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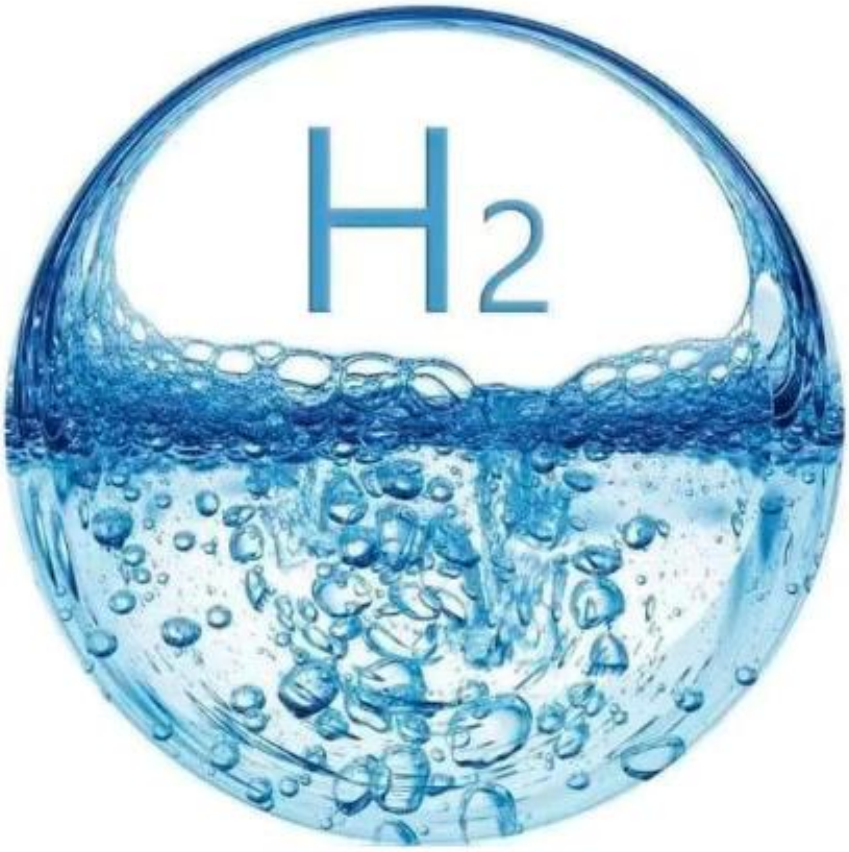

‘Is hydrogen the future fuel for our homes?’

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Introduction

We are entering the Anthropocene: ‘anthropo’ meaning human, and ‘cene’ meaning new. This is a new Epoch which many say we have entered, a new period during which human activity has become the dominant influence on climate and the environment.

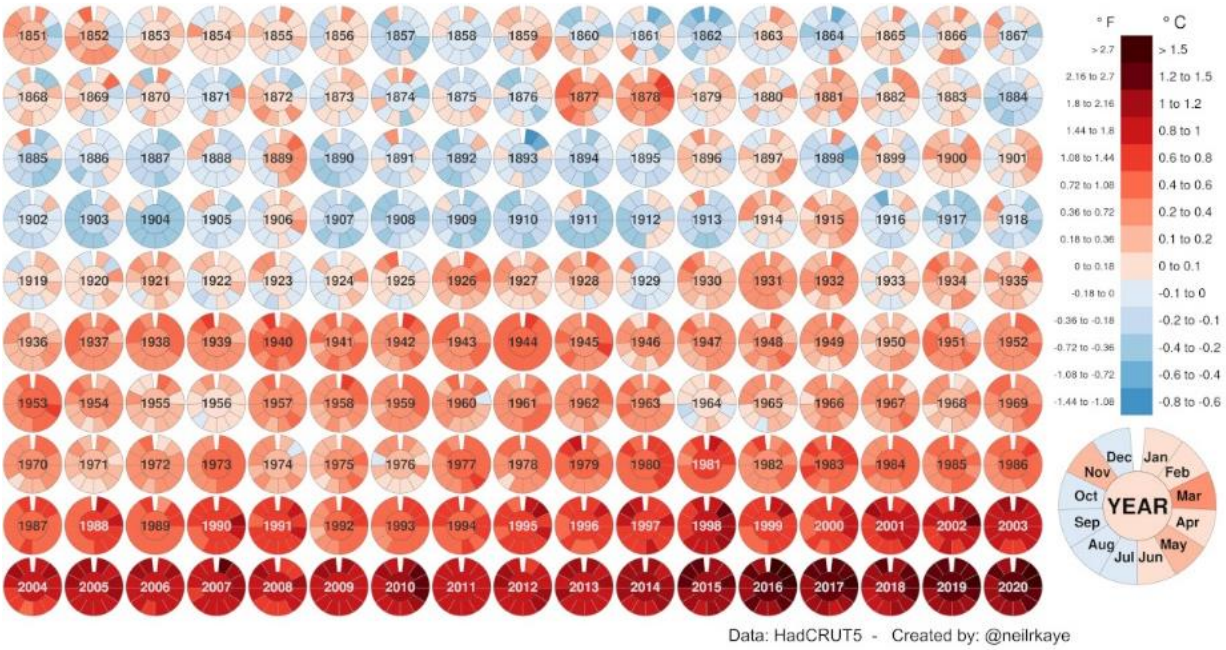
Climate change

Firstly, in order to highlight the importance of this research topic, we need to put into perspective the harsh reality of climate change and the urgency we must act with.

A warming planet

The last 7 years have been the warmest on record, diagram 1 shows the undeniably huge increase in global temperature in relatively recent times. The burning of fossil fuels to create power produces greenhouse gases which trap heat in the atmosphere.

Diagram 1 Changes in global mean temperatures 1851-2020 (vs. mean 1850-1900)

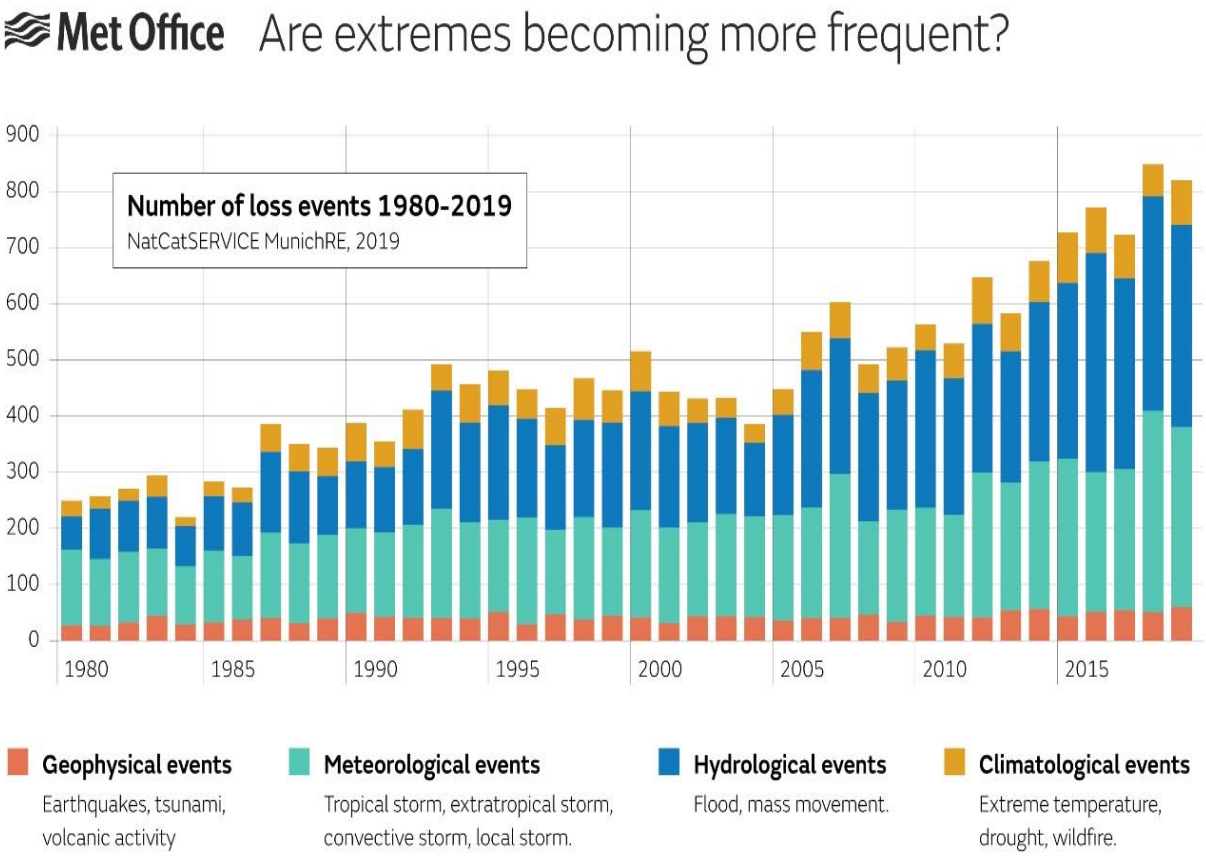


Extreme weather events

We can see from diagram 2 that extreme weather events have significantly increased over the last 40 years. Weather related disasters displace 23 million people every year

Greenhouse gases are the major driver of our warming planet. Adopting Hydrogen could help us accelerate our decarbonisation process and arrest these frightening trends.

Diagram 2 Frequency of extreme natural events

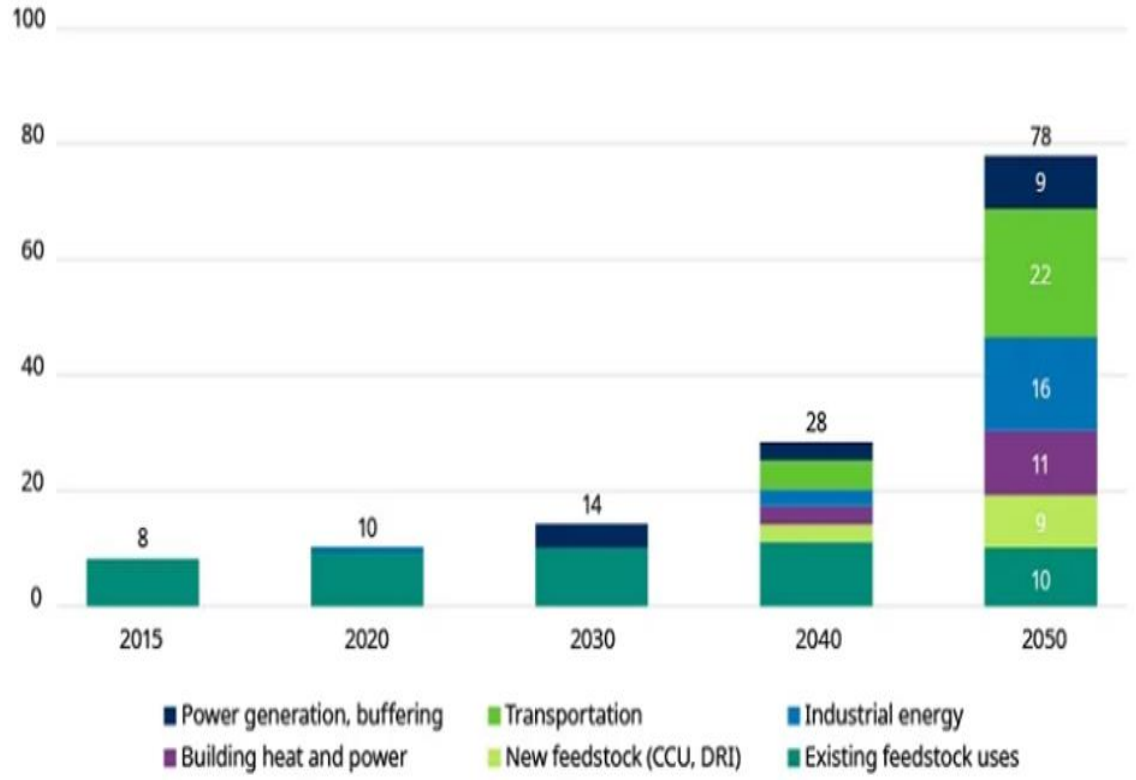


Alternative fuels – why hydrogen?

Renewable energy can and will decarbonise power generation and the automotive sector. However, these technologies will not be as viable for aviation, shipping, commercial vehicles, heating buildings and manufacturing. In all of these vital industries it looks as though hydrogen will be needed, or at least that hydrogen will be one of the most viable solutions, for decarbonisation.

Diagram 3. Projections for hydrogen market growth

(Global energy demand supplied by hydrogen, EJ)

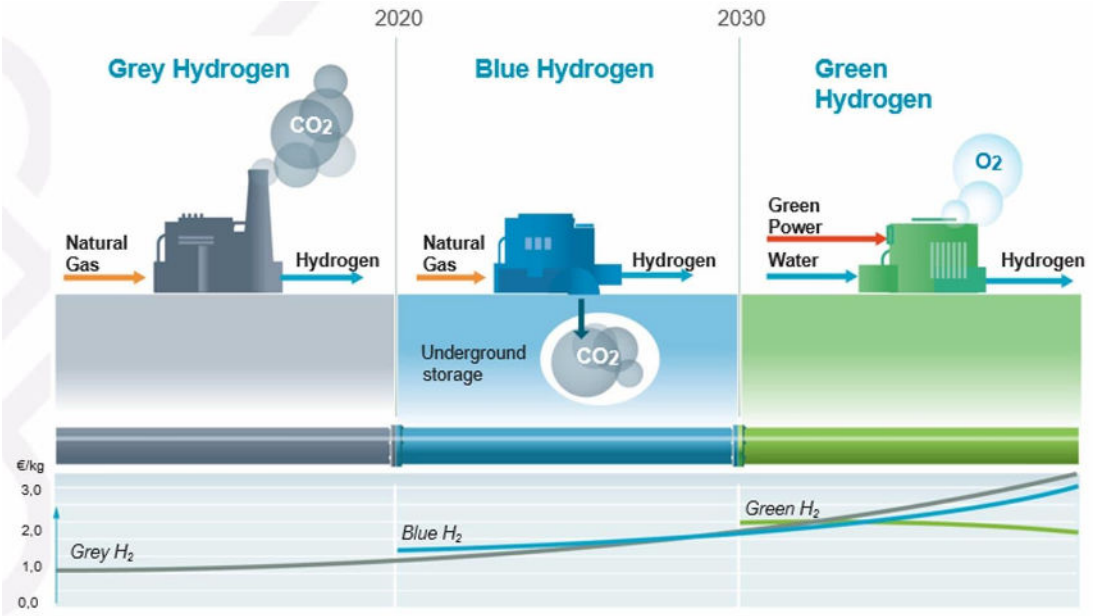


Source: Hydrogen Council. 536968

Where does our hydrogen fuel come from?

There are three main manufacturing processes in the production of hydrogen. They are colour coded; grey, blue and green

Diagram 4 – types of industrial hydrogen production



Source:tno.nl

Grey hydrogen - Unfortunately, 95% of existing hydrogen production is exceptionally polluting. The carbon dioxide produced in grey hydrogen production is not captured and stored

Blue hydrogen - blue hydrogen is produced in a similar way to grey, however the carbon is captured. This comes with added technical challenges and a big increase in cost though.

Green hydrogen - If renewable energy is used to produce the electricity, the hydrogen can essentially be made CO2-free. Despite being the most expensive now, diagram 4 shows green hydrogen is predicted to be the cheapest source of hydrogen after 2030.

However, one of the greatest challenges for hydrogen use is not its production but its storage and distribution.

Storage and distribution

Storage and distribution have been some of the greatest challenges with progressing hydrogen as a large-scale fuel.

Storage

Hydrogen is difficult to store because has very low volumetric energy density. To illustrate this, one liquid gasoline truck can hold the same amount of energy as 19 trucks of gaseous hydrogen.

Leakage

Leaks are difficult to detect by human senses since hydrogen is colourless, odourless, and tasteless.

Hydrogen embrittlement

Hydrogen embrittlement is when a metal loses its ductility and load bearing capability due to hydrogen atoms or molecules being absorbed by the metal. This can be a particular problem for steel pipelines and welds which are used to transport hydrogen, thus making it weaker and more susceptible to leakage.

The challenges that are presented by Hydrogen's storage and distribution are not insurmountable. To investigate how Hydrogen may be integrated into our homes I have looked at a current scheme operating in the UK to replace natural gas with hydrogen in a domestic setting.

Case study – H21

The 83% of domestic homes currently using natural gas for heating and cooking generate over a third of the UK's carbon emissions. To give carbon free heating for the majority of homes, reusing the existing gas network to transport hydrogen could be the most cost-effective and least disruptive route.

Who are H21?

H21 is a collection of projects taken on by the gas industry, carrying out crucial work to prove that in the future we can safely transport hydrogen on the existing gas network. For more than 2 years H21 have been gathering evidence to support the safety case for hydrogen becoming a fuel for heating homes in the UK. This has the potential to reduce carbon emissions by over 258 million tonnes a year by 2050, equating to over 80% of the UK's remaining reduction target.

Checking viability of using existing gas networks to distribute hydrogen.

H21 have been investigating how well the networks will perform with the new fuel, how hydrogen behaves when released and how the public might respond to a nationwide conversion program. The first step in the development of Hydrogen, probably the most key, is to be able to demonstrate that it is possible to convert gas networks from natural gas to hydrogen safely They were able to observe that essentially pipes which were gas tight with methane also remained gas tight with hydrogen. There were no pipes that only leaked on hydrogen: a good result. H21 also looked at the relative leak rates between natural gas and hydrogen and in all cases those fell between the predicted lines, so that was in line with the hypothesis and what they set out to achieve.

H21 also conducted experiments investigating ignition potential and explosion severity: what they found was that there were no big surprises and none of it outstripped the conservative assumptions that they had made at the start of the project.

The Leeds City Gate project.

This study by H21 is essentially a very detailed plan to convert the entire city of Leeds from natural gas to hydrogen. The report proposes we can divide the city into blocks of roughly 2,500 gas connections (buildings). Each block will be converted in a week. At the start of the week, the block will be disconnected from the gas grid. Then a workforce of about 1,000 will enter the block and convert all appliances, and the block will be reconnected to a newly hydrogen grid by the end of the week. The report drew a parallel to the way the gas industry converted from town gas to natural gas in the 1960s and 70s. Town gas, a combination of hydrogen, carbon monoxide and methane, was mostly produced from the distillation of coal and oil. This had been used for the first 150 years of the UK's gas industry. However, with the discovery of natural gas, which is predominantly methane, the UK undertook a nationwide programme to convert 40m appliances over a decade.

The main findings of the Leeds City Gate project

With minimal changes to the grid itself, it is possible to convert the grid in Leeds from natural gas to hydrogen. In addition, despite hydrogen having a lower volumetric energy density than natural gas, the grid capacity will still be sufficient. The total cost of the conversion for Leeds, including all infrastructure, conversion of appliances, and steam methane reforming but excluding the CCS infrastructure, would be 4 billion. This would result in a 7% average increase in the gas bill per household.

Project conclusions

We have seen that there are challenges for hydrogen. Storage and distribution have been identified as major hurdles. The Leeds H21 project demonstrates that these challenges can be overcome, particularly in domestic gas supply. Leeds has proven that existing infrastructure can be used, proved out by the H21 experiments in the Buxton research facility.

Leeds shows that just using hydrogen in our homes is not the perfect climate-friendly solution, the Leeds city gate project uses blue hydrogen with CCS. We must integrate carbon free hydrogen production into energy use domestically. Hydrogen is not the solution to climate change, but it is part of the solution and using clean energy to produce the hydrogen is key to this.

The development and implementation of new fuels and technologies come at a financial cost. These costs will be huge. To pay for this either governments will need to subsidise these costs, or the end user will have to pay for this in their energy bills. The total cost of the conversion of Leeds would be 4 billion GBP, resulting in a 7% increase in gas bills per household. This would have been seen as a huge increase but in the last few months we have seen a much bigger increase in the price of energy from global disruption to fuel supplies. It is likely that countries will likely embrace alternative fuels to reduce their reliance on international suppliers of traditional fossil fuels. This is an opportunity for hydrogen, albeit not in circumstances anybody would have chosen.

Furthermore, there are of course competitors to hydrogen as the fuel of choice for our homes. Heat source pumps are another major technology currently being promoted by the UK government to help decarbonise domestic energy usage. In future, people will heat their homes and cook their food using different technologies. Some of these will be better suited to different domestic settings i.e., housing density and types of property. Currently 83% of the population use natural gas to heat their homes and it is likely that they will favour the closest carbon-free alternative, hydrogen.

A lot will depend on regulation and which projects and fuels governments will choose to support. We must embrace multiple technologies and fuels as we look to the future. However, as we have seen in Leeds, Hydrogen is a viable and realistic alternative fuel which I believe has the potential to decarbonise our energy use as individuals, nations and as a planet.

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