



Department for
Energy Security
& Net Zero

HYDROGEN STRATEGY DELIVERY UPDATE

**Hydrogen Strategy Update
to the Market: December 2023**



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Any enquiries regarding this publication should be sent to us at: hydrogenhub@energysecurity.gov.uk.

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Ministerial Foreword

The UK is already leading the world in the transition to net zero. We have decarbonised more than any other major economy since 1990, reducing emissions by nearly half while growing our economy by two thirds. Over the past 13 years, for example, we have increased our share of renewable electricity from 7% to almost half. But the future success of our energy transition will depend on us developing a range of zero carbon technologies for different purposes – and as a clean and flexible super-fuel, hydrogen is a critical part of our plans. That is why we are powering up the UK hydrogen sector – an industry that capitalises on our natural resources, creates new skilled British jobs, boosts our energy security and drives economic growth.



This Hydrogen Strategy Delivery Update sets out the steps we have taken and will take to create a world-leading UK hydrogen market – including our announcement today of government support for 11 major new hydrogen projects across the UK, representing the largest number of commercial scale green hydrogen production projects announced at once anywhere in Europe.

In August 2021 we published our UK Hydrogen Strategy, explaining how we will develop every part of the hydrogen economy. Acknowledging that hydrogen is an emerging sector, the strategy explained our plans to promote domestic low carbon hydrogen production and use across heavy industry, power, transport and potentially heat. It also set out how hydrogen will require more varied energy infrastructure across a much wider geographical area than wind power, for example. Our plans to scale up hydrogen production, transport and storage will unlock over 12,000 jobs and up to £11 billion of investment across the UK by 2030.

Since the strategy's publication, we have made rapid progress developing one of the most comprehensive hydrogen policy frameworks in the world. We have designed funding mechanisms for the short and long term that will kickstart hydrogen projects and the growth of the market. UK industry, including through the Hydrogen Delivery Council, is also playing an integral role in helping to shape government policy, to rapidly scale up our hydrogen economy and maximise opportunities for UK businesses.

In response to rising global energy prices and the need to boost our energy security, last year we raised our low carbon hydrogen production ambition to have up to 10 GW capacity by 2030, placing the UK as a front runner in the global race to scale up hydrogen production. Furthermore, we pledged to design business models for hydrogen transport and storage infrastructure by 2025. The global energy crisis has spotlighted the importance of hydrogen within our energy mix, so we are fully focused on delivering these plans.

As 2023 draws to a close, the substantial progress we have made since the launch of the Hydrogen Strategy is clear. We have now announced the first electrolytic production projects to receive an offer of funding through our Hydrogen Production Business Model. These 11 projects, based in England, Wales and Scotland, are expected to create over 700 jobs during construction and produce 125 MW of environmentally friendly 'green' hydrogen, supporting energy security and local economic growth.

We know that clarity over future government plans is critical for industry and investors. That is why, alongside this update, we have also launched a second hydrogen allocation round with the aim to allocate up to 875 MW of production capacity, and have published a roadmap for how we will scale up UK hydrogen production over the next decade. This includes our ambition to run annual allocation rounds out to 2030. We have also set out a pathway for developing critical hydrogen transport and storage infrastructure, made a strategic decision to support blending of hydrogen into GB gas distribution networks and a published a consultation on potential support for hydrogen-fired power stations.

We are determined to step up the pace of delivery too. To reflect our new aims and delivery milestones, this update includes a refreshed UK Hydrogen Economy Roadmap. The roadmap sets out exactly how we aim to deliver our ambitions across the full hydrogen value chain, working in partnership with industry to generate the jobs, growth and energy security that hydrogen offers across the UK.

The energy transition provides the UK with unprecedented opportunities – for growth, energy security and tackling climate change. We aim to seize these opportunities by working with industry and investors to build a hydrogen economy that delivers for the whole United Kingdom, including businesses, consumers and our workforce. This Hydrogen Strategy Delivery Update, together with the full suite of hydrogen announcements and policies published today, demonstrates our resolve to build a world-class hydrogen sector – one that will make us more energy secure, more competitive economically, and on course to become a net zero nation by 2050.

The Rt Hon Claire Coutinho MP

Secretary of State for Energy Security and Net Zero

Introduction

Low carbon hydrogen will play an important role in UK energy security and achieving net zero, as a key enabler of a low carbon and renewables-based energy system. Produced using home-grown, clean British energy, hydrogen technologies can make our energy system more flexible, resilient and independent, and [could lead to billions of pounds of savings by 2050](#). We have a clear ambition for the UK hydrogen economy and we are aligning our policy development with our wider efforts to decarbonise the UK economy, aiming to harness the industrial opportunities that the growing hydrogen sector presents.

The UK can become a global leader in the production and use of low carbon hydrogen, drawing on strong domestic expertise and favourable geology, geography and infrastructure. We can use hydrogen to decarbonise UK industrial sectors, and provide greener energy across power, transport and potentially heat. We can also store it for long periods of time for use when demand is high. The hydrogen economy offers another avenue for reskilling across industry as we transition towards net zero, and provides new opportunities across our industrial heartlands in the planning and construction of new infrastructure to produce, transport, store and use this home-grown super-fuel. The infrastructure projects and associated supply chains needed to deliver our up to 10 GW low carbon hydrogen production capacity ambition could support over 12,000 jobs by 2030 and deliver up to £11 billion of private investment.

The [2021 UK Hydrogen Strategy](#) set out how we intend to realise our vision for this new low carbon energy vector over the 2020s and 2030s, outlining our whole system approach and the joint efforts of government and industry needed to deliver supporting policy and actual projects. This [vision has expanded since 2021](#), with our ambition increasing to have up to 10 GW of low carbon hydrogen production capacity by 2030, subject to affordability and value for money, and at least half of this capacity comprising electrolytic or 'green' hydrogen. We have announced a range of new policy to support this heightened 2030 ambition, and have also set a stretching interim ambition to have up to 1 GW of electrolytic and up to 1 GW of CCUS-enabled hydrogen production operational or in construction by 2025.

We are now delivering on our commitments. Having designed comprehensive, considered and enduring funding frameworks, these are now being implemented with funding and contracts allocated to the first production projects. Alongside this document we have published the [successful projects from the first electrolytic hydrogen allocation round \(HAR1\)](#) and [launched the second hydrogen allocation round \(HAR2\)](#). The landmark [Energy Act 2023](#) will also accelerate the development and growth of low carbon technologies, such as hydrogen, by legislating for business models to attract private investment. We are setting out the next stage in our strategic approach for hydrogen production and for transport and storage (T&S), with the publication of the [Hydrogen Production Delivery Roadmap](#) and the [Hydrogen T&S Networks Pathway](#), and the announcement of our [positive strategic decision on hydrogen blending](#). This next stage of future thinking is taking place across the energy system, for example we will be setting out our vision for carbon capture, usage and storage (CCUS) and our positioning on how the future electricity market will operate.

The Hydrogen Strategy Delivery Update (December 2023) represents an approximate halfway point between the publication of our UK Hydrogen Strategy in August 2021 and the five-year review point set out in the Strategy. We are taking the opportunity to reflect on progress to date and set out our future priorities and delivery timelines. This report presents the progress that government and industry have made in delivering the UK Hydrogen Strategy and reaffirms government's continuing commitment to develop a thriving hydrogen economy. This Hydrogen Strategy Delivery Update therefore represents a special edition of the Hydrogen Strategy Update to the Market.

Part 1 of this update considers our strategic approach to the UK hydrogen economy, setting out a refreshed roadmap and delivery timeline out to 2035. This roadmap reflects our updated ambitions and milestones and gives greater sight to industry and investors of government's direction of travel and anticipated timelines for delivery to 2030 and beyond.

Part 2 sets out the key policies and support that we have designed and delivered across the hydrogen value chain, and a forward look for delivery. It also summarises recent policy developments from August to December 2023, including details of the key announcements and publications that accompany this update.

Part 1: Scaling up the UK Hydrogen Economy

The UK Hydrogen Strategy set out government's vision for the role hydrogen will play in the UK reaching net zero. It also illustrated the scale of the challenge to realise this ambition: almost no low carbon hydrogen is produced today, but we estimate that [240-500 TWh could be required by 2050](#) – which is similar in scale to existing UK electricity use. The Strategy also set out the scale of the opportunity for hydrogen in the UK: to help deliver deep decarbonisation of heavy industry and transport, as well as helping to build a resilient and secure net zero energy system, while capturing economic benefits and green jobs. Producing, transporting, storing and using hydrogen will require new technology, infrastructure, supply chains, investment, jobs and skills to make our vision for hydrogen in the UK's future energy mix a reality.

Hydrogen's role in supporting greater energy security in the UK has come into increasing focus since 2022, spurring our efforts to develop the hydrogen economy further and faster. Hydrogen can be used as a long-term store of renewable energy and could provide critical flexibility for the power system. This is particularly valuable as we move to an increasingly electrified energy system where both electricity supply and demand are more variable. The [Independent Review of Net Zero](#) also noted the crucial role hydrogen will play in the government's wider strategy to deliver across three fronts: energy security, economic growth and net zero. Jane Toogood, in her former role as the UK's Hydrogen Champion, highlighted in her [March 2023 report](#) the important role hydrogen will have in decarbonising energy intensive industry as well as the substantial private sector finance required to deliver this and the UK's wider hydrogen ambitions.

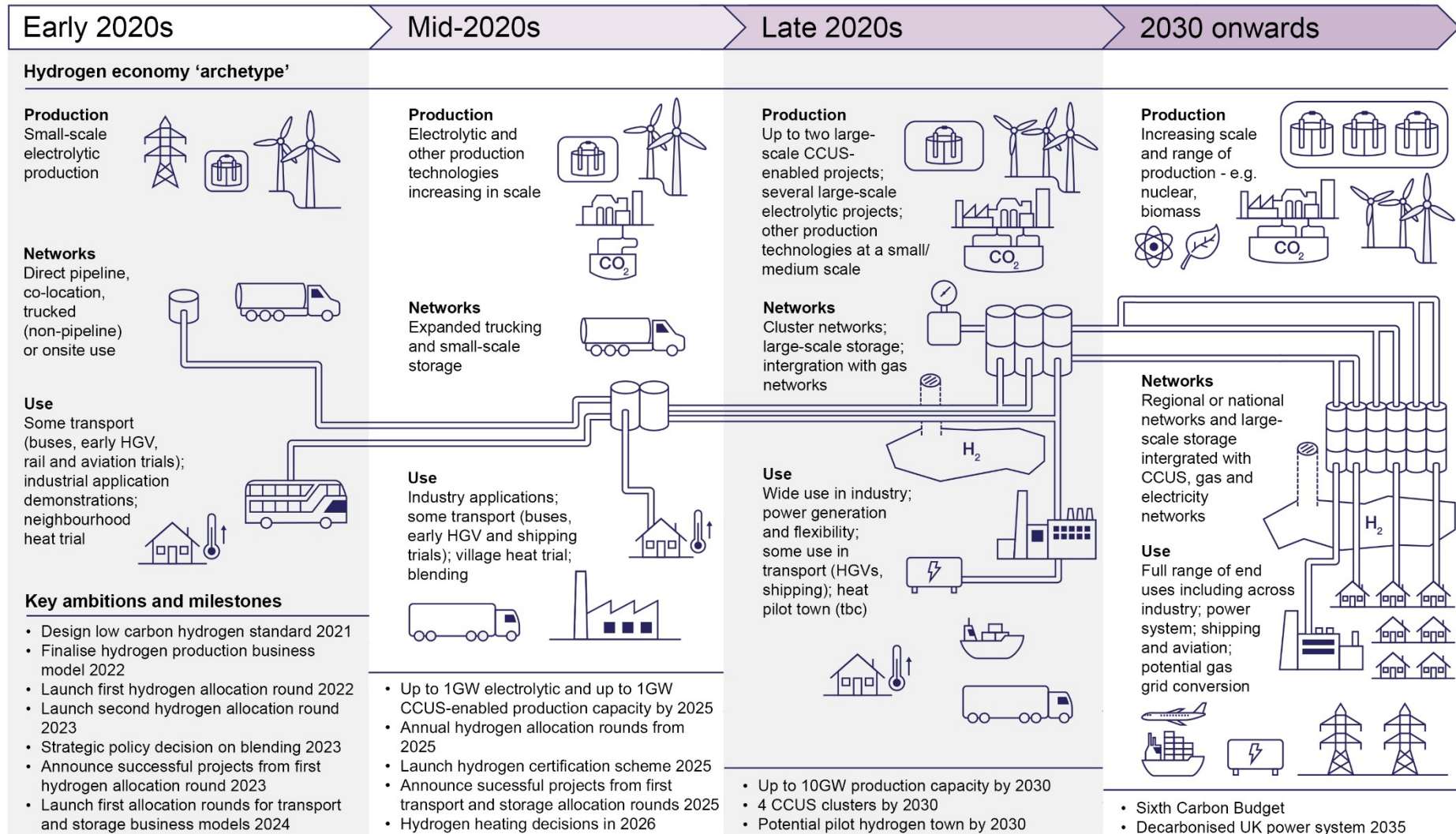
As the importance of hydrogen has grown, so too has our ambition. In April 2022 we doubled our hydrogen production capacity ambition to have up to 10 GW of capacity by 2030, as set out in the [British Energy Security Strategy](#). We have also expanded the range and number of policy mechanisms we are bringing forward, including annual allocation rounds for electrolytic hydrogen production and designing hydrogen transport and storage business models by 2025. We have delivered the [Energy Act 2023](#), which will provide a cleaner, more affordable, and more secure energy system, and includes facilitating the first large village hydrogen heating trial. Governments globally are investing large sums in their own nascent hydrogen industries, with many countries also considering becoming importers or exporters of low carbon hydrogen and its derivatives, indicating large potential growth of the global hydrogen market.

We continue to take a whole system approach towards developing the UK's hydrogen economy – driving progress across the full hydrogen value chain and integrating this with decarbonising UK energy systems. This includes developing the key role that hydrogen can play supporting our commitment for a decarbonised and secure power sector with hydrogen to power, considering alignment with any changes proposed through our Review of Electricity Market Arrangements (REMA). Our approach in the Strategy was to bring forward early projects to build out the supply chains and learn by doing, whilst establishing the longer-term

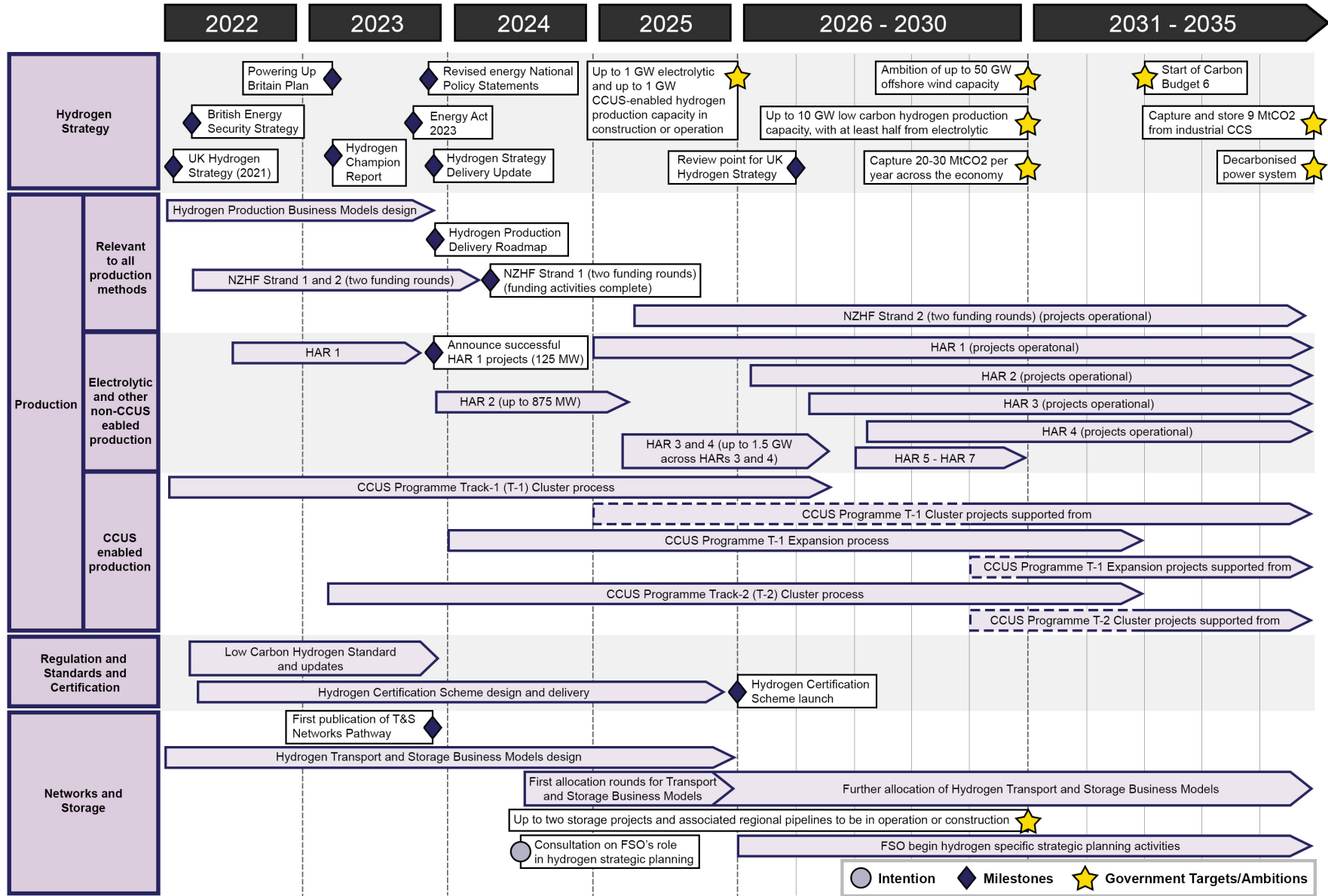
frameworks to develop a competitive hydrogen economy. We have also collaborated with international partners, including signing a recent [hydrogen partnership with Germany](#), to support first movers in the hydrogen economy and develop larger markets for deployment of hydrogen technology. Our proactive approach has seen us work bilaterally and through multilateral forums to promote global action on hydrogen, accelerate new research and share ideas, and advance the development of international markets for low carbon hydrogen.

In the [Hydrogen Strategy](#) we developed a roadmap with industry which set out our shared vision for the expected growth of the UK hydrogen economy to the mid-2030s. The fundamental approach set out in the roadmap remains, but as stated above, some of our ambitions and milestones have since evolved. Below we set out an updated roadmap which incorporates these revisions and is supplemented by a more detailed delivery timeline. This updated UK Hydrogen Economy Roadmap, alongside our newly published [Hydrogen Production Delivery Roadmap](#) and initial [T&S Network Pathway](#) document, provide a more detailed blueprint for implementing our world-leading Hydrogen Strategy.

Updated UK Hydrogen Economy Roadmap



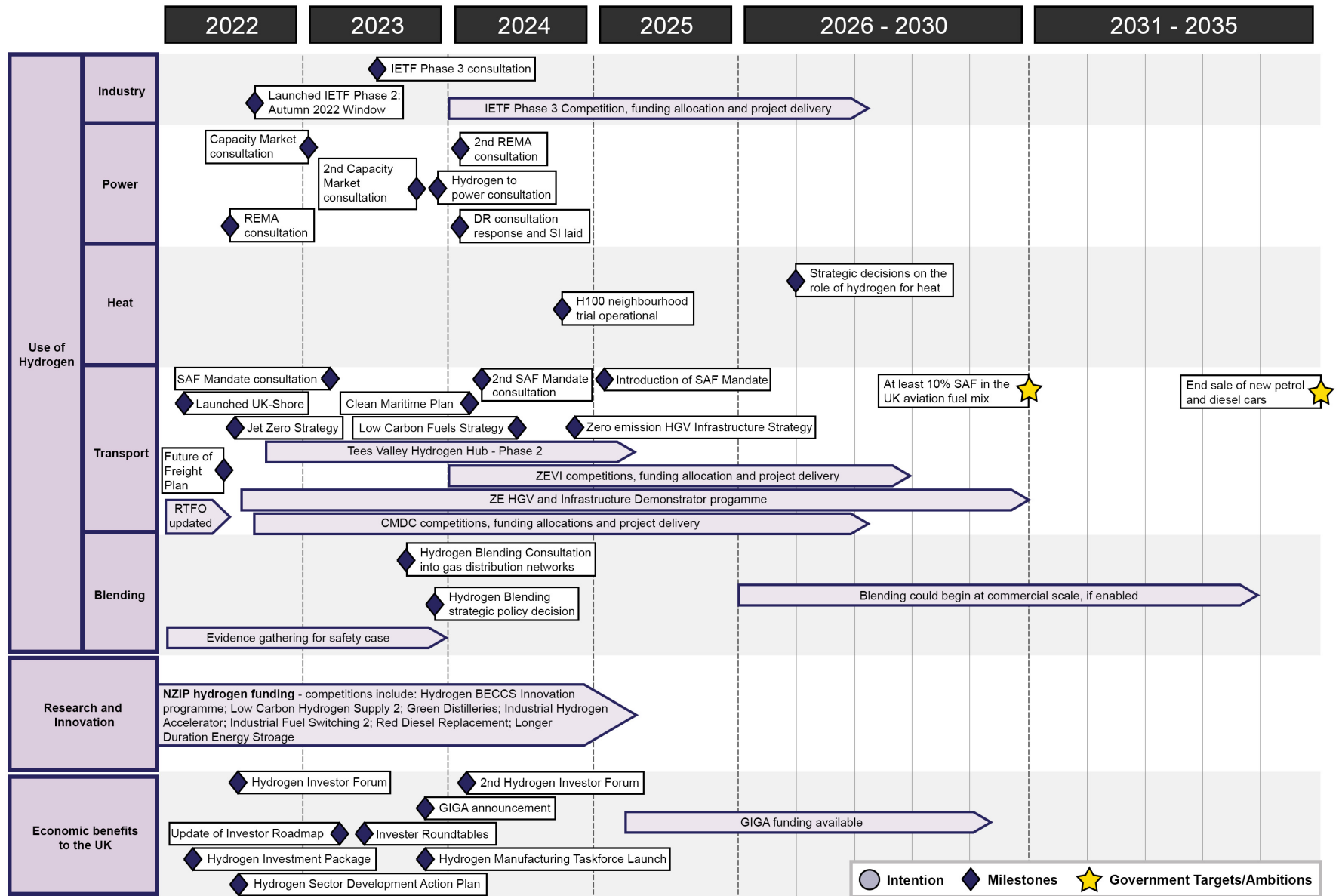
Hydrogen Strategy Delivery Update



NZHF - Net Zero Hydrogen Fund; HAR - Hydrogen Allocation Round; CCUS - Carbon Capture, Usage and Storage; T&S - Transport and Storage; FSO - Future System Operator

Timelines are indicative and subject to change.

Hydrogen Strategy Delivery Update



IETF - Industrial Energy Transformation Fund; REMA - Review of Electricity Market Arrangements; DR - Decarbonisation Readiness; RTFO - Renewable Transport Fuel Obligation; CMDC - Clean Maritime Demonstration Competition; NZIP - Net Zero Innovation Portfolio; BECCS - Bioenergy with Carbon Capture and Storage; GIGA - Green Industries Growth Accelerator; ZEVl - Zero Emission Vessels and Infrastructure

Timelines are indicative and subject to change.

Part 2: Strategic vision and delivery focus to 2035

Production

A roadmap for developing our hydrogen production capacity to 2035

In 2022, following the illegal Russian invasion of Ukraine and the subsequent impacts on energy markets, [the UK doubled its production ambition to up to 10 GW of low carbon hydrogen by 2030, with at least half coming from electrolytic hydrogen](#). This placed the UK [among the top three international leaders](#) and reaffirmed our intention to deliver a UK hydrogen economy at pace. This increased ambition, alongside our interim ambition to have up to 1 GW CCUS-enabled and up to 1 GW electrolytic hydrogen capacity in construction or operation by 2025, has guided our approach to designing funding support.

Our approach to developing hydrogen production encompasses multiple production routes, provided they comply with our [UK Low Carbon Hydrogen Standard](#) (LCHS). The LCHS provides clarity about the types of hydrogen production we intend to support and want to see in the developing UK hydrogen economy, to support investment, innovation and commercialisation of new production technologies which are consistent with the UK's net zero commitment. We continue to iterate the LCHS to keep the UK at the forefront of hydrogen standards, backing appropriate new production technologies as they arise. More detail on development of our certification scheme can be found in the *International trade in hydrogen* section of this update.

Innovation and first of a kind deployment of hydrogen technologies have brought their own learning in what market signals industry and investors find most useful to support hydrogen production. To give industry more information and certainty as to our policy direction, we published a [hydrogen production strategy update in July 2022](#), including reflections on the importance of locational signals and the role of electrolytic production in the energy system.

Further to this production strategy update we have now published a [Hydrogen Production Delivery Roadmap](#) alongside this document, as recommended in the [Independent Review of Net Zero](#). This roadmap sets out our planned approach to production to 2035 – more detail can be found in Box 1. This will provide greater clarity to investors and developers on the scaling up of hydrogen production and supply chain growth up to and beyond our central 2030 ambition.

Box 1: Hydrogen Production Delivery Roadmap

Just over 18 months after scaling up our hydrogen production capacity ambition in the British Energy Security Strategy, we have seen a strong response from industry and investors to say they are up to the challenge. We have announced 125 MW of capacity

through the first electrolytic hydrogen allocation round (HAR1) and are undertaking negotiations with projects with two CCUS-enabled hydrogen projects through Track-1 of the cluster sequencing process. We have also [announced the first successful applicants under our £240 million Net Zero Hydrogen Fund](#).

Delivering this ambition and developing a world class hydrogen economy represents a significant challenge to both industry and government, requiring a rapid scale up in hydrogen production from where we are today. Our experience from these early funding rounds, and engagement with project developers has shown us that we need to make sustainable progress whilst aiming to provide certainty for investors. We intend to:

1. Allocate up to 4 GW of our 2030 ambition to CCUS-enabled hydrogen through CCUS allocation rounds for Track-1, Track-1 expansion and Track-2, subject to project assessment, cluster assessment and successful negotiations with projects.
2. Allocate up to 6 GW of our 2030 ambition to electrolytic production, with alternative technologies also contributing towards this total.
3. Run annual allocation rounds for electrolytic projects, and potentially alternative technologies, between 2025-2030.
4. Allocate up to 875 MW of capacity in HAR2.
5. Allocate up to 1.5 GW across both HAR3 and HAR4, which are expected to launch in 2025 and 2026.
6. Review our trajectory in 2025 in light of learnings from early projects, the evolving evidence base and strategic decisions on the use of hydrogen, taking into consideration emerging evidence on cost reductions, innovation, infrastructure requirements and demand-side developments.

Achieving this ambitious deployment trajectory will be subject to affordability and value for money, and we will be looking to industry to rise to the challenge to demonstrate the significant cost reductions we expect to see as the UK hydrogen sector takes off. In addition to this we expect to see larger-scale electrolytic projects coming forwards, increasing deployment of low-cost renewable energy, and to ensure local communities see the benefits from high quality jobs. The siting of electrolytic projects could be beneficial from a systems perspective, helping to manage grid constraints or to use excess electricity that would have otherwise been curtailed or constrained.

Funding low carbon hydrogen production

To achieve our policy ambition, we are funding the development and delivery of early hydrogen production projects. We are doing this by supporting immediate construction (and other capital costs) through the £240 million [Net Zero Hydrogen Fund \(NZHF\)](#), as well as longer term

revenue support via the [Hydrogen Production Business Model \(HPBM\)](#) to overcome the economic challenge of producing low carbon hydrogen compared to cheaper high-carbon alternatives. Contracts for this support are being awarded through [hydrogen allocation rounds \(HARs\)](#), open to electrolytic and alternative technologies, and the [CCUS Cluster Sequencing process](#), as well as bespoke NZHF funding rounds.

The [announcement of successful HAR1 projects](#) (subject to contract award, to follow in early 2024), within two and a half years of publishing the UK Hydrogen Strategy represents a significant achievement. Taking inspiration from the [Contracts for Difference mechanism](#), which has supported significant growth in offshore wind capacity, we have rigorously assessed and delivered a business model at pace that works for producers and benefits the wider development of the UK hydrogen economy. It is also compatible with other existing support schemes such as the [Renewable Transport Fuel Obligation \(RFTO\)](#).

The 11 successful projects from HAR1, subject to contract award, will receive support from the [NZHF](#) and the [HPBM](#) over the course of a 15 year contract, developing a total 125 MW low carbon hydrogen production capacity by 2026. Alongside announcing successful projects from HAR1 we are [launching the second hydrogen allocation round \(HAR2\)](#), which will be open to electrolytic and alternative technologies. This second allocation round, together with HAR1 projects and successful NZHF Strand 2 projects will seek to deliver on our ambition to have up to 1 GW of electrolytic production capacity in construction or operational by 2025, subject to value for money and affordability. We have also been considering how the HARs should evolve over time. To inform this work in May 2023 we published [a Call for Evidence](#) future policy framework for the allocation of the HPBM and have published a summary of responses alongside this publication. Our expectations for the design and timeline of future HARs can be found in the Hydrogen Production Delivery Roadmap. The [Energy Act 2023](#) contains provisions that underpin the delivery of the HPBM and which will also enable government to introduce a hydrogen levy on gas shippers through secondary legislation. HPBM payments for projects awarded contracts through HAR1 will be funded by government until the hydrogen levy comes into effect.

In March 2023, [we also announced the first 15 successful applicants to Strands 1 & 2 of the NZHF](#) (see Figure 1 on page 20). These projects were offered total grant funding of up to £37.9 million to support their FEED studies and post FEED costs, or capital funding to support build costs. We delivered the NZHF at pace to support the first mover commercial-scale production projects, consulting, launching and allocating the first sets of funding for the NZHF within approximately 18 months. Case studies of successful NZHF projects announced in March 2023 from across the UK can be found in the Hydrogen Production Delivery Roadmap. We aim to announce the winners of the second round for these strands in early 2024.

In keeping with our approach to supporting multiple production routes, we are progressing with the negotiations for the capital and revenue funding for the UK's first commercial-scale CCUS-enabled hydrogen production plants. We announced [the HyNet and East Coast clusters progressing in Track-1](#), and have advanced to negotiating and shortlisting eight CO2 emitter projects, including two CCUS-enabled hydrogen projects as part of Phase 2 of the process. Maintaining our high tempo delivery, we announced our intention to expand the Track-1

clusters and launched [Track-2](#) of the Cluster Sequencing Process in March 2023. In July 2023 we then confirmed our belief that [the Acorn and Viking T&S systems](#) were best placed to deliver our Track-2 objectives and should proceed. We will launch a process shortly to begin further expansion of Track-1 clusters, beyond the initial deployment, identifying and selecting projects to fill the available storage and network capacity anticipated to be available in and around 2030. Carbon capture and hydrogen are closely related, and we continue to develop policy that acknowledges these links and complements both technologies. We will also publish a CCUS vision, which sets out the government's vision for the UK CCUS sector for the 2030s to raise confidence and improve visibility for investors, including how we envisage the CCUS market changing over time and ultimately becoming a self-sustaining CCUS market.

Innovation in hydrogen production

Our Strategy acknowledges the role that other hydrogen technologies could play in future. The UK is at the forefront of research and innovation (R&I) across the hydrogen value chain which we have continued to promote through innovation competitions. The £60 million [Low Carbon Hydrogen Supply 2 competition](#) has awarded contracts to ten ongoing projects to demonstrate novel technologies and move them closer to commercial deployment, with testing due to start in some projects in early 2024. Our [2023 Biomass Strategy](#) outlined the role biomass could play in the hydrogen sector, and to facilitate its development we launched the £31 million [Hydrogen BECCS Innovation programme](#). The programme supports the scaling up of technologies that generate hydrogen from biogenic feedstocks with integrated carbon capture, to push negative emissions technologies to market faster. In June 2023 we published [Phase 1 reports](#) and [announced the six project winners for Phase 2](#), who have been awarded a total of £26 million to turn biomass and waste, such as sewage, into hydrogen with carbon capture.

Recent developments: August to December 2023

- **Outcome of HAR1:** We have [announced the first 11 successful electrolytic hydrogen projects under HAR1](#) alongside this publication, with contracts to follow in early 2024. These are expected to be the first projects to receive funding via both the HPBM and the NZHF.
- **Launch of HAR2:** We [launched the second Hydrogen Allocation Round](#) (HAR2) alongside this update, with the aim of supporting up to 875 MW of capacity, subject to affordability and value for money. The application window will close in Q2 2024. Our launch event in December and further stakeholder engagement sessions throughout January will allow stakeholders the opportunity to hear more about the final design of this round.
- **Energy Act 2023:** The Act includes [provisions underpinning the delivery of the HPBM](#), including powers to designate a hydrogen production counterparty, to make regulations establishing a levy to fund hydrogen business model payments, and appoint a levy administrator.

- **HPBM regulations:** We published [the government response to the consultation on proposals for revenue support regulations in relation to the HPBM](#) in October 2023. The [draft Statutory Instrument](#) was laid in Parliament in November 2023.
- **New version of the LCHS:** We published [Version 3](#) of the LCHS in December 2023. This reflects our growing understanding of how hydrogen production technologies will work in practice.

Forward look

- **Reaching up to 10 GW hydrogen production capacity by 2030:** As set out in the [Hydrogen Production Delivery Roadmap](#), we intend to allocate up to 4 GW of CCUS-enabled hydrogen as part of our 2030 production capacity ambition, with the remaining 6 GW made up of electrolytic production, with alternative technologies also contributing towards this total.
- **Aim to award up to 875 MW of low carbon hydrogen production capacity through HAR2:** Our push to building low carbon hydrogen production capacity will continue with HAR2. We will also include alternative technologies within the scope of funding support ensuring multiple low carbon hydrogen production routes are supported. We intend that the allocation process will be increasingly cost-competitive from HAR2, and we aim to award contracts from 2025.
- **Annual HAR rounds from 2025 to 2030:** We plan to run annual allocation rounds for electrolytic projects, and potentially alternative technologies between 2025-2030, subject to affordability, value for money and market conditions. We will aim to ensure the design of these allocation rounds work alongside other policy mechanisms to support deployment at scale and cost reduction of hydrogen production, as well as broader outcomes such as harnessing electricity system benefits.
- **Allocating increasing amounts of capacity in future HARs:** We intend to allocate up to 1.5 GW of low carbon hydrogen production capacity across HARs 3 and 4, subject to cost reductions, affordability and value for money. Government plans to review our deployment trajectory in 2025 based on emerging evidence and strategic policy decisions as we accelerate towards 2030. The capacity targets for HARs 5-7 will be based on deliverability, cost reduction, affordability and achieving value for money. Our approach to future rounds will also be determined by factors such as emerging evidence on demand, our experiences from the preceding allocation rounds, and strategic decisions on the use of hydrogen across sectors.
- **CCUS Vision:** We will publish our CCUS Vision shortly, setting out how we reduce government's role in the CCUS market and transition towards a self-sustaining merchant market model, including its role in enabling low carbon hydrogen production.
- **Cluster Sequencing Process – Track-1:** We are now in negotiations to delivering first of a kind carbon capture projects in the UK. Our ambition remains to take Final Investment Decisions in 2024.

- **Providing new funding opportunities for CCUS-enabled hydrogen projects:** We will launch a process shortly to begin further expansion of Track-1 clusters, beyond the initial deployment, identifying and selecting projects to fill the available storage and network capacity anticipated to be available in and around 2030. We will set out the process by which capture projects for Track-2 will be selected to meet the stated ambitions in due course.
- **Launching the low carbon hydrogen certification scheme:** We plan to launch our certification scheme for hydrogen produced domestically from 2025.
- **Next steps for funding hydrogen:** Following the passage of the Energy Act, government intends to deliver a levy on gas shippers to fund HPBM payments and associated costs. We intend to consult on the design of the levy in 2024, and to implement the levy in 2026, subject to legislation being in place.

HAR1, NZHF & CCUS project updates December 2023

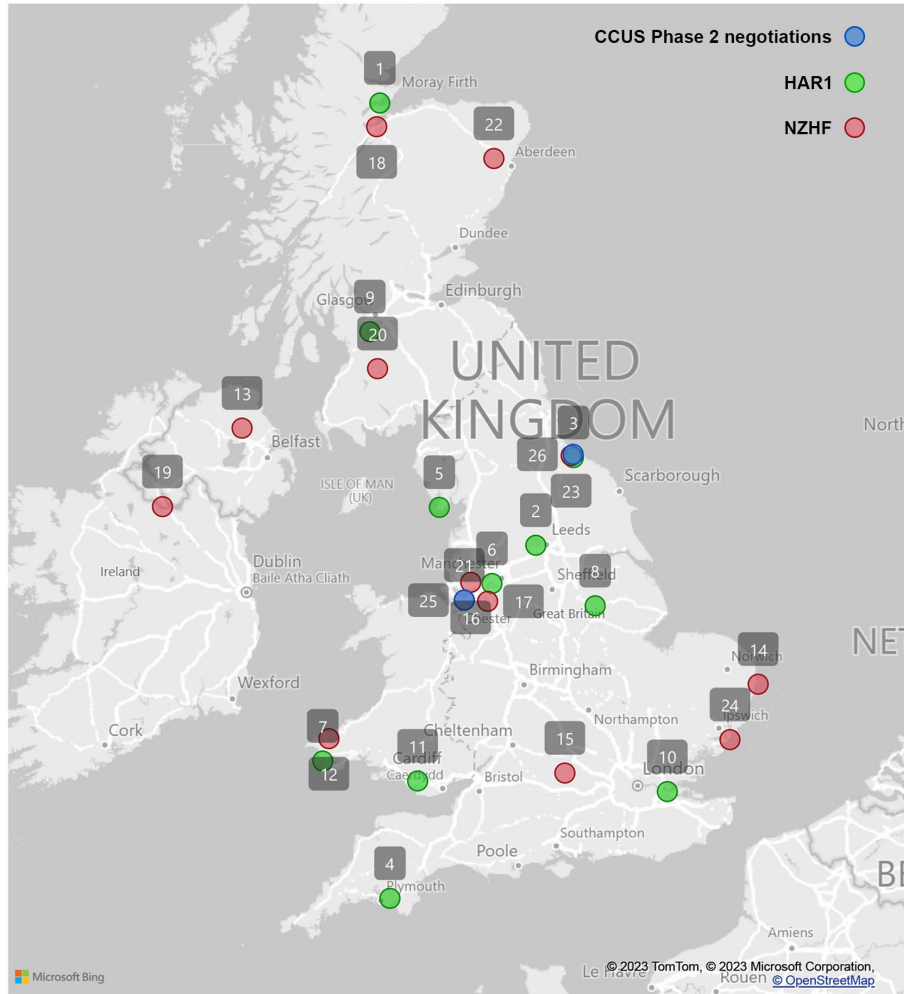


Figure 1: Successful projects through Strands 1 and 2 of the NZHF and HAR1 which have been announced as of December 2023, and the CCUS-enabled hydrogen projects in the latest stage of the Track-1 cluster sequencing process.

● HAR1	
1	Cromarty, Scottish Power and Storegga
2	Bradford Hydrogen, Hygen
3	Tees Green, EDF
4	Langage Green Hydrogen, Carlton Power
5	Barrow Green Hydrogen, Carlton Power
6	Trafford Green Hydrogen, Carlton Power
7	West Wales Hydrogen, H2 Energy and Trafigura
8	HyMarnham, JG Pears and GeoPura
9	Whitelee Green Hydrogen, Scottish Power
10	Green Hydrogen 3, HYRO
11	HyBont, Marubeni Europower

● NZHF	
12	Trecwn Green Energy Hub, Statkraft
13	Ballymena Hydrogen, Ballymena Hydrogen
14	Conrad Energy Hydrogen Lowestoft, Conrad Energy
15	Didcot Green Hydrogen Electrolyser, RWE
16	Green Hydrogen St Helens, Progressive Energy
17	Green Hydrogen Winnington and Middlewich, Progressive Energy
18	Inverness Green Hydrogen Hub, Getech
19	Mannok Green Hydrogen Valley, Mannok
20	Knockshinnoch Green Hydrogen Hub Project, Renantis
21	Hynet HPP2, Vertex
22	Kintore Hydrogen, Statera
23	H2 NorthEast, Kellas
24	Felixstowe Port Green Hydrogen, Scottish Power

● CCUS Phase 2 negotiations	
25	Hynet HPP1, Essar Energy Transition Hydrogen
26	bpH2Teesside, bp

Networks and storage

Funding hydrogen transport and storage

A UK hydrogen economy will require significant scale up of hydrogen T&S infrastructure to meet the varying needs of producers and end users. In August 2023, we set out our [minded-to position](#) that the Hydrogen Transport Business Model (HTBM) will be based on a Regulated Asset Base (RAB), with an External Subsidy Mechanism working alongside the RAB. For the Hydrogen Storage Business Model (HSBM) we intend to use private law contracts to deliver the business model, providing a “revenue floor” while also incentivising sales of storage. Our aim is that T&S business models will be designed by 2025.

For the HTBM, our minded-to position is for the initial focus to be on large-scale pipeline infrastructure to transport hydrogen as a gas. The HSBM will initially focus on supporting geological storage which can provide greater capacity at lower costs, but we are minded to keep the option open to support above-ground storage in certain instances. These business models will be aimed at addressing the costs and lengthy time scales to construct T&S infrastructure and the uncertain returns on investment associated with the early stages of market development.

We are developing these business models at pace as we see T&S as a critical dependency for new production projects and potential offtakers. The [Energy Act 2023](#) contains the legislative framework underpinning the delivery of the T&S business models, and alongside this update we have published market engagement documents for the [transport](#) and [storage](#) business models (see Box 2).

Box 2: Hydrogen T&S Business Model Market Engagement Documents

These documents focus on the development of the respective allocation processes and aim to provide confidence to industry as to the progress being made in their development. We intend to launch the first allocation rounds in 2024. The documents set out our ambition for the first allocation round of each business model and proposed assessment processes, including initial high-level proposals on eligibility and assessment criteria. We aim to set out further detail on application and assessment processes in Q2 2024.

We are also supporting early T&S infrastructure ahead of introducing the business models, as some small-scale infrastructure will be required sooner to strengthen the investment case and enable early electrolytic and CCUS-enabled hydrogen production projects to be delivered. We are providing funding for this via [Strand 1 of the NZHF](#), and T&S infrastructure is also eligible for support through the [HPBM](#) subject to necessity, affordability and value for money. [Successful HAR1 projects](#) announced today, subject to contract award include some early hydrogen transport infrastructure. Funding for limited T&S where it is linked to a hydrogen production facility may also be available through Track-1 of the Cluster Sequencing process.

We also continue to invest in research and development (R&D) in hydrogen infrastructure to further support its commercialisation and ‘investability’ in the UK. For example, EDF R&D UK has received funding through the [£69 million Long Duration Energy Storage competition](#) to demonstrate metal hydride storage to safely store large quantities of hydrogen for long periods.

Strategic planning for hydrogen transport and storage infrastructure

In August 2023, we set out the [minded to position](#) that in the short to medium term, the UK government, working closely with Ofgem and industry, should take a leading role in providing early strategic direction for the build out of hydrogen T&S infrastructure. For the longer term, we set out our position that the Future System Operator (FSO) should take on a central strategic planning role, within the statutory framework provided by the [Energy Act 2023](#). Our ambition, set out in the [Hydrogen T&S Networks Pathway](#), published alongside this document, is that the FSO formally takes on responsibilities for strategic planning for hydrogen T&S from 2026.

Prior to the FSO taking on these responsibilities, when undertaking hydrogen T&S planning, government will work closely with the FSO and draw on its expertise as the electricity and gas system planner. During this time, government and the FSO will work together to help ensure that the FSO is supported to best account for hydrogen in so far as is required to in meeting its obligations for electricity and natural gas.

Box 3: The FSO and long-term strategic planning for hydrogen T&S infrastructure

The Energy Act 2023 establishes a new, publicly owned FSO which, depending on a number of factors including discussing timelines with key parties, aims to be operational in 2024.

The FSO will hold key roles for electricity and gas networks and will take a whole energy system approach when operating, planning and developing these networks. The FSO will be independent – not only of other commercial energy interests, but also from the day-to-day operational control of government.

The government’s minded to position is that strategic planning for hydrogen T&S will not be a Day 1 activity for the FSO. However, from Day 1 the FSO will need to account for hydrogen production, transport, storage and use in power to the extent that it impacts the electricity and natural gas networks. Our ambition is that from 2026, the FSO will formally take on responsibility for strategic network planning for hydrogen T&S.

Details of the activities the FSO should take on for strategic planning for hydrogen T&S have not yet been determined, and government aims to consult on this by summer 2024. The 2026 ambition is therefore subject to progress being made on determining the scope of these activities, which will guide funding arrangements and any legislative and/or regulatory changes needed to enable this. The consultation could also help to ensure that the activities that the FSO takes on are aligned with its responsibilities for the other parts

of the energy system, including strategic planning for the electricity and natural gas systems.

Setting out a hydrogen T&S networks pathway

To provide the early strategic direction required for hydrogen T&S ahead of the FSO becoming fully operational, alongside this update we are publishing the [Hydrogen T&S Networks Pathway](#), which sets out government's current approach to strategic planning for hydrogen T&S infrastructure. A combination of central strategic system planning and market-led development will be required to deliver an efficient, coordinated build-out of T&S infrastructure and realise whole energy system benefits. This document details our strategic objectives for the development of T&S infrastructure and the variables across different hydrogen demand scenarios that have a significant impact on T&S infrastructure development. It sets out the existing evidence on near-term T&S network needs and sets the ambition for the first allocation round for each of the T&S business models.

The Pathway document includes consideration of hydrogen when assessing impacts across the whole energy system, which delivers on another recommendation made in the Independent Review of Net Zero. One lever we can use to create a framework for assessing whole energy impacts is the Strategy and Policy Statement for Energy, which we [recently consulted](#) on and sets out governments strategic priorities, policy outcomes and roles and responsibilities of those involved in implementing that policy. We can use this to set out roles for Ofgem, FSO, government and industry partners in addressing barriers to the near-term development of hydrogen infrastructure.

Box 4: Hydrogen T&S Networks Pathway

The document aims to set out a pathway for the development of hydrogen T&S infrastructure, to help ensure the right network is available to support the evolving hydrogen economy and whole energy system benefits. This first iteration of the T&S Networks Pathway sets out our ongoing process of strategic network planning and our early ambition for T&S infrastructure build out, including:

1. Our strategic objectives and a needs case for hydrogen T&S.
2. Our current understanding of where, when and for what purposes early demand for hydrogen is likely to materialise.
3. Updated illustrative demand scenarios for different hydrogen end uses: these hydrogen demand ranges are an update to those set out in the UK Hydrogen Strategy and reflect how our understanding of hydrogen demand continues to evolve.

4. Our ambition for the first T&S business models allocation rounds: to support up to two hydrogen storage projects and the associated pipeline infrastructure to be in operation or construction by 2030.

Recent developments: August to December 2023

- **T&S Networks Pathway:** We have published the first iteration of our [Hydrogen T&S Networks Pathway](#), alongside two market engagement documents for the Hydrogen [T&S](#) Business Models - see Boxes 2 and 4. We also set the ambition for the FSO to take on strategic planning for hydrogen T&S from 2026 – see Box 3.
- **Recommendations for hydrogen T&S infrastructure:** We have provided a [response](#) to the National Infrastructure Commission on their recommendations for hydrogen T&S infrastructure as set out in the 2023 National Infrastructure Assessment.
- **Offshore T&S infrastructure:** We published our government [response to the Offshore Hydrogen Regulation consultation](#) and subsequently laid a statutory instrument to bring new regulation into effect (see *Regulatory framework* section of this update for more information).
- **Energy Act 2023:** We have introduced primary legislative measures through the [Energy Act 2023](#) which will underpin the delivery of the hydrogen T&S business models.

Forward look

- **Strategic Planning for T&S Networks:** We intend to keep industry updated on government's approach to strategic planning for hydrogen T&S infrastructure. We intend to produce further analysis on T&S requirements in 2024, as evidence on the growth of hydrogen production and demand improves. We are aiming to provide updates on the emerging evidence of network needs in 2024. In 2024, government aims to consult on the scope of activities the FSO will conduct when it becomes responsible for strategic planning for hydrogen T&S.
- **Hydrogen T&S business models:** We plan to publish further detail on the allocation processes and assessment criteria for the first allocation rounds for the hydrogen transport and hydrogen storage business models in Q2 2024. This will take into account feedback from stakeholders on the Market Engagement documents and set out further information on the eligibility requirements and assessment criteria.
- **Gas flexibility Call for Evidence:** As announced in [autumn 2023](#), we aim to publish a Call for Evidence in the coming months to support policy development on the future role of flexibility in security of supply.
- **Market frameworks:** We intend to keep the existing market framework and industry commercial arrangements for hydrogen under review with a view to introducing timely amendments where warranted. This review will include ongoing work taking place

initially through the Hydrogen Delivery Council's transport and storage working group but will likely encompass further engagement with stakeholders, for example, via a call for evidence and/or consultation on more specific proposals in due course.

- **Regulatory frameworks:** We intend to continue to engage with industry and regulators to develop adequate regulation to support the deployment of hydrogen networks and storage. More information is in the *Regulatory framework* section of this update.

Use of hydrogen

We anticipate low carbon hydrogen will become increasingly used in the 2020s and 2030s to decarbonise industrial processes; to provide cleaner, homegrown power; as a feedstock or fuel for heavy transport applications including shipping and aviation; and potentially to heat homes. It can play a vital role in enabling these sectors to contribute to our aim to [have slashed emissions by 78% by 2035](#) in line with Carbon Budget Six, [decarbonise the UK power system by 2035](#), subject to security of supply, and [keep us on track towards delivering our legally binding target of net zero greenhouse emissions by 2050](#).

We have brought forward measures to stimulate demand for hydrogen across end use sectors which complement the funding we are providing via our hydrogen production and T&S business models. The UK's regulatory and policy framework is designed to support off-takers to invest and switch to hydrogen when commercial conditions are right. A comprehensive overview of the steps government is taking to promote demand for hydrogen across key sectors in the UK is set out below.

Industry

We see a significant role for hydrogen, alongside CCUS and electrification, to decarbonise industrial processes. Industrial users are expected to provide one of the largest new sources of demand for low carbon hydrogen. By 2030, UK industry could use an additional 12-19 TWh of hydrogen as an industrial fuel. Our ambition for 2035, set in the [Carbon Budget Delivery Plan](#) in March 2023, is for 50 TWh of industrial fuel switching to low carbon fuels, which we expect to be reached primarily via industry switching from fossil fuels to electricity and hydrogen.

Hydrogen provides a low carbon alternative to fossil fuels used in industrial heating, including for indirect applications such as steam boilers and Combined Heat and Power (CHP) systems, and direct heating processes, for example glass melting. Large industrial sites, which could represent demand anchors for hydrogen producers, could become early off-takers and support the creation of local hydrogen clusters by sharing the costs of accessing T&S infrastructure. We continue to engage with these types of sites to understand and manage any potential barriers to hydrogen fuel switching. We also continue to assess the interactions and impacts of other industrial decarbonisation schemes, such as the [UK Emissions Trading Scheme](#), on current and future industrial hydrogen producers and users.

Government is helping stimulate hydrogen demand in industrial sectors by funding innovation and deployment of hydrogen technologies across multiple applications. The [Industrial Energy Transformation Fund](#) (IETF) provides funding for industrial manufacturers seeking to deploy decarbonisation technologies, including providing study project support and upfront capital investment support for hydrogen offtakers to implement hydrogen fuel switching projects on their industrial sites. To date, the IETF has awarded up to £289 million of grant funding, including to hydrogen fuel switching projects. We expect the HPBM to increasingly make low carbon hydrogen a competitive option to decarbonise industrial sites, which we anticipate will enable increasing numbers of applications to the IETF for hydrogen projects. We have committed to a £185 million extension to the IETF, this includes £175 million of capital budget from the £6 billion announced at the [2022 Autumn Statement](#) to support the Department for Energy Security and Net Zero (DESNZ) to deliver energy efficiency objectives.

We continue to support innovation alongside funding for deployment. Six hydrogen projects have received a total of £19.7 million to produce physical demonstrations as part of Phase 2 of the [Industrial Fuel Switching competition](#), representing a third of the total funding available. The £13 million [Industrial Hydrogen Accelerator](#) is similarly bringing forward projects that demonstrate end-to-end industrial fuel switching to hydrogen. £10 million has also been provided to projects to carry out R&D for a variety of novel solutions to decarbonise the distilleries sector, with two hydrogen demonstrator projects being funded until March 2024.

We are working to use standards and regulations as another way to support hydrogen use in industrial manufacturing. We are sponsoring the British Standards Institution to develop a Publicly Available Specification (PAS) to support the standardisation of hydrogen-ready boiler equipment used in industrial settings. We have also sought evidence on how to support the [decarbonisation of CHP equipment](#) and on [hydrogen-ready industrial equipment](#). We are now considering policy options, including a potential carbon intensity criterion for CHP Quality Assurance accreditation, and will consult on proposals in due course. We are also assessing the merits of expanding decarbonisation readiness proposals for power generation (see details in the *Power* section below) to cover heat-only combustion plants, which are used in industry. This work may form the basis of a future consultation as we look to support industrial decarbonisation, including through hydrogen fuel switching.

Hydrogen is one of several decarbonisation options for non-road mobile machinery (NRMM). [NRMM generates around 2.7% of UK total emissions](#) and is used in sectors such as construction, mining and quarrying. We are working to prepare a legislative amendment to allow the road use of NRMM fuelled by hydrogen where that machinery would otherwise be allowed to be driven on the road if powered by conventional fuels.

We are also supporting hydrogen NRMM innovation and deployment. We have funded 18 hydrogen projects through Phase 1 and 2 of the £40 million [Red Diesel Replacement competition](#), which aims to demonstrate an end-to-end replacement of red diesel with low carbon alternatives. The IETF Autumn 2022 competition window expanded the competition scope to support projects that improve the energy efficiency and/or reduce emissions of NRMM in manufacturing, mining, quarrying, and waste processing sectors, including where it uses low carbon fuels such as hydrogen.

Power

The government is committed to [decarbonising the UK power system by 2035, subject to security of supply](#). We consider hydrogen to be a key component in supporting the delivery of this commitment, playing multiple roles in the power sector, including providing fuel for low carbon flexible generation technology (“hydrogen to power”) to help balance electricity supply and demand. Hydrogen to power also offers a clear decarbonisation pathway for existing unabated gas power plants. [Our analysis](#) shows that having hydrogen available in the power system could achieve lower emissions at a lower cost than scenarios without hydrogen. Long duration energy storage, supplied primarily by hydrogen, could provide [between £13 billion and £24 billion in savings to the electricity system](#) between 2030 and 2050. We therefore consider hydrogen to power will play an important strategic role in the UK’s future power system. In the [Hydrogen to Power Consultation](#), we outlined illustrative deployment ranges for hydrogen to power of between 5 and 12 GW of low carbon electricity generation capacity by 2035, rising to between 20 and 90 GW by 2050.

The existing energy markets will need to evolve to deliver our power sector decarbonisation commitments and integrate new low carbon technologies including hydrogen-fired power generation, whilst ensuring security of supply. We published our [follow up consultation and a call for evidence on the Capacity Market \(CM\)](#) in October 2023 to help drive forward our net zero goals and improve security of supply. Through the CM consultation, we are aiming to establish clear pathways for low carbon flexible technologies to access the CM, and for high carbon technologies to exit their long-term CM agreements early to facilitate decarbonisation. Our second REMA consultation will outline our proposals to secure investment in low carbon flexibility in the long-term. We also consulted on proposals for [updated Decarbonisation Readiness requirements](#) in March 2023. We are proposing that new build and substantially refurbishing combustion power plants are required to be built in such a way that they can easily decarbonise by converting to hydrogen-firing or retrofitting CCUS within the plant’s lifetime. We intend to publish our response in Q1 2024.

We see a key role for hydrogen in the future UK power system. We have engaged widely with stakeholders and commissioned research on the innovation needs and non-financial barriers to deploying of hydrogen to power. This work has informed our [hydrogen to power consultation](#), published alongside this document.

Box 5: Hydrogen to Power consultation

We are consulting on the need for and potential design of market intervention to support deployment of hydrogen to power. We commissioned [external research](#) which identified that first mover disadvantage and plant developers’ inability to effectively manage risk in enabling infrastructure is potentially reducing investment certainty in hydrogen to power. Government’s commissioned analysis indicates that market intervention could be necessary to mitigate these barriers and to support the accelerated deployment of hydrogen to power in order to support power sector decarbonisation and security of

supply. Our external analysis suggests that a variation of a Dispatchable Power Agreement-style mechanism, a “Hydrogen to Power Business Model (H2PBM)” could be suitable to mitigate the identified barriers to deployment and accelerate the deployment of hydrogen to power capacity. In the consultation, we also outline proposals for enabling hydrogen to power to participate in the CM as soon as practical to enable deployment pathways for a range of hydrogen to power plants.

Heat in buildings

Changing how we heat our buildings will be important to achieving net zero. The range of building stock, geographies and diversity of demand means one heating solution is unlikely to be suitable everywhere in the UK. Hydrogen could be a replacement heating fuel for some buildings currently heated by natural gas, providing an additional option to heat pumps and heat networks.

Government has committed to making strategic decisions on the role of hydrogen in heating in 2026. As 100% hydrogen heating is not yet a fully established technology, further work is required to understand the feasibility, costs and convenience of transporting 100% hydrogen in the existing gas grid and using hydrogen for heating and cooking. We are working with industry, regulators and others to deliver a range of research, development and testing projects to help establish the evidence required to inform strategic decisions.

We want to make any potential conversion to hydrogen heating in domestic settings as simple as possible, and we consulted in December 2022 on [the case for enabling, or requiring, new natural gas boilers to be easily convertible to use hydrogen \('hydrogen-ready'\)](#) by 2026. We are considering responses to this consultation and will respond in due course.

Together with Ofgem, we are supporting the gas network companies to undertake community trials of 100% hydrogen for heating to provide real-world evidence of the feasibility, cost, convenience and consumer acceptance of conversion. The preparation for the first of these, SGN's H100 trial in Fife, is well underway. This project will supply an expected 300 homes with electrolytic hydrogen through a new hydrogen network and is expected to be operational in the second half of 2024.

We also asked the gas distribution networks to develop proposals for a village-scale trial and, together with Ofgem, invited Cadent and NGN to undertake detailed design of their village trial proposals in May 2022. We confirmed in July that we would no longer be considering Cadent's proposal covering Whitby, Ellesmere Port. We have now decided not to proceed with the proposed trial in Redcar as designed, due to issues in obtaining a robust, local hydrogen supply. We continue to recognise the role that hydrogen could play in home heating and we will decide in 2026 whether, and if so how, hydrogen will contribute to household heat decarbonisation. This will be based on evidence from our wider research and development and testing programme, the H100 trial in Fife and similar trials in Europe.

To support work to accelerate analysis of potential heating options, including hydrogen, we will request the FSO's advice on the energy system impacts of different heat pathways in 2024. If the strategic decisions in 2026 conclude that hydrogen should have a role in heating, then we would also set out how that would be taken forward.

Transport

Across the [Hydrogen Strategy](#), [Transport Decarbonisation Plan](#), [Jet Zero Strategy](#) and other publications, government has set out how it expects the role of hydrogen in transport to expand during the 2020s and beyond as markets develop. This makes clear that hydrogen has an important role to play in decarbonising heavier transport applications such as aviation and shipping, and potentially some buses and Heavy Goods Vehicles (HGVs), thereby driving a significant proportion of hydrogen demand in the medium to long term. Programmes delivering and demonstrating hydrogen technologies are underway across transport modes, co-locating supply and demand to potentially address challenges including technology uncertainty, limited rollout of hydrogen infrastructure and the current higher cost of hydrogen vehicles and hydrogen production. This supports commercial readiness and real-world learning about the opportunities and barriers for any larger scale rollout.

Cross-modal

The Renewable Transport Fuel Obligations Order 2007 (as amended) ("the [RTFO](#)") imposes obligations that creates demand for low carbon fuels, including renewable hydrogen, and compensate for higher production costs compared to fossil fuels. In January 2022, the government expanded the scope of eligible fuels to include renewable fuels of non-biological origin including hydrogen, methanol and ammonia for use in maritime. In July 2023, the scope of fuels expanded again to include electrolytic hydrogen that blends both additional and non-additional renewable electricity. The Energy Act 2023 introduced powers to allow expansion in scope of the RTFO and forthcoming sustainable aviation fuels (SAF) mandate to support hydrogen made from nuclear energy as well as recycled carbon wastes from unrecyclable fossil wastes.

Aviation

Hydrogen is forecast to play an increasingly significant role in the decarbonisation of aviation, with 1-4 TWh by 2035.. The [Jet Zero Strategy](#) recognised the role that the direct use of hydrogen could play through providing 'Zero Emission Flight'. Since publication, industry has made progress in technology development, including Rolls Royce and Easyjet testing a hydrogen fuelled jet engine. We continue to support R&D through our [£685 million Aerospace Technology Institute Programme](#).

Beyond R&D we have been funding the scaling up of production of SAF, the production of which is often reliant on hydrogen. These drop-in fuels can be blended with fossil-based aviation fuels for use in existing aircraft and infrastructure without modification, offering the potential to deliver carbon savings. The £165 million [Advanced Fuels Fund \(AFF\)](#) will support our commitment to have at least five commercial-scale SAF plants in the UK by 2025. The first round of the AFF awarded five projects a share of £82.5 million and the winners of the second round of funding will be announced soon. Government is also creating demand by [introducing a SAF mandate in 2025](#), requiring at least 10% of jet fuel supplied to the UK to be made from sustainable sources by 2030. We ran a [second consultation on the SAF mandate](#) in 2023 and aim to publish a government response in early 2024 confirming the final design of the scheme. In September 2023, government committed to [design and implement a revenue certainty mechanism](#) to support a UK SAF industry as soon as possible. The mechanism will provide revenue certainty for SAF products, supporting investor confidence in SAF projects by providing greater certainty on potential returns on investment. The government has committed to publishing a consultation on the options for designing and implementing a mechanism within six months of the Energy Act 2023 being passed.

Maritime

Hydrogen-based and hydrogen derivative fuels are anticipated to play a key role in decarbonising the commercial maritime sector – the estimates presented in the [Hydrogen T&S Networks Pathway](#) suggest that the sector's demand for hydrogen could be up to 15-20 TWh by 2035. We recognise however that these estimates may be underestimating the hydrogen demand from maritime and we will publish updated estimates for domestic maritime in the next update of our Clean Maritime Plan in 2024. The [2019 Clean Maritime Plan](#) set out how we aim to decarbonise the sector through the uptake of zero and near zero GHG emission fuels, including hydrogen, and the 2024 refresh of the Plan will detail pathways to net zero and includes interim decarbonisation goals for the domestic maritime. The [Transport Decarbonisation Plan](#) committed to fund R&D in hydrogen maritime technologies, considered essential to decarbonise powertrains for commercial ships by the late 2020s. The first [Clean Maritime Demonstration Competition \(CMDC\)](#) in March 2021 provided over £23 million to R&D into zero emission shipping technologies and greener ports, with 17 of the 55 projects funded relating to hydrogen or hydrogen-derived fuels.

The £206 million [UK Shipping Office for Reducing Emissions \(UK SHORE\) programme](#) launched in March 2022, with the aim of accelerating the development of technologies necessary to decarbonise our maritime sector, including hydrogen and hydrogen-derived fuels, and is already delivering a wide range of interventions. These include the [second and third rounds of the CMDC](#), which have cumulatively allocated over £72 million to 50 projects across the UK to support feasibility studies and the development and demonstration of clean maritime solutions. 23 of these projects relate to hydrogen or hydrogen-derived fuels. The [fourth CMDC](#) will allocate another £34 million, with winners due to be announced in early 2024. The [£80 million Zero Emission Vessels and Infrastructure \(ZEVI\) competition](#), another UK SHORE intervention, is funding ten near-commercial clean maritime projects. UK SHORE is funding the

construction and set up of projects until March 2025, when the projects will then start a self-funded three-year demonstration period until March 2028. ZEV1 includes one hydrogen and one methanol project.

Road

There are now eight publicly accessible hydrogen refuelling stations in the UK, with four more planned, serving a current fleet of approximately 265 vehicles including buses, HGVs, vans and cars. The [£23 million Hydrogen for Transport Programme](#) (2017-2022) and our [£270 million Zero Emission Bus Regional Areas \(ZEBRA\) scheme](#) are two initiatives which have supported three new refuelling stations, upgraded two existing stations and supported the use of 182 fuel cell electric vehicles (179 cars, 3 buses) with 100 hydrogen fuel cell buses and accompanying refuelling infrastructure on the way.

The [Tees Valley Hydrogen Transport Hub](#) is deploying refuelling infrastructure and vehicles across Tees Valley to demonstrate the use of hydrogen across various transport modes. Projects will deploy hydrogen fuelled road vans and trucks, as well as offroad airside vehicles to demonstrate its benefits. The government remains technology neutral on which zero emission technology, or technology mix, will be best suited to decarbonise HGV operations. The government's [£200 million zero emission HGV and infrastructure demonstrators](#) will showcase hydrogen fuel cell and battery electric HGVs and install new refuelling stations, providing the road freight industry with the evidence needed to make investment decisions and have the confidence to transition to zero emissions technologies sooner.

Rail

Government is committed to supporting [the development of hydrogen trains](#). Since 2019, £12.5 million has been allocated to 33 First of a Kind projects helping to decarbonise the railway or reduce its harmful emissions, including [£750,000 for the UK's first hydrogen-ready passenger train](#), HydroFLEX, which was showcased at COP26 and Rail Live 2023. Research around feasibility and safety for the usage of hydrogen for rail continues.

Propulsion Technologies in the UK

We want hydrogen technologies to be manufactured in the UK, enabling investment and supporting UK exports. The Department for Business and Trade has enabled investment in hydrogen propulsion systems through the Advanced Propulsion Centre (APC) and the Aerospace Technology Institute (ATI), with the aim to establish the UK's design and manufacturing capabilities in these areas. In May 2023 [we announced £77 million to five projects developing clean hydrogen technologies for transport applications](#).

Blending

The UK Hydrogen Strategy set out that blending could bring potential market-building benefits for the early hydrogen economy. This could potentially address volume risk for early hydrogen producers and help bring forward investment.

HyDeploy and FutureGrid are leading safety trials and demonstrations to examine the potential for hydrogen blending into the GB gas distribution networks and gas transmission system. Government has been working closely with Ofgem, the Health and Safety Executive, the Devolved Administrations, the gas networks and wider industry to assess whether hydrogen blending meets the required safety standards, is technically feasible and provides strategic and economic value. We announced in September 2023 that we would make safety and strategic policy decisions on blending of up to 20% hydrogen by volume into GB gas distribution networks separately, with the aim to give greater certainty to networks, hydrogen producers and investors. This included announcing our aim to reach a strategic policy decision in 2023.

We published a [consultation on hydrogen blending](#) in September, which sought to further understand the potential strategic and economic value of blending and set out our assessment of aspects of the commercial, market, technical and billing arrangements that could accommodate blending, should blending be enabled by government. We have now announced our [positive strategic policy decision on hydrogen blending into GB gas distribution networks](#) together with our response to the consultation alongside this document.

Box 6: Strategic policy decision on hydrogen blending into GB gas distribution networks

We recently consulted on blending to build the evidence base to determine whether blending offers sufficient strategic and economic value to be supported by government, subject to the outcome of the review of blending safety evidence. Following this consultation, and published alongside our [consultation response](#), we have made a strategic policy decision to support blending of up to 20% hydrogen by volume into the GB gas distribution networks.

We believe the most appropriate strategic role for blending, if supported and enabled, would be to act as an offtaker of last resort to support hydrogen economy growth, whilst ensuring it does not 'crowd out' the supply of hydrogen to alternative end users who require it to decarbonise. Additionally, it may have value as a potential strategic enabler for certain electrolytic hydrogen projects to support the wider energy system.

Recent developments: August to December 2023

- **End-to-end hydrogen innovation funding:** The [Industrial Hydrogen Accelerator](#) programme awarded Stream 2B funding for innovation projects that can demonstrate end-to-end industrial fuel switching to hydrogen in September 2023. This were a project

on steel and a project supporting decarbonisation of the asphalt and cement production industry.

- **Red Diesel Replacement funding:** In September 2023, the [Red Diesel Replacement programme](#) awarded phase 2 demonstration support to six projects (five using hydrogen).
- **Hydrogen to Power Market Intervention:** Alongside this update, we have published our [consultation](#) seeking feedback on our minded to position that market intervention could be required to support hydrogen to power deployment. We outline a proposed business model design based on elements of the Dispatchable Power Agreement (DPA), designed for CCUS, but adapted for H2P needs. We also seek feedback on proposals to enable H2P to compete in the Capacity Market as soon as practical.
- **Decarbonisation Readiness:** We intend to publish the response to our [March 2023 consultation on Decarbonisation Readiness requirements](#) and any required legislative changes in Q1 2024. The proposals would require new build and substantially refurbishing combustion power plants to be built in such a way that they can easily convert to 100% hydrogen firing or retrofit CCUS within the plant's lifetime.
- **Strategic Heat Decisions:** The Government responded to the [Climate Change Committee's latest annual report in October 2023](#), which included the recommendation to narrow down the options for hydrogen heating ahead of decisions in 2026 to reduce uncertainty around heat decarbonisation plans. The response set out that heat pumps will play a major role in all 2050 scenarios, including those where hydrogen is used for heating and re-affirmed that there will be properties where hydrogen will never be a realistic option, such as those not on the existing gas grid. Additionally, the response outlined that from 2025 the Future Homes Standard (FHS) will ensure new homes are built with low carbon heating with the expectation that heat pumps will become the primary heating technologies for new homes with heat networks also playing a role. The response committed to accelerating work to analyse the costs and benefits of heat pathways and once established, requesting the FSO advise government on the energy system impacts of heat decarbonisation pathways.
- **Zero Emission HGV demonstrations:** We announced the [four winning projects for our zero emission HGV and infrastructure competition in October 2023](#), demonstrating zero emission HGV technologies at scale on UK roads. Up to 60 hydrogen fuel cell HGVs will be demonstrated, as well as seven refuelling sites.
- **Zero Emission HGV and coach infrastructure requirements:** We opened a [call for evidence on zero emission HGV and coach infrastructure requirements](#) in October 2023. Evidence will support development of a zero emission HGV infrastructure strategy, due for publication in 2024.
- **Investment opportunity in UK manufacturing of hydrogen propulsion systems:** The [Advanced Manufacturing Plan](#) announced a taskforce in November 2023 to make recommendations on how to maximise the investment opportunity for the UK manufacturing of hydrogen propulsion systems. This taskforce will enable government to develop a comprehensive investment proposition considering our manufacturing

industry's strengths, the commercial potential of different hydrogen propulsion systems, and the shape of their market demand by 2050.

- **Blending consultation:** In September 2023 we published a [consultation on Hydrogen Blending into GB Gas Distribution Networks](#).
- **Strategic blending policy decision:** Alongside the response to the consultation, we have issued a [strategic policy decision](#) to support blending of up to 20% hydrogen into GB gas distribution networks.

Forward look

- **Hydrogen-ready industrial boilers:** The British Standards Institute (BSI) has begun the development process for the PAS on hydrogen-ready industrial-sized boiler equipment, which is expected to take 12-15 months. We anticipate this will help standardise what constitutes a hydrogen-ready industrial boiler, giving confidence to end-users that this equipment can help facilitate fuel switching to hydrogen.
- **NRMM decarbonisation strategy:** In the [Net Zero Growth Plan](#) government announced its intention to publish an NRMM decarbonisation strategy following a Call for Evidence on NRMM decarbonisation options. More details on the Strategy and the Call for Evidence will be provided in due course.
- **Road use of NRMM fuelled by hydrogen:** We are preparing legislation to allow the road use of NRMM fuelled by hydrogen where that machinery would otherwise be allowed to be driven on the road if powered by conventional fuels. This will enable, for instance, the movement of hydrogen NRMM, such as diggers, for short distances between construction sites. We plan to consult on the draft legislative text in 2024.
- **Phase 3 of the IETF:** Following the announcement of a £185 million extension in the government's Powering Up Britain plan, [Phase 3 of the IETF](#) will open for new applications in January 2024, supporting industry to cut energy bills and carbon emissions through investing in energy efficiency and low carbon technologies such as hydrogen fuel switching projects.
- **Potential future H2P market intervention:** We intend to publish a response to our hydrogen to [power consultation](#) in Q2 2024.
- **Review of Electricity Market Arrangements:** We will publish the second REMA consultation in early 2024. The upcoming second REMA consultation will set out clear direction of travel on electricity market reform, including long-term support for low carbon flexibility.
- **Starting a neighbourhood trial:** To begin generating evidence including on the feasibility, cost-effectiveness and consumer experience of using hydrogen in homes, the H100 hydrogen heating trial, delivered by SGN, is due to start in late 2024.
- **Funding for hydrogen in maritime:** Winners of [CMDC4](#) will be announced in early 2024. This competition will allocate £34 million to support clean maritime technologies.

- **Updated Clean Maritime Plan:** We will publish an update to our Clean Maritime Plan in early 2024, which includes interim goals for the domestic maritime sector ahead of 2050 and a commitment on how we can increase the use of zero and near zero GHG emission in maritime.
- **Promoting the use of SAF:** Government will consult on a SAF revenue certainty mechanism in early 2024 to deliver the SAF mandate for the beginning of 2025.
- **Publication of the Low Carbon Fuels Strategy:** The Strategy will support investment by setting out a vision for the deployment of low carbon fuels across transport modes up to 2050. We intend to publish the Strategy in early 2024.
- **Infrastructure strategy to support HGV and coach decarbonisation:** The strategy will set strategic direction and outline the roles and responsibilities of government and industry in the rollout of future infrastructure. We intend to publish the Strategy in 2024.
- **Zero Emission Buses:** We will make announcements on future funding for zero emission buses (ZEBs) and end of sales dates for new non-ZEBs in due course.
- **Tees Valley Hydrogen Transport Hub:** The Hub will be operational from October 2024 and we will leverage its activity to attract private investment into the region's hydrogen economy.
- **Safety case for blending:** A decision on whether to enable blending into GB gas distribution networks will be informed by the positive strategic decision and will also be subject to the gathering, submission and review of blending safety evidence. This will help determine whether any legislative amendments need to be made, such as to the Gas Safety (Management) Regulations 1996 (GS(M)R), to enable blending at scale. We will work closely with industry and the Health and Safety Executive (HSE) to ensure that safety evidence is gathered and then independently and robustly assessed.
- **Economic assessment of blending:** Outcomes from the broader safety review may have implications for the economic assessment and realisation of strategic benefits which we have set out as part of the strategic policy decision, especially if certain restrictions or conditions are required to ensure that blending is safe. Following completion of the safety review, we also plan to review the strategic policy decision on whether to support blending into the GB gas distribution networks to ensure that any implications on blending's feasibility and economic assessment are accounted for.
- **Commercial support for blending:** Further work is also required on the detailed commercial design and allocation of support made available for blended volumes of hydrogen. We will aim to continue to engage with stakeholders on the design of commercial support for blending as we develop further thinking and policy positions in these areas (such as via working groups and bilateral engagement).

Creating a market

Since publication of the [UK Hydrogen Strategy](#), we have provided substantial funding across the hydrogen value chain, supporting innovation and early deployment to start the scale up of the UK hydrogen economy and our domestic hydrogen market. Table 1 below sets out funding available and already allocated across the UK hydrogen economy through our programmes. In addition to the funding set out in Table 1 (pages 37-39), UK Research and Innovation (UKRI) has played a significant role in funding hydrogen research and innovation across technology readiness levels (see the *Research and innovation* section of this update). The Devolved Administrations also provide separate funding, such as Scottish Government's Emerging Energy Technologies Fund, which is running in parallel with the NZHF and has up to £100 million available to support hydrogen projects.

Table 1: Summary of UK government funding for hydrogen since the publication of the Hydrogen Strategy.

Fund/competition	Capex ¹	Devex ²	Opex ³	Funding allocated/available through policy/competition	Status
Production					
Net Zero Hydrogen Fund	X	X		£37.9 million allocated; £240 million total funding available	Ongoing to March 2025
Hydrogen Allocation Rounds/ Hydrogen Production Business Model			X	Funding available across lifetime of contracts dependent on negotiations with individual projects	Successful HAR1 projects announced See Hydrogen Economy Roadmap for timelines of future HARs and cluster sequencing process
NZIP Low Carbon Hydrogen Supply 2 competition	X	X		£62 million allocated	Ongoing, running to March 2025
NZIP Direct Air Capture and Greenhouse Gas removal programme	X	X		£10 million; hydrogen spend only	Ongoing, running to March 2025
NZIP Hydrogen BECCS Innovation programme	X	X		£31 million allocated	Ongoing, running to March 2025
Networks and storage					

¹ Capex – Capital expenditure

² Devex – Development expenditure

³ Opex – Operating expenditure

Hydrogen Strategy Delivery Update

Fund/competition	Capex ¹	Devex ²	Opex ³	Funding allocated/available through policy/competition	Status
NZIP Longer Duration Energy Storage competition	X	X		£9 million; hydrogen spend only	Ongoing, running to March 2025
Use of hydrogen					
Industrial Energy Transformation Fund	X	X		£289 million available across all technologies, plus potentially another £185 million	Ongoing, Phase 3 running to 2028 subject to business case approval
NZIP Red Diesel Replacement competition		X		£26 million; hydrogen spend only	Ongoing, running to March 2025
NZIP Industrial Hydrogen Accelerator	X	X		£13 million allocated	Ongoing, running to March 2025
NZIP Industrial Fuel Switching 2 competition	X	X		£23 million; hydrogen spend only	Ongoing, running to March 2025
NZIP Green Distilleries competition	X	X		£6 million; hydrogen spend only	Ongoing, running to September 2024
Local Industrial Decarbonisation Plans competition		X		£5 million available	Ongoing, completing in December 2024
Clean Maritime Demonstration Competition (CMDc) Rounds 1-4		X		Rounds 1-3: £95million allocated Round 4: £34 million available	Rounds 1 and 2 completed, Rounds 3 and 4 running to March 2025

Hydrogen Strategy Delivery Update

Fund/competition	Capex ¹	Devex ²	Opex ³	Funding allocated/available through policy/competition	Status
Zero emission HGV and infrastructure demonstrators	X	X		Up to £85 million allocated for hydrogen HGVs/infrastructure; £140 million available	Ongoing, running to 2030
Advanced Fuels Fund		X		£135 million allocated	Ongoing, running to March 2025
APC's collaborative R&D competition – Round 22		X		£77.1 million joint government and industry funding allocated	Ongoing, running to late 2026
Zero Emission Vessels and Infrastructure (ZEVI) competition	X	X		£80 million available	Ongoing, running to March 2028
Tees Valley Hydrogen Transport Hub Fund		X		Phase 1: £2.6 million allocated Phase 2: up to £15 million available	Ongoing, running to March 2025
Zero Emission Flight Infrastructure Project	X			£4.2 million allocated	Completed March 2023

Regulatory framework

To support the growth of the UK's hydrogen economy, it is crucial to establish and assess the suitability of regulatory signals, such as standards, safety and purity, and planning and permitting regimes.

We established the Hydrogen Regulators Forum in 2021 to create a common understanding of how current non-economic regulation applies across the hydrogen value chain and where there are gaps or potential changes needed. The Forum supports knowledge-sharing and coordination among regulators to collaborate on ongoing and emerging regulatory challenges, including planning, environment, and health and safety regulation, and standards. Recent publications that have been informed by the Forum include:

- Guidance on environmental regulation in relation to [CCUS-enabled hydrogen production](#), with plans to provide similar guidance on electrolytic hydrogen.
- Draft revisions to the [Energy National Policy Statements](#) to provide more guidance and weight towards hydrogen projects in the Nationally Significant Infrastructure Project planning process.
- [Hydrogen Transport and Storage Infrastructure consultation response](#), that identified hydrogen networks can be delivered to an extent through existing regulatory and legal frameworks but noted that new rules and regulations may be needed to facilitate the expansion of the hydrogen economy.

Recent developments: August to December 2023

- **Offshore Hydrogen Regulation consultation:** In September we published our response to the [Offshore Hydrogen Regulation consultation](#), and subsequently laid a statutory instrument to bring new regulation into effect on 27 September. This regulation will be part of an initial framework to facilitate hydrogen trade via pipelines.
- **Hydrogen planning:** Completed the [Hydrogen Planning Barriers research project](#) with Verian (formally Kantar Public) to identify regulatory planning challenges for hydrogen projects. The report, published in December 2023, noted areas of valuable government action to support the existing planning process, and highlights ideas for innovative planning policy to support hydrogen projects in the future.

Forward look

- **Enabling first-of-a-kind offshore hydrogen production trials:** We are coordinating with project developers, relevant UK regulators and devolved administrations to enable first-of-a-kind hydrogen demonstration trials in Scottish waters. It is intended this will also identify learnings from regulatory issues experienced by early UK hydrogen projects to inform ongoing work on future regulatory design.

- **Continued engagement on non-economic regulation:** Government will continue working closely with industry, regulatory bodies and devolved administrations, including through the Hydrogen Regulators Forum, to consider the suitability of existing regulatory frameworks for hydrogen, with a view to introducing timely amendments where they are needed.

Economic benefits to the UK: supply chains, jobs, skills and investment

With development of the global hydrogen economy accelerating, we published a [Hydrogen Sector Development Action Plan](#) in July 2022, outlining our approach to seizing the economic opportunities of the developing UK hydrogen sector, including supply chains, jobs, skills and investment. We set out how UK hydrogen projects are bankable and investable propositions, complemented by a [Hydrogen Investor Roadmap](#) (updated in April 2023).

On 17 November, the Chancellor announced a [£960 million Green Industries Growth Accelerator](#) (GIGA) fund to support the expansion of strong, clean energy supply chains across the UK, including hydrogen, CCUS, electricity networks, nuclear and offshore wind. This will enable the UK to seize the significant growth opportunities presented by our transition to Net Zero.

Box 7: Green Industries Growth Accelerator

Announced on 17 November 2023, GIGA is a £960 million package which will bolster UK manufacturing capacity and strengthen supply chains in high opportunity sectors like low carbon hydrogen, CCUS, electricity networks, nuclear and offshore wind. Boosting the scale of our domestic hydrogen manufacturing base to supply both UK and export markets can bring greater economies of scale, potentially bringing down the cost of hydrogen technologies for all, including UK consumers. We will work with industry to carry out market engagement and develop an appropriate delivery mechanism that will maximise the economic opportunity for the UK, support key strategic elements of the supply chain, and sustain good quality jobs across our industrial heartlands.

We also need to leverage UK industry's collective expertise and commitment to realise domestic supply chain capabilities, strengths and requirements. Alongside the Action Plan in July 2022, we published the [first study into hydrogen supply chains](#). Over the last six months [Hydrogen UK](#) has been leading work, overseen by the Hydrogen Delivery Council's jobs, skills and supply chains working group, to build on this and identify high value opportunities and areas of future potential in the UK supply chain. We are grateful for industry's leadership, and welcome the initial analysis and outline voluntary commitments to UK content they are setting out. The second phase of this work will continue into 2024.

A growing number of skilled workers will be needed to deliver hydrogen projects across the UK. The UK government is part of the [Hydrogen Skills Alliance](#) (HSA), a collaboration between Cogent Skills and the High Value Manufacturing Catapult that is committed to building a skilled workforce for the UK hydrogen sector. Over the last six months, the HSA has been carrying out forward assessments of workforce and skills requirements. We are grateful to the HSA for leading this work which will also be used to inform hydrogen's role as part of the Green Jobs Plan. This cross sectoral plan, [announced in March 2023](#) and which will be published in the first half of 2024, involves collaboration between government, industry and skills providers and will be an action plan to deliver a skilled and sufficiently sized workforce. A key priority in 2024 will be the development of a Hydrogen Skills Strategy, in collaboration with the HSA and the Hydrogen Delivery Council's jobs, skills and supply chains working group.

As the global hydrogen economy accelerates, we are continuing to showcase UK capabilities and highlight investment possibilities in the UK. British embassies and consulates are actively promoting the UK to companies and government overseas, including at major trade shows, as we see direct industry engagement as a key avenue for stimulating inward investment to the UK and realising export potential. Beyond publicising the UK's hydrogen offer, we are also scoping potential opportunities for UK supply chains as international markets make progress against their own deployment plans. We are supporting UK Export Finance (UKEF) in their work to connect UK exporters with international hydrogen opportunities and are already supporting multimillion pound inward investment to UK supply chains. In June 2023, [UKEF announced a £50 million Export Development Guarantee](#) for Northern Ireland-based firm Wrightbus to boost its exports of hydrogen-powered buses. UKEF is also supporting homegrown research and development in hydrogen technologies, having [underwritten a £400 million loan to global multinational Johnson Matthey](#).

Box 8: Hydrogen Delivery Council

The Hydrogen Delivery Council comprises C-suite stakeholders across the hydrogen value chain and is the primary forum for government and industry to work together to meet the UK's hydrogen ambitions. It is currently co-chaired by Lord Callanan, Parliamentary Under Secretary of State, and Secretary of State, Claire Coutinho, who work closely with Jane Toogood as Council CEO. The Council is focussed on activity required across the 2020s and 2030s to expand the UK low carbon hydrogen economy, including guiding the implementation of the ambitions set out in the UK Hydrogen Strategy (2021) and the subsequent British Energy Security Strategy (2022).

In Spring 2023, the Council underwent a 're-set' to focus on driving forward delivery of the first hydrogen projects in the UK, and key near-term milestones set out in the British Energy Security Strategy and Powering Up Britain Plans. This has involved an overhaul of its membership and development of a two-year delivery work plan to 2025 driven forward by six industry working groups which report to the Council: Hydrogen Production; Hydrogen Transport & Storage Infrastructure; Demand & End Uses; Low Carbon Hydrogen Standard & Certification; Jobs, Skills & Supply Chains; and Regulators' Forum.

Over the course of this year we have held regular investor roundtables, hosted by our Ministers and the former UK Hydrogen Champion Jane Toogood, to take stock of our policy development and understand potential obstacles and opportunities to crowd in the [£11 billion of private investment needed](#) to meet our deployment ambitions for 2030 and beyond. In July 2022, we held a UK Hydrogen Investor Forum to showcase the strength of the UK investment environment for the hydrogen sector, improve understanding of our developing policy framework and foster connections between investors and industry. We are holding the second Hydrogen Investor Forum in early 2024.

We have also been working closely with the UK Infrastructure Bank (UKIB), a UK government owned policy bank with a mission to partner with the private and public sector to increase infrastructure investment across the UK. In September 2023, the bank [published a series of strategy updates](#) on how it will tackle financing problems in different sectors, including hydrogen, over the next 12-24 months and help amplify government policy. UKIB wants to help lead the market in overcoming barriers to investment that the markets on their own are unable to solve.

Recent developments: August to December 2023

- **Green Industries Growth Accelerator:** We announced that supply chains for the hydrogen economy form one of the strategic sectors of [the government's £960 million Green Industries Growth Accelerator](#).
- **Hydrogen Supply Chain Strategy:** We have worked with Hydrogen UK to develop Phase 1 of the Hydrogen Supply Chain Strategy, with an interim report and outline voluntary industry ambition published in December 2023.

Forward look

- **Green Industries Growth Accelerator:** In the first half of 2024 we aim to set out more information on how funding under GIGA will be deployed, and conduct market engagement to inform our approach to allocating funding.
- **Hydrogen supply chains:** Hydrogen UK will continue to lead the next phase of the Hydrogen Supply Chain Strategy in 2024. Further to Phase 1, this will include detail on monitoring and evaluation, and longer-term opportunities for growing the hydrogen supply chain.
- **Hydrogen-relevant skills:** We are working with the Hydrogen Energy Association to explore the potential to develop a new initiative to support early years/transitioning professionals in the hydrogen sector, similar to the CCUS Kickstarter programme. The aim would be to facilitate networking and knowledge access and sharing.
- **Hydrogen skills:** We intend to work through existing bodies, such as the Green Jobs Delivery Group and HSA, to ensure the hydrogen sector benefits from those with skills applicable to a range of net zero applications.

- **Green Jobs Plan in 2024:** This will outline the headline actions and solutions for government and industries that deliver the skills needed within the UK workforce to deliver net zero, including in hydrogen sectors.
- **Visibility of investment and partnership opportunities:** We plan to continue to publish regular updates to the UK Hydrogen Investor Roadmap and hold further events to showcase the UK project pipeline and investment opportunities. We also are developing an interactive matchmaking tool to support collaboration across the hydrogen value chain.
- **A second Hydrogen Investor Forum**, to be held in early 2024.
- **Testing the investment proposition of the UK hydrogen economy:** We intend to hold further roundtable events with investors and industry to test the ‘investability’ of our evolving policy framework and ensure we remain competitive internationally.
- **Freeports:** We will work to ensure that investors into the emerging low carbon hydrogen economy are aware of the benefits of freeports, including those looking to invest in the supply chain as well as along the value chain from production to demand.
- **Export of hydrogen technologies:** We plan to continue working within government to ensure the UK’s hydrogen interests are reflected in relevant trade negotiations and identify where government can facilitate trade of hydrogen and hydrogen-related goods and services.

Research and innovation

Many of the hydrogen technologies that will help to deliver the UK’s net zero ambitions still need to be demonstrated and commercialised at scale. We want to maximise the impact of R&I spending to support our net zero ambitions, enhancing the ability of the UK’s innovators, world-leading universities, small and medium-sized enterprises and established industrial players to commercialise the technology they develop in the UK and crowd in private investment to improve, iterate and conceive the next generation of technology. We will need to take a whole system approach to enable deployment and integration of hydrogen technologies.

To achieve our goals, we opened a sizeable share of the opportunities in our commercialisation-focussed £1 billion [Net Zero Innovation Portfolio](#) (NZIP) to hydrogen technology developers and, to date, have allocated over £170 million to hydrogen innovation projects. Many of these competitions are detailed elsewhere in this update, including the £60 million [Low Carbon Hydrogen Supply 2 competition](#). We are delivering expert support to help exciting demonstration projects in varied technologies across all aspects of the value chain to progress, with many now constructing advanced prototypes. By offering initial support for feasibility projects across several competitions and acceleration support for SME-led projects, we helped a wider range of innovators to secure significant demonstration funding awards and to use these to take their ideas and businesses to the next level.

We have already used the learning and feedback from supported innovation projects to inform our policy and regulatory frameworks. Projects delivered through the [Low Carbon Hydrogen](#)

[Supply 2 competition](#) identified a regulatory gap that we addressed through our [Offshore Hydrogen Regulation consultation](#) and subsequent legislative changes in September 2023. This can now potentially accelerate deployment of future offshore hydrogen T&S infrastructure projects.

Alongside policy development, we are continuing to invest in R&I to understand and identify the barriers and opportunities to integrating the hydrogen economy with our existing infrastructure. UKRI's Engineering and Physical Sciences Research Council (EPSRC) [invested £20 million in June 2023 in two hydrogen research hubs](#) that deliver options to integrate low carbon hydrogen into the domestic, industrial and transport energy systems.

UK government funding and private investment in hydrogen R&I is essential to help UK businesses compete internationally. We published a [brochure in July 2022](#) setting out which organisations fund different aspects of the hydrogen R&I ecosystem (see Figure 2 on page 47) as well as the [Net Zero R&I Framework Delivery Plan](#) to outline the Government's £4.2 billion investment in net zero R&D programmes for the current Spending Review period 2022-25.

We are also facilitating collaboration with industry through the [Clean Hydrogen Innovation Programme \(CHIP\)](#). Led by the Carbon Trust and supported by DESNZ, CHIP has produced a hydrogen [Innovation Needs Assessment](#) to systematically assess where innovation investment is likely best targeted across supply chain technologies. Carbon Trust will run open calls for projects targeting specific innovation needs which can deliver meaningful results within 1-2 years.

Research is a collaborative undertaking, and we have and continue to engage actively with global partners to share our research and learn from others. Domestically, we continue to share the reports of funded projects online and through specific showcase events as well as providing platforms for collaboration between R&I projects in relation to hydrogen end users and supply chains. Over 300 companies are now signed up to Innovate UK Knowledge Transfer Network [Supply Chain Directory](#).

Recent developments: August to December 2023

- **International hydrogen partnership:** Through an international programme between the UK, US, Canada and Australia, [UKRI invested £5 million in the Global Hydrogen Production Technologies Centre](#). This partnership aims to de-risk cost reduction and scale-up challenges associated with hydrogen production, with the UK consortia led by Cranfield University.
- **R&D in supply chains:** Innovate UK invested £4.2 million across eight projects in September 2023 in a [hydrogen storage and distribution supply chains collaborative R&D competition](#).
- **Future skills requirements:** Innovate UK invested £100,000 into hydrogen skills foresighting analysis, looking to identify the right education and learning that will be needed to meet the requirements of the sector going forward.

- **Hydrogen Innovation Initiative:** Innovate UK invested £6 million in the [Hydrogen Innovation Initiative \(Hii\)](#) Seed Programme, a strategic collaboration with partners including the Catapult Network, National Physical Laboratory, Net Zero Technology Centre, Advanced Propulsion Centre and the Aerospace Technology Institute.
- **Business Innovation Programme:** Innovate UK delivered a Global Business Innovation Programme to Australia, with 12 businesses learning about and building relationships within the Australian market. The programme was delivered as a pre-cursor to a [£5 million bilateral hydrogen collaborative R&D competition with Australia](#), launched in December 2023.
- [Ofgem's Strategic Innovation Fund \(SIF\)](#) delivered by Innovate UK with Ofgem, has:
 - invested £49 million in national demonstration projects for transporting hydrogen and mixed gases safely and reliably in the GB gas network pipeline.
 - invested £550,000 in feasibility studies across a range of hydrogen innovations including freshwater reduction and efficiency improvement in electrolysis, strengthening supply chains, and unlocking system flexibility.
 - launched a dedicated challenge as part of SIF Round 3 for innovations to support power-to-gas to provide system flexibility and energy network optimisation.















Forward look

- **Future innovation investment:** There continues to be a strong case for UK Government investment in clean energy innovation, and priority topics are mapped in the [Net Zero R&I Framework](#). Besides hydrogen electrolysers, which the IEA identifies as one of the world's key innovation opportunities, R&I needs include: demonstrating longer distance hydrogen transmission, modelling the needs of hydrogen grid transmission, enabling efficient use of short and longer-term hydrogen storage options, and demonstrating large, centralised hydrogen fuelled power generation. We are in the process of updating the [Energy Innovation Needs Assessments](#) and this will form an important piece of analysis to prioritise innovation investment over the coming years, including in hydrogen.
- **Outcomes of existing hydrogen innovation investment:** The two hydrogen research hubs funded by EPSRC ([HI-ACT](#) and [UK-HyRES](#)) have started to reach UK academic researchers across many world-renowned research groups. Similarly, in the next year, testing phases for NZIP demonstration projects will start to generate results in advance of fuller final reporting. The Hii is also working across industry to develop a Hydrogen Technology Strategy to be published in early 2024.
- **Bringing hydrogen innovators together to drive collaboration:** The UKRI Knowledge Transfer Network will continue to be updated, advertise opportunities from key funders and highlight research areas that need further exploration. A number of knowledge exchange events are also planned in 2024 under the £2.7 million [Environmental Response to Hydrogen Emissions research programme](#).

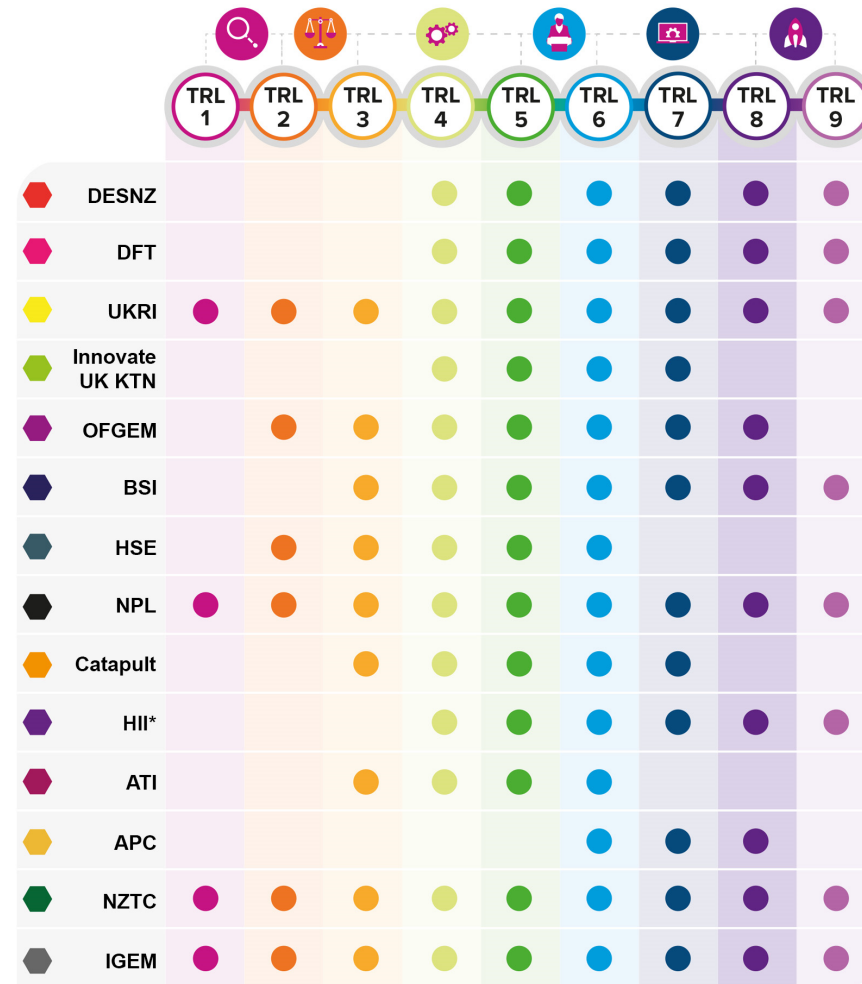
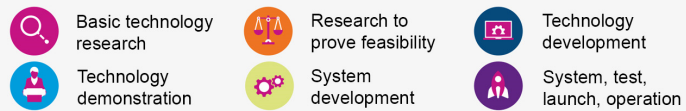
Public Sector Hydrogen Research and Innovation

Figure 2: Infographic visualising the hydrogen R&I ecosystem, showing where public sector organisations with major funding and support for UK hydrogen R&I sit in relation to the support they can offer across Technology Readiness Levels (TRLs). Adapted from the UK public sector support for hydrogen research and innovation brochure, published in July 2022.

Key Stakeholders - UK

 Department for Energy Security and Net Zero	 National Physical Laboratory
 Department for Transport	 Catapult Network
 UK Research and Innovation	 Hydrogen Innovation Initiative
 Innovate UK Knowledge Transfer Network	 Aerospace Technology Institute
 Office of Gas and Electricity Markets	 Advanced Propulsion Centre
 British Standards Institution	 Net Zero Technology Centre
 Health and Safety Executive	 Institution of Gas Engineers and Managers
----- R&I feedback loops	

Research and Innovation Key



*HII is a collaborative initiative bringing together hydrogen activity across The Catapult Network, NPL, APC, ATI, NZTC and other partners.

International trade in hydrogen

We want to play a key role in exporting high grade hydrogen from across the UK to others, especially to continental Europe where we see increasing demand. Based on industry intelligence, the UK has the potential to [develop up to 20 GW of low carbon hydrogen production capacity by the 2030s](#), and exports of hydrogen could help bring some of this potential pipeline of projects forward. Exports could help increase the overall low carbon hydrogen production capacity in the UK, develop supply chains and skills, bring economic opportunities, and increase the UK's strategic importance in the region as a trusted partner to supply energy to the continent. In the longer term, we also recognise the role that imports could play in supporting energy security as part of a diverse supply mix.

This is why we have been taking steps to facilitate the trade of hydrogen, including committing to set up a [Low Carbon Hydrogen Certification Scheme](#) from 2025, considering options for international transportation, networks, and storage, updating offshore and international regulations, and increasing our international collaboration on hydrogen. In the future, we intend to evolve the Low Carbon Hydrogen Certification Scheme to facilitate exports and to provide a robust way to assess the emissions of imports. We will seek to keep standards and certification for low carbon hydrogen aligned with international schemes, where appropriate. We published a [government response](#) to our consultation on the design of this certification scheme in October 2023.

We are shaping the creation of a regionally connected hydrogen market through our participation in the [North Sea Energy Cooperation Agreement](#). We are also active participants in international efforts to support the creation of global and regional markets for hydrogen and ensure interoperability and mutual recognition of certification schemes (see the *International* section of this update).

Recent developments: August to December 2023

- **Low Carbon Hydrogen Certification Scheme Consultation:** We published our [government response](#) on a low carbon hydrogen certification scheme in October 2023, setting out the key design features. We are continuing to focus on delivery of the scheme and future international alignment.
- **Offshore Hydrogen Regulation Consultation:** We published our [response to a consultation on Offshore Hydrogen Regulation](#) in September 2023, setting out changes that will allow developers to apply for permits to connect hydrogen produced offshore to continental Europe via pipeline.
- **Joint Declaration of Intent with Germany:** We launched a five-year [Hydrogen Partnership with Germany](#) in September 2023, which will include activities to promote trade in hydrogen and related goods and services.

- **Declaration of Intent on mutual recognition of certification schemes:** At COP28 we signed a [Declaration of Intent](#) on the mutual recognition of certification schemes for renewable and low-carbon hydrogen and its derivatives, alongside 38 other nations. This demonstrates the UK's commitment to work on mutual recognition and develop solutions that will enable interoperability between different schemes internationally.

Forward look

- **Meeting future international demand:** Exports could help to bring forward the [nearly 20 GW pipeline of known potential projects](#) across the UK. High demand in continental Europe, the UK's renewable energy capacity and its geographical proximity offer the potential for UK exports, including via pipeline in the longer term.
- **Delivering a certification scheme that can facilitate international trade:** Ahead of the certification scheme being launched from 2025, we plan to set out our envisioned pathway to international alignment for both standards and certification. This will be in line with the UK's commitments under the World Trade Organisation.

International engagement

Alongside developing our domestic hydrogen economy we are increasingly looking outwards, including to potential trading partners given our export ambitions. We have developed close relationships with key partner countries, sharing the UK's hydrogen policy expertise and collaborating to address barriers to deployment. In September 2023, we signed a [Joint Declaration of Intent with Germany](#), establishing a Hydrogen Partnership. This was the UK's first bilateral economic partnership with Germany since 2016 and demonstrates our intention to accelerate the global energy transition in the field of hydrogen alongside promoting UK trade and investment interests. The partnership, which will run initially for five years, will focus on accelerating the deployment of hydrogen projects; establishing international leadership on hydrogen markets; advancing R&I; promoting hydrogen trade and investment along the value chain; and joint market analysis for planning and investment.

In the last year we also formalised bilateral cooperation with other countries. We updated our memorandum of understanding (MoU) with Norway to include a specific Annex on hydrogen in March 2023, and signed a hydrogen MoU with Kazakhstan in March 2023. We also signed broader energy partnerships, including on hydrogen, with [France](#) (March 2023), [Denmark](#) (May 2023) and [Ireland](#) (September 2023), as well as a joint statement with [Japan](#) on energy innovation, which included hydrogen, in May 2023. In addition to government collaboration on hydrogen R&I and advancing hydrogen projects across the value chain, we intend to use our MoUs in future to support UK companies to access hydrogen trade opportunities in these countries.

At the regional level, [we signed an MoU with the North Seas Energy Cooperation \(NSEC\)](#) in December 2022, which sets out the terms of cooperation. We also signed the [Ostend Declaration](#) in April 2023, in which we committed to cooperate with eight European neighbours to develop the North Sea as a Green Power Plant of Europe, including through the future development of large-scale electrolytic hydrogen production.

As international interest and activity in hydrogen has been growing, we have been increasing our international collaboration to shape the development of global markets, rules and standards, accelerate new research and support the UK's hydrogen economy. The UK, alongside the United States and India, co-lead the [Hydrogen Breakthrough](#), which aims to make affordable renewable and low carbon hydrogen globally available by 2030. The recent [Breakthrough Agenda Report 2023](#) from the International Energy Agency (IEA), International Renewable Energy Agency (IRENA), and UN High Level Climate Action Champions, calls on governments to strengthen collaboration in key areas – such as standards and certification, demand creation, research and innovation, and finance and investment.

Through the [International Partnership on Hydrogen and Fuel Cells in the Economy \(IPHE\)](#) and the [International Energy Agency's \(IEA\) Hydrogen Technology Cooperation Partnership](#) (Hydrogen TCP) we are supporting work looking at the mutual recognition of certification schemes. We are also collaborating with other countries through the IPHE on hydrogen skills, trade and storage, amongst other issues. In summer 2023, we joined [the Clean Energy Ministerial's International Hydrogen Trade Forum](#), which will seek to foster open collaboration and sharing of expertise between exporters and importers, helping to develop an effective market in hydrogen trade. Through [Mission Innovation](#), where the UK is one of the co-leads of the [Clean Hydrogen Mission](#), we have facilitated international collaboration between governments, industry and research stakeholders to support innovations that will make low carbon hydrogen more cost competitive.

Recent developments: August to December 2023

- **Hydrogen Partnership with Germany:** In September 2023 we signed a [Joint Declaration of Intent with Germany which established a Hydrogen Partnership](#) and was launched at a major UK-Germany Hydrogen conference held at the British Embassy in Berlin.
- **Cooperation with Ireland:** In September 2023 we also [signed a MoU with Ireland](#), formalising our cooperation on the energy transition, including on renewable and low carbon hydrogen.
- **Working with global partners at COP28:** The UK along with other countries agreed new [Hydrogen Breakthrough Priority International Actions for 2024](#) at COP28, building on work underway across the international landscape. We also signed a [Declaration of Intent](#) on the mutual recognition of certification schemes for renewable and low-carbon hydrogen and its derivatives, supported the ISO (international standards organisation) methodology for greenhouse gas emissions assessment of hydrogen pathways, and

supported a Public-Private Action Statement on cross-border trade in hydrogen and hydrogen derivatives.

- **Cooperation with Brazil:** At COP28 UK and Brazil Ministers announced the establishment of the [UK-Brazil Hydrogen Hub](#), a co-convened multilateral platform with the aim of developing low-emission hydrogen as a viable and competitive energy option, including supporting the implementation of Brazil's National Hydrogen Programme.

Forward look

- **Delivering on our bilateral partnerships:** We plan to continue implementing plans and strengthening our existing bilateral partnerships, including with Germany, [Norway](#) and [Belgium](#), as well as pursuing further collaboration with others.
- **Working closely with our North Sea neighbours:** Building close relationships with our hydrogen neighbours will ensure the UK plays a key role in the evolving north-west Europe hydrogen market from the start, including through the NSEC.
- **Taking a lead in international forums:** We plan to continue using multilateral forums to influence the development of global hydrogen markets, rules and standards in line with UK interests and our net-zero targets.
- **Collaborating under the Hydrogen Breakthrough:** Working alongside our co-leads and with a range of supporting international initiatives, we aim to ensure delivery of the Hydrogen Breakthrough Priority Actions for 2024 in support of our collective goal to make affordable renewable and low carbon hydrogen globally available by 2030.

Conclusion

Low carbon hydrogen is vital for the UK to achieve net zero and energy security. Our UK Hydrogen Strategy continues to guide our approach to meeting these goals, and through our policy development we are ensuring that the developing hydrogen economy aligns effectively with our wider reforms of our energy system to deliver net zero and energy security for the UK. Since the launch of the UK Hydrogen Strategy in August 2021, we have made substantial progress to lay the regulatory and funding foundations for a thriving UK hydrogen economy, supporting new technologies that will be essential to establish hydrogen as a cost-effective option for different sectors to decarbonise. This update, and the [Hydrogen Production Delivery Roadmap](#) and [Hydrogen T&S Networks Pathway](#) published alongside it, have set out further detail on our policy and delivery intentions for the rest of this decade and beyond.

Our priority now is to deliver those ambitions – putting spades in the ground to build our first hydrogen projects and support the large pipeline of production and end user projects to begin operation. We have begun that push today, with the [announcement of 11 successful projects](#), representing 125 MW of capacity, through the first electrolytic hydrogen allocation round. Over the next two and a half years, ahead of the planned review of the UK Hydrogen Strategy, we aim to: allocate greater total funding through the HPBM and NZHF to stimulate low carbon hydrogen production; complete the design of other funding mechanisms, such as our T&S business models, and begin allocation; and promote the wider UK hydrogen value chain through direct funding support and bringing investors, innovators and industry together.

Through this approach, working with industry, we will see the first up to 1 GW electrolytic and up to 1 GW CCUS-enabled hydrogen projects start construction and operation on the way to our 2030 ambition, with anticipated emissions reductions and local economic benefits. We will also work with our international partners to build regional and global hydrogen markets, providing further opportunities for industry to export UK hydrogen and hydrogen technology abroad. We will continue to provide regular updates to the market, keeping industry informed of our policy development and delivery, as we start to see real projects delivered and kick-start a thriving hydrogen sector in the UK.

This publication is available from: www.gov.uk/government/publications/uk-hydrogen-strategy

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