



August 2022

National Innovation Pathway Round-up

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National Innovation Pathway Round up – United Kingdom

Introduction

Mission Innovation members agreed to develop **National Innovation Pathways (NIPs)** to describe and build collective understanding on how each member plans to pioneer clean energy technologies to meet their climate and energy goals.

Each member has their own approach to developing and identifying innovation needs and priorities, with some already having undertaken extensive strategy development. The Roundup provides a **single location of summary information on countries' innovation priorities** utilizing existing sources of information so members and interested stakeholders can easily find key information of interest.

All MI members were asked to provide answers to a survey (Annex A) providing as much information as possible, with some questions being optional. The survey asked questions relevant to each element of the National Innovation Pathway described in the Joint Launch Statement:

1. Energy transition scenarios and priority national-level energy innovation needs / priorities until at least 2030;
2. Strategies or national-level plans to address these energy innovation needs / priorities, including institutional design and working internationally
3. Information on how Members will measure innovation outcomes and innovation ecosystem developments;
4. Members' preferred modes and methods of collaboration; and
5. Any further supporting evidence that was used to identify the energy innovation needs / priorities, such as analysis of domestic competitiveness, economic opportunities or national level climate and clean energy plans.

Members will be asked to refresh this document annually if significant changes to national policy have taken place.

1. Clean Energy Innovation Strategy

1.1 Summary

In 2019 the UK became the first major economy to legislate to reduce greenhouse gas emissions to net zero by 2050. The Net Zero Strategy sets out the UK's current pathways to net zero and to delivering Carbon Budget 6, which requires greenhouse gas emissions to reduce by 78% from 1990 levels by 2035.

Produced under the guidance of the UK Government's Net Zero Innovation Board, the UK's Net Zero Research and Innovation Framework represents a first statement of the UK's net zero research and innovation priority areas, including those for energy over the next 5-10 years. It supports delivery of the UK's Net Zero Strategy and carbon budget commitments, drawing on the existing evidence-base and research and innovation work already being undertaken. It identifies the main sectors and their respective challenges for the UK to reach net zero, the key research and innovation needs that should be addressed and the timescales for doing so. Government funded research and innovation, appropriate policy and regulatory support, private sector innovation, investor funding and academic research will all play a key role in delivering these.

The UK Net Zero Research and Innovation Framework will help to ensure that the UK's public sector net zero research and innovation spending is aligned to agreed UK priorities. It aims to provide a clear signal to the private sector and our academic and research communities about the UK's focus areas as we move towards 2050, and to lay the foundations for a collaborative, whole-systems approach to net zero research and innovation activity. Taken together with the Net Zero Strategy, this provides an initial roadmap for maximising the contribution of innovation towards net zero, understanding the social and economic drivers of change and supporting international science and technology collaboration. The Framework can be found here:

<https://www.gov.uk/government/publications/net-zero-research-and-innovation-framework>, with the UK's Net Zero Strategy here: <https://www.gov.uk/government/publications/net-zero-strategy>.

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The UK's Framework document will be supplemented with the publication of our Net Zero Research and Innovation Framework Delivery Plan. This will be a record of what the UK Government is, or will be supporting over the course of the current UK Government Spending Review period, 2022-25, towards the delivery of the research and innovation challenges and needs identified in the Framework. The intention is to publish an updated Delivery Plan for each Spending Review period and to review progress regularly. The key energy related areas to be prioritised include Bioenergy; Carbon Capture Utilisation and Storage (CCUS) and Greenhouse Gas Removal (GGR); Heat and Buildings; Hydrogen, Nuclear; Renewables; and System Integration and Flexibility, including Energy Storage. Other net zero sectors on Transport and Natural Resources, Waste and F-gases are also covered.

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1.3 Methodology

UK Net zero research and innovation spending prioritisation is based on:

- Developing UK energy security.
- Expected contribution to delivering the UK's carbon budgets and major decarbonisation – accelerating the delivery of greenhouse gas emissions reductions by increasing certainty of technologies / solutions, including by taking into account the current state of technologies and the potential for research and innovation to make rapid progress.
- Building and maximising UK comparative advantage globally – focussing on areas with the highest potential for UK business and jobs. Developing and commercialising technologies, processes and business models for the energy transition can provide business opportunities and enhance economic competitiveness.
- Retaining optionality of different net zero pathways – investing in a portfolio of solutions, and tolerating some failure, including novel technologies for areas such as greenhouse gas removals.

Underpinning analysis to support this prioritisation is provided by a range of inputs including:

- Embedded professions in funding delivery teams.
- Lessons learned and progress analysis from previous programmes.
- National and international energy technology readiness analysis, for example the UK's Energy Innovation Needs Assessments (EINAs).
- Stakeholder engagement.
- International analysis, for example through the IEA.

The UK's EINAs are based on modelling carried out with the whole system model ESME (Energy System Modelling Environment) complemented by expert consultation. Technologies of interest were chosen by filtering out those with limited energy system cost reductions. Technologies were ranked based on their saving contribution to the energy system in an extreme innovation scenario. Those with very limited innovation value (system cost reductions) were excluded from subsequent analysis. This filtering process was based on extreme innovation scenarios, where each technology was run in ESME assuming zero capital costs. More information can be found here: <https://www.gov.uk/government/publications/energy-innovation-needs-assessments>.

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Table 1: RELEVANT DOCUMENTS AND POLICIES

Document or policy name	Description of the document or policy	Specific outcomes, goals or targets identified in the document or policy	Year	Web Link(s)
British Energy Security Strategy	Sets out how Great Britain will accelerate homegrown power for greater energy independence.	Boosting our diverse sources of homegrown energy for greater energy security in the long-term.	2022	https://www.gov.uk/government/publications/british-energy-security-strategy
<i>UK Net Zero Strategy</i>	Sets out policies and proposals for decarbonising all sectors of the UK economy to meet our net zero target by 2050.	Achieving UK carbon budgets, our 2030 Nationally Determined Contribution, and net zero by 2050. It includes: <ul style="list-style-type: none"> our decarbonisation pathways to net zero by 2050, including illustrative scenarios. policies and proposals to reduce emissions for each sector. cross-cutting action to support the transition. 	2021	https://www.gov.uk/government/publications/net-zero-strategy
UK Net Zero Research & Innovation Framework	The Net Zero Research and Innovation Framework is a guide to the research and technologies needed to reach net zero by 2050. Produced under the guidance of the government's Net Zero Innovation Board , it identifies the main net zero research and innovation challenges for the UK	The Framework takes a whole systems approach and covers Power, Industry and low carbon hydrogen supply, Carbon Capture Utilisation and Storage (CCUS) and Greenhouse Gas Removals, Heat and Buildings, Transport, Natural Resources, Waste and F gases.	2021	https://www.gov.uk/government/publications/net-zero-research-and-innovation-framework

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	over the next 5 to 10 years and across key sectors.			
UK Energy Innovation Needs Assessments	Evidence and analysis on the role of different technologies in the UK's future energy system.	<p>The EINAs take a whole-system view of the energy sector and provide evidence and analysis on:</p> <ul style="list-style-type: none"> the role of different technologies in the UK's future energy system. potential domestic and export growth opportunities. where innovation support and investment for those technologies could deliver the greatest benefits. 	2019	https://www.gov.uk/government/publications/energy-innovation-needs-assessments
Net Zero Research and Innovation Framework Delivery Plan	Detailing public sector investment and activity towards delivery of the research and innovation challenges and needs identified in the related Net Zero Research and Innovation Framework document.	For publication and internal governance use, as a record of what the UK Government is, or will be investing in over the course of the current UK Government Spending Review (SR) period, 2022-25.	Forthcoming	To be published

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2. Clean Energy Innovation Priorities

2.1 Overview of Clean Energy Innovation Priorities

Table 2: CLEAN ENERGY INNOVATION PRIORITIES

Innovation priority	Focus of innovation activity (tick all that apply)	Targets/Goals (if applicable)	Technologies or topics of interest	Total RD&D funding allocated, (2021-2025)	Planned demonstration Investments (2021-2025) - indicate if domestic or international spending where possible	Links to relevant reports or plans
Bioenergy	<input checked="" type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input checked="" type="checkbox"/> Product development <input checked="" type="checkbox"/> Demonstration <input type="checkbox"/> Commercialisation Other:	To improve production and pre-processing, to develop flexible gasification systems, and to explore routes to deploy BECCS by 2030; then for the longer term, ongoing work to identify the most cost-effective and greenhouse gas optimal approaches for the use of biomass.	<ul style="list-style-type: none"> Breeding Planting Cultivating Hydrogen from biogenic feedstocks combined with CCS 	Part of BEIS's £1bn Net Zero Innovation Portfolio (NZIP) as well as research and innovation delivered through UKRI	NZIP will support domestic demonstration.	https://www.gov.uk/government/collections/net-zero-innovation-portfolio
Carbon Capture Utilisation and Storage (CCUS) and Greenhouse Gas Removal (GGR).	<input checked="" type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input checked="" type="checkbox"/> Product development <input checked="" type="checkbox"/> Demonstration <input type="checkbox"/> Commercialisation Other:	Demonstrate how the technology can be deployed at scale; deliver performance and cost improvements; develop a clear understanding of life cycle emissions and focus on the development of business models	<ul style="list-style-type: none"> Cost reduction for CCUS in power, industrial and waste sectors. Feasibility and design of DAC and GGR technologies. 	Part of BEIS's £1bn Net Zero Innovation Portfolio as well as research and innovation delivered through UKRI	NZIP will support domestic demonstration.	https://www.gov.uk/government/collections/net-zero-innovation-portfolio

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		which provide incentives for investors.	<ul style="list-style-type: none"> 5 Demonstrators of land based GGR technologies. 			
Heat & Buildings	<input checked="" type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input checked="" type="checkbox"/> Product development <input checked="" type="checkbox"/> Demonstration <input type="checkbox"/> Commercialisation Other:	Testing whole house / building retrofit processes and technologies, both domestic and non-domestic, including development of new supply chain business models and energy efficiency solutions for hard-to-treat properties; working towards reducing the costs of heat pumps, the disruption caused by installation and use, and driving uptake.	<ul style="list-style-type: none"> Technologies for heating and cooling buildings including food cold chain. Innovation in Green Lending market. Innovative retrofit technologies and installation processes, including heat pumps. 100% hydrogen for heating trials. 	Part of BEIS's £1bn Net Zero Innovation Portfolio and Hydrogen Heating neighbourhood and village trials, as well as research and innovation delivered through UKRI	NZIP and the Hydrogen Heating programme will support domestic demonstration.	https://www.gov.uk/government/collections/net-zero-innovation-portfolio
Hydrogen	<input checked="" type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input checked="" type="checkbox"/> Product development <input checked="" type="checkbox"/> Demonstration <input type="checkbox"/> Commercialisation Other:	Work towards demonstrating efficient CCUS-enabled hydrogen and developing large-scale production capacity in industrial clusters along with related supply chain development.	<ul style="list-style-type: none"> Low Carbon Hydrogen supply solutions including production, transport, and storage. Enabling technologies for a wider hydrogen economy. 	Part of BEIS's £1bn Net Zero Innovation Portfolio as well as research and innovation delivered through UKRI	NZIP will support domestic demonstration.	https://www.gov.uk/government/collections/net-zero-innovation-portfolio
Nuclear	<input checked="" type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input checked="" type="checkbox"/> Product development <input checked="" type="checkbox"/> Demonstration <input type="checkbox"/> Commercialisation	To develop and work towards deploying Small Modular Reactors, and towards demonstration of Advanced Nuclear Reactors by the 2030's, in	<ul style="list-style-type: none"> Development of UK Small Modular Reactor design. 	£385m through the Advanced Nuclear Fund (ANF)	ANF will support domestic demonstration	https://www.gov.uk/government/collections/net-zero-innovation-portfolio

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	Other:	addition to longer-term fusion research.	<ul style="list-style-type: none"> Development of High Temperature Gas Reactor technology. 			
Renewables;	<input checked="" type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input checked="" type="checkbox"/> Product development <input checked="" type="checkbox"/> Demonstration <input type="checkbox"/> Commercialisation Other:	To accelerate the deployment of fixed offshore wind capacity and unlock the potential for floating offshore wind by 2030. Also, development of earlier stage renewables.	<ul style="list-style-type: none"> Lightweight composites for turbines. Floating Offshore Wind technologies. Mitigating impact on radar. Wave energy technologies. Combining offshore wind with hydrogen production. 	Part of BEIS's £1bn Net Zero Innovation Portfolio as well as research and innovation delivered through UKRI	NZIP will support domestic demonstration.	https://www.gov.uk/government/collections/net-zero-innovation-portfolio
Systems Integration and Flexibility	<input checked="" type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input checked="" type="checkbox"/> Product development <input checked="" type="checkbox"/> Demonstration <input type="checkbox"/> Commercialisation Other:	To prepare networks for the net zero transition, to demonstrate flexible demand and flexible market platforms, and to develop long term energy storage solutions by the end of this decade.	<ul style="list-style-type: none"> Bi-directional electric vehicle charging technologies. Automated secure data exchange. Interoperable Demand Side Response systems. Smart Meter based Internet of Things sensor devices. Smart Meter energy data repository. Longer duration energy storage 	Part of BEIS's £1bn Net Zero Innovation Portfolio as well as research and innovation delivered through UKRI	NZIP will support domestic demonstration.	https://www.gov.uk/government/collections/net-zero-innovation-portfolio

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			technologies including electric, thermal and power-to-x.			
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In October 2021, we published the UK’s first Net Zero Research & Innovation Framework, setting out key research and innovation challenges for the next 5–10 years and a roadmap to 2050. Work is underway to publish a follow-up Delivery Plan which will outline the Government’s Net Zero R&D programmes for the current Spending Review period 2022–25.

The UK is continuing to increase government investment in R&D to £22 billion by 2026/2027. This includes £1.5 billion specifically allocated to net zero innovation for 2022–25 as well as net zero research and innovation delivered through UKRI.

The BEIS £1 billion Net Zero Innovation Portfolio (NZIP) and £385 million Advanced Nuclear Fund will support priority areas in power, buildings, industry and disruptive innovations over 2021–2025. DfT is investing £300 million in R&D programmes to decarbonise land, sea, and air transportation and Defra will commit at least £75 million on research into natural resources, waste and F-gases. Further net zero research and innovation is delivered through core support to UKRI.



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2.2 Tracking Progress (Optional)

Monitoring and measuring progress against the research and innovation needed to meet net zero is vital. This will allow for agile policymaking to respond to new information and help steer the portfolio of Net Zero innovation to priority areas. This will also inform strategic discussions of the Net Zero Innovation Board chaired by the Government Chief Scientific Adviser. This Board is the main government forum for advising on plans related to net zero research and innovation and will play a key role in assessing progress against the Net Zero Research & Innovation Delivery Plan and the wider Framework.

More information on the Net Zero Innovation Board is available here: <https://www.gov.uk/government/groups/energy-innovation-board> .

3. Private Sector Engagement (Optional)

See further information in the UK's Net Zero Strategy, Net Zero Research and Innovation Framework and the related Net Zero Research and Innovation Framework Delivery Plan referenced earlier. These documents, the underlying scoping of technology progress analysis, alongside consultation, for example with regulators, private sector researchers, innovators, investors, and potential consumers, will continue to play an integral part in developing existing and future UK programmes.

4. International Collaboration (Optional)

International co-operation and collaboration, including access to research and innovation infrastructure, the sharing of experience and lessons learned and input to standards setting will also be important to supporting the UK's ability to meet its net zero target.

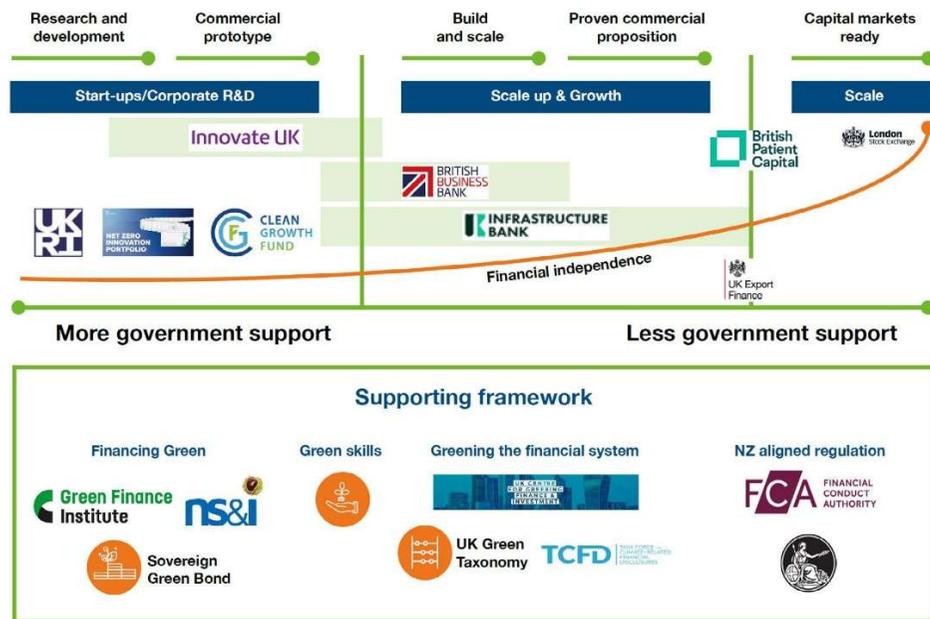
The UK considers that Mission Innovation is the primary international forum to strengthen cooperation on clean technology development. The UK is co-lead for the Clean Hydrogen and Green Powered Future Missions and is a core member of the Zero Emission Shipping Mission. The UK also intends to associate to the Horizon Europe research and innovation funding programme which, along with participation in around half of the International Energy Agency's Technology Collaboration Programmes, offers significant opportunities for knowledge sharing, network building and involvement in the development of future supply chain and market building.

The UK is also a major contributor to International Climate Finance, helping countries adopt low carbon pathways to meeting the energy needs of their populations and industries, as well as managing natural resources and adapting transport systems. Innovation plays a key role and the UK's £1bn Ayrton Fund commitment aims to help drive forward the clean energy transition in developing countries by developing, testing and demonstrating innovative technologies and the business models to commercialise them. This will focus on the transformation of the whole energy system and work with developing countries on a series of priority challenges including industrial decarbonisation, sustainable cooling, efficient end-use appliances, modern cooking, smart energy, energy storage, next generation solar, and inclusive energy leaving no-one behind.

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5. National Energy Innovation Ecosystem (Optional)

Section 2 of the UK’s Net Zero Research and Innovation Framework (from page 20) sets out the UK funding ecosystem in further detail. <https://www.gov.uk/government/publications/net-zero-research-and-innovation-framework>. Figure 6 is taken from page 23 and shows the public finance interventions across the stages of commercialisation, for example:



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Table 3: CLEAN ENERGY INNOVATION INSTITUTIONS

Institution name	Description of role	Innovation priority(ies) that they contribute to (taken from Table 2)	Description of funding modalities (e.g. grants, co-investment, where in tech development cycle focused)	Links
Department of Business, Energy and Industrial Strategy (BEIS)	UK Government Department with overall responsibility for Net Zero policy and the NZI programme	All areas identified	All forms used either directly or via partners.	Gov.uk/beis
Foreign, Commonwealth and Development Office (FCDO)	UK Government Department responsible for international diplomacy and international development programmes (ODA funds) including those which support clean energy innovation	All areas identified	Varied.	Gov.uk/fcdo
Department for Transport (DfT)	UK Government Department with responsibility for transport in the UK including supporting transition to low carbon transport modes.	Systems Integration and Flexibility,	Varied	Gov.uk/dft
UK Research and Innovation (UKRI)	UK Research and Innovation (UKRI) is the national funding agency investing in science and research in the UK, including UK Universities and Innovate UK (see below)	All areas identified	Varied	ukri.org
Innovate UK	Innovate UK is the UK's national innovation agency supporting business-led innovation in all sectors, technologies and UK regions	All areas identified	Varied	ukri.org/councils/innovate-uk

Annex A – National Innovation Pathway Roundup Survey Questions

1.1 Summary: Please provide a summary of your national clean energy innovation strategy i.e. the overall policies, framework and/or goals that help to define the innovation priorities you will describe in Section 2. We recommend including information about your national climate or energy targets (such as NDCs or renewable energy targets) as well as national innovation strategies and policies. You can share links to relevant documents in Table 1.

1.2 Methodology: Please describe the methodology to develop your national clean energy innovation strategy such as analysis, modelling or stakeholder engagement and include any links to relevant documents in Table 1. This will be used to help share learning between members.

2.1 Overview of Clean Energy Innovation Priorities: Please provide a list of your national clean energy innovation priorities (i.e. specific technologies, sectors or needs). Please complete Table 2 to provide information about where you are focusing in the innovation cycle for each priority; any targets or goals; RD&D interests; current allocated budgets (including specific demonstration funding) and links to relevant strategies or reports. In the text box following please provide a brief description of how you plan to respond to each innovation priority in the coming years, such as through future plans over the next 3-10 years to mobilise further investments for innovation, launch new major programmes and timelines for major demonstration projects.

2.2 Tracking Progress: Please describe how you plan to measure progress towards addressing your identified energy innovation priorities. Please describe any governance processes to manage and review energy innovation efforts and, where able, please list

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tracking indicators that are commonly used (e.g. such as patents, publications, rates of company formation, follow-on capital and private co-investment, technology performance upgrades).

3. Private Sector Engagement: Please can you describe your strategic approach and priorities to engagement with the private sector to address the clean energy innovation priorities identified in section 2. This could include for instance prioritising co-funding of RD&D initiatives; incubator/accelerator programs that are funded (in part or fully) by the private sector; tax credits and other fiscal incentives; initiatives that the private sector can engage with, grants, de-risking instruments such as loan guarantees etc.

4. International Collaborations: Please describe your strategic approach to international collaboration to tackle your clean energy innovation priorities (e.g. do you have an international strategy, or particular types of collaboration you are prioritising).

5. National Energy innovation Ecosystem: Please provide an overview of your national institutions, funders and organisations and describe how they contribute to tackling the innovation priorities identified in Section 2. Please either provide this information in the box or complete Table 3.

6. Further Supporting Information: Please add below any further information about your national energy innovation needs or approaches to tackling these that has not been covered above





Mission Innovation – Catalysing Clean Energy Solutions For All