

Developing a Hydrogen Roadmap and Evaluating Technology Capability Options for Northern Ireland

November 2022



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Foreword

Hydrogen has been recognised as an important element of the Net Zero Strategies of both the UK and Northern Ireland governments. There is significant opportunity for Northern Ireland to establish an active presence in the new hydrogen global economy and a major asset and strategic enabler is Northern Ireland's ability to generate green hydrogen by utilising its wind generated electricity. There are significant economic, decarbonisation and technology development benefits arising from green hydrogen production and hydrogen adoption by our end-use sectors from transport to gas network blending and industrial use. Specifically, transport can benefit from the introduction of hydrogen in land systems, such as busses and heavy vehicles for materials handling, zero carbon marine applications are being developed with significant industrial engagement and hydrogen technologies are under development globally to decarbonise the aerospace sector, opening local opportunities in storage technologies. All these hydrogen applications would require clear market pull and private sector investment, together with an appropriate regulatory framework and timely investment in infrastructure.

Research is vital for technology development in the era of the net zero and hydrogen economy from fuel cells and advanced electrolyzers to the design, test and manufacture of components and systems for the cost effective and safe deployment of hydrogen technologies in end-use sectors. The scope of potential hydrogen applications is very wide and to be effective, our efforts would need to be focused on a few selected areas in which Northern Ireland can demonstrate competitive technological know-how, industrial readiness to invest and ability to rapidly create relevant skills. Clearly, new technology development must be followed with a plan for the rapid and successful industrialisation of technological innovations. Hence, it is mission critical for Northern Ireland to ensure that our economy benefits by adding value locally, via manufacturing a selected range of high value parts and systems and forming local supply chains, and then exporting hydrogen products and services.

In early 2022, the Department for the Economy (DfE) and Matrix (the Northern Ireland Science Industry Panel) commissioned two interrelated hydrogen studies focused on capability identification (this study) and wider foresighting (Matrix study) for the years 2022 – 2030 and 2030 – 2050 respectively; their primary aim is to inform on the potential composition and next steps of Northern Ireland's Hydrogen Economy. This study engaged with stakeholders interested in hydrogen, defining an outline Hydrogen Roadmap for NI focusing on the short to medium term, to 2030, and considered options for developing hydrogen related technology capabilities in NI. The study has been carried out by a consortium comprising QUB, Catalyst and EY and would not have been possible without the funding and strong interest from DfE. The active and fully supportive engagement of a wide range of stakeholders from a variety of sectors is fully acknowledged. There has also been very effective coordination work with Matrix. This report outlines the key findings of the study and is freely available to inform the exploration of options for policy formulation and technology development by Northern Ireland government and the members of our vibrant hydrogen community of practice. The report may also serve to conceptualise how Northern Ireland's technological capabilities and priorities may be integrated within the emerging UK hydrogen ecosystem.

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Executive Summary



Executive Summary



In the HM Government Net Zero Strategy, it is stated that ‘Northern Ireland uniquely positioned to become a leader in the hydrogen economy’. Northern Ireland can utilise renewable electricity to produce green hydrogen and leverage the exceptional manufacturing supply chains in the engineering, advanced materials and transport sectors to feed into local and global supply chains for hydrogen production.



The NI Energy Strategy target is to double the size of employment in the green economy. With the right approach, NI can create sustainable jobs in the clean hydrogen sector and meet the objective to decarbonise the economy by 2050.



The next decade represents a critical time for the region to utilise its expertise and share learning to develop the potential of the hydrogen opportunity, deliver green growth and promote the region as a centre of excellence.

Highlights from the stakeholder engagement process

- Data was collected through an initial survey, five group round table and one-to-one sessions, and an industry workshop in March 2022.
- Over 50 stakeholders provided feedback, each bringing their unique insights.
- Stakeholders included private innovation / technology companies, network operators, research institutions, local authorities and regulatory/planning consultancy firms.

The consensus amongst stakeholders is that there is an urgent need for a collaborative effort and pro-active discussion on the future green hydrogen economy in Northern Ireland.

Key Highlights from Stakeholders

1. In the delivery phase of an NI roadmap, a whole system approach is required.
2. First of a kind projects are necessary to promote innovation and kick start both discussion and uptake of hydrogen usage.
3. Regulatory barriers must be broken down and new standards put in place however these must not delay early adoption across the value chain.
4. Although the UK Hydrogen strategy can be leveraged, specific requirements for Northern Ireland must be realised in policy decision making – market size, technical abilities, usage all differs from GB.
5. NI has the capacity to deliver a sustainable hydrogen economy and reduce energy dependency considerably thus supporting climate change and low carbon economy objectives.
6. A lack of current infrastructure needs to be addressed in order to build the market quickly and reduce operating costs.
7. A demand forecast is necessary – there is a current unknown in the balance between supply & demand - use cases are coming through that will drive uptake. However, a catalyst is required to kick off demand.
8. Northern Ireland is well placed to export hydrogen technologies and possibly hydrogen or hydrogen-based products.

Key considerations for hydrogen market development

1 Establish medium and long-term targets and vision for hydrogen and define plans towards achieving the targets

- ▶ National hydrogen roadmaps
- ▶ Targets for hydrogen use
- ▶ Economy-wide emissions targets
- ▶ National industrial strategies
- ▶ International agreements and commitments

2 Scale up commercial deployment using demand-side policies that encourage investment

- ▶ CO2 and pollution pricing
- ▶ Mandates and bans
- ▶ Targeted communication campaigns
- ▶ Electricity and gas market rules
- ▶ Tax credits

3 Aid private investment by mitigating risks arising from uncertain demand, unfamiliarity and value chain complexity

- ▶ Loans
- ▶ Export credits
- ▶ Risk guarantees
- ▶ Tax breaks

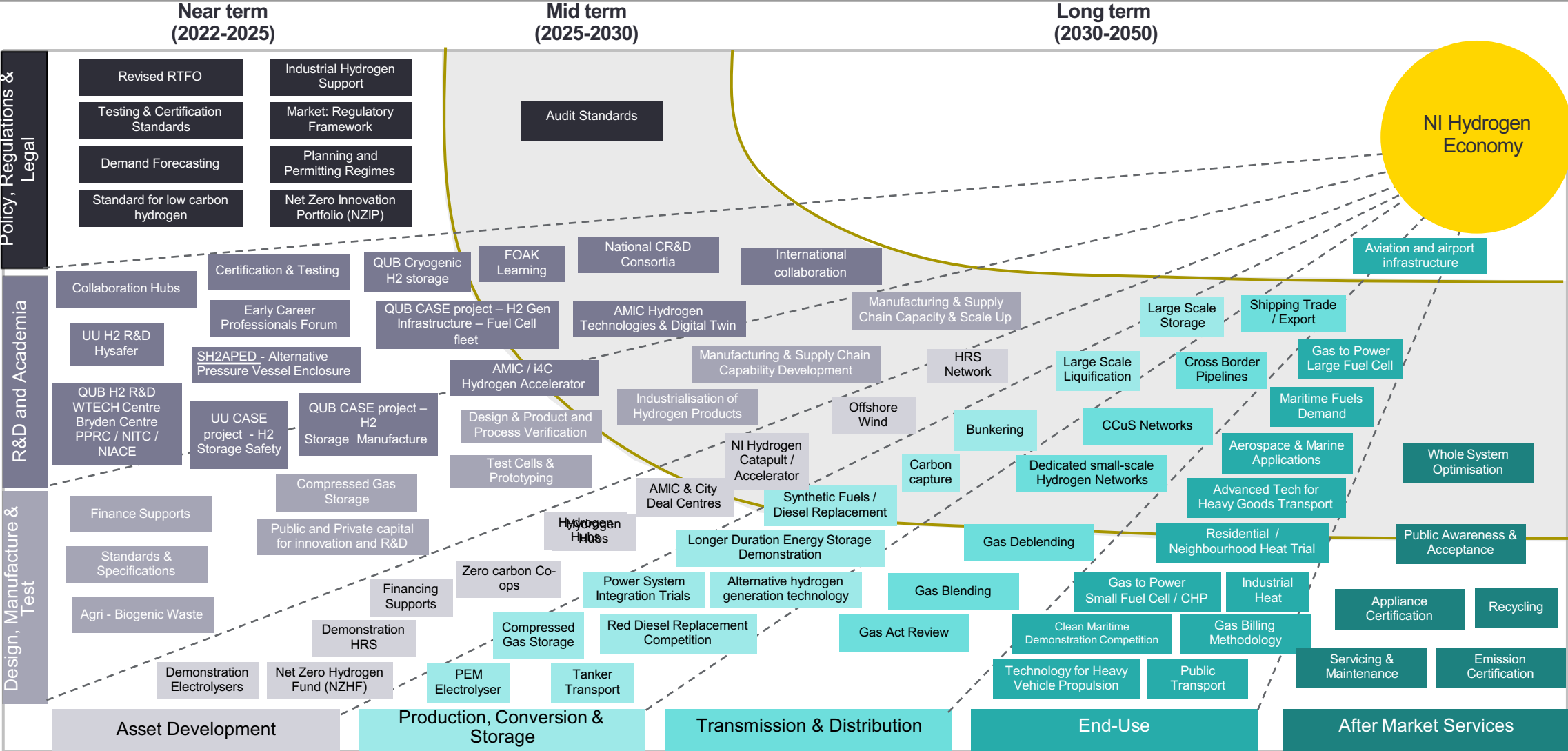
4 Lead early-stage high-risk projects and incentivise the private sector in driving innovation

- ▶ Direct project funding and co-funding
- ▶ Tax incentives
- ▶ Concessional loans
- ▶ Equity in start-ups
- ▶ Multilateral collaboration initiatives
- ▶ Prizes

5 Remove regulatory barriers and establish common standards that facilitate trade and ensure safety

- ▶ Safety standards
- ▶ Purity standards

A High-Level Hydrogen Roadmap for NI



Timelines are not to scale and are indicative. There is also a cross cutting nature of skill requirements.

Main messages after engagement with stakeholders (1/2)



The Hydrogen Economy in NI

Hydrogen will have a pivotal role in the decarbonisation of the Northern Ireland economy. Hydrogen will help achieve net zero emissions by 2050 and will be essential to reduce reliance on fossil fuels across the heat & transport sectors.



Northern Ireland is uniquely placed to use renewable electricity to produce green hydrogen and to leverage the exceptional manufacturing supply chains in the engineering, advanced materials and transport sectors to feed into local and global supply chains for hydrogen production.



In addition, it is estimated that growing the hydrogen economy could unlock 75,000 jobs across the UK by 2035. With the right approach, NI can create thousands of sustainable jobs in the clean hydrogen sector.



Funding and Research & Innovation (R&I) Support

An important part of the vision and planning for the transition to net-zero and encouraging the hydrogen economy is how it will be funded.



Government must work in partnership with industry and universities to ensure that the appropriate roll out of R&I infrastructure is funded and that existing and potential projects are supported to showcase our potential to develop cutting-edge hydrogen technology.



As the size and complexity of hydrogen projects grow, project finance will play an important role in the expansion of the sector. Northern Ireland must make the most of available funding and innovation support mechanisms and appropriate business models must be selected to provide assurance to investors.



A Shared Stakeholder Platform

The establishment of a hydrogen stakeholder network and community of practice would provide leading-edge and multifaceted expertise that will encourage greater collaboration between research and business.



The aim for further development would be to bridge the gap between research findings and their development into commercial propositions, and to provide R&I support in scale required to have a timely impact.



Specific areas for intervention might include:

- Developing the hydrogen value chain including the manufacturing supply chain
- Building of tools to help innovators
- Demonstration capability

Main messages after engagement with stakeholders (2/2)



Cost Competitiveness

Currently, green hydrogen is more expensive than fossil-based alternatives. The International Renewable Energy Agency estimates that on a globally averaged basis, green hydrogen costs between \$3 and \$6 per kilogram (kg), compared to \$1.5—\$2.5/kg for blue hydrogen.



Primary drivers of green hydrogen price include electrolyser capex and renewable electricity. Comparative blue hydrogen prices are based on local natural gas prices.



Financial levers to offset higher costs of production, whether through production tax credits, contract-for-difference schemes, or other subsidies, can provide support across the hydrogen value chain and spur green hydrogen deployment.



Accelerating Technology Development

With the wide range of uses of hydrogen across the economy, the technology readiness of hydrogen use varies greatly, therefore there is a need to accelerate technological developments across all areas of the hydrogen value chain.



Policy and funding support for RD&D of new technologies and end uses can go a long way in ensuring that the emissions from these sectors can be addressed quickly by replacement with hydrogen-based solutions. Creating demand pull through procurement style policies provides a strong market signal to hydrogen developers.



Development and deployment of technologies for new end-uses of green hydrogen in hard-to-abate sectors must happen in parallel with financial levers that drive green hydrogen production.



Infrastructure

Physical infrastructure is essential to provide the backbone for a hydrogen ecosystem. With siting and permitting conditions leading to multiple year timelines for building this infrastructure, recognising its need and planning for its use now can prevent bottlenecks and delays in the system later on.



Knowledge infrastructure, like guarantee of origin or production certification schemes, ensure meaningful carbon dioxide emission reductions promised by hydrogen's production and use are actually achieved.



Validation and verification of these schemes can be supported by associated policy. Safety standards and other regulations, enable production, distribution, and use of hydrogen economy wide.

Potential models and support mechanisms for the delivery of a NI Hydrogen stakeholder collaboration group

A NI Hydrogen Stakeholder Platform could consider the following:



Subsidies to cover externalities associated with production of low-carbon hydrogen, enable investors in low-carbon methods of hydrogen production to compete with the incumbent carbon-intensive fuel



Technology-specific support to prevent more mature technologies. Technology-neutral support (which takes account of differences in carbon-intensity) will likely be more efficient as the market matures



Transfer of demand risk away from investors to incentivise investment. Uncertainty around demand for low-carbon hydrogen poses a significant risk for prospective investors, and this needs to be mitigated



Reductions in support for successive investments once technologies are proven. The lack of full value chain deployment means that the first producers may face higher risks associated with first-of-a-kind projects

The following support mechanisms could be explored:

Support Model	High-Level Description
End user subsidies	Abatement subsidy is offered to industrial emitters
Regulated returns	Regulated returns models such as a Regulated Asset Base (RAB) model or a Cap and Floor model allow the hydrogen producer to earn a regulated return on costs
Contractual payments to producers	The hydrogen producer receives a subsidy which covers the incremental cost of low carbon hydrogen above the carbon-intensive alternative fuel. The level of the subsidy (per unit of output or per year) is contracted between the recipient and a government party
Obligations	An obligation is imposed on parties outside the hydrogen production sector (e.g. fuel suppliers or end users) to supply or consume a certain quantity of low carbon hydrogen. This obligation is policy-based rather than contractual, and can be adjusted over time

Funding for Hydrogen-related projects



Regional Funding

The Northern Ireland Energy Strategy (2021) outlines policy objectives for the transition to a low carbon economy including the importance of hydrogen. Currently there are limited regional funding opportunities however the recently announced £4.5m Green Innovation Challenge Fund 2022 will lead to a later full roll out of a £30m fund over 3 years. The SIB are also exploring technical studies and strategic business case preparation for NI water to develop Power to X schemes.

The Belfast Regional City Deal [AMIC/MEA] Complementary Fund has also been approved and is at OBC tendering stage (for a hydrogen technology hub).



National Funding

Funding in Northern Ireland mainly reflects current UK Government policy, notably the levelling up, clean growth and research and development agenda. The UK Hydrogen Strategy (2021) outlines opportunities to maximise research & innovation strengths, to attract investment and for realising export opportunities. National funds almost all now consistently reference the need for projects to align to the government's clean growth and net zero aims, which again increases the potential for hydrogen schemes to be included.



Research Funding

A number of recent research led funding initiatives have been successful including a £619k project led by Queen's University focused on creating and developing innovative solutions to meet the Net-Zero goal through the use of Zero-Carbon Co-operatives, funded by the Department of Levelling Up, Housing and Communities.

£1.2m of funding direct to Queen's by the Advanced Propulsion Centre is also creating high value research jobs as part of the low emission bus research project and has led to the development of a Centre of Excellence in Zero-Emissions Hydrogen Technology in Ballymena, with public-private investment of £700,000 from the UK Government's Community Renewal Fund, the Department for Communities Covid-Revitalisation Fund and EP UK Investments. A number of research led projects under the Hydrogen Safety Engineering and Research Centre (HySAFER) are also currently available in Ulster University.



Private Funding

Private funding is likely limited in scale but represent an important source of funding or investment, especially in research and demonstrator technologies.



1. Background



Background

The aim of the scoping study was to evaluate the rationale for and feasibility of creating a Hydrogen technology hub in Northern Ireland together with the evaluation of strategic options regarding models and vehicles for its delivery and implementation. There were three key areas:



1. Community of Practice

Identify and engage with the main stakeholders interested in hydrogen to ensure multi-sectoral and regional engagement, buy-in and representation.



2. NI Hydrogen Roadmap

Develop a potential Hydrogen Roadmap for NI, in the context of UK policies and the links with ROI, to underpin decision making.



3. Hydrogen Technology Acceleration Models and Supports

A high-level evaluation of options available for accelerating the technological development of NI's hydrogen economy.

This study was compiled in early 2022, using publicly available information and insights from engagement with local stakeholders.

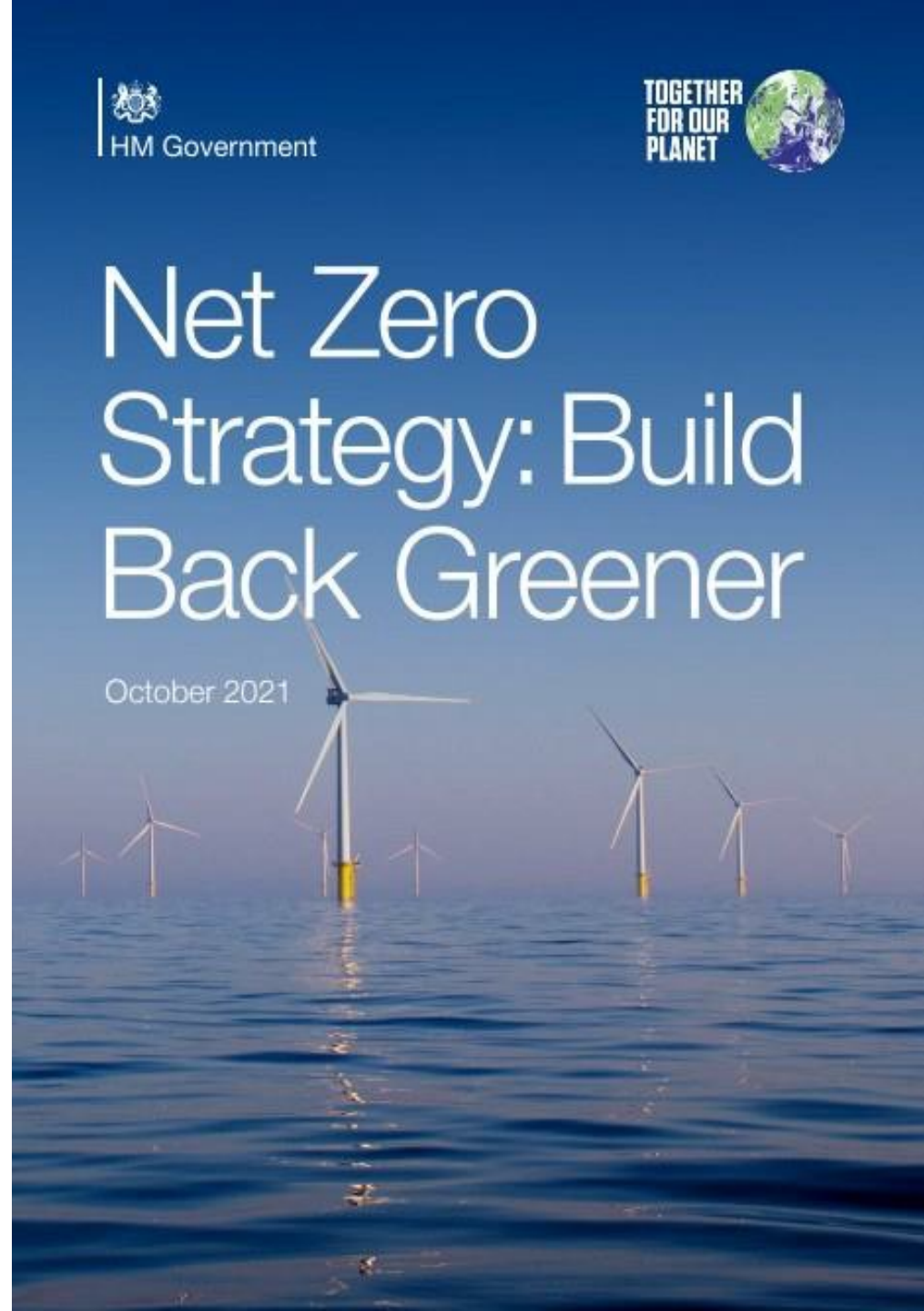
“

Northern Ireland is uniquely positioned to become a leader in the hydrogen economy and secure these benefits locally ”

Net Zero Strategy: Build Back Greener, October 2021

Net Zero Strategy: Build Back Greener

October 2021



2.0 Community of Practice



2.1 Approach



Approach

Stakeholder mapping

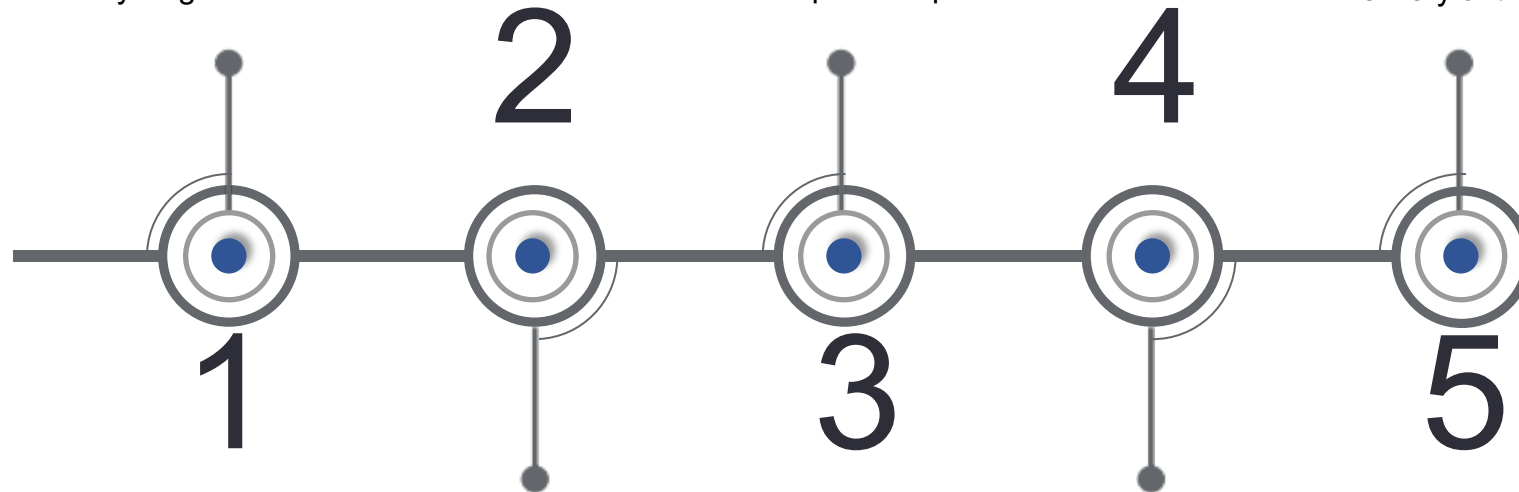
Initial stakeholder mapping exercise to identify key players across the Hydrogen value chain

Stakeholder round tables and one-to-one sessions

Engagement with stakeholders to explore further considerations in the roadmap development

Confirmation of the High-Level Roadmap

Delivery of the high-level roadmap



Survey

Initial survey to stakeholders to gauge level of interest and activity in the Hydrogen economy

Workshop

Workshop to disseminate information, discuss and gather further input

Stakeholder Engagement

- Northern Ireland already has a large ecosystem of involved and interested stakeholders in the hydrogen economy
- The stakeholder mapping exercise, and subsequent survey allowed for interested parties to join in on further engagement
- Stakeholders who expressed interest in participating in the scoping study were divided into 5 themes / areas
- It is likely that many of these stakeholders will be actively involved in any future roadmap and be at the forefront of Northern Ireland's hydrogen economy

1	Technology & Research
2	Production, Conversion & Storage
3	Networks & Utilities
4	Transport, Retail & End-Use
5	Policy, Regulation & Legal

2.2 Survey



Survey Overview – February 2022

Q1: Are you interested in supporting the development of a hydrogen roadmap?

Q2: Please tell us a little about yourself.

Q3: Is your organisation currently monitoring or pursuing hydrogen opportunities within or from Northern Ireland?

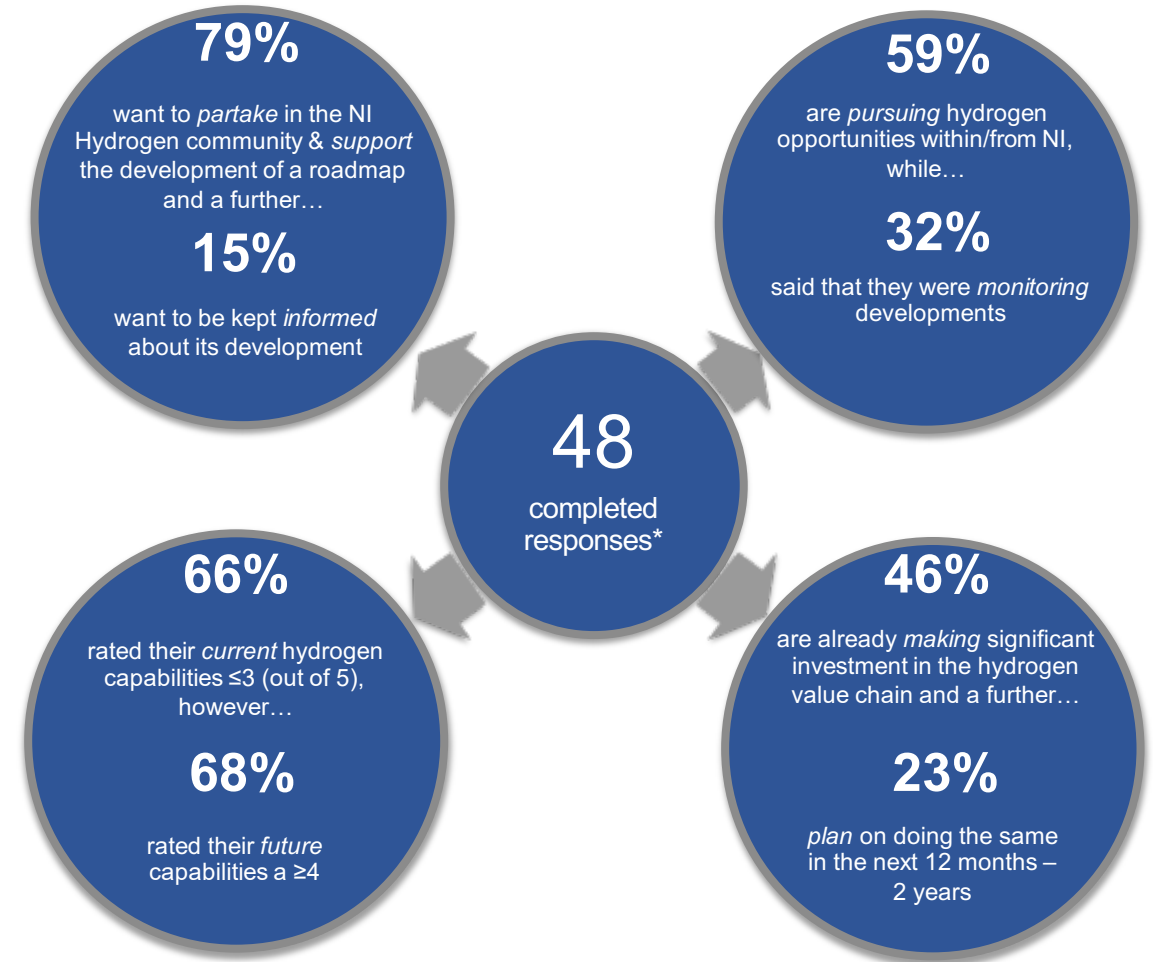
Q4: How would you rate your current hydrogen capability and future ambition?

Q5: Where applicable, which hydrogen value chain segments do you have capability in or are developing capability in?

Q6: If applicable, when do you expect to make your first significant investment in any part of the hydrogen value chain?

Q7: What do you foresee as the most exciting opportunities for the hydrogen sector in Northern Ireland?

Q8: What do you foresee as the greatest barriers facing the development of a hydrogen economy in Northern Ireland?



2.3 Roundtables





1. Technology & Research

Summary

Northern Ireland has readily available training opportunities, a skilled workforce and a number of hydrogen based initiatives. More has to be done to align government policy that benefits Northern Ireland, reduces uncertainty and increases investor confidence. There is currently a high level of ambition.

Current state

- NI companies already have patented a number of technologies in the area and are addressing limitations in the supply chain
- NI companies have already secured Government funding or loans for projects such as Ballylumford Power-to-X and innovative products being developed by Catagen to name a few
- There is a great opportunity to export hydrogen technologies and possibly hydrogen or hydrogen based products
- There is insufficient demand at the moment which could be seen as a barrier to investment
- Funding applications remain resource intensive – especially for SMEs

Strengths

- Advanced manufacturing skills and centre in NI
- Strong transport capability e.g. buses, maritime & aerospace
- Suite of skills training from Level 3 to Level 5 and above
- Advanced composites – in particular storage tanks

Development areas

- Manufacturing capability and capacity gap across the value chain
- Industry vertical integration
- Testing standards and certification
- Reduction in the cost of hydrogen equipment across the value chain
- Accelerate current pathway on provisional roadmap and hone in on 5/6 elements to fast-track

Heard in the sessions

“Engagement with industry & international partners is required”
“We need investor confidence”



2. Production, Conversion & Storage

Summary

Northern Ireland companies are at the forefront of innovative technologies in many areas of the hydrogen value chain. Early Government funding and innovation loans have been secured for project development which will show case opportunities and provide tangible benefits to the NI economy.

Current state

- Hydrogen Technology and Research in Northern Ireland is already quite advanced
- A research led approach to education is advantageous
- There is a suite of training courses available across the region and the local workforce is actively upskilling – the demand for specific skills is already in place
- End user requirements and forecasting need further development to aid investment
- Legislation and regulatory unknowns are leading to delays and uncertainty
- Financial support is available but there are challenges in terms of access and resource capability (for applications)
- There is a lack of a unified voice in some areas

Strengths

- Export potential for technology
- Large scale storage to support RES integration, security of supply and ancillary services
- Existing workforce skills sets can be adapted

Development areas

- NI SME funding & application support
- Driving the cost of green hydrogen down
- Developing partnership opportunities
- Specific skills including business development, financial modelling, supply chain management and sales & marketing
- Regulations, physical planning and infrastructure development

Heard in the sessions

“Existing industry can be adapted to this new green economy and produce equipment that is needed”

“There is insufficient demand at the moment and we need some sort of catalyst to kick it all off”

3. Transport, Retail & End-Use



Summary

Northern Ireland and other UK regional governments have made significant investment in clean public transport and infrastructure with local companies reaping the rewards for their innovative products. There is still however a question on the supply of hydrogen in the short term.

Current state

- Operating costs are still high and need to be lowered
- Early adopters may be required to import hydrogen including blue hydrogen before a sufficient indigenous supply of green hydrogen becomes available
- There is a lack of available infrastructure for wide-spread adoption
- There is a need to build route to market;
- Hydrogen up-skilling has proven very valuable

Strengths

- Hydrogen storage (tanks) – used in all transport applications and could be a quick win for NI.
- Transport, construction and mining equipment manufacturers
- Multiple projects including the Belfast Maritime Consortium, the Translink Zero Emission Bus Programme etc.

Development areas

- Development of the hydrogen hub / technology accelerator model
- Council / public company fleet
- Standards and testing
- Local partnerships or joint ventures
- Increasing apprenticeships
- Collaboration, prototyping and product trials and peer review
- Postgrad courses in hydrogen (are in development)

Heard in the sessions

“There are skills shortages across the board and therefore we need to enthuse the youth with a new form of energy”

“We need to get industry focused around green regional connectivity for NI”



4. Networks & Utilities

Summary

NI has an abundance of renewable energy that is not being fully utilised. There is also a clear understanding and acceptance of the fact that a hydrogen ready gas network and storage facilities are vital however there is a need for further analysis of the path to net zero that includes a scaled up hydrogen economy. The region is in a strong position to inject hydrogen into the network.

Current state

- 2021 saw 41% of total electricity consumption from RES. Curtailment (of wind) remains in the region of 15-20%.
- Onshore and offshore wind capacity and solar PV are set to increase further, yet demand will stay relatively flat in the region.
- 6247 km gas network with up to 291,000 customer connections (60% of NI house holds have access)
- Decarbonising heat remains a challenge - 2/3 of NI energy consumers still use oil-fired heating.
- Hydrogen / bio-methane likely zero carbon heating solutions (along with heat pumps etc.)
- NI has a head start however we still have a due diligence process to go through.

Strengths

- Network ready for gas blending opportunity
- Leveraging experience from GB networks and already developed 'future energy scenarios'.
- A clear understanding and acceptance of the fact that a hydrogen ready gas network and storage facilities are vital

Development areas

- An integrated energy system is much more affordable and pragmatic – this needs to be drawn out
- Public perception and opinions (on hydrogen) are varied – education should be developed.
- Analysis of the path to net zero that includes a scaled up hydrogen economy – DfE Decarbonising Heat Consultation

Heard in the sessions

"The strategy is beginning to come over the line - now starts the real learning with some hands on opportunity"

"In the delivery phase of a NI roadmap, network led whole system planning is the key, to make it tangible & joined up"

5. Policy, Regulations & Legal

Summary

Policy drivers will set the landscape to build the hydrogen roadmap. Local Government and industry must work together to deliver sustainability, green growth and a decarbonised economy.

Current state

- 80% RES target by 2030 and Net Zero 50 targets formally introduced
- One of the main concerns here in NI (& globally) is the lack of Regulatory positions in the Hydrogen value chain
- Slow development of Hydrogen specific Regulations will hinder commercial development
- Nationally, there appears to be some dis-connect between various regulatory bodies however NI participation at UK level forums is positive
- Requirements should be flagged as early as possible to increase understanding of needs (for infrastructure etc.)

Strengths

- Government recognition and support
- A number of pilot projects already in place which will provide some level of certainty for scaling up & identify unforeseen barriers
- A UK hydrogen strategy is in place
- More mature hydrogen economies could provide a basis for approach – for example, Germany & Australia

Development areas

- Regulations are often underpinning EU regulations despite Brexit – these must be aligned to
- Alignment with the future hydrogen strategy in Ireland
- Collaborate with regulatory bodies to fast-track, or at least speed-up, the development of the hydrogen ecosystem

Heard in the sessions

"Perhaps some consideration needs to be given to decommissioning or disposal of plant and machinery in the longer term"

"We need to find common ground now and the way forward in short-medium term – We need to 'learn together' "

3.0 High-Level Hydrogen Roadmap



3.1 Context



Key Strategy Documents Influencing the NI Roadmap



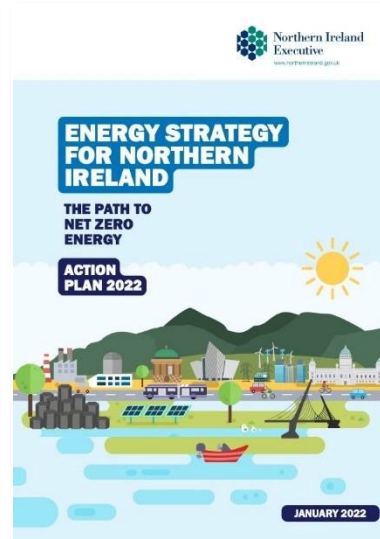
UK hydrogen strategy

<https://www.gov.uk/government/publications/uk-hydrogen-strategy>



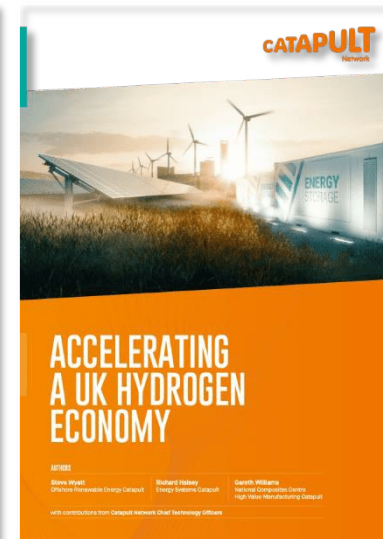
Energy Strategy - Path to Net Zero Energy

<https://www.economy-ni.gov.uk/publications/energy-strategy-path-net-zero-energy>



Energy Strategy - Path to Net Zero Energy - Action Plan

<https://www.economy-ni.gov.uk/publications/energy-strategy-path-net-zero-energy-action-plan>



Accelerating a UK Hydrogen Economy

<https://es.catapult.org.uk/report/accelerating-a-uk-hydrogen-economy>



Hydrogen Investor Roadmap - Leading the way to Net-Zero

<https://www.gov.uk/government/publications/hydrogen-investor-roadmap-leading-the-way-to-net-zero>

UK Government Context: UK Hydrogen Strategy

- The first ever [UK Hydrogen Strategy](#) focused on driving progress to scale up hydrogen economy in 2020s and to position low carbon hydrogen to help meet Carbon Budget 6 and Net Zero commitments
- The initial 5GW production ambition by 2030 has been doubled to 10GW in the revised UK Energy Strategy 2022.

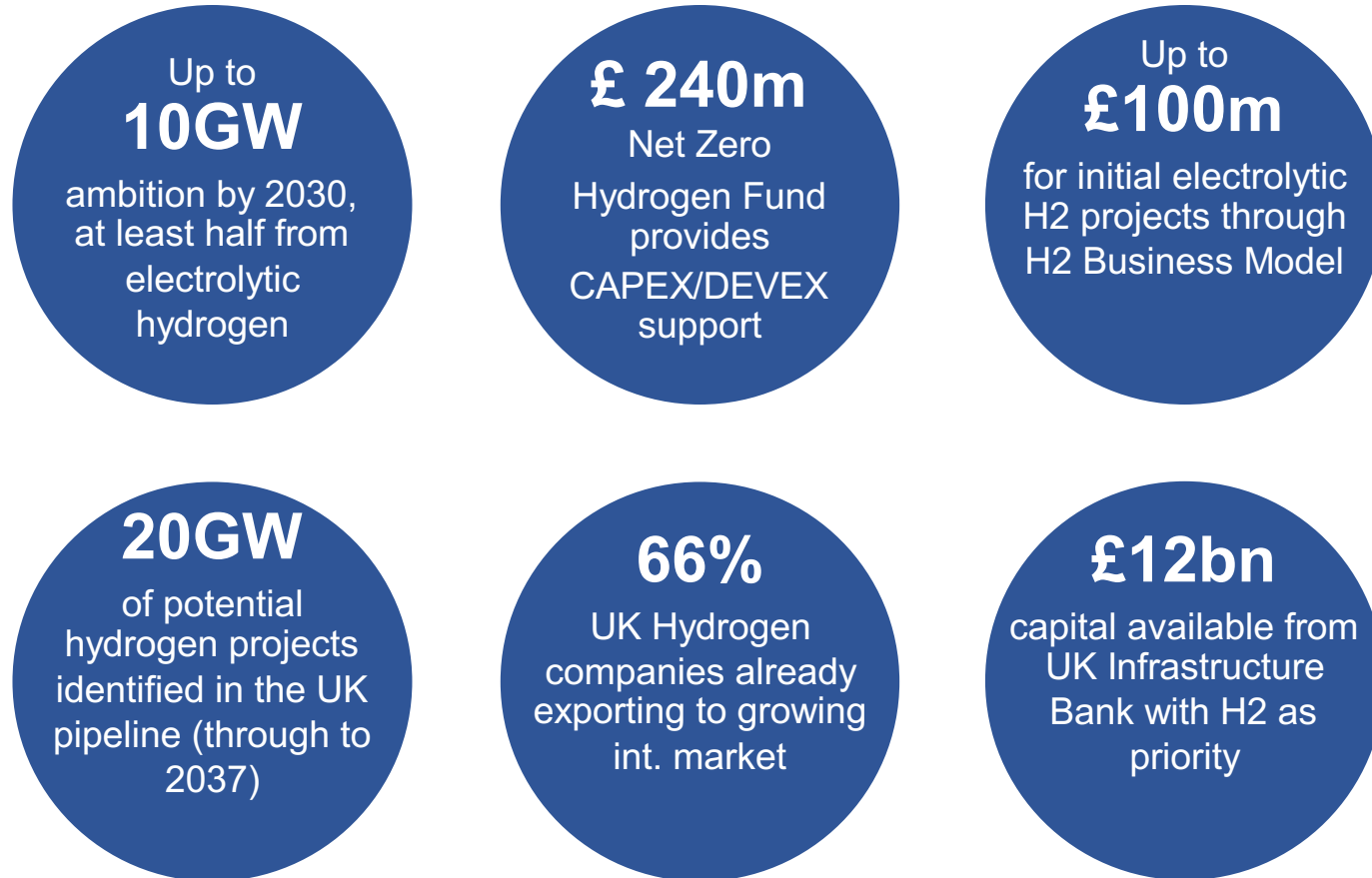
Key elements:

- Sets out up to £1bn in UK Govt support for hydrogen and other low carbon technologies, including over £400m for hydrogen.
- Consultations on support for hydrogen production:
 - Hydrogen [Business Model](#) to provide revenue support
 - [£240m Net Zero Hydrogen Fund](#) for capital co-investment
 - A UK [standard for low carbon hydrogen](#).
- Sets out innovation and demonstration funding for hydrogen applications across industry, power, heat and transport.
- Seeks to secure economic opportunities from outset – 9,000 UK jobs & £900m GVA by 2030, unlocking £4bn investment

Aims of the Strategy



UK Government Context: Hydrogen Investor Roadmap



Supply Chain & Skills

Government is :

- 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

Government expects industry to:.

- Support growth of the UK supply chain
- Nurture and train employees to be the low carbon hydrogen leaders of tomorrow

Technology and Innovation Context: Accelerating a UK Hydrogen Economy

“

Innovation is critical to overcome technology and integration challenges through the entire value chain that will be required to achieve scale, volume, reliability, efficiency and phased roll out of the enabling infrastructure”

“

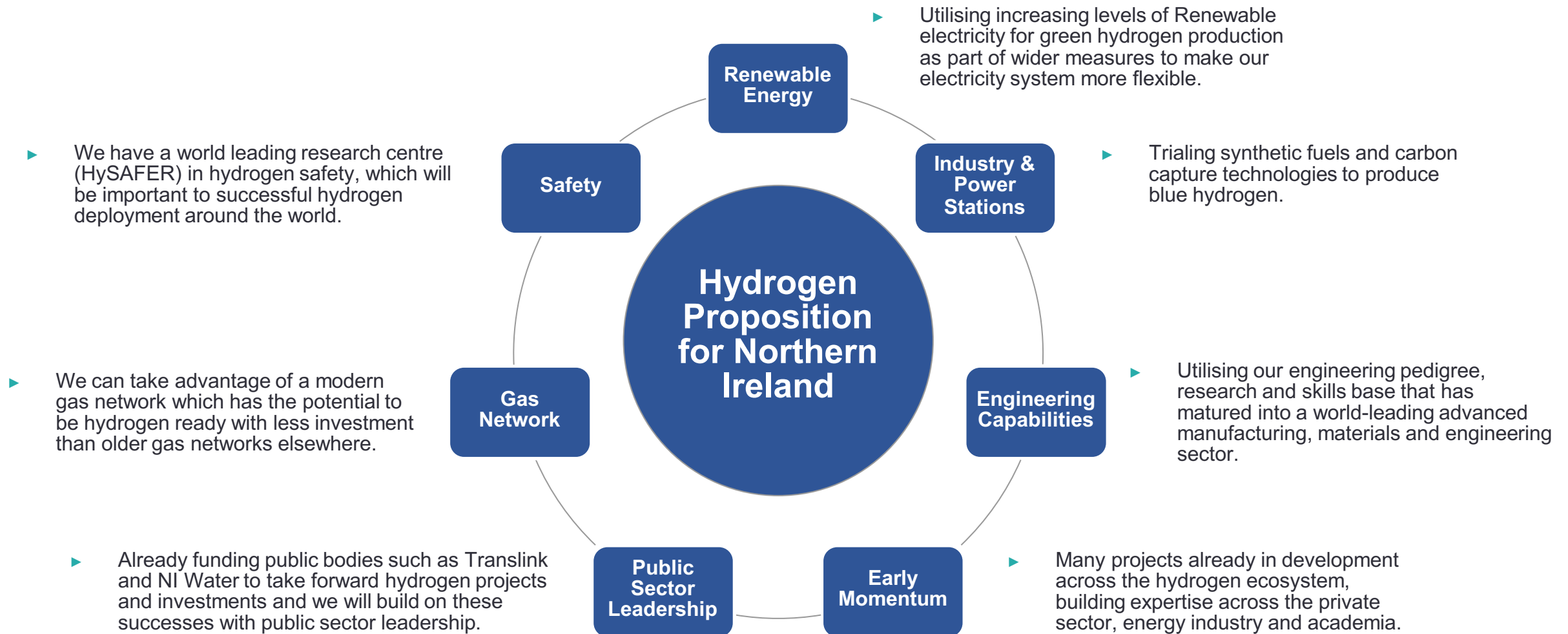
Coordinated R&D with new ways of delivering public-private partnerships that brings together national and local governments, regulators, industry and investors is required to achieve this at an unprecedented rate”

“

There is a significant risk of R&D investment and activity being drawn overseas if we do not keep pace with the investments and commitments made by other countries”

In order to deliver a thriving Hydrogen Economy and to capitalise on the potential economic benefits this presents, the UK must continue to invest in innovation across production, distribution and consumption of hydrogen to accelerate R&D and innovation, to forge new linkages across sectors and to accelerate exploitation routes for technology.

NI Government Context: The Path to Net Zero Energy



UK Regional Industrial Clusters and Net Zero / Hydrogen Initiatives

- The UK has one of the most mature hydrogen markets globally with **six main industrial clusters**.
- These will be the starting point for a new carbon capture industry and support up to 50,000 jobs in the UK by 2030.
- **Additional locations are developing local or regional hydrogen strategies.**

Source: UK Hydrogen Council's Hydrogen Insights Report 2021, Media scanning

Liverpool City Region

- Assets: SMR and Electrolyser production facilities.
- Investment opportunities: LCR Hydrogen Bus project and HyNet blue hydrogen production.

HyNet North West

A low carbon and hydrogen energy project that will unlock a low carbon economy for the North West and North Wales and put the region at the forefront of the UK's drive to net zero. Aside from decarbonising homes and industry, this project will create 6,000 local jobs and, by 2035, support 75,000 more across the UK.

Derby – hydrogen roadmap development

- Strong cluster of advanced manufacturing and engineering excellence;
- Wealth of large scale sites with high development potential as green hubs;
- Network of research institutions and collaborators;
- Large potential users with strong transport infrastructure.

Midlands Engine – Hydrogen Technologies Strategy

- The Midlands Engine partnership is a unifying pan-regional force spanning 65 local authorities, one combined authority, 20 universities, nine local enterprise partnerships and over 800,000 businesses

Wales

- Assets: include Energy Kingdom at Milford Haven (blue hydrogen) and energy hub at Holyhead.
- Investment opportunities: include the Hydrogen Highway and ports infrastructure.

South Wales Industrial Cluster (SWIC)

- South Wales is at the forefront of reducing the UK's emissions, through SWIC's use and production of hydrogen, along with carbon capture & storage.
- This project will enhance the ability to locally manufacture low or net zero carbon cement and steel, creating Welsh jobs and unleashing economic growth.

Grangemouth

- Assets: include existing pipelines connecting major industrial hub connecting Scotland to mainland Europe.
- Investment opportunities: at the power station for CCS in Peterhead.

Tees Valley

- Assets: include existing underground hydrogen storage and Teesside Freeport.
- Investment opportunities: include a first of its kind Hydrogen Transport Hub at Tees Valley.

Humber

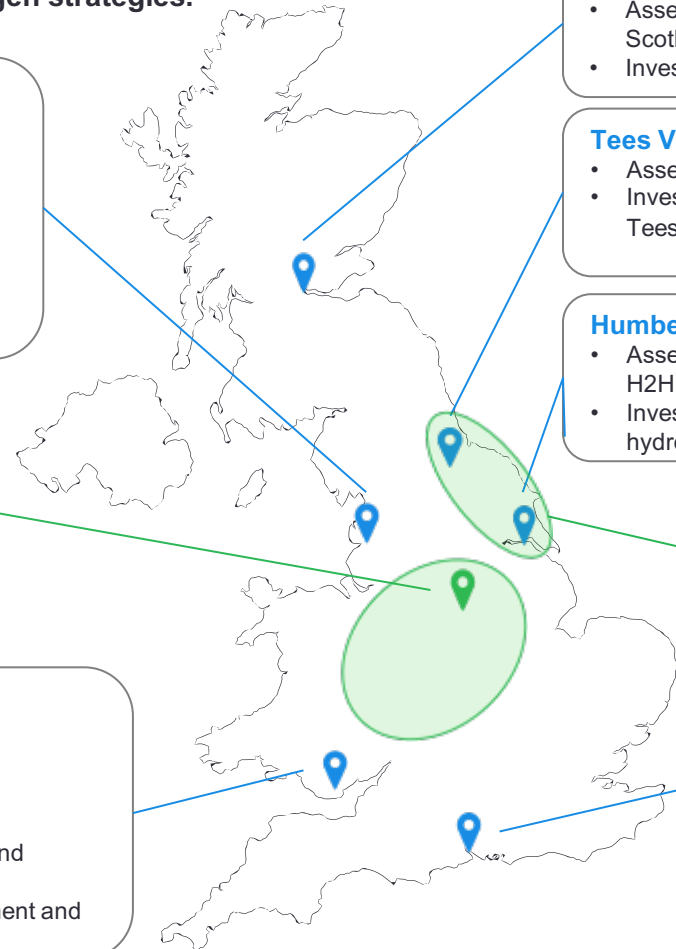
- Assets: include empty gas and salt caverns for hydrogen storage and Equinor's H2H Saltend.
- Investment opportunities: include shared hydrogen pipeline and Green hydrogen projects such as Gigastack.

East Coast cluster

A collection of industrial, power and hydrogen businesses which aim to decarbonize their operations through the deployment of carbon capture utilization and storage (CCUS).

Solent (Southampton)

- Assets: include H2 Research and Refuelling Station.
- Investment opportunities: the hydrogen super-hub in the port of Southampton is a key investment opportunity at the Solent cluster.
- The project will look at the potential for creating a hydrogen super-hub in the Port of Southampton and developing a centre of excellence for hydrogen production and distribution on the south coast.



Hydrogen Activity in NI

Past & Current Projects

i4C Hydrogen Training Academy and Integrated Green Hydrogen Hub

- Mid and East Antrim Council
- Belfast met
- Energia
- EP UK Investments
- Firmus Energy
- Northern Regional College
- QUB
- Translink
- Ulster University
- Wright Bus

HySkills

- EIFI TECH
- Erasmus+
- South-West College

Centre for Advanced Sustainable Energy (CASE)

1. Breakthrough safety technologies for hydrogen vessels
2. Developing a type IV polymer composite tank for hydrogen storage
3. Hydrogen generation infrastructure to support fuel-cell fleet

Belfast Power to X

- B9 Energy
- Belfast City Council
- EIFI TECH
- Firmus Energy
- Mutual Energy
- Northern Cyrogenics
- Northern Ireland Water
- QUB
- The Strategic Investment Board
- Translink

GENCOM

- Belfast met
- Energia
- HyEnergy Consultancy
- Interreg Atlantic Area
- NUI Galway
- Pure Energy Centre

Ballylumford Power-to-X

- B9 Energy Ltd
- Islandmagee Energy
- Mutual Energy
- Net Zero Technology Centre

Belfast Maritime Consortium

- Ards & North Down Borough Council
- Artemis Technologies
- Belfast City Council
- Belfast Harbour
- Belfast met
- Catalyst
- Condor Ferries
- Creative Composites
- InvestNI
- Power NI
- QUB
- Spirit AeroSystems
- Ulster University

SeaFuel

- Action Renewables
- HyEnergy Consultancy
- Interreg Atlantic Area
- NUI Galway

Green Seas Consortium

- Artemis Technologies
- Mott MacDonald
- NIE Networks
- PowerNI
- QUB
- Ulster University

Northern Ireland Hydrogen Transport (NIH2 Transport)

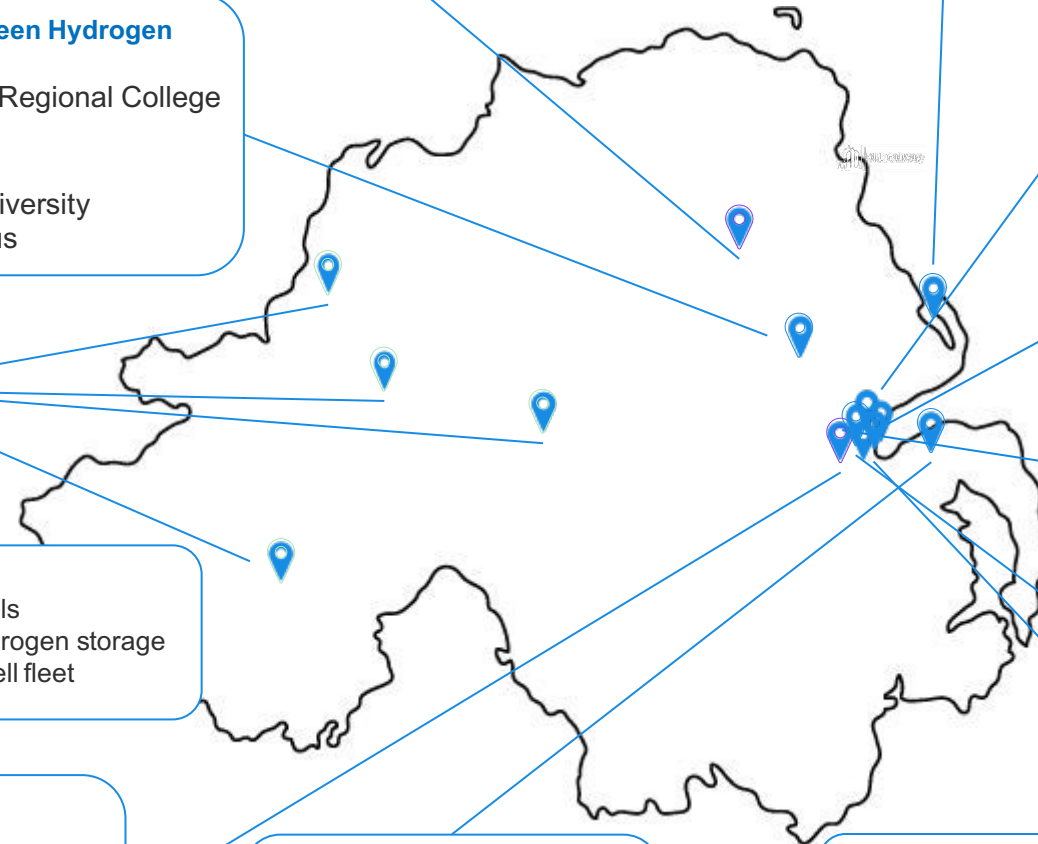
- Energia
- HyEnergy Consultancy
- Translink

Translink Zero Emission Bus Programme

- Wright Bus
- Translink
- ChargePoint
- Ryze Hydrogen
- Logan Energy

H2 & O2 Pilot

- B9 Energy Ltd.
- CPH2
- Lagan MEICA
- Northern Ireland Water



NI Hydrogen Landscape and Potential Manufacturing Supply Chain Opportunities

Production & Large Scale Storage	
Company / Project	Hydrogen area of interest
Ballylumford Power-to-X	Full-cycle hydrogen economy, from production, storage and distribution to usage at the site.
Belfast Power to X	Whole energy system innovation
GENCOM	Smart Hydrogen Integrated renewable energy generation and storage project
Northern Ireland Water	Electrolysis, RES integration and industrial process (water treatment)
B9 Energy Ltd.	Large scale centralised storage (salt cavern)
CATAGEN	Novel green hydrogen production, storage and e-fuel
Energia	Green hydrogen production (Electrolysis)

Gas Network	
Company / Project	Hydrogen area of interest
Mutual Energy	Blending / de-blending, centralised / large scale storage, metering and billing, high-pressure pipeline, line pack and compression
Phoenix Natural Gas	Blending / de-blending, distributed high-pressure storage, metering and billing, medium/low pressure pipeline, line pack and compression
Firmus Energy	

Mobility and Small Scale Storage	
Company / Project	Hydrogen area of interest
Wrightbus	Automotive fuel cell powertrains (FCPs)
Artemis Technologies	Marine electric propulsion systems; simulation and performance prediction tools; advanced manufacturing
Translink Zero Emission Bus Programme	Automotive, hydrogen bus operation, refuelling
CCP Gransden	Advanced composite manufacturing, HP vessels / hydrogen fuel tanks
Linamar	Automotive fuel cell powertrains and hydrogen storage
Belfast Maritime Consortium	Zero carbon marine technology development; zero-emission passenger ferry; advanced manufacturing
Green Seas Consortium	Green hydrogen production, bunkering, cold ironing, digital twin
NI Hydrogen Transport (NIH2 Transport)	Pilot project including offtake agreements and a hydrogen refuelling station
ADS Northern Ireland	Aerospace, Defence, Security and Space applications
Kingspan	Composites, fuel storage and green steel production,

R&D and Design Manufacturing and Test	
Institution / Project	Hydrogen area of interest
NIACE – Advanced Composites and Engineering (Queen’s University Belfast and Ulster University)	Manufacturing of Hydrogen Storage tanks: <ul style="list-style-type: none"> Compressed Storage Cryogenic Storage Liner expertise / production
Polymer Processing Research Centre (PPRC) at Queen’s University Belfast	State of the art processing and analytical facilities, education & training. Compressed Storage
WTECH Centre at Queen’s University Belfast	Transport / Modelling / Simulation / Power trains / Energy Data Analytics / Smart Grid / Distribution / Integration
Bryden Centre at Queen’s University Belfast	Production / Generation / Conversion / Green H2 / Agri waste / Zero Carbon Co-ops
Advanced Manufacturing and Innovation Centre (AMIC)	Design, manufacturing and prototyping, including verification and supply chain
Hydrogen Safety Engineering and Research Centre (HySAFER)	Industry-driven research, consultancy, knowledge and technology transfer in the area of safety science and engineering, primarily hydrogen and fuel cell technologies (Modelling / Simulation / Composites)
i4C Hydrogen Training Academy	Skills for hydrogen technologies and hydrogen economy
HYSkills – South West College	Skills development for Hydrogen safety
Centre for Advanced Sustainable Energy (CASE)	R&D projects related to hydrogen storage and safety
AMIC / i4C Technology Accelerator Hub	Powertrains, fuel cells and storage development, and integration with industrial scale test cells

Hydrogen in the Republic of Ireland



No formal Hydrogen Strategy has been published.



Several initiatives have already been proposed under the Shared Island Forum, with funding already committed for cross-border initiatives. A Green Hydrogen Plan for the road network focussing primarily on buses and HGVs has been proposed.



Identifying the vast wind reserves in Ireland and the opportunity to create an export industry; private initiatives including hydrogen hubs and green hydrogen production are in planning. Co-operations are being explored, including the newly formed German-Irish Hydrogen Council.

Summary of Key Points from Contextual and Strategic Analysis

- Northern Ireland is well positioned to capitalise on the burgeoning hydrogen economy
- Stakeholders welcome collaboration and agree it is critical to increase activity as soon as possible to build on early momentum
- UK energy policy and subsequent energy and hydrogen strategies are well advanced. However, Northern Ireland must consider technology strengths and investment priorities if the NI value chain is to become visible in a national context, leading to joint ventures and attracting investment and talent
- There is significant risk of R&D investment and activity being drawn overseas if we do not keep pace with the investments and commitments made by other countries
- Several key areas of capability in the NI hydrogen manufacturing value chain include advanced manufacturing techniques for composites, high-pressure storage solutions, fuel cell powertrains and potentially new green hydrogen and synthetic fuel production technology. These should be championed both nationally and internationally
- NI world class hydrogen safety expertise should also be promoted (for example through the UK Hydrogen Regulators Forum & Advisory Council)

3.2 Hydrogen Roadmap Proposal and Pillars

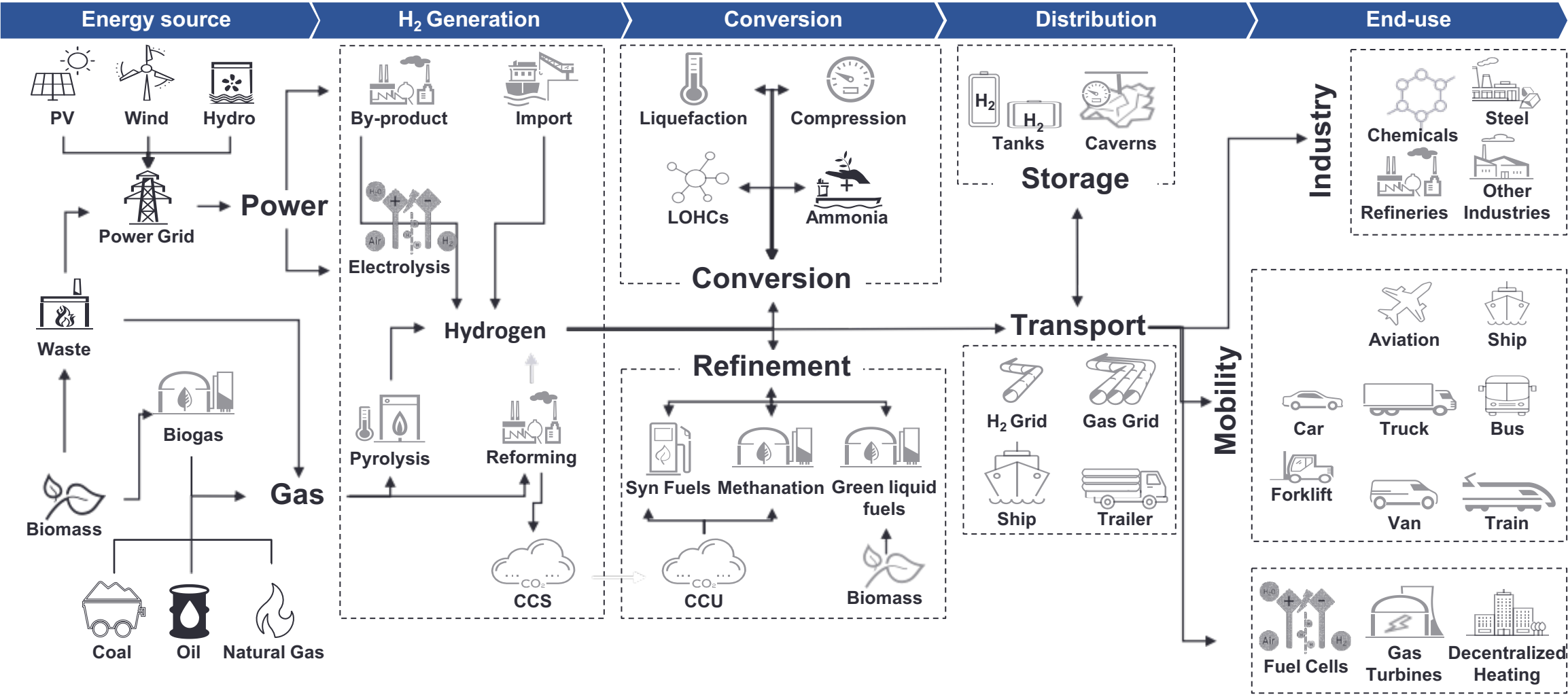


Rationale and Approach for Creating the NI Hydrogen Roadmap

- The UK Hydrogen Strategy identified a baseline for the 2020's hydrogen roadmap including pillars for Production, Networks and Use. The roadmap includes a number of supporting policy and activities – what needs to be in place to deliver
- The NI Roadmap aimed to replicate this, expanding the number of pillars to include additional elements for R&D & Academia, Policy/Regulation, Design, Manufacturing and Test, and after market services
- Stakeholders grouped under these areas helped shape the roadmap
- The scope of this project was to focus on technology options and considerations in the near to medium term up to 2030, aligning with the newly published UK Hydrogen Investor Roadmap

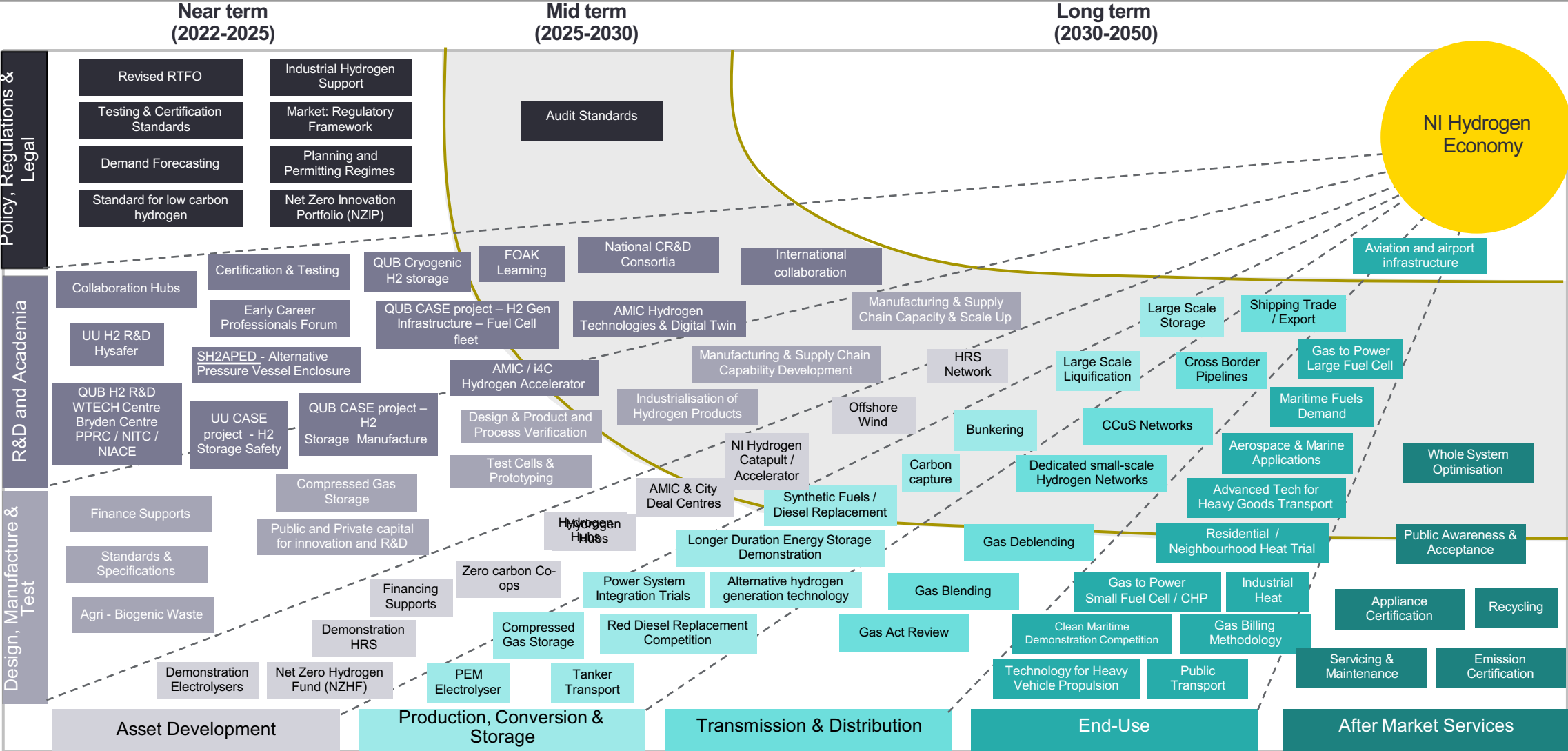


NI-specific Hydrogen Value Chain



Sources: IRENA, IEA, EY analysis

A High-Level Hydrogen Roadmap for NI



Timelines are not to scale and are indicative. There is also a cross cutting nature of skill requirements.

Manufacturing Supply Chain opportunities

Each component of the Roadmap must consider the opportunities presented for the Northern Ireland supply chain by the industrialisation and local value adding of the following hydrogen products. Examples include:

- **Compressed hydrogen storage components**

Carbon fibre	Specialised materials
Polymer Liner	Specialised materials
Regulators	Sub-component
Valve	Sub-component
Pressure vessel	Sub-system
Tank system integration	System

- **PEM Electrolyser critical components**

Catalyst	Specialised materials
Membrane	Sub-component
Membrane electrode assemblies	Sub-component
PEMEL stack	Sub-system
Ionomer	Specialised materials
Porous transport layer / gas diffusion layer	Sub-component
Bipolar plates	Sub-component
PEMEL system	System
Membrane support	Specialised materials
H2 sensor	Sub-component
H2 conditioning	Sub-system
AC-DC power supply	Sub-system

- **Micro-CHP PEM Fuel Cell components**

Supported catalyst	Specialised materials
Membrane	Sub-component
Membrane electrode assemblies	Sub-component
Gas diffusion Layer	Sub-component
PEMFC stack	Sub-System
PEMFC system	System
Membrane support	Specialised materials
Ionomer	Specialised materials
Bipolar plates	Sub-component
Air handling / recirculation	Sub-component
H2 sensor	Sub-component
H2 Storage tanks	Sub-component
Power electronics / inverters	Sub-system

- **Hydrogen refuelling station (HRS) critical components**

H2 Storage tanks	Component
Dispensers/ hose	Component
H2 compressors	Sub-system
H2 sensor	Sub-system
HRS solution integration	System
Flow meters	Component
Precooling	Sub-system

Policy, Regulations & Legal

Description

Policy drivers will set the landscape to build the hydrogen roadmap. Local Government and industry must work together to deliver sustainability, green growth and a decarbonised economy. Strengths include:

- Government recognition and support
- A number of pilot projects already in place which will provide some level of certainty for scaling up & identify unforeseen barriers.
- A UK hydrogen strategy is in place
- More mature hydrogen economies could provide a basis for approach – for example, Germany & Australia

Roadmap	Near term (2022-2025)	Mid term (2025-2030)	Long term (2030-2050)
	<div>Revised RTFO</div> <div>Testing & Certification Standards</div> <div>Demand Forecasting</div> <div>Standard for low carbon hydrogen</div>	<div>Industrial Hydrogen Support</div> <div>Market: Regulatory Framework</div> <div>Planning and Permitting Regimes</div> <div>Net Zero Innovation Portfolio (NZIP)</div> <div>Audit Standards</div>	

Next steps

Next steps are broadly in line with the UK Hydrogen Strategy where:

- 1 Government to set out further details of the revenue mechanism both Nationally and within NI.
- 2 Ensure participation in the UK Hydrogen Regulators Forum and actively engage with regional stakeholders.
- 3 Assess market frameworks to drive investment and deployment of hydrogen and provide an update in early 2022.
- 4 Assessment of regulatory barriers facing hydrogen projects
- 5 Complete an early assessment of the value for money case for blending up to 20 per cent hydrogen into the existing gas network and propose a policy decision as soon as possible.

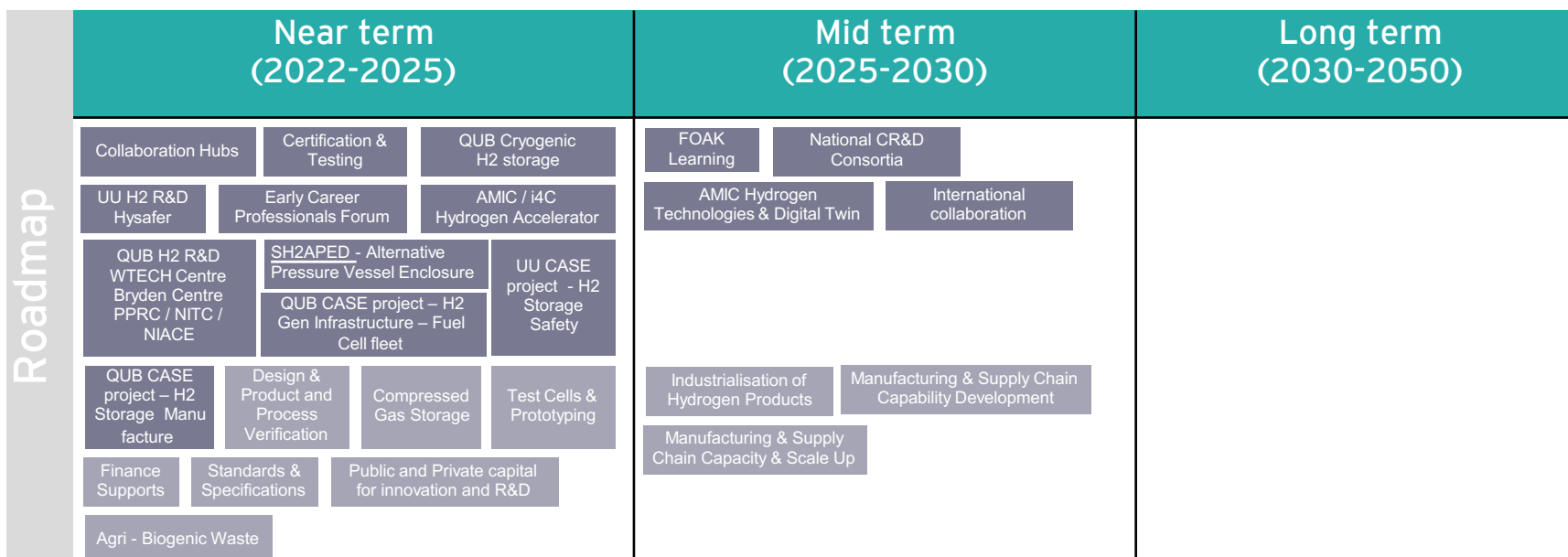
R&D and Academia + Design, Manufacture & Test

(Prototyping & industrialisation of products)

Description

Northern Ireland has readily available training opportunities, a skilled workforce and a number of hydrogen based initiatives. More has to be done to align government policy that benefits Northern Ireland, reduces uncertainty and increases investor confidence. There is currently a high level of ambition. Strengths include:

- Advanced manufacturing skills and centre in NI
- Strong transport capability e.g. buses, maritime & aerospace
- Suite of skills training from Level 3 to Level 5 and above
- Advanced composite manufacturing capability – in particular storage tanks



Next steps

- 1 Take a whole-system approach to Technology Innovation and Research throughout the 2020s to be able to deploy and integrate hydrogen technology and systems holistically in the context of wider social, environmental and economic developments.
- 2 Build out a 'Community of Practice' enabling a shared stakeholder platform.
- 3 Support commercialisation and leverage opportunities such as the UK £1 billion Net Zero Innovation Portfolio (NZIP).
- 4 Build an understanding of scale of private sector investment and promote investment in NI based companies.
- 5 Foster collaboration with international partners

Production, Conversion & Storage

Description

Northern Ireland companies are at the forefront of innovative technologies in many areas of the hydrogen value chain. Early Government funding and innovation loans have been secured for project development which will showcase opportunities and provide tangible benefits to the NI economy. Strengths include:

- Export potential for technology
- Large scale storage to support RES integration, security of supply and ancillary services
- Existing workforce skills sets can be adapted
- TRL7 innovative projects (System prototype demonstration in operational environment)

Roadmap	Near term (2022-2025)		Mid term (2025-2030)	Long term (2030-2050)
	PEM Electrolyser	Alternative hydrogen generation technology	Carbon capture	
	Longer Duration Energy Storage Demonstration	Power System Integration Trials	Bunkering	
	Red Diesel Replacement Competition	Tanker Transport	Large Scale Liquification	
	Small Scale Storage		Large Scale Storage	

Next steps

- 1 Support pilot and small scale projects and exploit learn by doing. By the mid-2020s, larger hydrogen projects could be deployed with production and end-use closely linked.
- 2 Quantify the ambition / set targets for low carbon and green hydrogen production capacity for 2030 and beyond
- 3 Leverage funding opportunities including the UK £240m Net Zero Hydrogen Fund in early 2022 for co-investment in early projects.
- 4 Incorporate the UK standard for low carbon hydrogen (expected in early 2022)¹ in future policy..
- 5 Capitalise on future alternative hydrogen generation technologies.

End-Use (including Transport) + After Market Services

Description

Northern Ireland and other UK regional governments have made significant investment in clean public transport and infrastructure with local companies reaping the rewards for their innovative products. There is still however a question on the supply of hydrogen in the short term. Strengths include:

- Hydrogen storage (tanks) – used in all transport applications and could be a quick win for NI
- Transport, construction and mining equipment manufacturers
- Multiple projects including the Belfast Maritime Consortium, the Translink Zero Emission Bus Programme etc

Next steps

- 1 Leverage on the success and learning from the case study projects (e.g. Translink Zero Emission Bus Programme).
- 2 Explore cross-border opportunities (including during consultation of a Hydrogen Strategy in Ireland in Summer 2022).
- 3 Explore options for future gas billing to prepare for potential changes to gas blends (reflecting different calorific values between methane, biomethane and hydrogen).

Roadmap	Near term (2022-2025)		Mid term (2025-2030)	Long term (2030-2050)
	Gas to Power Small Fuel Cell / CHP	Industrial Heat	Residential / Neighbourhood Heat Trial	
	Clean Maritime Demonstration Competition	Gas Billing Methodology	Maritime Fuels Demand	
	Heavy Goods Transport	Public Transport	Gas to Power Large Fuel Cell	
	Public Awareness & Acceptance	Technology for Heavy Vehicle Propulsion	Aviation and airport infrastructure	
	Servicing & Maintenance	Recycling	Aerospace & Marine Applications	
	Emission Certification	Appliance Certification	Advanced Tech for Heavy Goods Transport	
			Whole System Optimisation	

Transmission & Distribution + Asset Development

Description

NI has an abundance of renewable energy that is not being fully utilised. There is also a clear understanding and acceptance of the fact that a hydrogen ready gas network and storage facilities are vital however there is a need for further analysis of the path to net zero that includes a scaled up hydrogen economy. The region is in a strong position to inject hydrogen into the network. Strengths include:

- Network ready for gas blending opportunity
- Leveraging experience from GB networks and already developed ‘future energy scenarios’.

Roadmap	Near term (2022-2025)		Mid term (2025-2030)		Long term (2030-2050)	
	Demonstration Electrolysers	Net Zero Hydrogen Fund (NZHF)	Offshore Wind	HRS Network		
	Demonstration HRS	Financing Supports	AMIC & City Deal Centres	NI Hydrogen Catapult / Accelerator		
	Gas Act Review	Hydrogen Hubs	Gas Deblending	Cross Border Pipelines		
	Gas Blending		Dedicated small-scale Hydrogen Networks	Shipping Trade / Export		
			CCuS Networks			

Next steps

- 1 Enabling hydrogen blending into the natural gas network will be fundamental to the energy transition since the network can absorb hydrogen produced locally before there is a great demand of other end users. This will encourage hydrogen production and thus the full utilisation of the RES-e generated by wind power. Gas blending, heat trials and relevant policy enablers should be encouraged in the near term. This will also require investment in new gas network management solutions and modelling.
- 2 Holistic and integrated system planning will also be critical to assess the constraints in both the gas and electricity networks and to deliver optimal solutions for both hydrogen (& bio-methane) injection. Transmission and distribution network owners and operators must collaborate as early as possible.

3.3 Skills Assessment

[Completed by Catalyst]



NI Skills Policy Highlights

The Skills Strategy for NI* has developed 3 major policy objectives:

- Addressing Skills Imbalances, Driving Economic Growth
- Creating a Culture of Lifelong Learning
- Enhancing Digital Skills, Developing a Digital Spine.

Which is supported by a further 3 policy enablers:

- Enhancing Policy Cohesion
- Building Strong Relationships
- Investment in the Skills System

The strategy summary document noted the recognition and need for:

“the need for transformational change in our skills system”

* Skills Strategy for NI skills for 10X Economy, Department for the Economy

The **Energy Strategy for NI*** outlines the implementation of energy priorities for the skills needs to support low-carbon heat and renewable energy sector, using existing training and education pathways.

Medium to long-term engagement with Northern Ireland Skills Forum is suggested in the Skills for a 10X economy. A new Energy Skills Forum will identify skills gaps for emerging low carbon technologies, which will ensure appropriate programmes for skills development.

Within 2022 NI policy has set out to offer support for:

- Implementation of TRL Level 7 and above will be funded by a private sector challenge fund through DfE support
- Green funding opportunities ezine to provide updates on available support.

*Energy Strategy NI, 2021, <https://www.economy-ni.gov.uk/publications/energy-strategy-path-net-zero-energy>

Skills development within policy is an ongoing and evolving process to address the challenge areas and drive the economic and social development across the region. Ongoing work within NI to create a pipeline of talent includes:

The Review of Hydrogen
Energy in Further Education

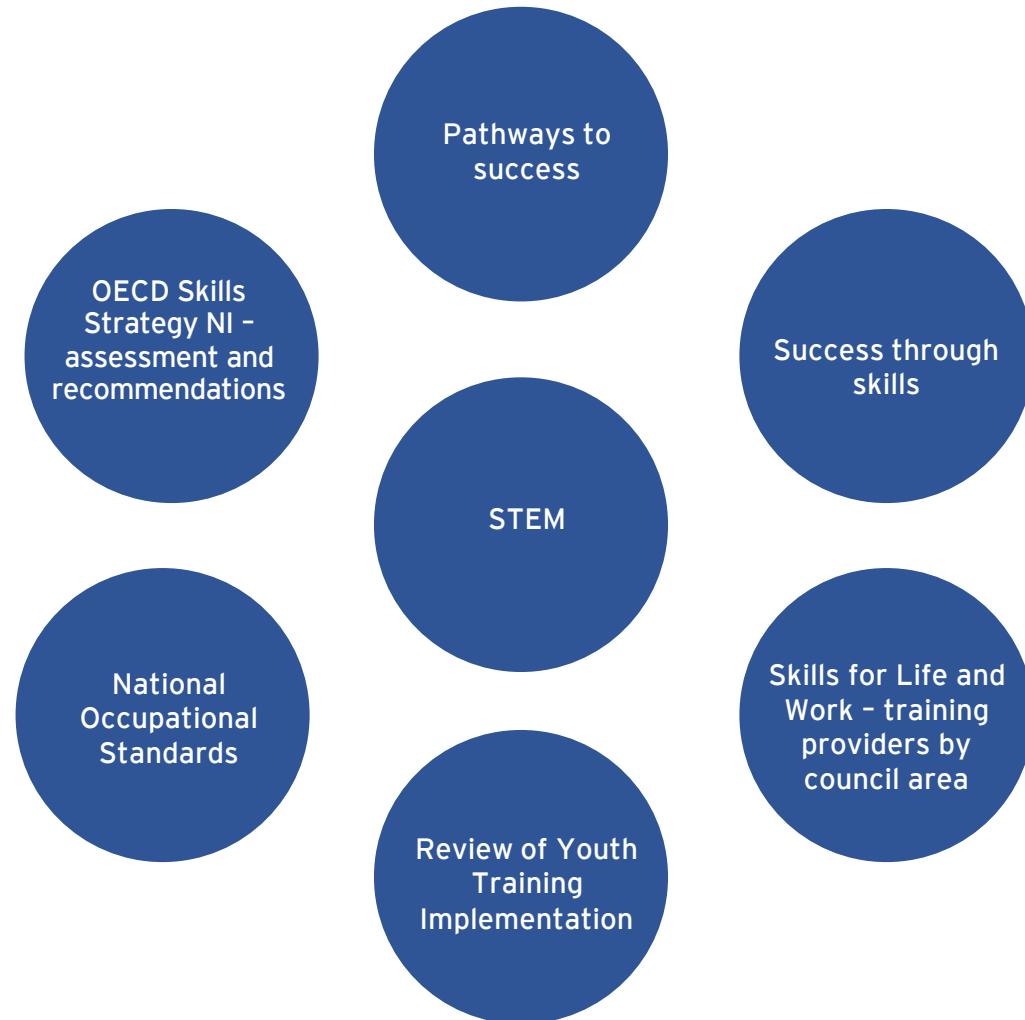
‘Women in STEM’, which seeks to
address the significant under-representation
in these areas of study



The ‘Independent Review of Education’, announced
by the Minister of Education in December 2020

The joint DE/DfE ‘Transition of Young
People into Careers (14 – 19) Project’

A Range Of Skills Strategies Are Currently In Place:



Industry Informing Curriculum

Engagement with policy development is through Sectoral partnerships, which bring together employers, FE providers and other experts to develop qualifications and curriculum frameworks, and the delivery of Apprenticeships to meet the current and future needs of industry in NI.

The purpose is to review and develop the content of all youth traineeship and apprenticeship frameworks from level two to level eight to ensure that all those involved in training are industry ready.

The partners work together in a cycle to establish the sectoral partnership, curriculum development and delivery and review; there are 15 sectoral partnerships across a range of sectors that have been established to date.

Institutional design work has taken place* and has recommended an integrated economic skills innovation policy agenda that includes key actions, which are being enacted on. Policy makers should allocate a timeframe for actions to be completed by.

1.

Integrating skills into
broader economic
strategy

2.

Specific institutional
requirements to
support integration,
such as Strategic
Oversight Group for
Skills to include
implementation
oversight

3.

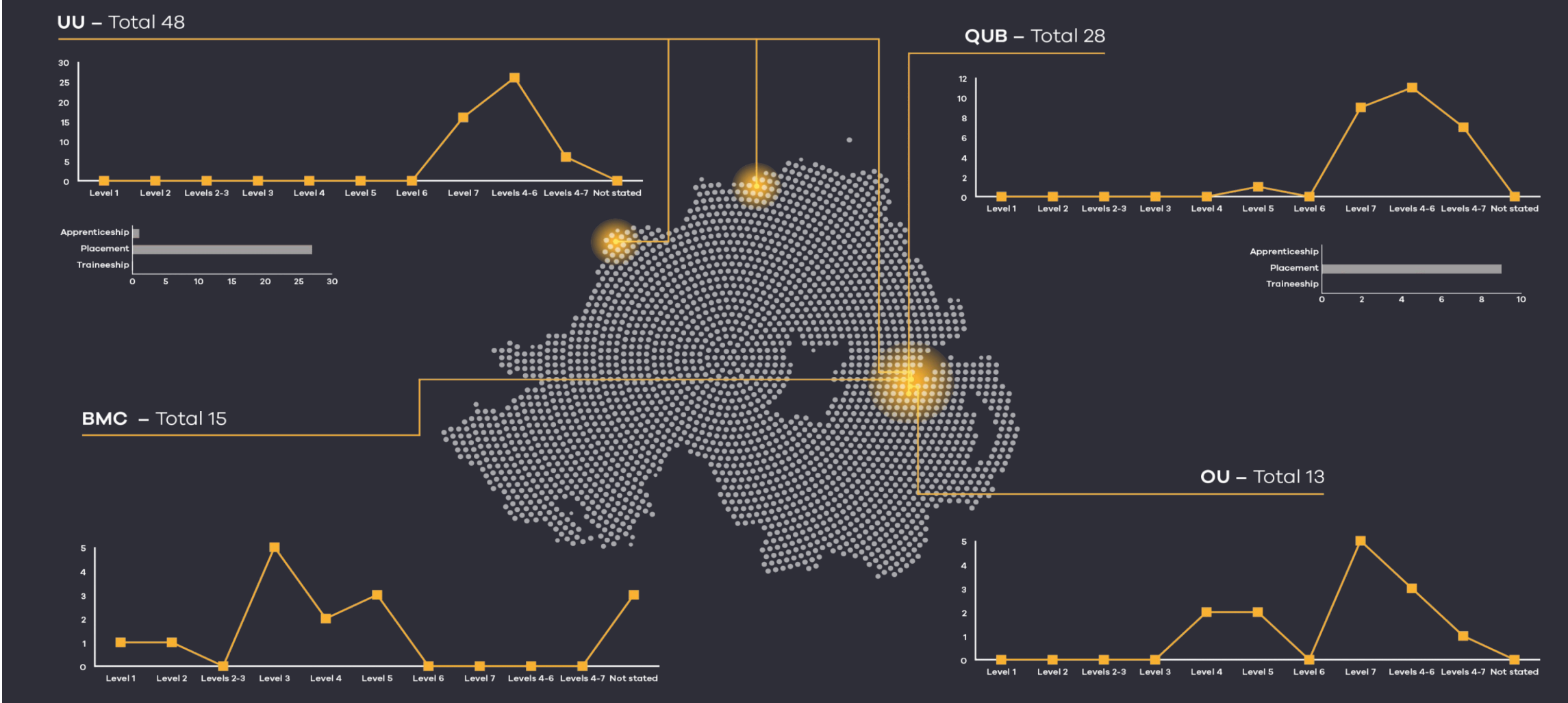
External stakeholder
engagement,
investing in informal
and deliberate
engagement

*Institutional design to support integrated economic skills innovation policy agenda, David Skilling, Landfall Strategy group

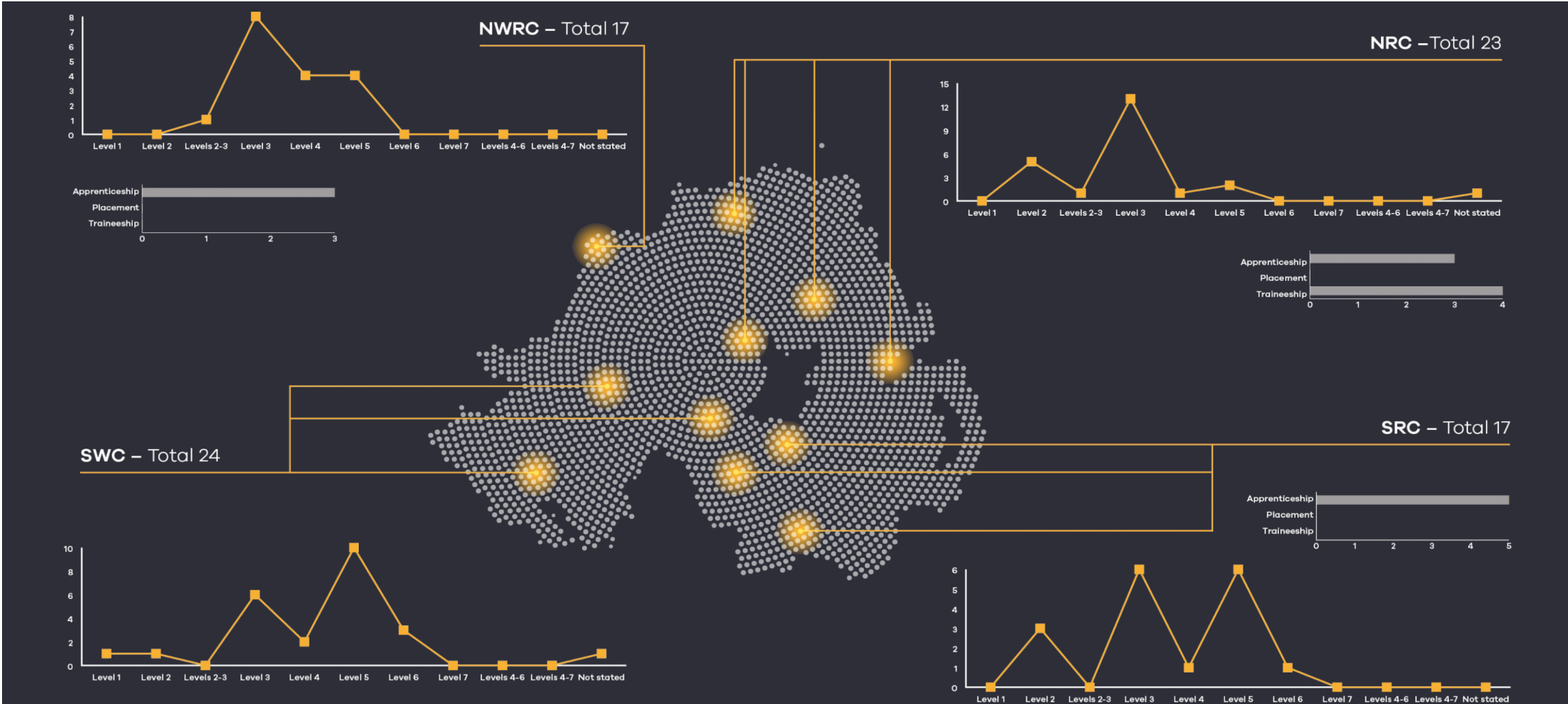
NI skills provision mechanisms through existing programmes, outside of traditional courses, include:

- Apprenticeships
- Assured skills pre-employment
- Assured Skills Academies
- Flexible Skills Fund to support upskilling and reskilling; and
- Proposals for investment in leadership and management training

NI Skills Provision Throughout NI



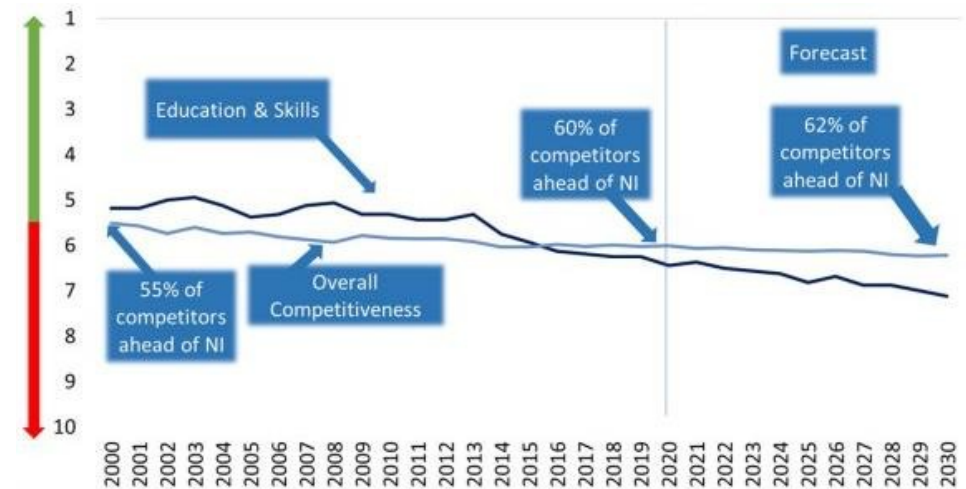
NI Skills Provision Throughout NI



National skills challenges

The Hydrogen Economy is an emerging and fast-growing sector, challenges are faced by many industries. The emergence of new technologies and markets within Hydrogen makes these challenges even more complex, some challenges acknowledged are:

- Current and future skills shortfalls
- Ageing workforce demographics and reduced migration
- Fragmented education and training systems
- Rapid digitalisation of industries and supply chains
- Comparatively small higher-technical skills base
- Poor demand alignment across sectors and across technologies



Source: Page 14, Skills Strategy for NI Summary; Ulster University Economic Policy Centre

Change is needed within NI:

Skills forecasting* suggests that competitors are increasing ahead of NI, with a widening gap over the next decade before 2030.

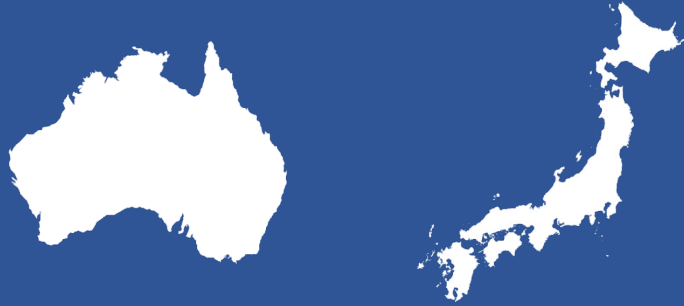
* Skills barometer for NI 2019 summary

International highlights for skills development within the Hydrogen economy



Germany

- Skills and competency development
- Centres of excellence in research institutions
- Special PhD programmes
- Vocational training



Australia and Japan

- Governments collaborating internationally through PROJECT X linking creation of green hydrogen in Australia to supply chain usage in Japan



Norway

- Bespoke project design 'PROJECT X' accelerating energy technology projects from concept to market in green transition
- In 2019, 2 consortiums funded to develop full-fledged hydrogen production and supply chains in different regions of Norway (total £6m)
- £550m of Grant funding invested in R&D on hydrogen, fuel cells and water electrolysis from 2009 and 2019

3.4 International case studies within high technology sectors



Future skills for new technologies

Existing collaborations and groups of practice providing proactive preparation of **skills forecasting** and future standards. Systems to work on two tracks for current and future needs, education leading skills changes for employers that are available with industry identifies a market opportunity.

Establishing 'Expert Educator Team' from FE and HE based on reputation and anticipated local needs for education in the emerging technologies. Their role is to **interpret future technology needs into a curriculum** that can be incorporated into existing academic offers. 'Thinking and Doing Competency Maps'

Standards and certification

Qualifications should be developed in parallel with existing standards to avoid delay and may become incorporated in standards later. There is acknowledgement of the need for a modular, interoperable, 'building brick' approach for these programmes to increase education and training provider responsiveness.

Interdisciplinary Apprenticeships for Hydrogen technologies, aimed at second- and third-year apprentices as additional learning in industrial and technical areas recognises the potential of networked systems in their own company and to participate in the conception, implementation and selection of suitable methods and technologies.

Access to emerging technologies

Integrated and joined up FE and HE activity defines the curriculum in a collaboration between academic educators and industrial technologists. The improved integration of knowledge of capacity would also support planning and securing appropriate supply chain capability. Two-way exchange of need and current technology capabilities

Technical Training Facilities

Government investment in a specialist workforce skills force training, whereby industrial training and education courses are provided alongside academic modules, typically taking a few days in each semester per student, with learning outcomes certified by their institution.

Investment in physical assets is matched with skills investment from the beginning, with the continuing development of teaching staff and curriculums using collective programmes.

Skills Delivery Methods

Problem-based learning built on industrial needs, potentially using a blended learning with low-cost augmented reality (AR) and virtual reality (VR) tools using online modules, increases overall teaching quality and can be delivered by shared investment of industry and research.

Up-to-date, live, case study material will encourage trainers to adapt to the latest technologies.

Adapt a learning/smart factory approach with education delivered using shared teaching scenarios that reflect local industry while remaining common across various education providers.

Hydrogen technologists within NI should be integral to developing associated curriculum for secondary education, FE and HE. Courses can be built on technologies developed in NI and de-sensitised to comply with IP requirements. Students would be working on regional capability, understand the local industries better and potentially move into the hydrogen and associated industries.

Upskilling

There is a upskilling effort by individuals needed as well as being led by business. A credit system could be used to accumulate towards certification at different TRL levels and/or standard accreditation.

Public funding for lifelong learning activities for future skills needs. Part-funding offers for accredited modular learning.

Flexible approach of modular learning for upskilling adult learners; alternative pathways to achieve higher technical qualifications.

NI specific industry-focusing model for skills development

Industry, academia and government have a shared responsibility to build a workforce fit for the future.

Leaders in industry and innovation need to work together to provide a long-term vision of our skills needs and communicate this effectively to our partners in education, training and government. We need a clear mechanism to bring us together to develop a coherent delivery plan.

It is widely proven that successful innovation is dependent on the availability to a skills base for the translation of research within the Catapult for full exploitation of the technologies and discoveries being realised.

From the Hydrogen group consultations, a specific Northern Ireland model of skills activity and outputs is presented to offer a strong link between innovation and skills development.

Hydrogen Skills Framework for NI

Goals for hydrogen skills development	Workforce aligned to future technology	Certification embedded for future proofed training	Access to emerging technologies	Provide quality assurance for courses and industry	Supporting innovation	Delivering for industry needs
	Establish needs and current position >>		Enthuse for and create opportunity >>		Evolve and deliver excellence	
Activity	Understand knowledge gaps in NI Understand technical standards to gauge current capability	Define and establish certification needs and standardisation requirements	Develop and deliver modular curriculum content	Create validation process for skills provision, for accessible and a regionally coordinated offering	Establish excellence in training	Scaling and growth

Goals for hydrogen skills development	Workforce aligned to future technology	Certification embedded for future proofed training	Access to emerging technologies	Provide quality assurance for courses and industry	Supporting innovation	Delivering for industry needs
	Establish needs and current position >>		Enthuse for and create opportunity >>		Evolve and deliver excellence	
Actions	Workforce skills and demand	Design a NI specific forum for certification, starting point hydrogen safety	Integrated HE and FE awards and delivery of skills provision, using agile, adaptable and modular approach shaped for industry need	Regionally co-ordinated credit awards to support upskilling and adult learners	Focused training to support early adopters or industrial technology leaders	Adaptable skills provision to industry needs
	Develop clear, integrated pathway for learning and development	When NI technology roadmap agreed, pilot workforce processes to support standardisation and qualifications review	Embed post-doc researchers into industry across different sectors	Micro certification to form agile pathway for continued learning	Supported SME access to training provision, with easy access to funding avenues for upskilling	Provision of CPD of non-technical skills to support business growth. Coordination of engagement with technical units and business support units in HE and FE
	Prioritise higher technical skills related to industrial transition	Collaboration leadership and stakeholder commitment for shared purpose	Use of digitalisation for training delivery	Industry informing micro modules	'Train the trainer' approaches to facilitate speed of transfer of knowledge	
	Publicly fund co-designed industry-led doctoral level studies		Integrate Expert Educator methods, with industry engagement	Widen perspective of full value chain for skills to include business development, quality control and others	'Education of educators' in two way academia to industry flow of information to adapt training provision	
	Design a focused agenda for upskilling and lobby for funding support		Shared learning and experience learning		Explore needs of a Consumer education strategy to support local and domestic hydrogen adaptation	

3.5 Conclusions and Next Steps



Key Actions Arising from the Roadmap

Key Actions Timeline

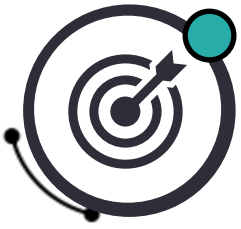


Now
(0-5 years)



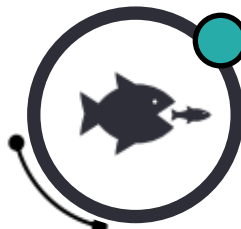
Next
(5-10 years)

Maintain and further develop the Region-Specific Roadmap and develop an action plan



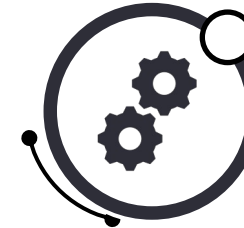
Government must work with industry, utilities and academia to set out a clear vision and commitment to support the energy transition, including a long-term commitment to developing, trialing, demonstrating, and ultimately deploying the most promising technologies and providing incentives for early adoption. The NI Hydrogen roadmap is essential in order for the technology strengths and investment priorities of NI to become visible in a national context, leading to joint ventures and attracting investment and talent.

Understanding the Competitive Landscape



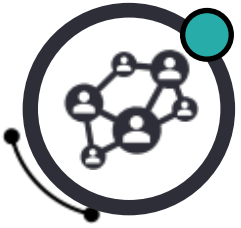
Understanding the competitive landscape both nationally and internationally will be crucial to create business strategies and maximise opportunities. Evaluating our hydrogen related activities in the national competitive landscape is vital in order for NI to identify the technology development areas in which we have private sector readiness, innovation capability and specialist knowhow in which to focus our public and private investment and develop skills and supply chain.

Promote whole energy system integration and planning



Whole system integration and planning will be essential to realise the full potential of the hydrogen value chain and to maximise social welfare gains. This is especially important for a small geographical region such as Northern Ireland.

Establish Stakeholder Working Arrangements



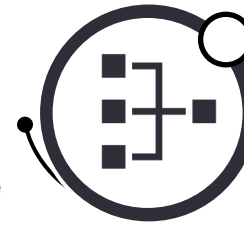
The establishment of stakeholder engagement and collaboration through a 'Community of Practice' or a Technology Accelerator/Catapult Model would encourage greater collaboration between research and business, build the hydrogen market, drive economic growth and lead to the development of commercial propositions. The UK Catapult Network has already defined how it may accelerate the UK's Hydrogen Economy and it is essential that NI clusters its technological and innovation capabilities to create a Catapult Centre to support our Region and collaborate nationally.

Funding and de-risking



An important part of the vision and planning for the transition to net-zero is how it will be funded. The two largest cost elements will be the cost of the infrastructure and the cost of production of hydrogen. Support to be able to trial or buy technology may be required. For infrastructure, a variety of business models are possible to ensure investors can expect to recoup costs. Government must work in partnership with industry to ensure the appropriate roll out of infrastructure is funded. The de-risking of new hydrogen technologies and the industrialization of new products requires focused public and private investment in innovation R&D, supply chains and skills.

Infrastructure Deployment



The challenge of a 'chicken and egg' problem between end-use demand and production or deployment of the required infrastructure can be overcome through coordinating deployments of demand usage and infrastructure, as well as the setting of the clear vision, and providing funding support for both elements during the early stages. Data collection will be critical to understanding real world demand behaviour and infrastructure reliability to enable a balanced uptake throughout the transition.

Building the NI Supply Chain



Developing supply chains for zero-emission and hydrogen technologies will provide jobs and growth for the economy. To achieve this, early procurement activities should be structured to maximise NI and UK supply chain opportunities. Demonstrations will create initial supply chains, and the outputs of early prototyping, technology demonstrator and industrialisation capability development activities, including open standards, should lead to an open playing field for new entrants.

Regulations and Standards



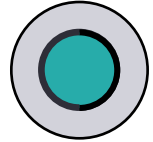
Development of technologies and deployment of infrastructure must take place within a supportive regulatory environment to enable the required progress to be made. Infrastructure and planning regulations may need to be revised to facilitate this and other elements of the national transition to Net Zero. New standards will also be required to ensure systems are safe, reliable, and interoperable.

Develop Trust in the Technology



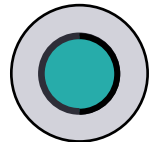
Many stakeholders are cautious about the unknown. The best way to alleviate these concerns is to demonstrate the technology options working in a wide range of real-world conditions. Before this, early tests and small trials should be carried out to confirm sufficient performance and reliability, since it is important that demonstration participants have a positive experience to improve their trust levels.

Main Considerations



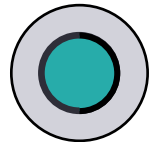
Opportunity Potential

Northern Ireland has the potential to be a global leader in the hydrogen sector and should quickly establish a more formalised approach to stakeholder collaboration to unify the regional strength of the hydrogen value chain, share ambition and add value



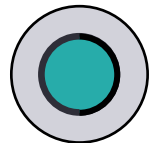
Timing of Opportunity

Time is of the essence to capitalise on both funding opportunities, potential market share of hydrogen technologies and to build out infrastructure to meet climate change objectives



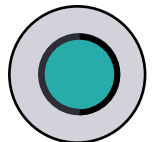
Capability

Complete an in-depth mapping of Northern Ireland's hydrogen technology capabilities to support promotion of strategic investment. This would include an expansion and review of commonalities in the regions future projects to identify areas for partnership and growth



Additionality

A comprehensive review of investment readiness is required – where some technologies are at an advanced stage prior to commercialisation. Support should be offered to assess the additionality of projects and encourage the up-take of intervention funding opportunities



Partnership Opportunities

Specific partnership opportunities should be explored to advance proposals and accelerate research and development or project proposals

4.0 Options for Creating a Northern Ireland Hydrogen Centre of Excellence



4.1 National & Regional Context



The value of Research and Innovation is clearly recognised in the UK Hydrogen Strategy

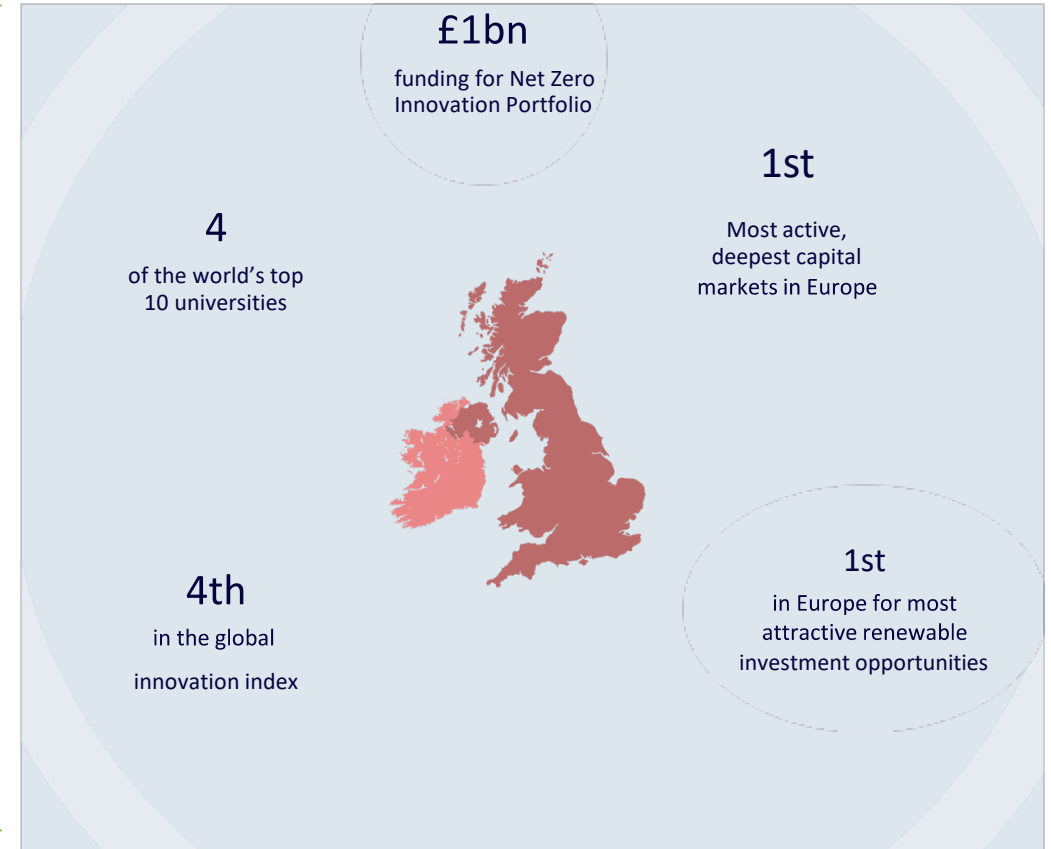


- The Hydrogen economy 2020s Roadmap includes Research and Innovation programmes for the 2022-2025 and 2025 – 2030 periods
- These include feasibility and technology demonstrators, de-risking technological options and investment, followed by deployment studies and more advanced technology development programmes for the second half of the decade.
- BEIS has allocated Innovation funding (TRL4-7) in their NZIP Proposed Industrial Hydrogen Accelerator and the Industrial Fuel Switching programmes

Innovation is Seen by UK Government as a Vital Accelerator and Investment Enabler in Hydrogen

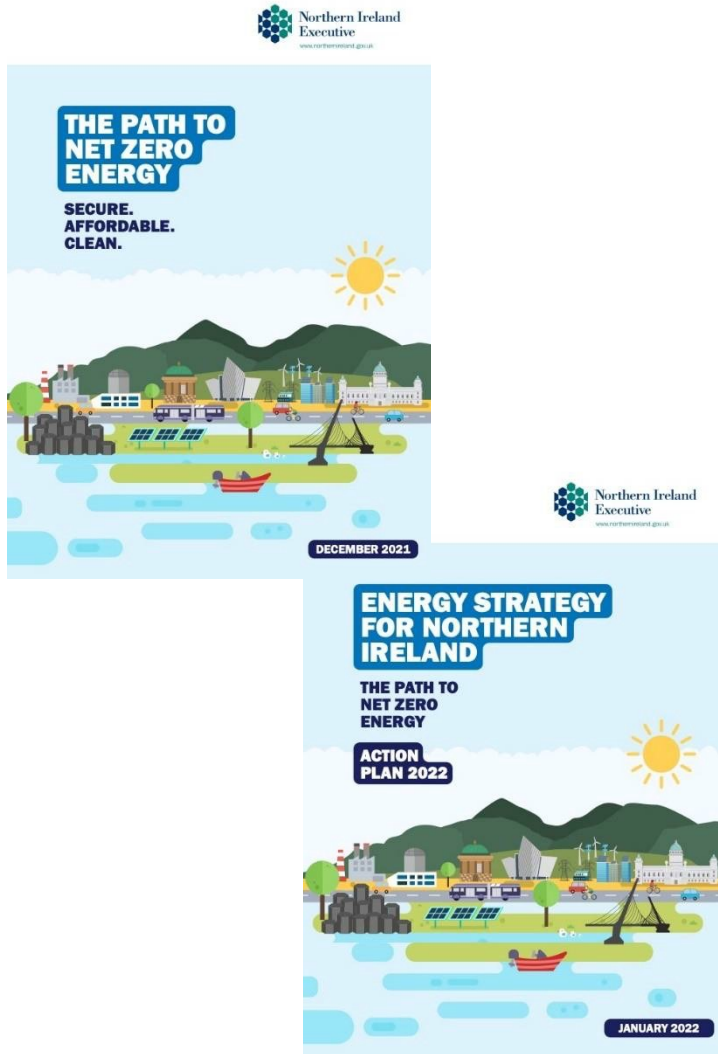


- The Hydrogen Investor Roadmap (April 2022) makes clear reference to the innovation capability of the UK and the strength of our universities
- It outlines a £100m fund for Innovation in production



Page 3 of Hydrogen Investor Roadmap

NI Government's Strategy and Regional Context



- Hydrogen is a clear priority area of NI Government's 'The Path to Net Zero Energy' Strategy.
- The Strategy includes the ambition for Northern Ireland to become a leading low carbon innovation hub.
- Further, the 'Action Plan 2022' makes reference to developing a Hydrogen Centre for Excellence in partnership with academia.
- Research has always been a strength of NI's Universities, and the City and Growth Deals have provided significant opportunities and funding for the creation of large scale innovation centres in partnership with business. This will assist the creation of a Hydrogen Centre of Excellence in Northern Ireland.

The UK CATAPULT's Perspective – Accelerating a UK Hydrogen Economy

The following is outlined in this document:



Accelerating a UK Hydrogen Economy

<https://es.catapult.org.uk/report/accelerating-a-uk-hydrogen-economy>

‘The Catapult Network will play a key role in enabling the cross-cutting innovation that is required for the creation of UK Hydrogen Economy and in realising the economic opportunities from the development of global hydrogen markets.

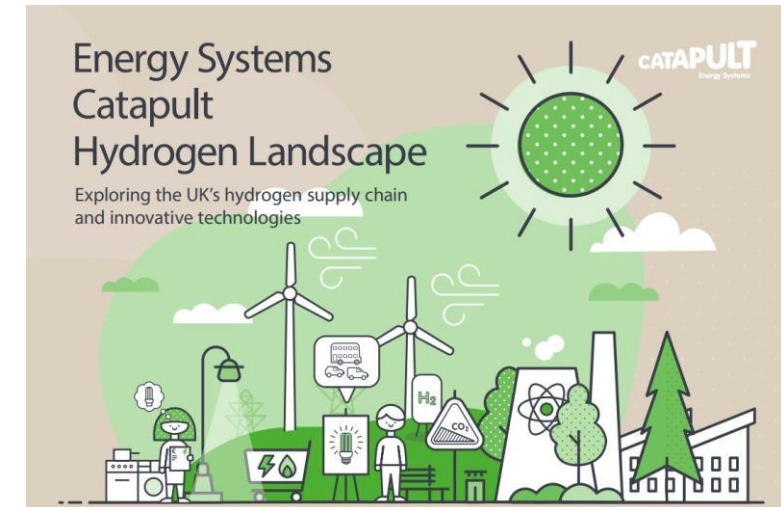
The Catapults will collectively bring their expertise to provide leadership, identify gaps and innovation priorities in the end-to-end hydrogen value chain, and partner with UK innovators and academia to deliver solutions to this emerging global market.

Recognising the opportunity for investment in hydrogen to support economic recovery and Net Zero ambitions, the Catapult Network is creating a new special purpose vehicle - The Hydrogen Innovation Initiative - to support implementation of a UK hydrogen innovation roadmap through a wide range of innovation projects and programmes. This aims to help government and industry collaborate in the creation of a UK hydrogen economy and the coordination and alignment of R&D activity. The Initiative will also help to forge strategic linkages and establish a focal point for a connected innovation backbone.’

- It is clear that the UK Catapults have positioned themselves in a key position to Lead, Fund, Invest and Connect UK's communities, companies and universities in the Hydrogen Innovation space.
- It is strategically imperative that Northern Ireland must have an entity / innovation centre around the table of the Hydrogen Innovation Initiative, for the benefit of our companies and Region.

Hydrogen Innovation Initiative

- Members of the UK CATAPULT Network including the Offshore Renewable Energy Catapult, the Energy Systems Catapult and the High Value Manufacturing Catapult together with partner innovation centres such as the National Physical Laboratory, the Advanced Propulsion Centre UK and the Aerospace Technology Institute created a dedicated special purpose vehicle - The Hydrogen Innovation Initiative (HII).
- This will combine collective strengths, capabilities, national locations and industrial reach with an aim to accelerate innovation, develop growth in the UK hydrogen supply chain and overcome technology and integration challenges to establish an effective UK hydrogen economy.
- The Hydrogen Innovation Initiative does not have an entity / innovation centre from Northern Ireland around the table as a full member, notwithstanding the approaches made. Obviously, this reduces NI's ability to engage, influence and lead UK wide strategic initiatives for the benefit of Northern Ireland's businesses and the economy.



4.2 Options for creating the conditions for stakeholder R&D collaboration



Potential models and support mechanisms for the delivery of a NI Hydrogen stakeholder collaboration group

A NI Hydrogen Stakeholder Platform could consider the following:



Subsidies to cover externalities associated with production of low-carbon hydrogen, enable investors in low-carbon methods of hydrogen production to compete with the incumbent carbon-intensive fuel



Technology-specific support to prevent more mature technologies. Technology-neutral support (which takes account of differences in carbon-intensity) will likely be more efficient as the market matures



Transfer of demand risk away from investors to incentivise investment. Uncertainty around demand for low-carbon hydrogen poses a significant risk for prospective investors, and this needs to be mitigated



Reductions in support for successive investments once technologies are proven. The lack of full value chain deployment means that the first producers may face higher risks associated with first-of-a-kind projects

The following support mechanisms could be explored:

Support Model	High-Level Description
End user subsidies	Abatement subsidy is offered to industrial emitters
Regulated returns	Regulated returns models such as a Regulated Asset Base (RAB) model or a Cap and Floor model allow the hydrogen producer to earn a regulated return on costs
Contractual payments to producers	The hydrogen producer receives a subsidy which covers the incremental cost of low carbon hydrogen above the carbon-intensive alternative fuel. The level of the subsidy (per unit of output or per year) is contracted between the recipient and a government party
Obligations	An obligation is imposed on parties outside the hydrogen production sector (e.g. fuel suppliers or end users) to supply or consume a certain quantity of low carbon hydrogen. This obligation is policy-based rather than contractual, and can be adjusted over time

Options for future stakeholder collaboration (1/2)



Option 1

A do nothing approach may lead to failure of potential funding opportunities being secured, would not support efficient stakeholder collaboration or shared learning.

Companies and stakeholders would navigate the hydrogen value chain taking an uncoordinated and siloed approach.

The 'Do Nothing' Approach



Option 2

CoPs enable practitioners to exchange knowledge and skills with people. Open membership offers access to a wide range of expertise to help with technical challenges, fuel continuous improvement and allows more meaningful contributions to larger goals.

CoPs are informal and self-managing by nature, community members are empowered to design the types of interactions and determine the frequency that best meets their needs.

Building and integration of a Community of Practice (COP)

Options for future stakeholder collaboration (2/2)

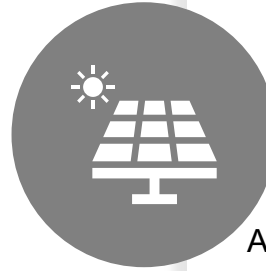


Option 3a

A catapult model would benefit Northern Ireland by building the hydrogen market and driving economic growth. The establishment of a hydrogen network would provide leading-edge technology and expertise and encourage greater collaboration between research and business.

The catapult would aim to bridge the gap between research findings and their development into commercial propositions.

Invest in a Hydrogen Catapult & Leverage City and Growth Deal Infrastructure



Option 3b

Achieving the same benefits as Option 3a with better regional inclusion. Additional investment required for developing new project infrastructure. Specific areas for intervention may include:

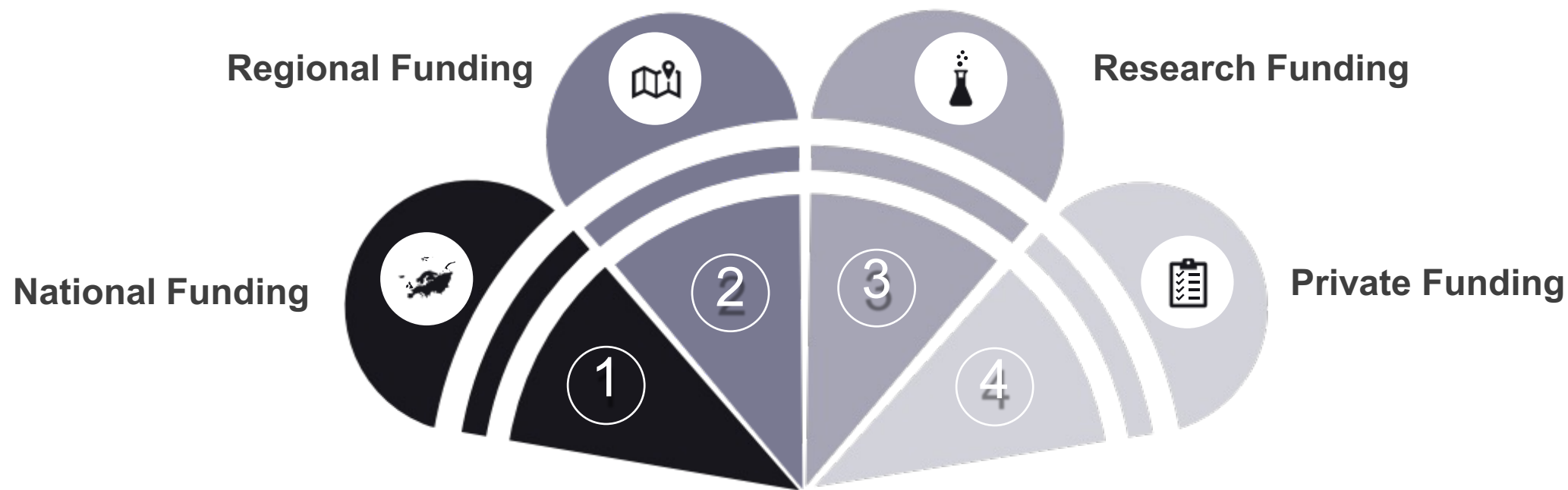
- Developing the value chain – establishing understanding and analysis to develop whole value chain capability;
- Building of tools to help innovators connect - this will support new market development and create a range of offers to smaller companies;
- Demonstration capability - in the development, deployment and management of multi stakeholder, real world demonstration and scale-up environments.

Invest in a Hydrogen Catapult and develop new infrastructure

4.3 Funding Opportunities



Funding areas for Hydrogen-related projects (1/2)



Funding areas for Hydrogen-related projects (2/2)



Regional Funding

The Northern Ireland Energy Strategy (2021) outlines policy objectives for the transition to a low carbon economy including the importance of hydrogen. Currently there are limited regional funding opportunities however the recently announced £4.5m Green Innovation Challenge Fund 2022 will lead to a later full roll out of a £30m fund over 3 years. The SIB are also exploring technical studies and strategic business case preparation for NI water to develop Power to X schemes.

The Belfast Regional City Deal [AMIC/MEA] Complementary Fund has also been approved and is at OBC tendering stage (for a hydrogen technology hub).



Research Funding

A number of recent research led funding initiatives have been successful including a £619k project led by Queen's University focused on creating and developing innovative solutions to meet the Net-Zero goal through the use of Zero-Carbon Co-operatives, funded by the Department of Levelling Up, Housing and Communities.

£1.2m of funding direct to Queen's by the Advanced Propulsion Centre is also creating high value research jobs as part of the low emission bus research project and has led to the development of a Centre of Excellence in Zero-Emissions Hydrogen Technology in Ballymena, with public-private investment of £700,000 from the UK Government's Community Renewal Fund, the Department for Communities Covid-Revitalisation Fund and EP UK Investments. A number of research led projects under the Hydrogen Safety Engineering and Research Centre (HySAFER) are also currently available in Ulster University.



National Funding

Funding in Northern Ireland mainly reflects current UK Government policy, notably the levelling up, clean growth and research and development agenda. The UK Hydrogen Strategy (2021) outlines opportunities to maximise research & innovation strengths, to attract investment and for realising export opportunities. National funds almost all now consistently reference the need for projects to align to the government's clean growth and net zero aims, which again increases the potential for hydrogen schemes to be included.



Private Funding

Private funding is likely limited in scale but represent an important source of funding or investment, especially in research and demonstrator technologies.



Funding opportunities

Correct as of 1 April 2022 & subject to change

Below is a synopsis of available funding opportunities which could support the hydrogen economy in Northern Ireland.

Opportunity	Funding Organisation	Total Fund	Specific Alignment to Hydrogen	Alignment to Decarbonisation
Proposed Industrial Hydrogen Accelerator (IHA) Programme	BEIS	TBC	✓	✓
Red Diesel Replacement phase 2	BEIS	£40m	✓	✓
Carbon Capture, Usage and Storage (CCUS) Innovation 2.0 competition	BEIS	£19.5m		✓
Net Zero Hydrogen Fund (NZHF)	BEIS	£240m	✓	✓
Industrial Energy Transformation Fund (IETF) Phase 2: Spring 2022	BEIS	£60m		✓
Green Innovation Challenge Fund 2022	DfE	£4.5m		✓
APC 20: Developing automotive technologies and growing capability towards net zero	Innovate UK	£25m	✓	✓
Innovate UK Smart grants: Jan 2022	Innovate UK	£25m		✓
Automotive Transformation Fund Feasibility Studies: Round 3	Innovate UK	£10m		✓
The UK-Catalyst Partnership	Breakthrough Energy	£400m	✓	✓
UK Infrastructure Bank	UK Infrastructure Bank	£22 B		✓
UK Shared Prosperity Fund	UK Gov	£2.6 B		✓
Flexibility Innovation Programme	UK Gov	£65m		✓
The Clean Hydrogen Partnership	Horizon Europe	€300.5m	✓	✓

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- Clean Power Hydrogen
- Core Systems
- DfE
- DJV Insulations Ltd
- EirGrid
- ESB
- Foyle Port
- Frontier Economics
- Health & Safety Executive For Northern Ireland
- HSENI
- Hydrogen NI
- Innovate UK
- InvestNI
- KCS Limited
- Kingspan
- Lagan MEICA
- LCC
- Les Ross Planning
- Linamar
- Matrix
- McCloskey International
- mdmrl
- Mid and East Antrim Council
- mjmrenewables
- Mutual Energy
- National Grid Gas
- NIEN
- NIWater
- Phoenix Natural Gas
- Queens University Belfast
- RenewableNI
- SIB
- Solo Renewables
- SONI Limited
- Terex GB Ltd
- Translink
- Ulster University
- Ulster University, Hydrogen Safety Engineering and Research Centre (HySAFER)
- Utility Regulator

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