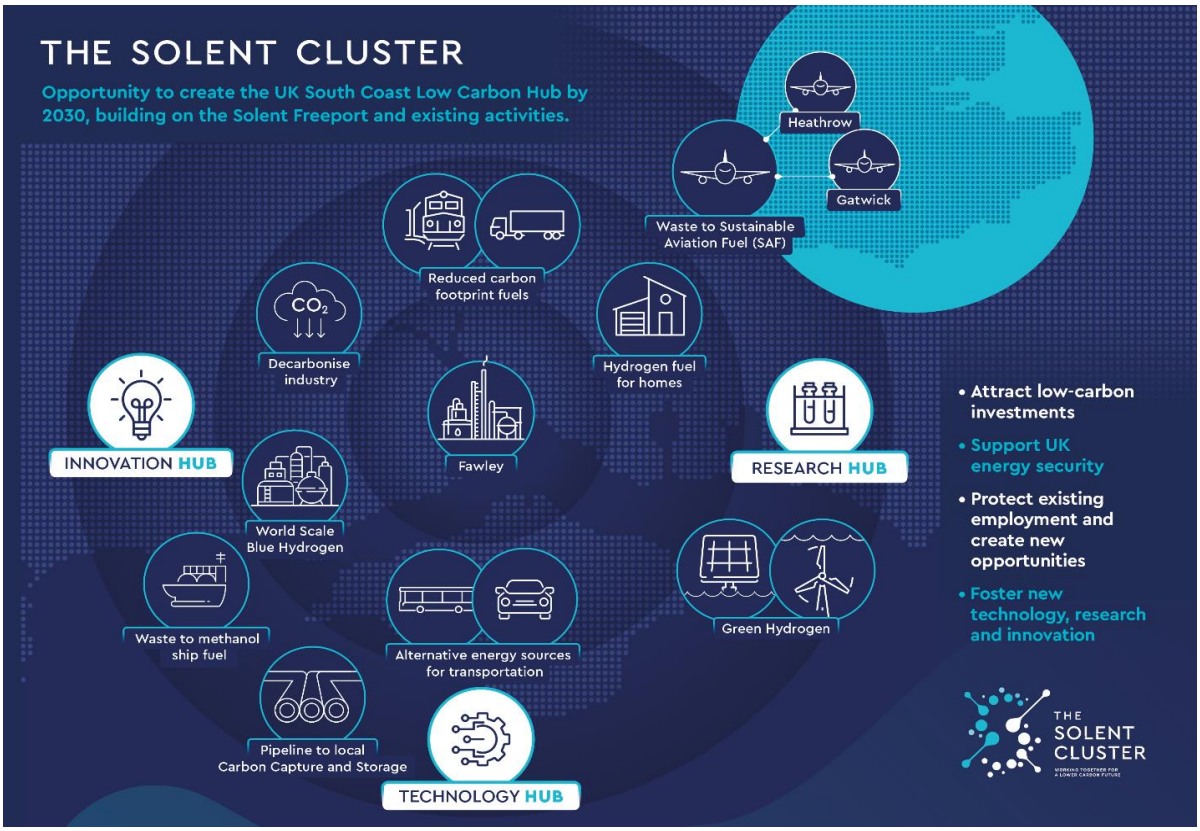
See: The Solent Cluster

There are many more aspects of the project: The Solent Cluster | ExxonMobil UK

And further detail is given by another partner, IDRIC - Solent Industrial Cluster | IDRIC. It says:

"The Solent Cluster partnership represents a once-in-a-generation opportunity for communities, the region, and the UK and can affect real change in energy production and consumption. The cluster will play a fundamental role in the world's fight against climate change, enabling the UK to reach Net Zero emissions by 2050.

"The aim is for the Solent to embrace future fuel technologies as a reliable alternative in a wide variety of industries and sectors. In becoming a leading centre for low carbon investment, the cluster can grow the regional economy, protect skilled jobs, and create new employment opportunities in the technologies and industries of tomorrow, while significantly reducing carbon emissions." (See the link above for a detailed list of proposed activities.)



Our questions:

What is the relationship between the Solent Cluster, IDRIC Solent Cluster, and the Solent Freeport? Are the Clusters accountable in any way to the Freeport? Are they run by separate boards and separate finance? Is there any democratic accountability in their structures?

Is it realistic, given the short timescale we have for decarbonisation, to regard hydrogen production and CCS/CCUS as adequate to the task?

Why is existing hydrogen production not being cleaned up, rather than driving new markets for hydrogen?

The fossil fuel industry is known to be lobbying hard for hydrogen production as a way of staying in business in a declining market, and continuing to sell natural gas/methane. The process of creating blue hydrogen is very inefficient and needs at least 40% more methane to produce – therefore helping the fossil fuel companies continue "business as usual" into the future. However, CCS may take a long time to get to any kind of scale to meet future needs. On the other hand, renewable electricity in the form of wind and solar is already in existence, doesn't need to be invented, doesn't need expensive new

pipelines or places to store carbon, is the most efficient way to power and heat and needs to be given urgent priority. Hydrogen may be the solution to the problems of decarbonisation remaining when all others have been dealt with – but it shouldn't direct investment money or Government policy away from renewable electricity production.

Local authorities and other partners in the Solent Cluster may want to be involved in aiding research into these solutions of last resort via hydrogen production, but their attention right now should be focused on production of renewable energy from wind and solar, and insulation of domestic and commercial premises – getting the easiest gains first, rather than focusing solely on the most remote. Hydrogen could well be a dead end, leading to misguided investment and eventual loss of jobs.

The proposed activities of the Solent Cluster will probably attract substantial Government investment, either directly or through its agents, such as IDRIC. There is a question to be asked about the ethics of giving taxpayers money to a company such as Exxon Mobil which just declared record annual profits of $55.7bn in 2022. If the Cluster is located for tax purposes within the Freeport, then earnings made by, and investment given to, members for the purposes of hydrogen production will presumably be tax free and business rate free.

In the Solent it seems that the biggest CO2 industrial emitters are ExxonMobil and SSE. It is likely that grey hydrogen is produced by ExxonMobil at Fawley and that it will be aiming to transition to blue hydrogen in the near future to try to reduce these emissions. (Grey hydrogen is used to produce fertilisers and in petro-chemical refining processes and emits 2% of global CO2 emissions – as much as all aviation.) SSE produces electricity from gas at Marchwood Power Station and is also a big emitter.

Conclusion

We recommend that Southampton Climate Commission takes evidence from the Solent Cluster on its planned activities for the coming decade. Our analysis shows that very few of the activities so far listed by the Cluster are likely to aid the transition to zero carbon in the near term. Those processes which could become viable in the medium to long term require a massive increase in locally produced renewable energy to be feasible. Hydrogen can only be a niche solution in hard-to-decarbonise industries and for storage next to wind farms to solve problems of seasonality. The decarbonisation needed now in the Solent area should be focused on a huge increase in the production of renewable electricity and insulation of all properties.

Mark Hancock, Angela Cotton, Roger Munford, Liz Batten (with thanks to Greg Ford, Luke Blunden and Danny Lee)
Transition Southampton and Southampton Climate Action Network
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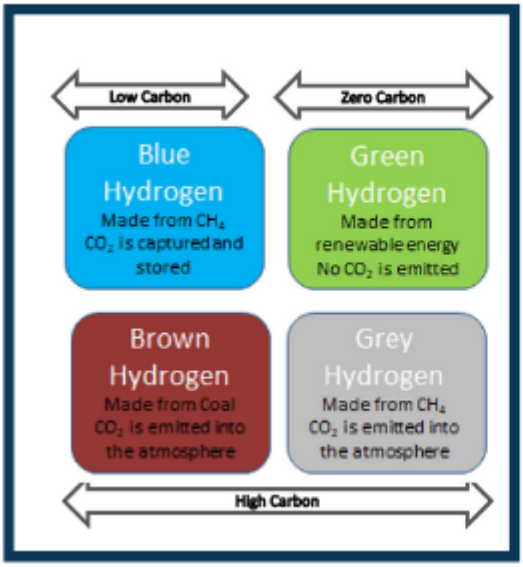
Helpful information

The colours of hydrogen

In order to understand the arguments put forward it helps to know about the "colours of hydrogen". This is shorthand to describe the various ways in which hydrogen can be produced and their relative CO2 emissions. In the diagram below CH4 is natural gas or methane.



Watch this conversation with Professor David Cebon from 7 minutes 45 seconds in to fully understand the huge inefficiency of hydrogen when compared to use of direct renewable electricity. As well as a very good technical summary, the conversation highlights the reasons why the fossil fuel industry is lobbying so hard for blue hydrogen (more natural gas needed). Prof Cebon gave evidence to the House of Commons Science and Technology Committee and is quoted in its report.

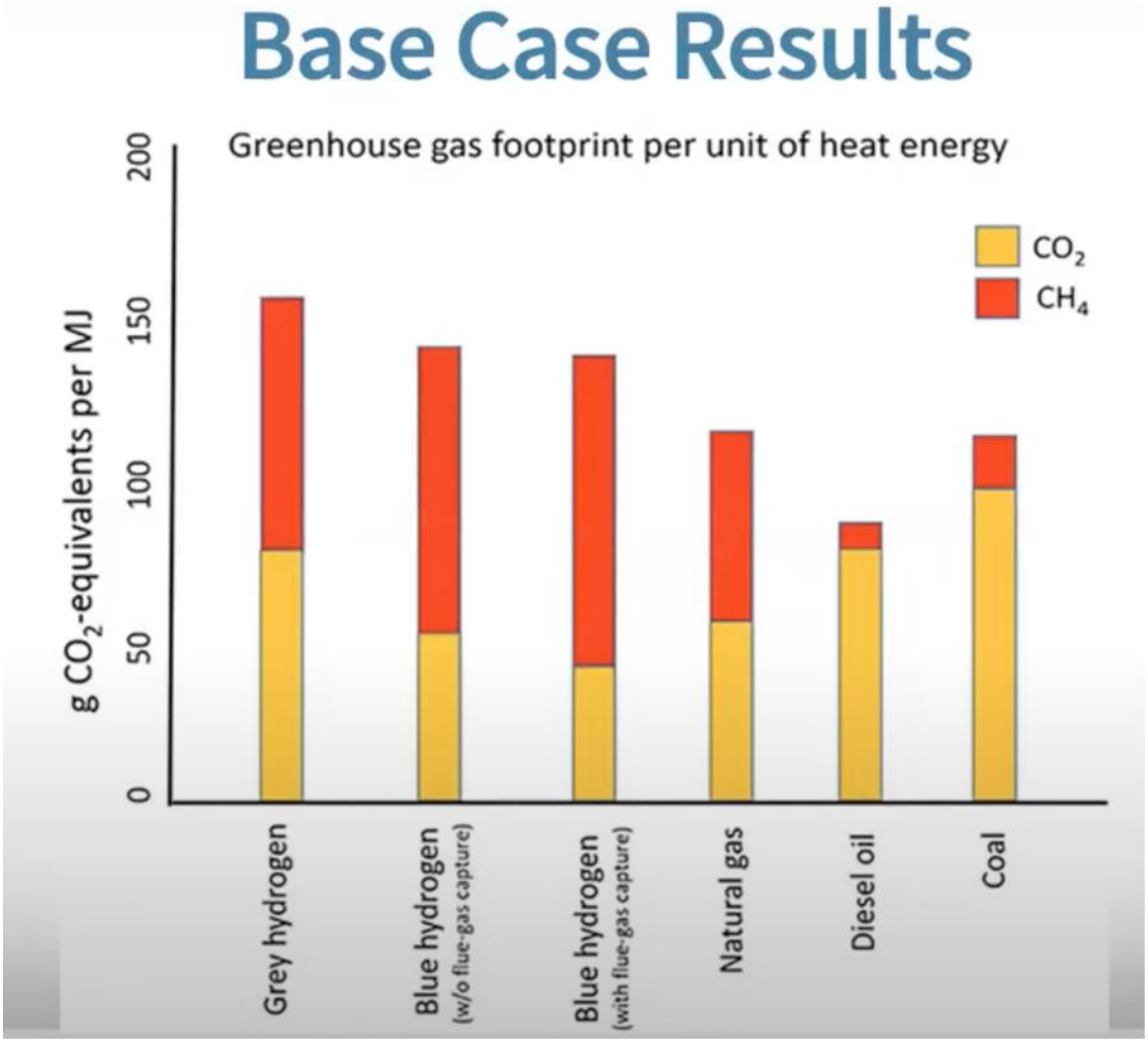
Explanation of Work and Chemical or Heat energy

Work energy kWh (kilowatt-hours) has a different use value from that of chemical energy also in kWh. Chemicals generally need to be burnt to produce heat and, in an internal combustion engine found in most vehicles, expand gases to make them go. This is 30-45% efficient. (There is another system of a fuel cell making electricity which is slightly more efficient, up to 50%). A vehicle which uses electricity directly into an electric motor is generally more than 90% efficient. As an example, while an electric battery car will go for 100miles with 25kWh in the battery, a hydrogen car would go 33-50miles with 25kWh of hydrogen.

Carbon capture and storage

Watch this 15 minute summary. It's clear and informative. In the case of Exxon Mobil, we believe the carbon dioxide waste product will be captured from the production of Grey Hydrogen in the refinery. This will then be loaded onto ships and taken to old oil wells and pumped down and capped, with attendant risk of leakage, or possibly used to pump out oil from existing oil wells.

Further reading: [Hiding behind hydrogen (theecologist.org)]
[Guest post: Can 'green hydrogen' grow fast enough for 1.5C? - Carbon Brief]



From [Howarth and Jacobson] (2021) referenced in [https://youtu.be/3UEFQxIkaVg]