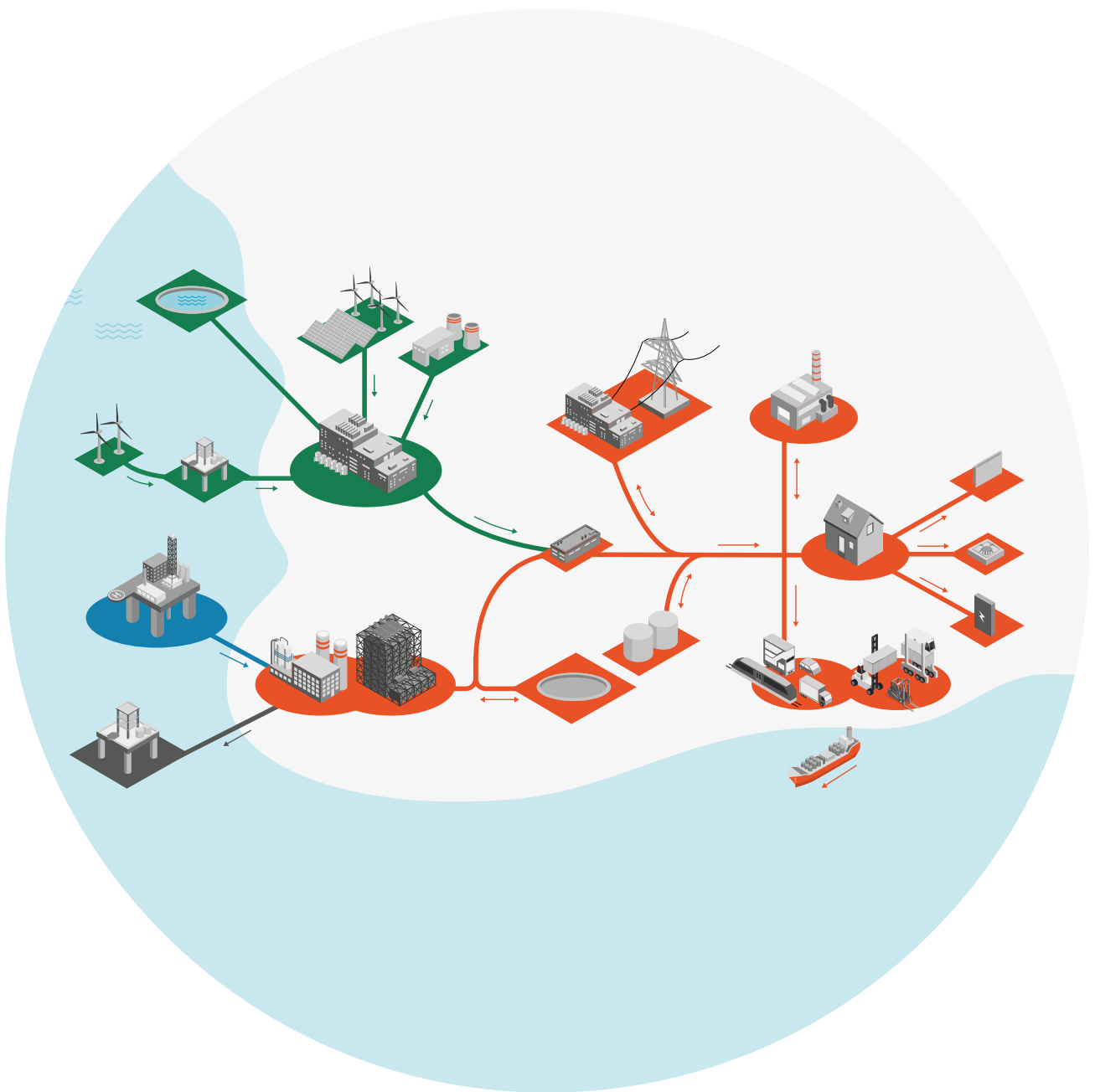


Establishing a Hydrogen Economy

The Future of Energy 2035



The establishment of a strong hydrogen economy is a very real opportunity and within reaching distance. Private sector investment, facilitated by appropriate government policy will allow the UK to benefit from significant decarbonisation across the entire energy system. A hydrogen economy could be a major differentiator for the UK's energy, transport and industrial sectors with substantial export potential.

ESTABLISHING A HYDROGEN ECONOMY

Encouraging a future hydrogen economy

The UK has a significant opportunity to decarbonise our energy system and act as a role model for countries looking at low carbon pathways. Following on from Arup's thought provoking report, 'Energy Systems: A view from 2035', it is clear there is a pivotal role for hydrogen in the UK energy market of tomorrow.

This report explores the future of the UK's hydrogen economy and lays out a series of action points. The insights captured here are the result of extensive consultations and workshops Arup has carried out across the country with industry players, academics, and other key stakeholders. This work advances a much needed conversation on how best to take advantage of the opportunities presented by the hydrogen economy; the utilisation of hydrogen as an important energy store and vector.

Hydrogen in the UK doesn't come without challenges. There are many hurdles to overcome before we see the development of hydrogen at scale, but the potential benefits greatly outweigh the challenges. It is difficult to see how the UK can achieve a secure, resilient and decarbonised energy system, able to balance supply and demand, without a substantial role for hydrogen.

Building resilient infrastructure also requires having the right policies in place to secure the capital investment needed to create a successful hydrogen economy. Arup's report rightly highlights the progress already being made in utilising hydrogen for transport and heat, albeit in small pockets. However, further policy progress will require even closer collaboration between academia, the private sector and other stakeholders to shape future demand, change consumer perception and create the strong supply chains needed to allow the hydrogen economy to thrive.

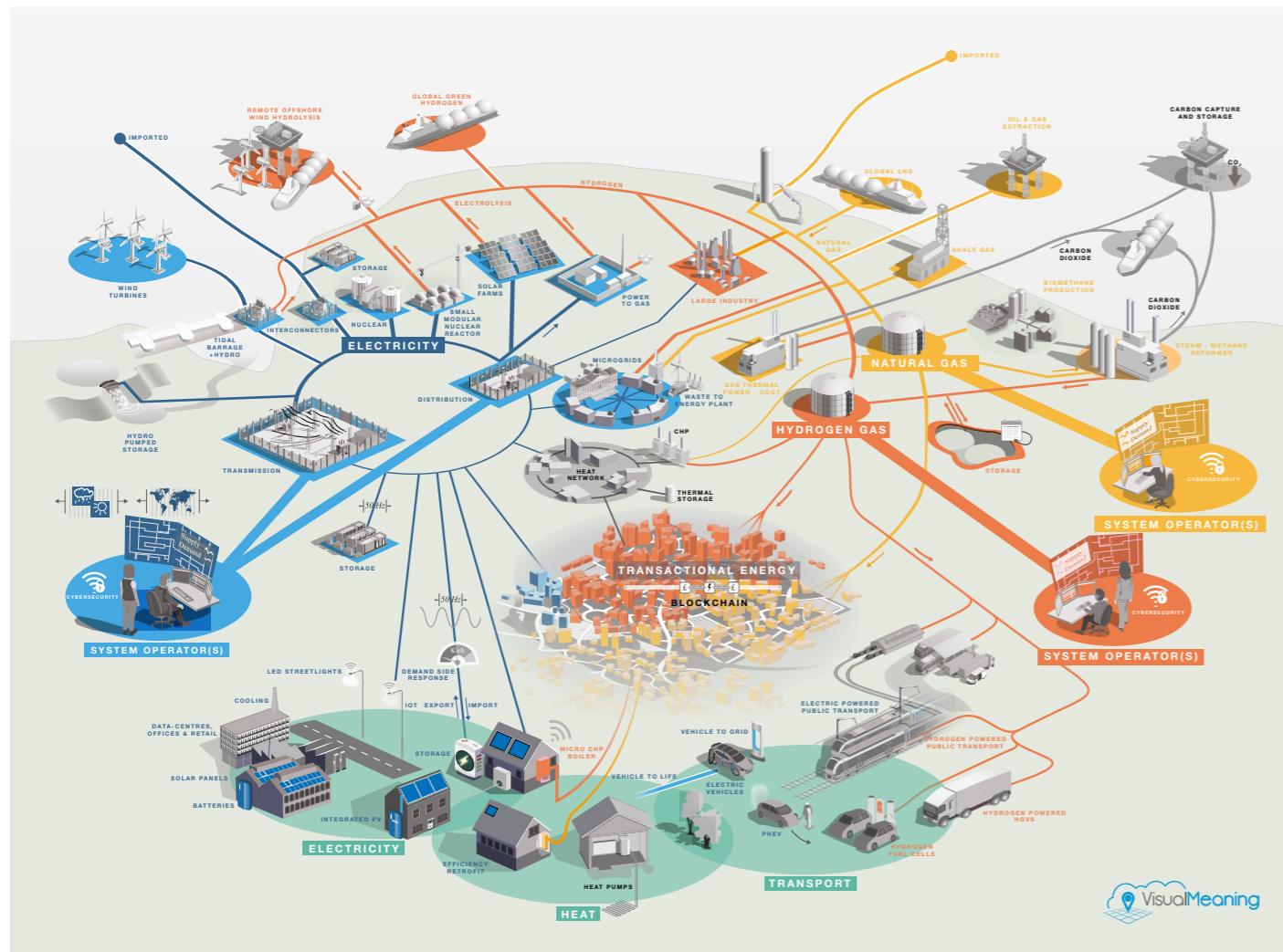
This in turn will boost affordability and create numerous job opportunities for years to come – benefits that can be shared by all.

Hydrogen has great potential to be the catalyst for decarbonising the UK energy system and with the work of Arup and others, we can transform this aspiration into reality. We need to see rapid progress in the coming years to meet our legally binding emission targets, and this report provides a roadmap to show that we all have a role to play on this journey.



KEITH MACLEAN,
UKERC BOARD MEMBER

The essential hydrogen economy



▲ Arup's 'Future of Energy 2035' map, showing the energy system of the future.

Arup has undertaken significant work to explore what the future energy system could look like through the transition to 2050. Our findings have identified hydrogen as an integral part of the future system to assist in decarbonisation.

With hydrogen gaining traction in a number of countries across the world including the UK, New Zealand and Japan, this report explores how we are on the cusp of a hydrogen economy.

A FUTURE PERSPECTIVE

Arup undertook a series of workshops with public and private sector organisations involved or interested in hydrogen - from government and across a section of the supply chain. In an emerging and immature market, our facilitated workshops helped industry explore the challenges and opportunities. This perspective explores the findings and the next steps to ensure a viable hydrogen economy.

THE UK AS A CASE STUDY

This report uses the UK as a case study and outlines how hydrogen will be a credible and prominent feature to a 2035 energy system model.

THE CURRENT MARKET

In recent years considerable progress has been made within the hydrogen industry across production, transportation and use, including:

- Orkney Surf & Turf and Levenmouth Bright Green Hydrogen demonstrators
- Health and Safety Executive approval for the HyDeploy, a project trialling up to 20% hydrogen blend in the gas network
- Transport sector using hydrogen-powered trains, buses and fleet vehicles
- The first demonstrations of H₂ fuelled domestic central heating boilers

ONGOING RESEARCH

Following the Leeds City H21 projects, which showed it might be possible to repurpose the gas distribution network for hydrogen, there are many research projects underway, largely funded by government bodies and the gas distribution companies. These are looking at a diverse range of issues including safety, technical feasibility, economics and consumer acceptance.

There appears to be little need for new technology as at a component level, much of this already exists. It is the co-ordination between government and industry players that is the key challenge that needs to be overcome.

It's clear there is still work to be done before hydrogen can fulfil its potential as a key enabler in decarbonising the UK energy system.

Hydrogen Economy 2035

By 2035, hydrogen could already be playing an important role in the UK's effort to decarbonise its energy system.

Our graphic demonstrates the different methods for producing low carbon hydrogen, as well as the opportunities for using the energy once it is created.

HYDROGEN CREATION

Electrolysis via renewables is a method in which electricity splits water into hydrogen and oxygen. The hydrogen can then be stored, and the oxygen can be released into the air or stored.

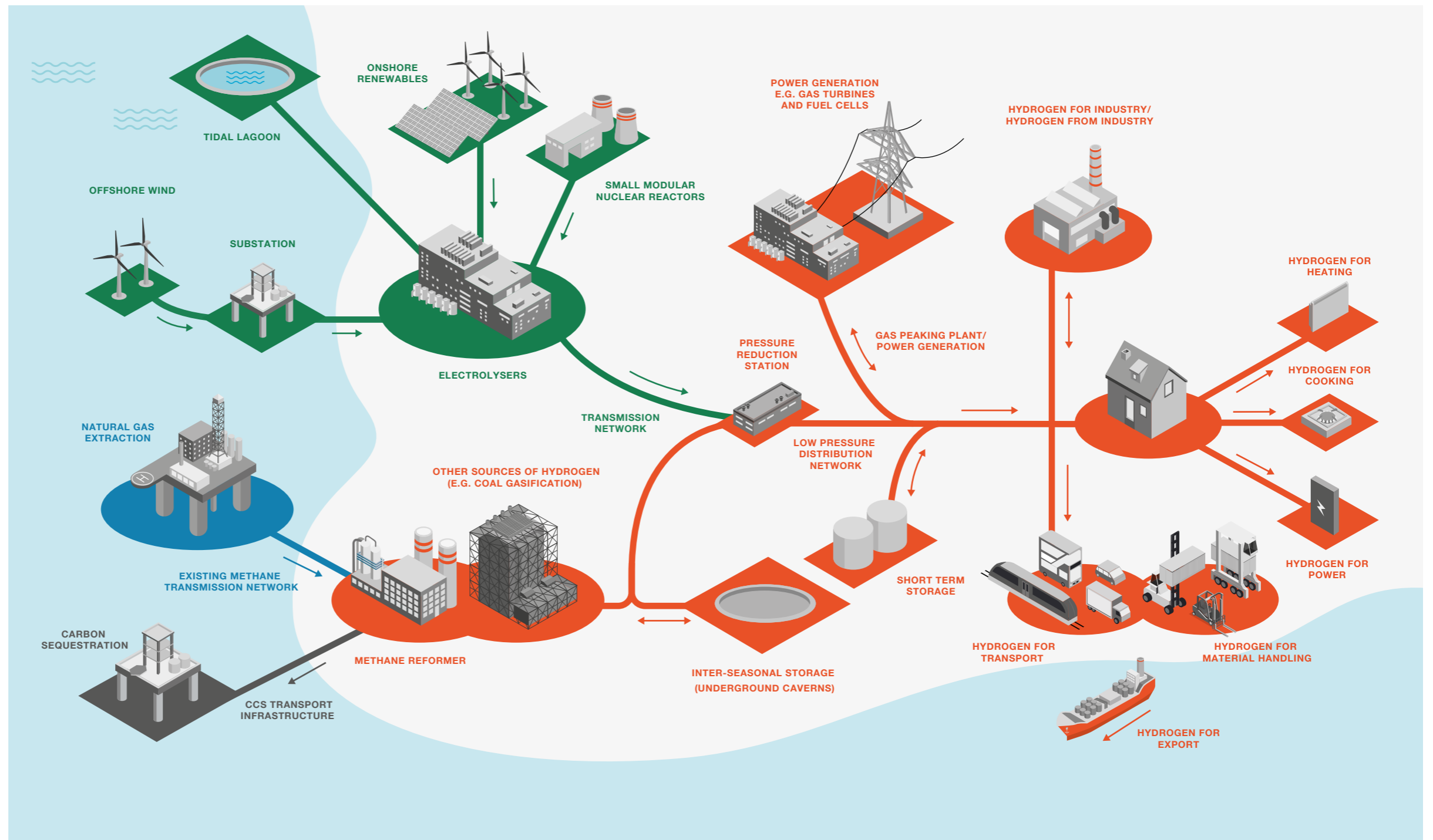
Reformation from methane is another way of producing hydrogen. Carbon capture storage (CCS) technology can capture the carbon dioxide that is produced from the process.

HYDROGEN USAGE

Transport: Improved fuel cell technology for buses, trains and ferries demonstrating hydrogen use where its rapid refuelling time and higher efficiency density give it an advantage over batteries.

Industry: Heavy industry, for example glassmaking and pottery, use high temperature furnaces that emit large volumes of CO₂. A move to hydrogen offers a big opportunity to decarbonise. Steel making also has the potential to export hydrogen to the grid, as a by-product of the production process.

Homes: Using existing gas infrastructure hydrogen could provide a safe and reliable source of energy for heating, lighting and appliances, where retrofit for electrification could prove costly.



What are the challenges the hydrogen economy needs to overcome to succeed?

The UK needs to overcome numerous challenges over the coming years to allow organisations, industry bodies and individuals to feel confident in investing in the hydrogen economy supply chain.

ATTRACTING DEMAND

Without growing demand, the large scale production of hydrogen will not happen. This demand could come from a number of sources, all of which require a broad range of end user appliances and equipment that is standardised, desirable, safe and affordable. However, without a strong supply chain which acts to reduce the costs of hydrogen, and provide confidence in the capability of industry to deliver a secure and affordable fuel, consumers and public and private sector buyers will be reluctant to purchase hydrogen products.

This is the dilemma that needs to be addressed: how to incrementally build demand and supply in the most cost-effective manner.

ENABLING INFRASTRUCTURE AND INVESTMENT

Hydrogen requires infrastructure to get it from source to end user. The capital investment needed is significant and reliant on long term indication and forecasts. If new business models and new tariff arrangements are to emerge and thrive, policy-makers need to establish a robust, credible and flexible framework. This may not necessarily take the form of the traditional regulated network model. Especially if it is based on a modular approach that increases network size and applications over time, as demand for hydrogen grows incrementally on a regional or market basis.

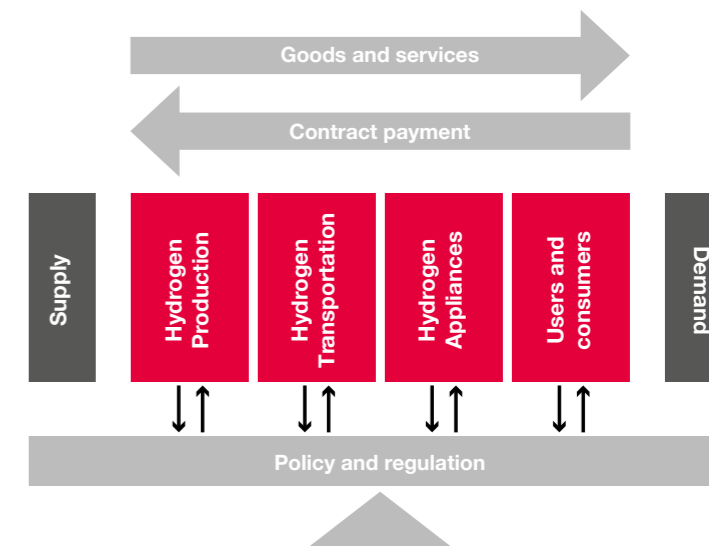
The end goal is to have a sustainable hydrogen economy with both the production and infrastructure in place and importantly - a demand from end users.

ONE APPROACH TO POLICY

Government has an essential role to play for hydrogen to establish its place in the UK energy system. Policymakers have both the opportunity to stimulate demand and the tools to ensure hydrogen is able to compete on a level playing field with other decarbonisation pathways. The challenge for government is to establish how it can most effectively stimulate the hydrogen economy, both for the established energy players and disruptive market entrances. The challenge for the industry is to speak to government with one voice about what is needed.

Ultimately it is consumer demand that will support and sustain the business case for a future hydrogen economy. The perception of hydrogen must change so it is seen as a trusted alternative to current fuels and as a means to decarbonise. A strong narrative is required around how hydrogen can deliver benefits to consumers and value to investors. It is about providing consumers a choice and allowing the transition from one fuel source to another fuel source. Continuing to bring together key players in collaborative way will help push the cause further.

Raising the awareness about the challenges the different parties face, identifying solutions and establishing relationships across the supply chain and government is an essential next step.



How to achieve the hydrogen economy

A clear road map and vision should be established to make the hydrogen economy achievable. Below are some key considerations which can help the industry overcome the challenges and grasp the hydrogen opportunity. These focus areas have been a discussion point throughout the public and private sectors from transport to large scale consumer. Some are short term achievements whilst others are long term initiatives, but all essential to a successful decarbonised energy system.

One thing is certain - action needs to start now



BRING CONSUMERS ALONG

Consumers are at the centre of the hydrogen economy - they will drive demand for hydrogen through their purchasing choices.

Effective communication with consumers needs to be clear around the requirements to change their behaviour to assist in decarbonising transport and heat and use alternative energy sources. It's important there's recognition that remaining with the status quo is not an option as it will lead to missing the legally binding Climate Change Act targets, higher costs in the longer term and a burden to future generations.

Consumer confidence is built incrementally, with safety concerns addressed over time, in a planned and strategic way; however, there is urgency to start now. The benefits associated with hydrogen need to be communicated in such a way that is beneficial to consumers.

We need to highlight air quality improvements, reduced noise and greater range extension on electric vehicles. As part of this we also need to focus on education, inspiring the younger generation about a cleaner future and upskilling the industry.



QUICK WINS

Focus should be on delivering high profile projects quickly, such as hydrogen use in transport - in particular public transport and return-to-base fleets. This will build confidence, experience and a supply chain needed to tackle more complex challenges such as using hydrogen for heating. Utilising otherwise wasted surplus hydrogen - including banning flaring – could be a significant step for the industry.

Building on the good work already underway to demonstrate hydrogen as a community solution, particularly where renewable energy is constrained. These examples should be used as good models to support further roll out.

The limits placed on how bills are calculated and the type of gas used in the network requires expensive interventions and limits the introduction of other gases such as hydrogen. Changing this is a no regrets step to blending hydrogen into the network.

Government should explore implementing policy design to stimulate investment and lead to a levelling of the playing field, given the high levels of government support for other low carbon technologies. It is important to seek parallels and lessons from other transitions, where new technologies and industries have been successfully developed and emissions reduced, following policy interventions.

One way to do this is to place an obligation on energy companies to supply increasing amounts of decarbonised gas, such as hydrogen, in much the same way that has been done for renewable electricity.



INTO THE FUTURE

There should be a focus on stimulating demand in stages. First around transport and heavy industrial processes. This would be followed closely by blending in the gas network, before we can consider a move to 100% hydrogen for heat.

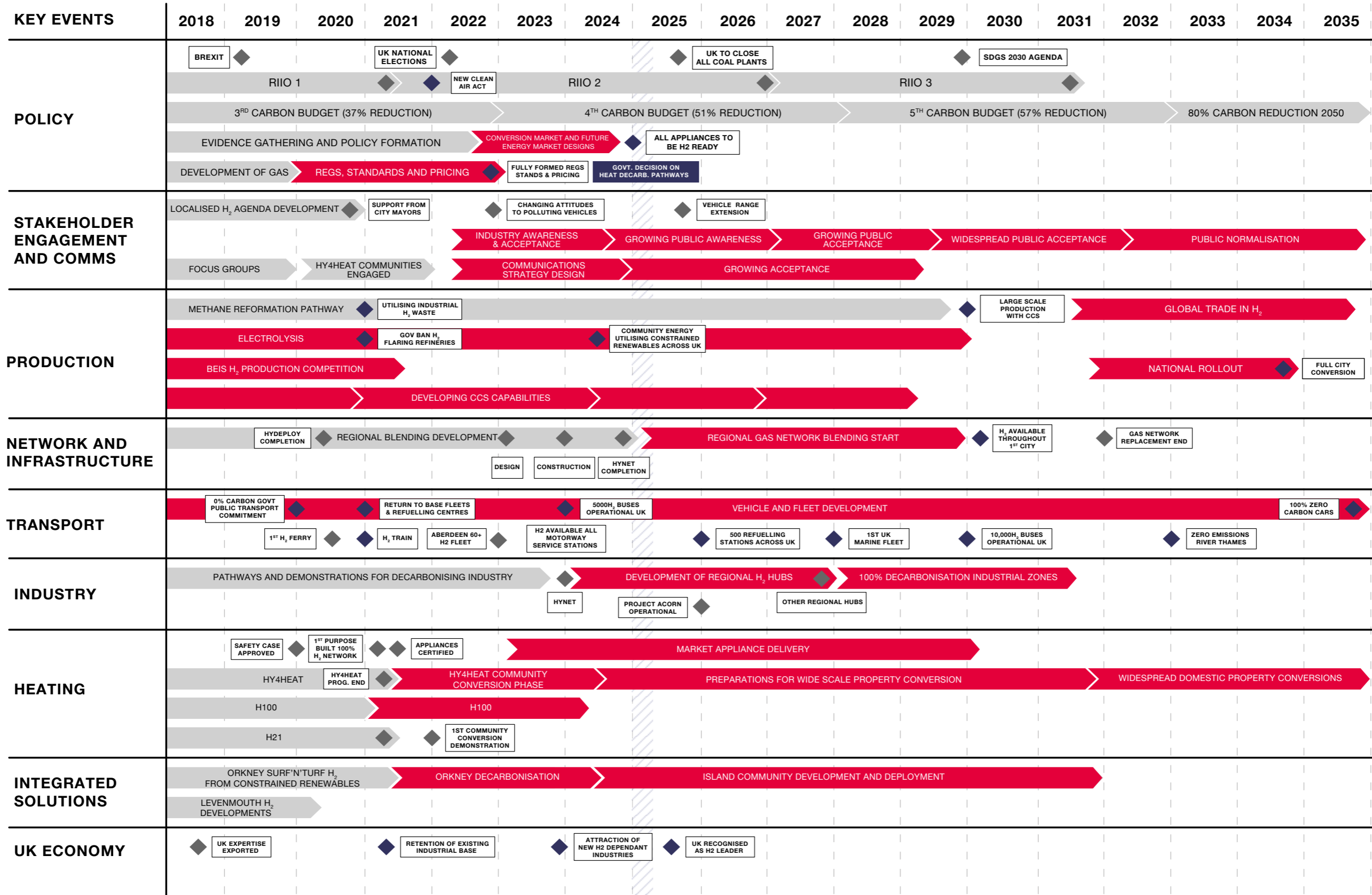
Ports and ferries are areas where uptake of hydrogen solutions will have air quality improvements and a range of benefits over purely battery alternatives.

Heavy industrial processes provide an ideal anchor for hydrogen projects. The construction of a number of regional hubs, supplying hydrogen to meet industrial demand, and blending surplus into the gas network would deliver substantial carbon savings. Gradually increasing the proportion of hydrogen, up to 20%, the point at which current domestic applications can still work, will support the incremental build-up of the capacity and capability to produce hydrogen.

Investments can therefore be incremental, with a reduced risk profile. It will lead to a gradual reduction in the cost of hydrogen for all applications, and prepare for a possible future conversion to a 100% hydrogen gas network.

Hydrogen is not an all or nothing approach. The hydrogen economy isn't entirely dependent on the outcome of 100% hydrogen for heating. The case for hydrogen in transport, industry, as a blended fuel, and storage medium is sufficient to stand alone.

Hydrogen Roadmap to 2035



This road map summarises the key activities and outcomes which could occur on the journey to a vibrant hydrogen economy by 2035.

KEY: Enacted Process (grey arrow), Enacted Milestone (grey diamond), Recommended Process (red arrow), Recommended Milestone (red diamond)

What happens next?

Having explored the challenges and opportunities, what needs to happen for the UK to establish a leading position, it is clear there is urgent need for action.

Government policies are needed in the imminent future to establish a robust supply chain, encourage new business models and inject investment into infrastructure. It's all possible and achievable to reach emission and climate change targets. Below are some final thoughts to consider about the potential of hydrogen in the UK as well as other countries.

THE FUTURE OF HYDROGEN IS HERE

- *Pilots and at scale demonstrations* – to support the development of policy, business cases, technology, consumer confidence and build supply chain capacity.
- *Public understanding* – a shift in the public perception of ‘energy’ as just electricity, the need to decarbonise the entire energy system and promote the role hydrogen could play.
- *Coordinated research* – a centrally coordinated group from across academia and industry to determine knowledge gaps and agree a portfolio of evidence gathering research.
- *Learn from overseas* – whilst the UK is leading some elements of the hydrogen economy, there are opportunities to learn and build on best practice from across the world, from advanced blending to repurposing transmission pipelines.
- *Policy and market design* – government and industries must work together to develop innovative market structures that provide value for money for tax payers and offer options to de-risk for the industry.

- *Jobs and employment* – the hydrogen economy offers a fantastic opportunity to support high quality jobs which will require highly skilled and trained workers, as well as export opportunities for the UK in a growing international market.

Hydrogen in conjunction with other technologies represents a significant opportunity for the UK to decarbonise the energy system and generate jobs.

Taking action now will enable the UK to take a leading role for the benefit of industries and the population.

Special thanks to all those who participated in various hydrogen workshops to explore these issues.



We shape a
better world

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