Hydrogen Hype, hope or slow burner?

The hydrogen economy has been gaining significant attention in recent years, with many experts and industry leaders touting it as a game-changer in the transition to a low-carbon economy with many others questioning its value and criticising the hydrogen industry for overpromising and underdelivering on its potential; citing some projects for failing to meet expectations. However, the question remains: is hydrogen a hype, a hope, or a slow burner?

March 2025

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1.0: Preface

There has been a lot attention given to hydrogen in the past years both in the policy arena and within the energy industry, indeed the term “hydrogen-hype” has been used. This has introduced some noise into an otherwise constructive, but at the same time divided, discussion. Divided yes, because now as we sit in the first half of 2025 there is no clear path for the use of hydrogen in our future energy system. Indeed, there are many who argue that green hydrogen would be used extensively across the economy, whilst others question the economics of the whole ecosystem, and at the same time many others disqualify technologies that are widely accepted in many parts of Europe, such as the blending of natural gas with hydrogen.

In the short term, green hydrogen is not be the cure-all for the energy crisis, it is not a silver bullet but in the long term it will be indispensable in the fight against climate change.

Hydrogen is the talk of the town with the European Commission with many other countries making it a big priority in their industrial strategies. Green is the new black!
Are we about to enter the golden age for hydrogen or is just another false dawn for the molecule?

Now as we continue into 2025 we are witnessing a sobering of the hydrogen market. Questions arise, has Hydrogen moved to a position of beyond the peak of inflated expectations? Has the hydrogen market seen a period of overcorrection?
Hydrogen generated by electrolysis is the best link between physical energy from renewable sources and chemical energy. Will hydrogen in its elemental form ever become a dominating energy carrier?

The question of whether hydrogen is a "hype" or "hope" is a complex and debated topic that depends on various factors, including technological advancements, market dynamics, and policy support.

So, is the focus on hydrogen, with decarbonization and energy security front and centre in the global energy vision, all just wishful thinking *(hope*) or bravado (*hype*)?

The ‘hydrogen economy’ has been gaining significant attention in recent years, with many experts and industry leaders touting it as a game-changer in the transition to a low-carbon economy. However, the question remains: is hydrogen a hype, a hope, or a slow burner?

2.0: Introduction

Hydrogen is the topic of the day. The much heralded global ‘Hydrogen Revolution’ has prompted many politicians from across the world to follow the hydrogen bandwagon and to follow suit without questioning the promises of the hydrogen enthusiasts. The hydrogen economy has indeed garnered significant attention in recent years, with proponents advocating for its potential to play a crucial role in the transition to a low-carbon economy. However, critics continue to raise concerns about the industry's ability to deliver on its promises, citing instances of projects failing to meet expectations. To provide a balanced assessment, it is essential to examine the current state of the hydrogen industry, its challenges, and its potential.

On the one hand, hydrogen has several advantages that make it an attractive alternative to traditional fossil fuels. It is a clean-burning fuel that produces only water and heat as byproducts, making it an ideal solution for reducing greenhouse gas emissions. Additionally, hydrogen can be produced from renewable energy sources, such as solar or wind power, which can help to decarbonize the energy sector. Furthermore, hydrogen can be used as a fuel for transportation, power generation, and industrial processes, making it a versatile energy carrier.

On the other hand, there are several challenges that the hydrogen industry needs to overcome before it can realize its full potential. One of the primary concerns is the high cost of producing, storing, and transporting hydrogen. Currently, the majority of hydrogen is produced from fossil fuels, which undermines its environmental benefits. Moreover, the infrastructure for hydrogen production, storage, and transportation is still in its infancy, which limits its widespread adoption.

Despite these challenges, there are several reasons to believe that hydrogen is not just a hype, but a slow burner with significant potential. Firstly, governments and industries are investing heavily in hydrogen research and development, which is driving innovation and reducing costs. For instance, the European Union has set ambitious targets to increase the use of hydrogen in its energy mix, and several

countries, such as Japan and South Korea, are actively promoting the development of hydrogen fuel cell technology.

Secondly, there are already several successful hydrogen projects around the world that demonstrate its potential. For example, the city of Fukuoka in Japan has been operating a hydrogen fuel cell bus system since 2019, which has reduced greenhouse gas emissions and improved air quality. Similarly, the Port of Rotterdam in the Netherlands is exploring the use of hydrogen as a fuel for ships, which could significantly reduce emissions from the maritime sector.

A transition to a hydrogen economy would be a sea change in our energy infrastructure and is generating significant debate as to the fit, timing and indeed even need for the technology. As an energy carrier, hydrogen is being compared to electricity, with some stating that in our journey to net zero it is the only widespread and possibly viable alternative

When hydrogen is employed to transmit renewable electricity, only ~50% can reach the end user in a power-to-power arrangement due to 'round-trip' losses incurred from hydrogen production (via electrolysis), hydrogen compression and transport, and fuel cell conversion of hydrogen back to power. Many are stating that the current 'rush' into a hydrogen economy is neither supported by energy efficiency arguments nor justified with respect to economy or ecology. In fact, it appears that hydrogen will not play an important role in a sustainable energy economy because this 'energy carrier' cannot be more efficient than the energy from which it is made. Renewable electricity is better distributed by electrons than by hydrogen.

The opposite may be true. Because of the much-cited efficiency wastefulness of a hydrogen economy, the promotion of hydrogen at all costs may counteract other reasonable measures of energy conservation. Even worse, the forced transition to a hydrogen economy may prevent the establishment of a sustainable energy economy based on an intelligent use of precious renewable resources.

This paper is positioned to elicit debate from all sides of the green molecule discussion and to direct attention to some fundamental problems of a hydrogen

economy. The perception of hydrogen as either "hype" or "hope" or “slow burner” is a matter of perspective (regional, national, and international). Yes: horses for courses, the low carbon future will look different in different places – one size does not fit all.
Green hydrogen has the potential to play a crucial role in decarbonizing sectors that are difficult to electrify directly, such as heavy industry, long-haul transportation, and certain types of heating. Hydrogen can act as a form of energy storage, complementing the variability of renewable energy to be captured and stored for later use, helping to stabilize grids and address intermittency issues. Hydrogen can also be used in a wide range of applications, from fuel cells for vehicles to industrial processes. Its versatility makes it a potentially valuable tool for achieving clean energy goals across various sectors.

3.0: What is the difference in hype and hope?

There are many questions that need to be answered if we are to discern the gap between hype and hope in the hydrogen economy. It is agreed that more energy is needed to split water into hydrogen and oxygen than can ever be later retrieved from the generated hydrogen.

1. How much energy is really consumed to make, package, distribute and transfer hydrogen?
2. Where does the energy come from?
3. How efficient is the distribution of the lightest, thus most impractical of all energy gases. How much energy is needed to run a hydrogen economy?
4. Can we afford such a wasteful hydrogen economy at all?

These questions need to be answered before investments are made in a hydrogen future. It will cost trillions of dollars to convert the entire energy system to hydrogen. Thus, it is simply due diligence to question the optimistic claims of the hydrogen promoters before tax money is spent on research, development and hardware. Any new energy technology must be based on a sound platform of science, engineering and economics.

In addressing the questions above we need to be mindful of the starting question in the debate. What are the current and future possible uses of hydrogen and what are their scale? How flexible could these uses be? The use of hydrogen to store electricity is inflexible, however what about steel making and providing high temperature industrial heat? If we can develop flexibility in the process, then it could lower whole system costs.

3.1: Hydrogen Hype

Some critics argue that hydrogen has been overhyped as a solution to various global challenges, such as decarbonization and energy transition. They highlight the following concerns:

- Hydrogen production faces many yet to be solved technical challenges. Specifically, green hydrogen (produced using renewable energy) involves complex processes and technologies. Some critics believe that these technologies are not yet mature enough to be deployed at a large scale cost-effectively.
- Hydrogen requires specialized infrastructure for production, storage transportation, and distribution, which may not be readily available or economically viable in many regions. Adapting existing infrastructure for hydrogen use can be expensive and resource intensive.
- The process of producing hydrogen can be energy-intensive, particularly if not produced using renewable energy sources. Critics argue that the energy input required for hydrogen production may outweigh the benefits gained from its use.
- Many point out that other clean energy alternatives, such as electrification and battery technologies, are more practical and cost-effective for certain applications, making the push for hydrogen less necessary.

4.0: Hydrogen economy – opportunities but also question marks?

Hydrogen especially green hydrogen has real potential to:

1. Fuel the energy transition away from fossil fuels
2. Help countries develop energy autonomy
3. Accelerate our decarbonisation journey
4. Develop a balanced pathway for a just transition for all

Hydrogen can play a part in decarbonising certain sectors, including transport, as well as complementing the variability of renewables. However, it is essential that hydrogen production shifts towards clean methods (e.g. water electrolysis and other low-carbon techniques) rather than relying on hydrocarbons such as reformation of natural gas, as mainly occurs in 95% of production today.

We are an economy in transition, one where a fully-fledged clean energy sector is now being established, driven by both long-standing industry players and start-ups at the forefront of innovation. A new economy that can propel our industries to sustainable growth. Many proponents and supporters of low-carbon hydrogen see it as clean energy vector, a promising solution with significant potential to address key global challenges:

Many countries are investing in hydrogen research and development, and there is a growing international interest in establishing a hydrogen economy. This collaboration could drive technological advancements and cost reductions over time. The past four years have witnessed a true surge in expectations about hydrogen and its possible use cases in the EU's decarbonisation, but the peak of inflated expectations is over by now, and because of emissions, cost and technical reasons the sector is coming off the clouds. Once this temporary disillusionment is over, there will be no other way to continue decarbonisation than to turn to hydrogen. But its large-scale use is going to come at a later stage than expected currently in the still hyped policy arena.

5.0: Is green hydrogen a settled technology?

5.1: Hydrogen is it worth the hype?

Industry advocates and policymakers worldwide have heralded hydrogen energy as the “fuel of the future”. But, when you clear away the industry smoke screen, there are many reasons to be sceptical. On closer examination it’s hard to see the hydrogen hype as anything other than a greenwashing effort from fossil fuel interests, especially in the case of ‘blue’ hydrogen (hydrocarbon production with the carbon by-product captured and stored). So-called hydrogen energy isn’t an energy source, but rather an energy vector. Hydrogen “energy” is inherently inefficient, expensive, and whilst low-carbon hydrogen has low/zero emissions at point of production, other types of hydrogen such as grey hydrogen is emissions intensive. This hype will cost billions of dollars, with few, if any climate benefits to show for it.

Hydrogen technology has been used for limited purposes for many years now, but only recently has a global interest in the technology become more widespread. Water is bountiful in supply, and whilst it is resource-intensive to split water into hydrogen and oxygen, it is essentially an infinite resource. Hydrogen can be stored for long periods of time and has the potential to decarbonise the industrial energy sector and vastly improve replaced fossil fuels in heating buildings. Experts have also highlighted that vehicles driven by hydrogen fuel cells can be used along with electric vehicles to help decarbonise the transport sector and other hard to decarbonise sectors.

Less than 1% of the global total annual hydrogen production is green (i.e., produced via electrolysis of water). Although hydrogen is the most common element in the Universe, energy is required to extract it from fossil fuels and water by breaking the chemical bonds that allow it to be released from carbon (in the case of methane) and oxygen (in the case of water). It is not energy efficient – round trip efficiencies for hydrogen production, treatment, storage, transport and power generation are around just 50%. This makes the production of hydrogen extremely expensive. What’s more,

research and innovation are needed to make hydrogen harnessing cheaper and more sustainable. Hydrogen's lower density means it needs to be stored and transported under high pressure, which is costly and carries safety risks**.**

The production of green hydrogen is also highly energy intensive and cannot compete without subsidies. No matter the colour, hydrogen is full of problems. It greenwashes and entrenches harmful industries like oil refining, fracking, and unsustainable fertilizer. And while there could be a few niches uses for hydrogen energy, there's are arguments against universal use. Cars and home heating don't need hydrogen and can be electrified.

As the hydrogen hype grows, we must be wary of industry claims. Before making any investments in hydrogen or issuing permits, governments must evaluate the full impact of hydrogen. That includes comparing it to the tools we already have to transition away from fossil fuels, such as electrification, energy efficiency, and clean renewable energy.

5.2: Hydrogen the foundations for hope

Green hydrogen is a catalyst for hope. It has real potential to play a significant role in fostering positive change and optimism for a more sustainable decarbonised, energy autonomous future. Green hydrogen goes beyond just being a clean energy vector delivering decarbonisation and enhanced energy storage. Green hydrogen delivers economic, environmental, and social versatility, from the creation of a new clean economy with job creation, enhanced innovation, and international collaboration opportunities.

The Paris Agreement has identified green hydrogen energy as an element of parts of possible solutions to meeting the worldwide zero-emissions target**.** Governments around the world are including hydrogen as part of their strategy to reduce greenhouse gas emissions, and the versatility of hydrogen is attracting strong interest from a diverse range of governments and companies across the globe. Investments in hydrogen can generate a new clean energy economy that will in turn create new technological and industrial development in economies around the world,

creating new industries, new career opportunities and developing cleaner greener economic policies and developments.

Green hydrogen is a clean energy vector, a key part of the EU's 'REPowerEU' plans and a pillar in the transition toward a decarbonized society. It has many advantages over traditional fossil energy due to its zero-carbon emission, high conversion efficiency, and high energy density. By 2050, hydrogen-based energy consumption could account for up to 20% of the world's final energy consumption and will reduce CO_2 emissions by up to 80 gigatons, accounting for 20% of cumulative emission reductions. Moreover, hydrogen can outcompete or complement renewable energy in many applications. For example, green hydrogen can function as a storage medium of renewable-based electricity to stabilize the grid system. Regarding the construction industry, hydrogen-ready combined heat and power systems are more cost-competitive and efficiency-enhanced than other alternatives.
Over 30 countries and regions have issued hydrogen strategies and roadmaps. These policies differ in orientation, scope, and scale and reflect a mix of green, blue and grey hydrogen.

Interestingly five patterns of worldwide hydrogen energy development are as follows.

- Strategic technology reserves. (The United States and Canada.) They aim to engage emerging technologies and regards hydrogen energy as a strategic technological path to achieve energy security and independence.
- Realizing deep decarbonization (EU). As a global energy transition pioneer, the EU has been using hydrogen energy to achieve decarbonization in industry, transportation, and other sectors. It clarified that the hydrogen strategy aims to realize carbon neutrality by 2050.
- Energy Exports. (Australia). Major energy exporters, such as Australia and Russia (following the energy export sanctions imposed on Russia in 2022), are racing to lead in the global hydrogen trade. Australia plans to become one of the top three exporters of Asian hydrogen markets by 2025 and to host a billion-dollar hydrogen export industry by 2050.

- Developing system security and industrial development. (Japan and Korea.) Japan has shown urgency in producing hydrogen energy to replace oil and natural gas due to limited natural resources and volatile global energy prices.
- Competitive Global positioning (China) China views hydrogen as an opportunity to establish a competitive industry since it has the world's cheapest industrial by-product hydrogen resource and diverse application scenarios. In 2022, China's hydrogen blueprint aims to realize deep decarbonization, energy security, and emerging industry development.

6.0: Is green hydrogen technologically and economically optimistic?

The transformation of our economies and societies to address the challenges of the climate and nature crisis are deeply political, will necessarily involve securing the voice and support of the democratic will and support of citizens and cannot be reduced to techno-fixes. Equally, given that the transformation of our societies means shifting to different types of societies, we must firmly, but gracefully, let go that our salvation lies in 'greening' or decarbonising 'business as usual'.

This is not particular to hydrogen, but we need to guard against dominant narratives that there is a technological solution to the crisis, and especially when such risky and empirically ungrounded views are coupled with narrow neoclassical models and understandings of economics. What is being focused on here is the risky and sub-optimal transformation pathways that will result from frankly mythic thinking about technologically 'decoupling' orthodox GDP economic growth (and associated patterns of globalisation, consumerism, including the current structure of our political economy under capitalism etc.).

As a recent report noted: "Strategies to reduce greenhouse gas emissions have so far focused primarily on increased energy and greenhouse gas efficiency to *decouple resource use or emissions from economic growth. The scientific evidence for the effectiveness of this strategy is weak*"[1]. Therefore, if we are to fully appreciate the reality of the situation now facing humanity, and while not abandoning technological developments, hydrogen should be explicitly framed within the context of helping us move beyond 'greening business as usual'. This would not only be scientifically and social scientifically appropriate but would constitute a welcome and disruptive departure from technological innovations being in the service of the economic status quo, as defined by a narrow understanding of economics. What is meant by this is that the dominant understanding of economics and economic

[1] *Aigner, E et al (2023), Special Report on Climate Friendly Living: Summary for Policymakers, (Austrian Panel on Climate Change)*

calculation that underlines everything from the Integrated Assessment Models of IPCC reports to cost-benefit calculations of climate action and energy transition options, to ‘commonsense’ thinking about economics from the boardroom to the bar room, is deeply problematic and producing risks.

Neoclassical economics firstly is only one version of economics, there are others. It is largely ecologically ignorant, and its assumptions deeply disconnected from scientific principles of how the material world functions. But even more than that. Not only are there superior forms of economic thinking and analysis available (such as ecological/green political economy), but these are also much more ‘fit for future purpose’ in helping us navigate future energy and climate pathways.

Neoclassical economics is anything but ‘neutral’, ‘objective’ or ‘value-free’, but rather (as all forms of political economy are) deeply ideological and normative. That is, neoclassical economics does not objectively describe how the ‘economy’ is, but prescribes how its ‘ought’ to be, namely a capitalist, growth oriented one. And so, what needs ‘decoupling’ is not capitalism and economic growth from greenhouse gas emissions and resource intensity via technological innovation, but rather the *decoupling of technological innovations, such as green hydrogen, from capitalism and growth*.

Hydrogen is not a “slam dunk.” Even the most ardent advocate, on closely examining the many challenges, will pause. Governments must develop a coordinated plan for introducing hydrogen that recognizes the nature of technology development, markets, and business investment.

There are recognised limitations of a hydrogen economy, the transition from fossil fuel-based energy economy to a hydrogen one is not a given. All losses within a hydrogen economy are directly related to the nature of hydrogen. Whilst these losses are significant at present, they can be reduced through use selection and research and development. We must accept that hydrogen is the lightest element, and its physical properties do not suit the requirements of all the applications of a clean energy market. It is not a question of hydrogen at any cost, it is a question of what and where hydrogen sits in a multitude of clean energy solutions as we tackle our

use of, and the damage caused by fossil fuels. Current production, packaging, storage, transfer and hydrogen delivery techniques are so energy consuming, and in certain applications not sufficiently efficient, therefore other solutions must be investigated. We must identify certain benefits for this energy use, the market economy will always seek practical solutions and, as energy becomes more expensive, select the most energy-efficient of all options. In today's world, with a fossil fuel-based energy model, the envisaged hydrogen economy will never become a reality, we will only witness this when we devise a new energy model fit to drive a clean economy and recognise that the benefits of hydrogen will gradually become more important as energy transport, a storage medium and more as we measure these benefits on economic, environmental and social values.

The adoption and integration of hydrogen into existing energy systems is a complex pathway that will require significant technological advancements, infrastructure development, and policy support. These processes will take time, making hydrogen a "slow burner" in terms of its gradual and steady evolution rather than a rapid and immediate transformation. The challenges related to cost, efficiency, infrastructure, and market development contribute to this slow progression.

Hydrogen the unknown - the concept that hydrogen, despite its potential and various applications, still holds many uncertainties, challenges, and unexplored aspects. While hydrogen has gained attention as a potential solution for energy and sustainability challenges, there are several dimensions to its "unknown" nature. These are well documented and include, technical challenges, infrastructure development obstacles, economic viability, market dynamics, public acceptance, and integration challenges:

While hydrogen holds great promise for addressing climate change, decarbonizing industries, and contributing to a sustainable energy future, it's important to acknowledge that its journey is still marked by various unknowns. Researchers, policymakers, industries, and the public are collectively navigating these uncertainties and working toward realizing hydrogen's potential while addressing its challenges.

7.0: Will hydrogen fulfil expectations?

At this point in time, it is not possible to say with certainty what the range and scale of hydrogen could and should be as an energy vector in a net-zero future, with many advocates and detractors providing competing views. This debate is ongoing in the UK, but the '*Future Energy Scenarios*' published each year by Great Britain's electricity system operator, National Grid ESO, has afforded energy professionals a sober and reliable deep analysis of credible decarbonisation pathways to allow Britain to reach net-zero by 2050. Over the last 13 years, National Grid's annual '*FES*' report has become a principal knowledge source for the energy industry.

FES 2024 published in Summer 2024[2], has produced three net-zero pathways: '*Holistic Transition*', '*Electric Engagement*' and '*Hydrogen Evolution*'. In each of the pathways identified, a role for hydrogen, in combination with electrification, is forecast to a greater (393TWh produced per annum) or lesser (142TWh/annum) extent. Industrial, commercial, and road, rail and aviation transport sectors are all identified as end users, with residential homes also forecast to receive hydrogen in the case of the 'Hydrogen Evolution pathway. Based on this analysis, we can say that hydrogen will have a crucial role to play in a net-zero future.

It is for this reason that the UK Government is supporting the development of low carbon hydrogen projects, with the Scottish Government also taking a leading role given the majority of the UK's wind energy resource is in Scotland - potentially resulting in a huge hydrogen export opportunity for Scotland, not dissimilar to the position of Ireland. In addition to a mutually supportive policy environment, the UK and Scottish Governments have implemented economic support schemes intended to accelerate the nascent hydrogen energy sector, which largely remains in the research and development, and demonstration phases. Key UK government schemes include:

- Net-Zero Hydrogen Fund (NZHF): £240 million to fund development and deployment of new low-carbon (electrolytic and CCUS-enabled) hydrogen production to de-risk investment and reduce lifetime costs. Funds are available to support DEVEX and CAPEX costs.

[2] download (nationalgrideso.com)

- Hydrogen Production Business Model (HPBM): Incentivizes the production and use of low carbon hydrogen via revenue support (subsidy) to overcome the cost gap between low carbon hydrogen and existing hydrocarbon fuels in use today.
- Net Zero Innovation Portfolio (NZIP): Provides funding for low carbon technologies and systems and has awarded £170 million to hydrogen innovation projects.

The Scottish Government's £10 million Hydrogen Innovation Scheme (HIS) also offers funding to projects to help deliver and demonstrate renewable hydrogen technologies.

Collectively, the approach taken in the UK towards electrolytic (green) hydrogen is to award grant funding to innovation projects via competitions and 'Contract for Difference' (CfD) revenue subsidy auctions via the HPBM mechanism. This strategy relies heavily on market-based solutions, emulating existing renewable energy subsidy support mechanisms, and taking a 'wait-and-see' approach to new grant-supported low-carbon technologies with the expectation that innovation can bypass cost disparities between mature hydrocarbon energy sources and low carbon hydrogen.

The risk of the current UK strategy towards low-carbon hydrogen is that this project- and market-driven approach, which lacks coherent direction and buy-in from key stakeholders involved in planning energy infrastructure in the UK, has resulted in hydrogen energy projects being stranded and left to fend for themselves when their implementation results in disruption or perceived disruption to the status quo. Two high-profile examples from 2023 include:

1. The cancellation of a project to convert an existing natural gas network in the town of Whitby to hydrogen for home heating by distribution network operator, Cadent, in the face of local opposition.
2. The cancellation of the Redcar hydrogen for home heating trial after the associated 'HyGreen' BP hydrogen production facility was not awarded CAPEX funding support via the UK government's NZHF.

These challenges evidence the real risk that a ‘hydrogen bubble’ may emerge, where hydrogen as an energy vector remains confined to demonstration projects and unable to play the full role that National Grid ESO and others believe is required at an energy-system-level.

In the UK, electricity represents only ~20% of final energy consumption. Thus, decarbonisation progress to date relates primarily to the power sector (i.e., the low-hanging fruit). The journey to net-zero will require significant changes to the way we produce, transport, store, and consume energy. Relatively undisruptive changes to electricity generation and consumer-led electrification have so far not significantly challenged the architecture of the existing, largely fossil-based, energy system. However, key decisions needed to implement net-zero must be taken now if we are going to avoid what National Grid calls its ‘*Counterfactual’* 2050 future energy scenario, where heavy reliance on fossil fuel remains in place, hydrogen production is limited to a mere 25 TWh per annum, and net-zero is not achieved.

In the UK, a positive development has been undertaken recently to improve planning and coordination of the energy transition with the launch this year of a new public-corporation, the National Energy System Operator (NESO), which incorporates part of National Grid ESO via renationalization. The new NESO has been charged with planning Great Britain’s electricity and gas networks and will be responsible for coordination across the whole energy system and will consider the connections between energy vectors and their relationship with the wider system. It is hoped this effort to undertake joined-up thinking and planning can implement the most appropriate evidence-driven net-zero pathway, of which hydrogen should be a feature, and thus ensuring hydrogen can meet its full potential.

8.0: Conclusion

Hype or hope are opposite poles on the same continuum with slow burner somewhere in the middle. It has to be recognised that the hydrogen industry faces significant challenges, it is not just a hype or a hope, but a slow burner with significant potential. By doing so, we can unlock the full potential of hydrogen and create a more sustainable energy future.

The perception of hydrogen as either "hype" or "hope" or “slow burner” is a matter of perspective (regional, national, and international). While there are challenges and uncertainties associated with hydrogen adoption, there is also significant potential for it to contribute to a sustainable energy future, particularly when integrated with other clean energy technologies. The trajectory of hydrogen's role in the global energy landscape depends on ongoing advancements, policy decisions, and market dynamics.

Hydrogen’s role likely falls somewhere among these three perspectives. While there has been a certain degree of hype and excitement around its potential, there is also genuine hope for its contributions to a sustainable energy future. However, the practical challenges and complexities mean that its widespread adoption and integration will likely occur over a longer timeframe. The answer to the question hype, hope or slow burner is likely a bit of all three. There's no doubt that hydrogen has experienced a surge of hype, fuelled by its potential as a clean energy carrier and the increasing urgency to decarbonise various sectors and the need to find alternative green fuels to address the energy crisis post Russia’s invasion of Ukraine. However, whether this translates into a rapid revolution, or a more gradual evolution depends on many factors as discussed.

Hydrogen's trajectory will depend on continued research and development, advancements in production and storage technologies, supportive policies, and the evolution of global energy markets. It's essential to approach hydrogen with a balanced perspective that acknowledges both its potential and the practical considerations involved in realizing that potential. The concept of green hydrogen as a catalyst for hope reflects the belief that its potential benefits can inspire positive

actions, policies, and advancements toward a more sustainable and environmentally friendly future.

This article provides material to power the ongoing debate for the strengths and weaknesses of hydrogen as a clean energy carrier. Certainly, the proportion of energy lost depends on the application and current technologies utilised. Currently transporting hydrogen gas by pipeline over thousands of kilometres is difficult, compression or liquefaction of the hydrogen, and transport by trucks does incur large energy losses. However, hydrogen solutions are viable for certain niche applications, 350 bar pressure use in buses and HGVs, low pressure storage in stationary tanks for cogeneration with engines or fuel cells and storing excess wind electricity as hydrogen for power generation during periods of calm are all current applications that are being deployed. As technology advances and next generation electrolysis technologies evolve then we will start to overcome the current obstacles and cross the current liminal threshold to a green economy built with hydrogen as one of the foundation blocks.

In conclusion, for many reasons hydrogen is the current hot issue and has become the victim of way too much public attention resulting in too high expectations and diverging views on its possible role in future energy systems. The current hype will settle and lead to an intelligent degree of rationalisation and acknowledgement that hydrogen will play an important role in decarbonising industry and heavy-duty transport while blending on a longer time scale will help to overcome renewable oversupply and effectively contribute to the decarbonisation of the gas sector as well. Europe may be one market, but it is certainly not a level playing field for green hydrogen production, storage, distribution and use. Therefore, the current envisaged “one-size-fits-all” approach will need to change and be reflective of the diverging characteristics and potential for renewable energy production across European countries.

While hydrogen holds immense promise, it will not be an overnight revolution. The hype of 2022 and 2023 has cooled off and we are entering a state of reality where we can expect a more gradual transition, with early adoption in niche markets like heavy-duty vehicles and industrial applications. As technology matures and costs

decrease, hydrogen will likely play an increasingly important role in the global energy mix. With continued investment in research and development, infrastructure development, and government support, hydrogen can play a crucial role in the transition to a low-carbon economy. However, it is essential to acknowledge the challenges and limitations of the industry and to adopt a pragmatic approach to its development.

As we look for solutions to our climate crisis, energy crisis and energy security we have a plethora of experts but what is required is leadership. In our expert world we quite rightly value expertise and knowledge informed and supported by data, metrics, analytical frameworks, and statistics. Experts, by nature, are conservative and cautious whilst leaders take us forward to new territories. The US diplomat Henry Kissinger stated, "Most foreign policies that history has marked highly, in whatever country, have been originated by leaders who were opposed by experts. It is, after all, the responsibility of the expert to operate the familiar and that of the leader to transcend it."

In closing, while hydrogen's journey may take time, the latest market trends, increasing investments, and supportive policies point to a promising future. Hydrogen is evolving from a hyped concept to a tangible, strategic solution, with its role in decarbonising industries and transport becoming increasingly clear. As technology matures and infrastructure develops, hydrogen is set to play a crucial, accelerating role in the global transition to a sustainable energy future.