Hydrogen Investor Roadmap

Leading the Way to Net Zero

April 2022

Withdrawn

GREAT
BRITAIN & NORTHERN IRELAND

Hydrogen Investor Roadmap

Leading the Way to Net Zero

Low carbon hydrogen will be vital to achieving net zero by 2050, with the potential to help decarbonise key UK industrial sectors and provide energy across power, transport and heat.

After setting out an aim for 5GW of low carbon hydrogen production capacity by 2030 in the UK Hydrogen Strategy we are now doubling our ambition to up to 10GW by 2030, subject to affordability and value for money, with at least half from electrolytic hydrogen.

The recent policy announcements on a Net Zero Hydrogen Fund to support deployment, a business model to ensure long-term revenue support, and a Low Carbon Hydrogen Standard to enable market access and certainty represent the next substantial step forward to developing a thriving UK hydrogen economy.

We expect that up to 2GW of low carbon hydrogen production capacity will be in operation or construction by 2025, providing the necessary certainty to unlock over £9bn of private investment we want to see by 2030.

The UK has one of the world's most attractive business environments

£1bn
funding for Net Zero Innovation Portfolio

4
of the world's top 10 universities

1st
Most active deep capital market in Europe

4th
in the global innovation index

1st
in Europe for most attractive renewable investment opportunities

- World's most competitive capital allowances regime, including 130% super-deduction on plant and machinery equipment
- Generous R&D and patent tax reliefs
- Lowest and most stable labour costs in Western Europe (compared to Germany, France and Italy)
- The most business-friendly employment laws in Europe
- The UK-EU Trade Cooperation Agreement post EU exit allows zero tariff market access with the EU
- Further UK Free Trade Agreements to turbocharge exports to the rest of the world (currently 70 plus EU)
- Significant commercial advantage from leveraging UK's legal system and language

Why invest in UK Hydrogen?

Up to 10GW
ambition by 2030, at least half from electrolytic hydrogen

£240m
Net Zero Hydrogen Fund provides CAPEX/DEVEX support

Up to £100m
for initial electrolytic H2 projects through H2 Business Model

20GW
of potential hydrogen projects identified in the UK pipeline (through to 2037)

66%
UK Hydrogen companies already exporting to growing international market

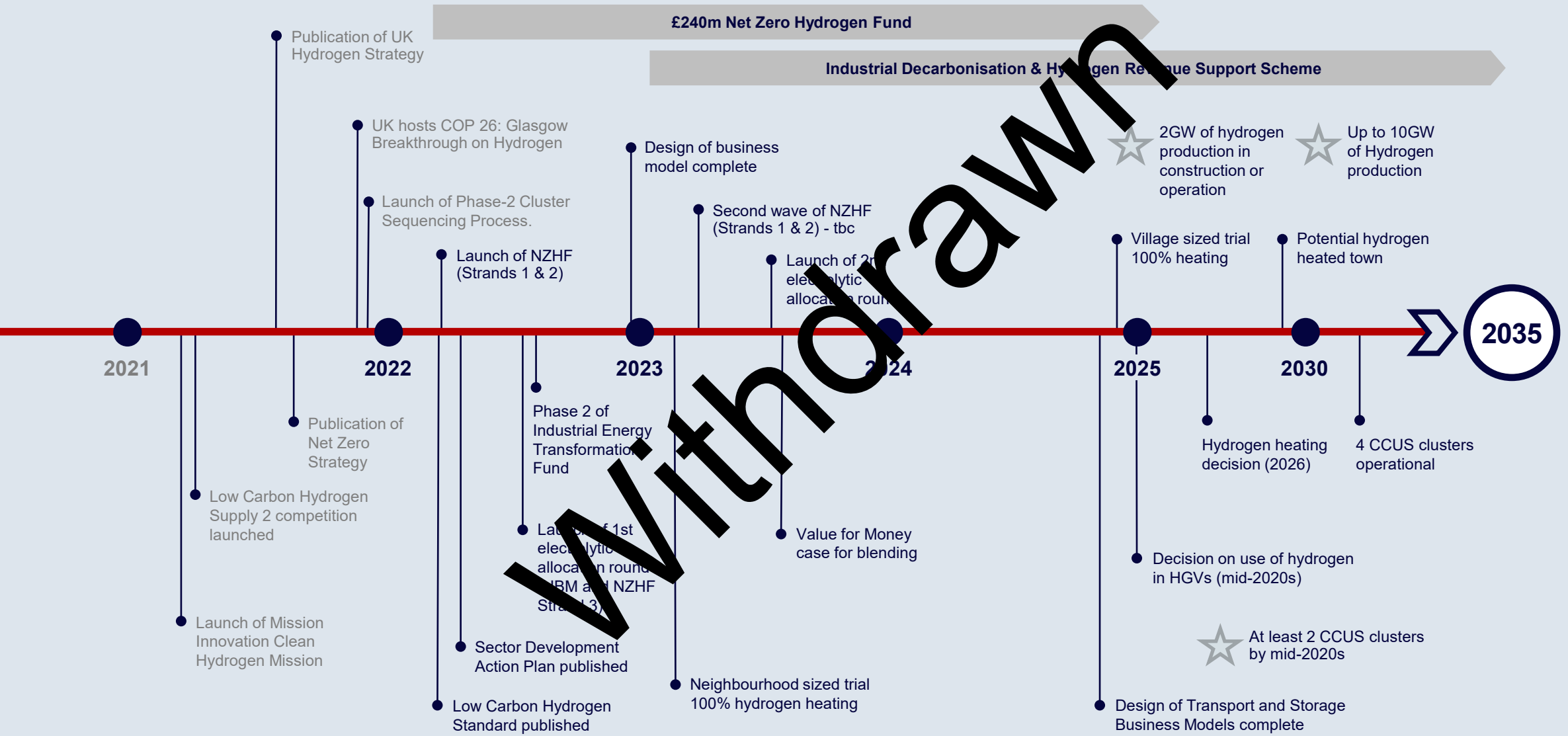
£12bn
capital available from UK Infrastructure Bank with H2 as priority

Opportunities in an advanced & growing sector:

- **Revenue support:** Hydrogen Business Model focusing initially on electrolytic & CCUS-enabled hydrogen production
- **Allocation rounds:** commitment to allocate business model support in 2023 and 2024. Ambition to subsequently run yearly electrolytic allocation rounds
- **Regulatory environment:** a new Low Carbon Hydrogen Standard
- **Existing natural assets and expertise:** salt caverns, depleted oil & gas fields and gas pipeline infrastructure can be redeployed
- **Projects under development:** Over a dozen large-scale hydrogen projects ongoing or pending (e.g. Acorn, Gigastack, H21), two CCUS clusters under development
- **Leading UK companies:** 196 companies working on hydrogen fuel cell technologies in the UK
- **Global player:** UK consistently in top ten countries globally for hydrogen technology patent rates

Our 2035 Delivery Plan

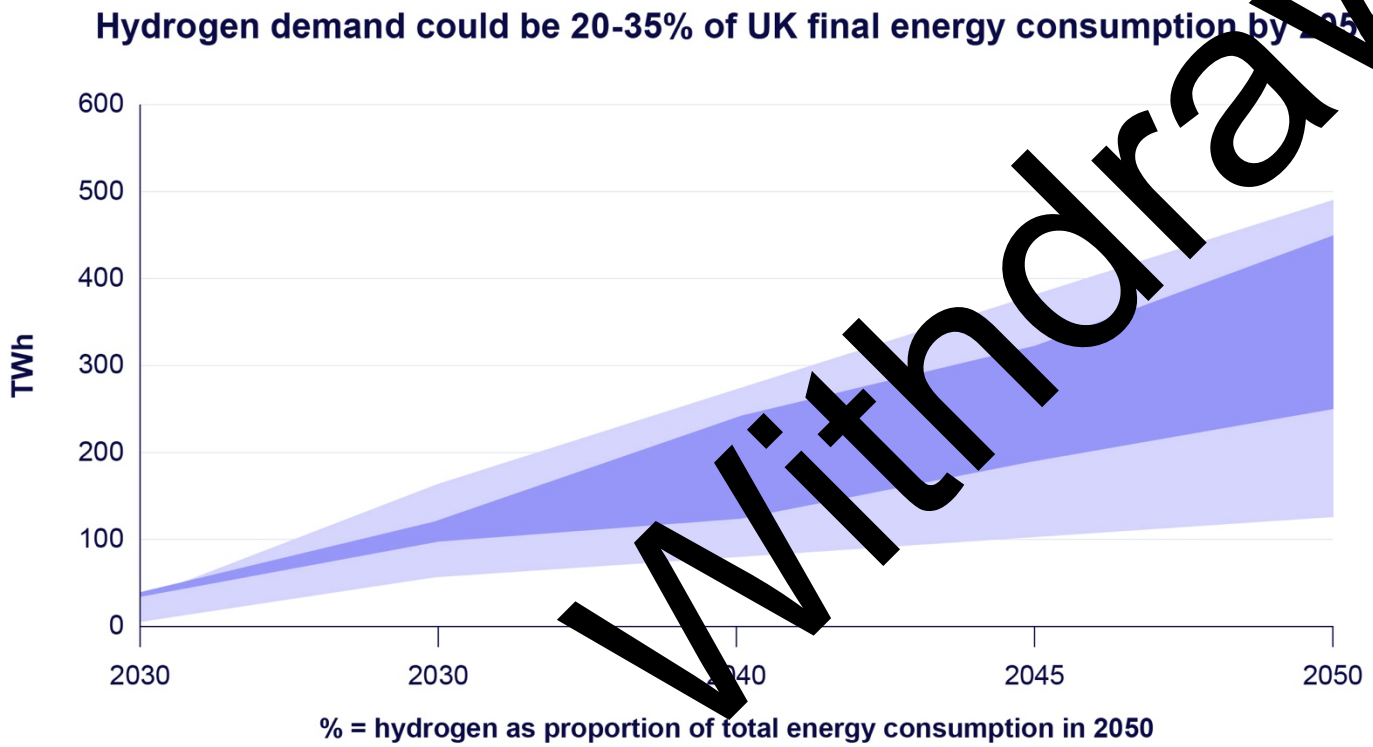
Critical activities and milestones on a path to developing the UK hydrogen economy



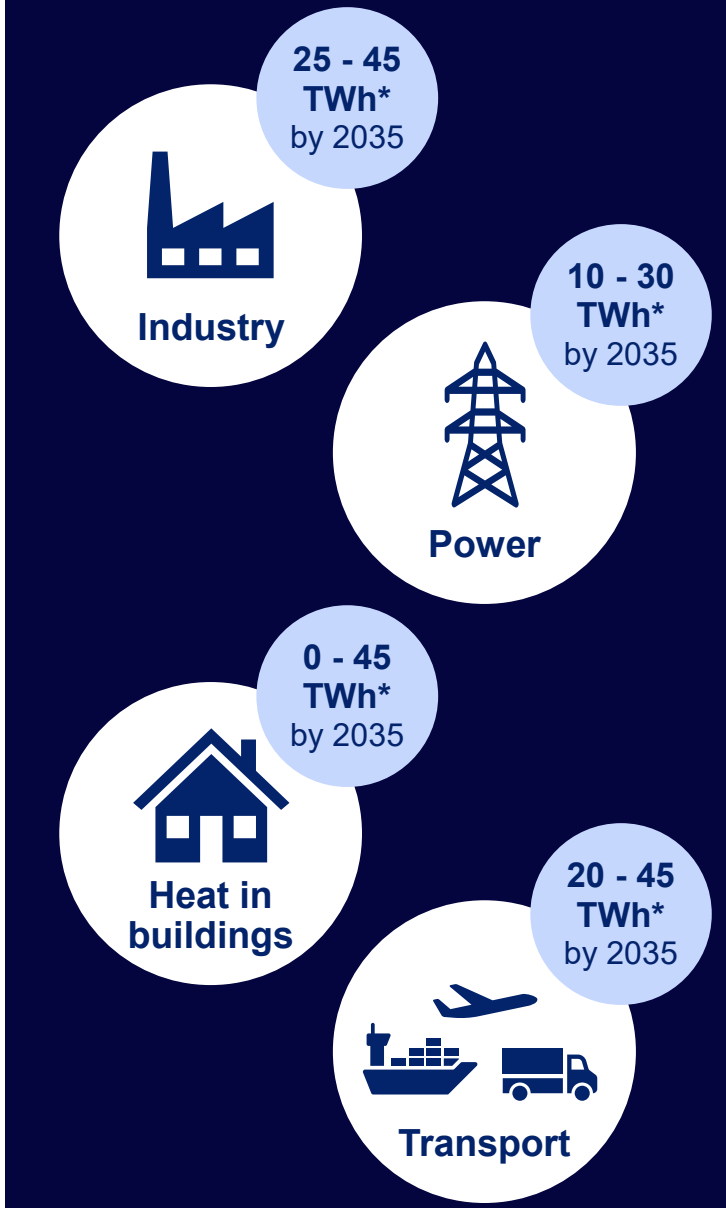
Hydrogen will play crucial role in future UK energy system

Our ambition for up to 10GW of low carbon hydrogen production capacity by 2030 will help to create a thriving hydrogen economy in the UK.

Analysis for UK Hydrogen Strategy shows that low carbon hydrogen will play a key role in UK energy system, becoming comparable in scale to existing electricity use by 2050.



Source: Central range – illustrative net zero consistent scenarios in CB6 Impact Assessment. Full range – based on whole range from UK Hydrogen Strategy Analytical Annex. Final energy consumption from ECUK (2019).



*Illustrative demand based on analysis for the UK Hydrogen Strategy (2021) https://www.gov.uk/government/publications/uk-hydrogen-strategy

Government and industry working together to deliver long-term success

Providing certainty to the market

	What we are delivering	What we look to industry to deliver
Production	■ Supporting variety of production methods through innovation and deployment support – NZHF and hydrogen business model.	■ Progress research and innovation to bring forward a range of low carbon production technologies. Move towards Final Investment Decision on basis of supportive policies to help reach up to 10GW ambition by 2030.
Use	■ Stimulating demand by supporting research, development and demonstration of hydrogen use across UK industry, power, heat and transport to support our energy transition.	■ Embrace fuels of the future and trial the use of hydrogen in manufacturing operations, power generation, domestic heating and a range of transport modes.
Infrastructure	■ Supporting innovation in hydrogen infrastructure, and the development of network and storage facilities through the design of new business models for hydrogen transportation and storage (T&S) infrastructure that will provide the commercial framework and reduce risk.	Explore and identify suitable infrastructure options for their needs.
Funding support	■ Providing funding schemes to support early market development.	■ Develop low carbon hydrogen projects in response to Net Zero Hydrogen Fund and Hydrogen Business Model allocation rounds and lower costs of hydrogen production.
Regulation	■ Using regulation to unlock access to energy markets and provide greater certainty on rules and frameworks.	■ Working with government and regulators to deliver a robust regulatory framework.
Supply Chain & Skills	■ Working with industry to build a world class supply chain for hydrogen in the UK, attracting investment and facilitating new export opportunities through UK Export Finance, DIT and FCDO overseas networks. Leveraging existing expertise and ensuring we have the right skills at the right time.	■ Support growth of the UK supply chain. Nurture and train employees to be the low carbon hydrogen leaders of tomorrow.
Innovation	■ At least £100m of funding as part of the Net Zero Innovation Portfolio to support industry to switch to low carbon fuels, including hydrogen. Includes £60m Hydrogen Supply 2 to support innovative hydrogen production, transport and storage technologies.	■ Projects that accelerate the commercialisation of innovative, low carbon technologies and support government aims, such as reducing costs of hydrogen supply, increasing carbon saving potential, building knowledge and skills.

Growing Hydrogen Production

Supporting multiple production methods

Supporting production

What we have done

- The Hydrogen Strategy published in 2021 sets out our 'twin track' approach, supporting a variety of production methods, including electrolytic & CCUS-enabled hydrogen
- Confirmed initial funding for hydrogen business model under the Industrial Decarbonisation and Hydrogen Revenue Support Scheme
- Announced the first two CCUS cluster sites under phase 1 of sequencing process
- Hydrogen use in transport supported by Renewable Transport Fuel Obligation

What we are doing

- Reducing financing costs with grant funding through the £240m Net Zero Hydrogen Fund
- Providing long-term certainty to investors through revenue support via the Hydrogen Business Model
- Identifying a potential UK pipeline of up to 20 GW production capacity

What we committed to

- Ambition for up to 2 GW capacity in operation or construction by 2025
- Up to 10 GW production ambition by 2030, subject to affordability and value for money
- Aim for four CCUS clusters by 2030

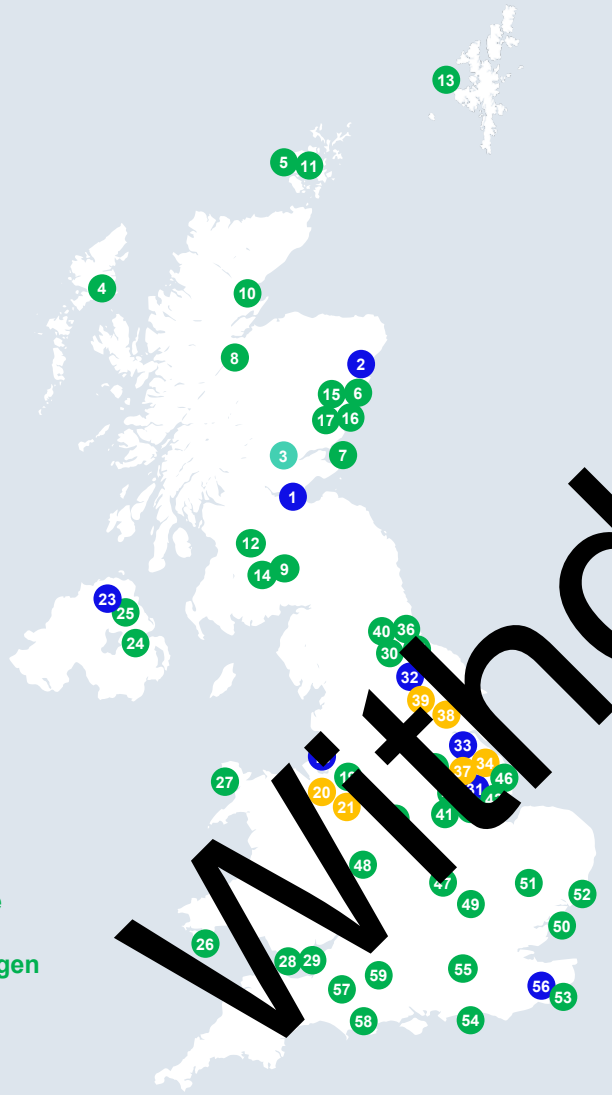
Sample of potential hydrogen projects across the UK

Scotland
1. Fife Hydrogen Hub
2. Acorn Hydrogen
3. BEIS & Ofgem: H100 Heat Trial
4. CNES
5. EMEC
6. ERM (Dolphyn)
7. ERM (Salamander)
8. H2 Green
9. Hy2GO
10. Cromarty Firth Green Hydrogen
11. Repsol Sinopec
12. Scottish Power (Whitelee)
13. Shetlands Island Council
14. Octopus Hydrogen
15. Kittybrewster HRS
16. Aberdeen Hydrogen Hub
17. BayoTech

North West England
18. Hynet: HPP
19. Trafford Green /Carlton Power
20. Hynet: Phase 2 & 3 pipeline (Cadent)
21. Hynet: Salt Cavern Storage (INOVYN)
22. Octopus Hydrogen

Northern Ireland
23. Skuunaq
24. GenComm/Belfast Met
25. NI Water

Wales
26. RWE Pembroke
27. Mentor Mon
28. Octopus Hydrogen
29. Protium Magor



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North East England
30. BP: CCUS enabled hydrogen and green hydrogen
31. Uniper Humber Hub
32. H2NorthEast
33. H2 to Humber S[illegible]
34. Aldbrough storag[illegible] (SSE)
35. Protium
36. EDF Tees G[illegible]
37. ECC pip[illegible]at Grid Ventures)
38. [illegible] Union[illegible]t Grid Gas)
39. East [illegible]t Hydrogen (NGN)
40. Tee[illegible] Val[illegible] Transport Hub
41. O[illegible]pus Hydrogen
42. Ant[illegible]nized
[illegible] Project Mayflower

East England
50. Sizewell
51. Octopus Hydrogen
52. Lowestoft Port

South East England
53. Ryze
54. Shoreham Port Green Hydrogen Production
55. Viridor
56. Acorn: Project Cavendish

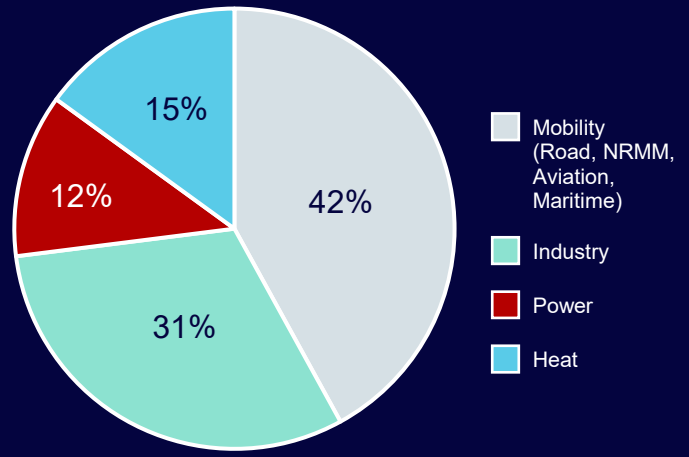
South West England
57. Bristol Airport
58. Canford Renewable Energy
59. Octopus Hydrogen

Yorkshire & Humber
44. Yorkshire Energy Park
45. Oyster Project
46. Gigastack

East & West Midlands
47. Tyseley Energy Park
48. Shropshire Council
49. Octopus Hydrogen /MIRA Technology Park

- CCUS enabled projects
- Electrolytic projects
- Storage & Distribution

Electrolytic end use (indicative)



Note: Includes plans and proposals for projects that are in the public domain. Many more projects are under development in all parts of the UK. Total UK pipeline estimated up to 20GW as of April 2022. Location of projects on this map is approximate.

Simultaneously stimulating demand

Making the case for use of hydrogen

	What we have done	What we are doing	What we committed to
Industry	■ £315m Industrial Energy Transformation Fund for equipment deployment	■ Following a Call for Evidence, exploring whether to enable or require hydrogen-ready industrial boilers, which could be a significant source of early demand for low carbon hydrogen	■ Working with cluster projects to better understand the opportunities for industrial sites to foster an initial market for low carbon hydrogen
Power	■ Published a Call for Evidence in 2021 on Decarbonisation Readiness for combustion power plants through either CCS or hydrogen generation technology	■ Publishing a Decarbonisation Readiness Consultation in Summer 2022. Actioning Net Zero Strategy commitment to explore the need and case for further market intervention on hydrogen to power	■ Assessing potential for hydrogen in the future power system through providing firm, dispatchable low carbon generation as new renewables are integrated
Heat in buildings	■ £25m Hy4Heat programme completed critical technical innovation work on potential of domestic H2. HSE overseeing trials assessing the impact of hydrogen blending on consumer appliances	■ Working with industry and others to deliver a neighbourhood trial by 2023, a village scale trial by 2025 and a potential hydrogen heated town by 2030	■ Government is aiming to make a decision on blending by end of 2023 and plans to take decisions in 2026 on the role of hydrogen in heating
Transport	■ Launched UK's first 'Hydrogen Transport Hub' in Tees Valley in 2021, delivering pilot trials on hydrogen propulsion technologies across all transport modes	■ £23m Hydrogen Transport Programme delivering new hydrogen refuelling stations, upgrading existing stations and deploying hundreds of new hydrogen vehicles	■ Continuing multi-million pound support for transport decarbonisation, including deployment, trials & demonstration of hydrogen buses, HGVs, shipping, aviation and multi-modal transport hubs

Enabling infrastructure for the hydrogen value chain

Connecting hydrogen production and uses

	What we have done	What we are doing	What we committed to
Hydrogen Transportation & Storage (T&S) Infrastructure	■ Set out in government responses in 2022, early development of T&S infrastructure for initial H2 production projects supported by business model & Net Zero H2 Fund	■ Currently undertaking a review into systemic H2 network & storage requirements in 2020s and beyond, including need for economic regulation & funding, with update provided f in H2 Business Model government sponse	■ Signific t development of new H2 ne work and st ge infrastructure to support the growth of H2 economy through the design of new business models for transportation and storage by 2025
Networks	■ Since 2002, the Iron Main Risk Reduction Program replacing iron gas distribution networks with plastic, which is well-suited to transporting H2 ■ Industry has undertaken a series of projec ts to build the evidence base for using pipelines to transport H2 as part of H21	■ To support network tra industry will test tran porting hydrogen through the gas netw k as pa f FutureGrid ■ Industry e ring th otential for a hyd gen tra mission network ans ting hy gen between the cl ters a part of Project Union	■ Parts of existing gas network could be used to transport H2 and we plan on engaging stakeholders on the future of the gas system in 2022 ■ Working with industry to deliver H2 heating trials including a neighbourhood trial by 2023, a village scale trial by 2025 & a potential hydrogen heated town by 2030, resulting in building a new network for the neighbourhood trial and repurposing the existing network for the village trial
Storage	■ In 2021, we launched a £60m Hydrog Supply 2 competition to support range of demonstration projects, including H2 storage technologies ■ In 2021, we launched a £68m Longer Duration Energy Storage Demonstration competition	■ Industry developing plans for one of the world's largest H2 storge facilities at Aldbrough on the East Yorkshire coast	■ Working with industry to deliver hydrogen heating trials, resulting in the assessment of storage needs for a working hydrogen heating system

Funding support

Stimulating investments in the hydrogen economy

Net Zero Hydrogen Fund

What we have done

- Publication of consultation on Fund design
- Split funding into four strands to align with IDHRS* and CCUS timelines, enabling projects to apply over a longer time period:

1. DEVEX grant co-funding to support FEED studies
2. CAPEX grant co-funding for projects that do not require IDHRS support
3. CAPEX grant co-funding for non-CCUS projects that are seeking revenue support through IDHRS
4. CAPEX grant co-funding for CCUS enabled projects that are seeking revenue support through IDHRS

What we are doing

- Using grants to de-risk projects and unlock private capital
- Targeted Development Expenditure (DEVEX) support to stimulate project pipeline
- Phased approach to get funding to projects as quickly as possible
- Complement and maximise the impact of other BEIS innovations – notably IDHRS and the CCUS programme
- Stimulating new build low carbon hydrogen production projects

What we committed to

- Up to £240 million, delivered between 2022 - 2025, to support new H2 production in UK
- CAPEX grant funding to be delivered in tandem with a long-term revenue settlement provided through IDHRS
- Open funding windows to our first two strands in early 2022
- Allocate funding for electrolytic projects via the hydrogen business model and NZHF strand 3 in 2023

Net Zero Hydrogen Fund & Industrial Decarbonisation and Hydrogen Revenue Support (IDHRS) together aim to:

- Enable commercial deployment of low carbon hydrogen, CCUS and the required infrastructure in the 2020s
- Deliver sufficient capacity to meet our legally binding carbon budgets and net zero
- Create a framework to reduce costs and risks to have a cost-competitive and self-sustaining market

Funding support

Stimulating investments in the hydrogen economy

Withdrawn

	What we have done	What we are doing	What we committed to
Hydrogen Business Model	■ Publication of government response on business model design, alongside indicative Heads of Terms of the business model contract ■ Launch of process to allocate funding to initial CCUS-enabled hydrogen production projects through CCUS cluster sequencing Phase-2 ■ Announcement of Industrial Decarbonisation and Hydrogen Revenue Support scheme (IDHRS) to fund business model	■ Developing detailed model design t provide producers with revenue support and help overcome operating cost gap between hydrogen and fos fuels and an ROI ■ Designing an allocati nd f electrolytic hydroge projec and engaging industry t ough a rket Engagement cise with e aim of launchin the rou in summer 2022 ■ Sel ting th first CCUS-enabled ydr n proj ts to enter into bilateral ne otiati s with through the CCUS Clus r Seq cing process	■ lise the business model in 2022 ■ Support up to 1GW of electrolytic hydrogen projects in operation or construction via initial two allocations in 2023 and 2024. ■ Announce funding envelope in 2022 to support delivery of up to 1GW of CCUS-enabled hydrogen by mid-2020s. ■ Ambition to run yearly electrolytic allocation rounds for the hydrogen business model and to move to price-competitive allocations as soon as market conditions and legislation allow
Transport & Storage Business Model	■ Set out in the government response o the H2 Business Model design that early development of transportati nd storage infrastructure for initial H2 production projects can be covered	■ U dertaking a review of systemic H2 n works and storage requirements in 2020 and beyond, including economic regulation and funding	■ Design new business models for H2 tr ansportation and storage infrastructure by 2025

Other sources of financing available

Industrial Energy Transformation Fund	UK Infrastructure Bank	UK Export Finance	Breakthrough Energy Catalyst

Robust regulatory environment

Maximising UK capabilities

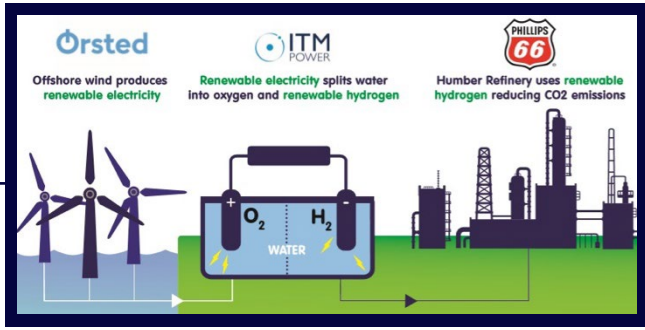
	What we have done	What we are doing	What we committed to
Low Carbon Hydrogen Standard	■ Published the final design of the low carbon hydrogen standard ■ The consultation sought views on design options for a UK standard defining 'low carbon' hydrogen, to underpin our support for hydrogen production	■ Developing a greenhouse gas emissions threshold for 'low carbon' hydrogen and the methodology for calculating emissions ■ Consulting on potential including the standard under the Green Taxonomy, to support investment in low carbon hydrogen	■ Levelling the playing field by setting up a hydrogen certification scheme by 2025, so the UK can play an active role in the international hydrogen market ■ Taking full advantage of future global trade and investment opportunities by ensuring the standard is developed in line with international developments
Non Economic Regulations	■ Established a Hydrogen Regulators Forum to determine current and future non-economic regulatory responsibilities across the hydrogen value chain	■ Working to identify, prioritise and implement any changes to the existing non-economic regulatory framework – including addressing any gaps – to support the growth of a hydrogen economy	■ Addressing regulatory barriers facing first-of-a-kind H2 projects. Using regulation to unlock access to new markets. Ensuring role for H2 is considered in broader reviews of regulation

World class UK supply chains, skills and innovation

Maximising UK capabilities

	What we have done	What we are doing	What we committed to
Supply chains	■ Established strengths in electrochemical technologies, including fuel cells and electrolysers, which UK companies are exporting overseas and our functional strengths in planning, legal, professional and financial services	■ Government working to promote growth of UK supply chains to meet hydrogen deployment ambitions. ■ UK Export Finance providing enhanced support for investments to developing export capabilities	■ Supporting UK expertise in high-end manufacturing, oil & gas, renewables, chemicals, safety and EPCm
Skills	■ Published the Green Jobs Taskforce report and established a Green Jobs Delivery Group with representatives from industry, the skills sector and other key stakeholders to support the development and delivery of the Government's plans for green jobs and skills	■ Working with industry and others to ensure investment in skills needed across the value chain and drive local and regional opportunities, helping to level-up across our industrial heartlands ■ Continue to deliver relevant green T-levels, apprenticeships and skills bootcamps	■ North Sea Transition Deal includes a commitment to facilitate the reskilling of existing parts of the oil and gas workforce to ensure people and skills are transferable across the wider energy sector
Funding innovation	■ Government has supported the development of innovative low carbon hydrogen technologies, providing over £90m in direct R&I funding across the supply chain in the last 5 years. Hydrogen is a key priority area in our £1bn Net Zero Innovation Portfolio	■ The UK co-leads the Clean Hydrogen Mission, with the goal of reducing end-to-end costs to $2 per kilogram by 2030	■ Programme of key research and innovation challenges across all net zero sectors over the next 5-10 years, including hydrogen. Continued collaboration with UKRI, including Innovate UK

Hydrogen Investment Case Study – ITM Power Gigastack Project



ITM, Ørsted, Phillips 66, Elem… Energy (Sheffield / Humber)

Substantial private investment … ITM supported (incl. **£250m fund…aise**)

>100 direct jobs creat… (p…cted further 180 in supp… cha… & could catalyse 1,70… …er time)

- Secured £7.5m innovation fu…ding …ared to commercialisation, from forerunner of NZIP. Multi…r su…ort for the sizeable Gigastack demo project, p…file fro… HMG award. In same period, ITM moved into new Gigaf…tory si…
- Project helped r…fine tec…ology and scale-up production, including vi… semi…utomate… processes. ITM says “milestones represent a s…-change in ambition and capacity which should enable a 40% re…uction in costs for electrolyser stacks over the next t…ee y…rs.”
- …M use… innova…on project learning to improve processes and as …art o… the… showcase for investors. They raised £250m in Oct 21 to…uild tw… more Gigafactories.
- …t year end, ITM had a record order backlog (~500MW), and a sizab…e tender pipeline (~1GW).
- NZIP continues with a commercialisation focus and backs demos of sufficient scale to interest investors, with competed-for funding and expert monitoring.

Department for International Trade

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