



August 2022

# National Innovation Pathway Round-up

All MI Member Countries



# National Innovation Pathway Roundup

## 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.

The responses to the survey are compiled into this report and published separately on each MI Member Country webpage. Members will be asked to refresh their National Innovation Pathway Round ups annually if significant changes to national policy have taken place.

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# AUSTRALIA

## 1. Clean Energy Innovation Strategy

### 1.1 Summary

Australia's NDC sets out a target to achieve net zero emissions by 2050, and to reduce greenhouse gas emissions by 43% below 2005 levels by 2030. Australia plans to drive emissions reduction through rapid deployment of existing technologies, and investing in the technologies and industries of the future. The Australian Government's Powering Australia plan is the key strategy to create jobs, cut power bills and reduce emissions by boosting the accessibility and deployment of clean energy technologies across the economy. Powering Australia aims to drive the uptake of technology and innovation in existing industries, while investing in the technology and industries of the future to help meet the goals of the Paris agreement. Among other goals, it aims to increase the share of renewables in Australia's National Electricity Market to 82% by 2030.

Technology is integral to Australia's clean energy innovation strategy. Australia has focused on technologies predicted to have a significant impact on emissions reduction to direct and prioritise funding and investment. The technologies in focus include hydrogen, energy storage, and ultra low-cost solar. Australia is investing in key technologies through multiple competitive, merit-based mechanisms, including the Australian Renewable Energy Agency (ARENA), Clean Energy Finance Corporation (CEFC), and the Cooperative Research Centres (CRC) Program.

The Australian Government will establish a Powering the Regions Fund to support innovation by existing industries, and the creation of new industries in regional areas. The fund will support: industry with its decarbonisation priorities, such as energy efficiency improvements and fuel switching (e.g. hydrogen); new clean energy industries like green hydrogen and

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bioenergy; existing workers to upskill into new technologies; and the continued purchase of Australian Carbon Credit Units (ACCUs). Programs to support these priorities are currently under development.

To expedite deployment of renewables, the Australian government is investing in clean energy infrastructure, including an AUD \$20 billion investment to modernise the electricity grid through the Rewiring the Nation plan. Australia is committed to making the clean energy technology the world needs for the energy transition, with the support of initiatives such as the AUD \$15 billion National Reconstruction Fund. This Fund will support innovation in new and revitalised clean industries. As part of this, Australia is investing in renewables and low emission technologies. Commercial opportunities being targeted include: components for wind turbines; production of batteries and solar panels; modernising steel and aluminium; and hydrogen electrolyzers. Australia will also invest AUD \$100 million to deliver an initial 85 solar banks, giving households that are unable to install rooftop solar access to cheaper energy.

## 1.2 Methodology

Australia's policies for clean energy innovation are extensively informed through modelling, analysis, and stakeholder engagement. Australia's energy innovation covers whole of economy energy innovation, and is also directing funding towards key priority technologies. The Rewiring the Nation plan will invest \$20 billion dollar to rebuild and modernise the Australian electricity grid, ensuring it can handle an increasing proportion of renewable energy. The plan will increase the reliability of the grid while driving down prices by allowing renewable energy projects to access the grid and by storing electricity within community batteries. This plan will also invest in hydrogen electrolyzers and fuel switching, as well as clean energy component manufacturing.

Australia's emission reduction plan, Powering Australia, was modelled independently by RepuTex, and will reduce emissions by 43% by 2030. The role of the Climate Change Authority in providing independent, expert advice to Government will be emphasised. The Authority will assess and publish progress against the Government's emissions reduction targets, and advise Government on future targets, including the 2035 target, contributing to an Annual Statement to Parliament on climate change.

Our energy and innovation strategies are informed through consultation with stakeholder groups across key priority technologies or industries, as well as through public consultation processes, including with State and Territory Governments. Early and ongoing community engagement, including with Traditional Owners, will be key to understanding community values, concerns and aspirations as clean energy sectors grow. Australia is committed to supporting research, development, demonstration and early-stage commercialisation through investment and co-investment, and using consultation to inform our investment strategy.

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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)
Powering Australia	Australia's plan to create jobs, cut power bills and reduce emissions by boosting renewable energy	To reach an economy-wide net GHG emissions target of 43% reduction from 2005 levels in 2030. Increase the share of renewables in the National Electricity Market to 82% by 2030	2021	<a href="https://keystone-alp.s3-ap-southeast-2.amazonaws.com/prod/61a9693a3f3c53001f975017-PoweringAustralia.pdf">https://keystone-alp.s3-ap-southeast-2.amazonaws.com/prod/61a9693a3f3c53001f975017-PoweringAustralia.pdf</a>
Powering Australia (modelling data)	The economic impact of the Powering Australia plan	Analysis of economic and emissions impact of Powering Australia	2021	<a href="https://keystone-alp.s3-ap-southeast-2.amazonaws.com/prod/61a966013f3c53001f975016-REPUTEX_The%20economic%20impact%20of%20the%20ALP's%20Powering%20Australia%20Plan_Summary%20Report.pdf">https://keystone-alp.s3-ap-southeast-2.amazonaws.com/prod/61a966013f3c53001f975016-REPUTEX_The%20economic%20impact%20of%20the%20ALP's%20Powering%20Australia%20Plan_Summary%20Report.pdf</a>
Australia's NDC	Australian nationally determined contribution (NDC) under UNFCCC Paris Agreement	Sets an economy-wide target of 43% below 2005 levels by 2030.	2022	<a href="https://unfccc.int/sites/default/files/NDC/2022-06/Australias%20NDC%20June%202022%20Update%20%283%29.pdf">https://unfccc.int/sites/default/files/NDC/2022-06/Australias%20NDC%20June%202022%20Update%20%283%29.pdf</a>

## 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, (include budget years where applicable)	Planned demonstration Investments (include budget years and indicate if domestic or international spending where possible)	Links to relevant reports or plans
Clean Hydrogen	<input type="checkbox"/> Early-stage research <input type="checkbox"/> Applied research <input type="checkbox"/> product development <input checked="" type="checkbox"/> Demonstration <input checked="" type="checkbox"/> Commercialisation Other:	Clean hydrogen production under \$2 per kilogram (kg)	Renewable electrolysis Hydrogen storage and transportation	AUD \$464 million Clean Hydrogen Industrial Hubs program (FY21-26)	ARENA has given conditional approval for a \$32 million grant to build a commercial scale 10 megawatt electrolyser to produce clean hydrogen in Wodonga, Victoria. This will be amongst the largest in the world. Under this	<a href="https://www.industry.gov.au/news/funding-available-for-clean-hydrogen-industrial-hubs">https://www.industry.gov.au/news/funding-available-for-clean-hydrogen-industrial-hubs</a>



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					project, 10% hydrogen will be blended into existing gas pipelines supplying 40,000 homes and businesses, a key step towards decarbonising Australia's gas networks. This is one of three projects conditionally approved for \$103.3 million in total under ARENA's Renewable Hydrogen Deployment Funding Round	
<i>Ultra low-cost solar</i>	<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 checked="" type="checkbox"/> Commercialisation Other:	Solar electricity generation at \$15 per MWh. ARENA Solar 30 30 30 initiative's goal to achieve 30% module efficiency and 30 cents per installed watt by 2030	Enhancing module efficiency through solar cell design Reducing balance of system costs	AUD \$40 million Ultra Low Cost Solar PV Research and Development Round (FY22-27)		<a href="https://arena.gov.au/funding/ultra-low-cost-solar-pv-research-and-development-round/">https://arena.gov.au/funding/ultra-low-cost-solar-pv-research-and-development-round/</a>

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<i>Energy Storage</i>	<input type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input checked="" type="checkbox"/> product development <input checked="" type="checkbox"/> Demonstration <input checked="" type="checkbox"/> Commercialisation Other:	Electricity from storage for firming under \$100 per MWh	Lithium-ion batteries Pumped hydro Hydrogen	AUD \$100 million Battery Manufacturing Precinct; AUD \$100 million Large Scale Battery Storage Funding Round ARENA	AUD \$1.38 billion Snowy 2.0 pumped hydro; \$AUD 657 million Kidston Pumped Hydro Energy Storage	<a href="https://www.snowyhydro.com.au/">https://www.snowyhydro.com.au/</a> <a href="https://www.alp.org.au/policies/aust-ralian-made-batteries">https://www.alp.org.au/policies/aust-ralian-made-batteries</a> <a href="https://arena.gov.au/projects/kidston-pumped-hydro-energy-storage/">https://arena.gov.au/projects/kidston-pumped-hydro-energy-storage/</a> <a href="https://arena.gov.au/funding/large-scale-battery-storage-funding-round/#step-1-read-the-program-guidelines">https://arena.gov.au/funding/large-scale-battery-storage-funding-round/#step-1-read-the-program-guidelines</a>
<i>Low emissions materials (steel and aluminium)</i>	<input type="checkbox"/> Early-stage research <input type="checkbox"/> Applied research <input checked="" type="checkbox"/> product development <input checked="" type="checkbox"/> Demonstration <input checked="" type="checkbox"/> Commercialisation Other:	Low emissions steel production under \$700 per tonne; Low emissions aluminium under \$2,200 per tonne (based on the marginal cost)	Clean hydrogen and direct reduction of iron; Renewable electricity and inert anodes	AUD \$39 million Heavy Industry Low-carbon Transition (HILT) CRC	ARENA provided an \$11 million grant to Alcoa to trial electrification of steam production for process heat at its Wagerup alumina refinery in Western Australia. ARENA also provided a \$579,000 grant to Rio Tinto to assess	<a href="https://www.hiltcrc.com.au/">https://www.hiltcrc.com.au/</a>

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					the viability of hydrogen calcination at its Yarwun alumina refinery in Gladstone, Queensland. Both projects will help decarbonise alumina, Australia's sixth largest export	
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The Australian Government has been driving investment in a number of key technologies, to accelerate the domestic and global transition to net zero. These include: clean hydrogen, ultra low-cost solar, energy storage, and green steel and aluminium. These investments feed into many aspects of our economy, and will enable the transition in a number of ways.

Under the Government's Powering Australia plan, Australia will look to drive the uptake of technology and innovation in existing industries, while investing in the technology and industries of the future to help meet the goals of the Paris agreement. Through the National Reconstruction Fund, the Government is planning to support the uptake of clean energy and green technologies, including in: wind turbine component manufacturing; battery and solar panel supply chain and manufacturing; modernising steel and aluminium manufacturing; hydrogen electrolyzers; new livestock feed to reduce methane emissions; bioenergy and biomass; and innovative packaging solutions for waste reduction.

The Australian Energy Market Operator (AEMO) has recently updated its Integrated System Plan in 2022. This plan provides a roadmap for the National Energy Market and the transition to net zero emissions in the electricity sector. The ISP was developed with extensive consultation, with involvement of over 1,500 stakeholders. This Plan will enable and facilitate the transition to renewables, which are expected to meet 83% of the energy required for the National Energy Market by 2030–31. AEMO is developing a plan for the energy sector that will take the ISP forward.

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The Australian Government is investing in these technologies through deployment of infrastructure that supports increased renewable energy integration with the electricity grid, including a \$20 billion investment in Rewiring the Nation. Investments are also being made through agencies including ARENA (Australian Renewable Energy Agency) and CEFC (Clean Energy Finance Corporation), and through Cooperative Research Centres.

## 2.2 Tracking Progress (Optional)

To measure progress against the Powering Australia plan and the emissions reduction target, the Australian Government has announced it will introduce an annual statement to Parliament by the Prime Minister or Minister for Climate Change and Energy on climate policy. This is intended to improve integrity in decision-making and transparency on climate change policy and progress. The statement will include reporting on progress against national targets and international developments, with the first statement will be delivered by the end of 2022. Separately, the Australian Government has announced the domestic Climate Change Authority will provide independent, expert advice to Government on climate change policy and emissions reduction targets, and will provide input to the Annual Statement to Parliament.

The Australian Government measures the impacts and progress of investments in clean energy technology by tracking funding; enabling policies; progress on international partnerships; co-investment, and jobs supported. It also tracks other impacts including costs for clean technologies, deployment of these technologies, exports supported by these technologies, and emissions reductions enabled by these technologies.

Australia has a number of public organisations that support research, development, demonstration and early-stage commercialisation of clean energy technologies. Some of these organisations also publish information that tracks project progress and investments.

### 3. Private Sector Engagement (Optional)

Australia has a number of public organisations that support research, development, demonstration and early-stage commercialisation of clean energy technologies through co-investment with the private sector. This includes the Department of Climate Change, Energy, the Environment and Water (DCCEEW), the Department of Industry, Science and Resources (DISR), the Department of Education (DoE), Clean Energy Regulator (CER), Australian Renewable Energy Agency (ARENA), Clean Energy Finance Corporation (CEFC), Australian Research Council, Cooperative Research Centres and the Commonwealth Scientific & Industrial Research Organisation (CSIRO).

Most of the relevant programs are administered under a competitive, merit-based mechanism. Many are also designed to attract co-investment from other parties, including private sector entities. The Australian Government has committed to at least AUD\$24 billion in public investment across the electricity, industry, agriculture and transport sectors over the coming years, which is expected to drive AUD\$76 billion in total public-private investment. Government investment from the named entities can take the form of grants, tailored debt finance or equity.

The Australian Government supports innovation and investment in research and development in the private sector through the Research and Development Tax Incentive (R&DTI). The R&DTI offers a tax offset for companies conducting eligible R&D activities. It encourages investment in R&D to help companies grow and innovate.

## 4. International Collaboration (Optional)

Australia is taking action to become a renewable energy superpower. To achieve this, the Australian Government is prioritising cooperation with our international partners to accelerate technology development that will underpin a secure and clean energy transition. Collaboration with our international partners will provide the certainty and confidence for the scale of investment needed to transition to clean-energy economies.

Australia is prioritising international collaboration on clean energy technology through bilateral partnerships, as well as established and emerging multilateral fora, including the Quad, Clean Energy Ministerial, Mission Innovation, LeadIT, Indo-Pacific Economic Framework, International Energy Agency, APEC, G20, and UNFCCC including the Breakthrough Agenda. To achieve our clean energy priorities, Australia is focused on working with our international partners to:

- accelerate the development and deployment of clean energy technology;
- develop new clean energy supply chains;
- establish favourable market conditions for clean energy trade and uptake;
- deepen cooperation on technology deployment through technical assistance and capacity building;

In July 2022, Australia co-hosted the Sydney Energy Forum with the International Energy Agency, bringing together government and industry from the Indo-Pacific to share and discuss the challenges and opportunities of the global energy transition. The Sydney Energy Forum represents Australia's commitment to be a global leader on climate action, and highlights our priority of strengthening regional cooperation on clean energy technology.

At the Sydney Energy Forum, Australia and the United States announced the Net Zero Technology Acceleration Partnership. This Partnership will drive investment and trade in, and the development and deployment of, low and zero emissions technologies, including long duration energy storage, digital grids, hydrogen, and carbon dioxide removal, including direct air capture, as well as cooperation on critical minerals supply chains.





## 5. National Energy Innovation Ecosystem (Optional)

**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
Australian Research Council (ARC)	The Australian Research Council (ARC) expands knowledge and innovation for the benefit of the Australian community by funding the highest quality research, assessing the quality, engagement and impact of research, and providing advice on research matters.	The ARC's research priorities include: energy and advanced manufacturing.	The ARC is focused from early-stage R&D to market demonstration	<a href="https://www.arc.gov.au/funding-research/application/science-and-research-priorities">https://www.arc.gov.au/funding-research/application/science-and-research-priorities</a>
Cooperative Research Centres (CRCs)	The government supports industry-led collaborative research through grants under the Cooperative Research Centres (CRC) Program. CRCs have established projects in areas of competitive strength that align with government priorities, including developing and deploying low emissions technologies	CRCs have established projects in areas of competitive strength that align with government priorities, including: HILT CRC, Future Fuels CRC and Reliable Affordable Clean Energy (RACE). These CRC's priorities include clean hydrogen, industrial decarbonisation, and improving energy technology businesses.	CRCs are focused from early-stage R&D to deployment and commercialisation	<a href="https://business.gov.au/grants-and-programs/cooperative-research-centres-crc-grants/current-cooperative-research-centres-crcs">https://business.gov.au/grants-and-programs/cooperative-research-centres-crc-grants/current-cooperative-research-centres-crcs</a>

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Commonwealth Scientific and Industrial Research Organisation (CSIRO)	The Commonwealth Scientific and Industrial Research Organisation (CSIRO) works with universities, research institutes and industry to develop technologies and support commercial uptake across many areas of the economy, including low emission technologies.	Clean hydrogen production, energy storage, industrial decarbonisation and agricultural emission reduction.	CSIRO is focused from early-stage R&D to deployment and commercialisation	<a href="https://www.csiro.au/en/research">https://www.csiro.au/en/research</a>
Australian Renewable Energy Agency (ARENA)	To support the global transition to net zero emissions by accelerating the pace of pre-commercial innovation, to the benefit of Australian consumers, businesses and workers.	Optimise the transition to renewable electricity Commercialise clean hydrogen Support the transition to low emissions metals	Since 2012, ARENA have supported 625 projects with \$1.86 billion in grant funding, unlocking a total investment of almost \$8.04 billion in Australia's renewable energy industry. ARENA is focused from early-stage R&D to deployment and commercialisation	<a href="https://arena.gov.au/about/">https://arena.gov.au/about/</a>
Modern Manufacturing Initiative (MMI)	The Modern Manufacturing Initiative (MMI) supports projects from market demonstration through to commercial scale-up. This includes translating high-quality research into marketable products, integrating intermediate products into new domestic and global value chains, entering new markets and creating transformational business-to-business and business-to-research collaborations.	Priorities under the Recycling and Clean Energy National Manufacturing Priority roadmap highlight opportunities in hydrogen technologies, batteries, next-generation photovoltaic modules, and low emissions metals	The MMI is focused from market demonstration to diffusion.	<a href="https://www.industry.gov.au/news/modern-manufacturing-initiative-and-national-manufacturing-priorities-announced">https://www.industry.gov.au/news/modern-manufacturing-initiative-and-national-manufacturing-priorities-announced</a>
Clean Energy Finance Corporation (CEFC)	The Clean Energy Finance Corporation (CEFC) works with the private sector to demonstrate the financial viability of near-commercial low	New technologies highlighted as CEFC investment opportunities include hydrogen, grid, and energy storage.	CEFC is focused from deployment and commercialisation to market diffusion.	<a href="https://www.cefc.com.au/media/pfupku4s/cefc_2021-22_corporate_plan.pdf">https://www.cefc.com.au/media/pfupku4s/cefc_2021-22_corporate_plan.pdf</a>

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	emissions technologies and the bankability of new revenue streams. The CEFC takes a commercial approach, providing tailored debt finance and equity to businesses and projects.			
Clean Energy Regulator (CER)	The Clean Energy Regulator (CER) administers Australian Government schemes for measuring, managing, reducing and offsetting Australia's greenhouse gas emissions. These include the Emissions Reduction Fund (ERF) and Safeguard Mechanism, the Renewable Energy Target, the National Greenhouse and Energy Reporting Scheme and the Australian National Registry of Emissions Units.	CER is developing certification frameworks and platforms to give confidence to investors and consumers as new technologies and industries evolve. These include the Guarantee of Origin Scheme for Hydrogen, and the Australian Carbon Exchange.	The CER is focused from market growth to diffusion.	<a href="https://www.cleanenergyregulator.gov.au/About">https://www.cleanenergyregulator.gov.au/About</a>
Australian Energy Market Operator (AEMO)	Australian Energy Market Operator (AEMO) manages electricity and gas systems across Australia. They also provide strategic forecasting and planning services.	AEMO published a comprehensive roadmap for the National Electricity Market, the 2022 Integrated System Plan (ISP). This roadmap will support the energy system transformation to net zero emissions.	AEMO is focused on managing system stability during renewable deployment and diffusion.	<a href="https://aemo.com.au/">https://aemo.com.au/</a>

## 6. Further Supporting Evidence (Optional)

Through Powering Australia, \$200 million is being invested in 400 new community batteries across Australia. This will maximise the benefits of Australia's rooftop solar transformation, support the grid and provide shared storage for up to 100,000 households. The government is also investing \$100 million to deliver 85 solar banks around Australia. This will provide access to solar for around 25,000 households who are unable to install rooftop solar, including renters and low-income households. This will help to lower the price of energy for these households and support our emissions reduction goals.

The [Towards Net Zero Mission](#) of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) is focused on working together with Australian regions and industries to achieve net zero emissions. This mission will develop and demonstrate high abatement technologies to support Australian and global emissions reduction.

The CSIRO's [Hydrogen Industry Mission](#) is aimed at building Australia's hydrogen industry. This Mission will focus on research, development and demonstration, and will include feasibility studies, strategy, and collaborative hydrogen production demonstration projects.

# AUSTRIA

## 1. Clean Energy Innovation Strategy

### 1.1 Summary

Austria has set itself the goal of being **climate neutral by 2040** at the latest. Corresponding measures will be implemented on the basis of an amended climate protection law with binding reduction paths until 2040 and interim targets until 2030 as well as clear responsibilities and schedules. A mandatory and independent climate check of laws and regulations makes climate protection a central decision-making criterion applied in many ways.

The current framework of the clean energy innovation policies in Austria are the **Climate and Energy Strategy #mission2030** (published in 2018) and its **implementation plan** (National Energy and Climate Plan NECP); submitted to the European Commission in 2019). By 2030, Austria pursues the following goals:

- reduction of green house gas emissions by 36% compared to 2005
- providing 100% of its total electricity consumption (national balance) from renewable energy sources
- increase in the share of renewable energy in the gross final energy demand to 46-50%

In 2020, Austria has published an **updated Implementation Plan for the Energy Research Initiative** (Research Chapter of the NECP). It covers missions and related innovation goals, public R&D measures and concrete innovation activities. Austria has started three new RD&D initiatives, which will result in demonstration labs in the fields of

- **100% Renewable Energy Regions:** up to 5 innovation labs will demonstrate how wholistic and systemic energy solutions such as sector coupling (power, heat, mobility, industry) will enable flexible, resilient and regional energy supply.
- **Climate Neutral Cities** aim to accelerate the development of climate-neutral cities by implementing climate-neutral strategies, process and regulatory innovation in urban living labs and cities
- **Circular Economy:** implementation of the Austrian circular economy strategy by promoting cross-cutting RD&D in the areas of circular procurement & manufacturing, intensification of usage and recycling.

## 1.2 Methodology

Following on from the 2010 Energy Research Strategy and its mission statement of "Making the Zero Carbon Society Possible", in the spring of 2016 the Federal Ministry of Transport, Innovation and Technology, together with the Climate and Energy Fund, began the consultation process "Dialog Energiezukunft 2050" (Future of Energy 2050), with the aim of aligning future energy research and innovation policy with the challenges of energy supply and current targets. The starting point for the dialogue was a topic-based paper in which experts from the individual focus areas set out the key challenges and courses of action along with future priorities and central issues. In a public consultation process between August and October 2016 a community of experts and interested members of the public were invited to comment on the key issues outlined and to work together to develop possible solutions. The resulting ideas were compiled and consolidated in further expert workshops. In keeping with the mission statement of the vision – "Making Austria the global innovation leader in energy for the future".

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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)
Climate and Energy Strategy #mission2030	The strategy aims to align with the 2030 sustainability goals in the areas of GHG reduction, renewable energy and energy efficiency to achieve the goals of the European Union.	The Strategy lays down guidelines for climate and energy policy up to 2030.	2018	<a href="https://www.bmk.gv.at/dam/jcr:36595bff-3fbb-40f2-b573-9bc75f30f75b/mission2030_oe_climatestrategy_ua.pdf">https://www.bmk.gv.at/dam/jcr:36595bff-3fbb-40f2-b573-9bc75f30f75b/mission2030_oe_climatestrategy_ua.pdf</a>
National Energy and Climate Plan NECP	The NEKP is a comprehensive plan that shows the way to achieve Austria's energy and climate targets by 2030 and that includes those sectors that are not subject to the EU emissions trading system, such as transport, agriculture or buildings.	Goals for 2030: <ul style="list-style-type: none"> <li>Reduction of GHG emissions (non-ETS) by 36% compared to 2005</li> <li>Increasing the proportion renewable energy in gross final energy consumption to 46–50%, as well 100% coverage of electricity consumption from renewables (national/balance sheet)</li> <li>Improvement of Primary energy intensity by 25–30% compared to 2015</li> </ul>	2010	<a href="https://www.bmk.gv.at/themen/klima_umwelt/klimaschutz/nat_klimapolitik/energie_klimaplan.html">https://www.bmk.gv.at/themen/klima_umwelt/klimaschutz/nat_klimapolitik/energie_klimaplan.html</a>
Implementation Plan for the Energy Research Initiative	The implementation plan for the energy research initiative for the period 2020–2030.	The plan gives a detailed descriptions of the following three missions, goals and corresponding activities: <ul style="list-style-type: none"> <li>Plus energy quarters</li> <li>Integrated regional energy systems</li> <li>Break-through technologies for industry</li> </ul>	2020	<a href="https://nachhaltigwirtschaften.at/de/e2050/publikationen/schriftenreihe-2020-22-umsetzungsplan-eforschungsinitiative.php">https://nachhaltigwirtschaften.at/de/e2050/publikationen/schriftenreihe-2020-22-umsetzungsplan-eforschungsinitiative.php</a>
RTI – Roadmap Geothermal Energy	Shows potential, but also difficulties for expansion and is a central component of an overarching overall strategy for heating, cooling and electricity.	In addition to RTI topics, the RTI – Roadmap also addresses important non-technological difficulties for the required massive expansion of geothermal energy in Austria – this includes access to planning information and strengthening visibility through innovative showcase projects.	2022	<a href="#">FTI-Roadmap Geothermie: Vision und FTI-politische Fragestellungen – Nachhaltig Wirtschaften</a>

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Hydrogen strategy for Austria	Based on fields of action, the strategy enables a targeted and efficient use of climate-neutral hydrogen in strategic consumption sectors embedded in the overall system.	<p>The goals are:</p> <ul style="list-style-type: none"><li>• Use of climate-neutral hydrogen in the industry until 2030</li><li>• Increase of capacity (1 GW electrolysis capacity until 2030)</li><li>• Market development</li><li>• Establishment of hydrogen production by electrolysis as integral part of the energy system</li><li>• Infrastructure development</li><li>• International cooperation and hydrogen partnerships</li><li>• Research &amp; Development</li></ul>	2022	<a href="https://www.bmk.gv.at/wasserstoffstrategie-fur-oesterreich">Wasserstoffstrategie für Österreich (bmk.gv.at)</a>
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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, (include budget years where applicable)	Planned demonstration Investments (include budget years and indicate if domestic or international spending where possible)	Links to relevant reports or plans
Break-through technologies for industry	<input type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input type="checkbox"/> product development <input checked="" type="checkbox"/> Demonstration <input type="checkbox"/> Commercialisation Other:	Break-through technologies for the industry, the reduction in leaps and bounds of raw material and energy requirements with the same output as well as significantly reduced emissions and enable increased added value across the value chains in Austria as a whole.	Energy intensive industry	35 Mio. € [see demos]	35 Mio (Programme: Transformation of the Economy, 1 <sup>st</sup> Call 2022), domestic	<a href="https://nachhaltigwirtschaften.at/de/e2050/publikationen/schriftenreihe-2020-22-umsetzungsplan-eforschungsinitiative.php">https://nachhaltigwirtschaften.at/de/e2050/publikationen/schriftenreihe-2020-22-umsetzungsplan-eforschungsinitiative.php</a>
Plus energy quarters	<input type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input type="checkbox"/> product development <input checked="" type="checkbox"/> Demonstration <input type="checkbox"/> Commercialisation Other:	Development of plus energy quarters, which are able to meet their entire energy needs from renewable sources.	Integrated planning, construction, and operational processes	30.7 Mio. € [=12 Mio. € (Pioneer City, domestic, 2022) + 8 Mio. € (City of the Future, 9 <sup>th</sup> Call, domestic, 2021) + 2.2	8.5 Mio. € [=7 Mio. € Resilient Cities: Lighthouse projects 2040, domestic, 2022 +	<a href="https://nachhaltigwirtschaften.at/de/e2050/publikationen/schriftenreihe-2020-22-umsetzungsplan-eforschungsinitiative.php">https://nachhaltigwirtschaften.at/de/e2050/publikationen/schriftenreihe-2020-22-umsetzungsplan-eforschungsinitiative.php</a>

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				€ (Driving Urban Transitions, 1 <sup>st</sup> Call, int.) + 8.5 Mio. € (see demos)]	1.5 Mio. € MI Call 21 – “Positive Energy districts (PEDs) and neighbourhoods for Climate neutrality, 2022 int.]	<a href="https://eforschungsinitiative.php">eforschungsinitiative.php</a>
Integrated regional energy systems	<input type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input type="checkbox"/> product development <input type="checkbox"/> Demonstration <input type="checkbox"/> Commercialisation Other:	Development of integrated regional energy systems and grids that enable up to 100% energy from renewable sources in local and regional energy supply and the participation of companies and citizens in regional value chains and national markets.	Cross-sector, cross-energy source and cross-infrastructure integration, provision and use of significantly high shares of renewable energy	15.1 Mio € [=4.3 Mio € (Clean Energy Transition Partnership, int., 2022) + 2.8 Mio € (IEA Research Cooperation, int., 2022), + 8 Mio. € (Energy Research, 8th Call, domestic, 2021)]		<a href="https://nachhaltigwirtschaften.at/de/e2050/publikationen/schriftenreihe-2020-22-umsetzungsplan-eforschungsinitiative.php">https://nachhaltigwirtschaften.at/de/e2050/publikationen/schriftenreihe-2020-22-umsetzungsplan-eforschungsinitiative.php</a>

A total of 14 innovation goals were developed for the three missions (aka innovation priorities) by Austrian companies and research organisations. A total of 39 energy technology development plans (“innovation activities”) were identified by Austrian companies and research organisations. All 39 innovation activities contribute to the achievement of one or more innovation goals and thus the missions. On the basis of the three pillars (missions, innovation goals and innovation activities), public-sector measures are currently being derived that are intended to support the innovation actor.

## 2.2 Tracking Progress (Optional)

In order to be able to effectively steer developments in the field of research, technology and innovation and also to achieve longer-term goals, regular monitoring of energy innovations and their evaluation is necessary.

Two essential parameters of the innovation system have already been monitored in Austria for more than ten years:

1. Surveys of public energy research expenditures as a financial input into the innovation system.
2. Surveys on the market development of innovative energy technologies as the market outcome of the innovation process.

### 3. Private Sector Engagement (Optional)

Close cooperation between the public sector and businesses is an important key to success in Austria. It is the intensive partnership between the state and private investors that opens significant opportunities for Austria's economy. Therefore, Austria pursues the approach of complementing comprehensive industrial research investments with public funds and involving business enterprises in the development of innovative solutions for the public sector. A special feature of Austrian innovation activities is the strong market and implementation orientation.

## 4. International Collaboration (Optional)

Since internationalisation is without any alternative for innovation-oriented companies – not least due to globalisation as well as the relatively manageable home market – in Austria, companies are supported in this challenging growth phase. Decisive for the successful positioning of Austrian energy technology providers is, on the one hand, the active networking and cooperation of Austrian actors in international RTI initiatives (such as participation in the global Mission Innovation initiative, participation in the Strategic Energy Technology (SET) Plan of the EU and the cooperation programmes of the International Energy Agency (IEA)) and, on the other hand, the strategic bundling of individual strengths into presentable and communicable comprehensive solution offers.

## 5. National Energy Innovation Ecosystem (Optional)

A key for success in Mission Innovation is the strong public-private cooperation. Austria has installed a national governance structure, ensuring a broad involvement of Austrian industry and R&D stakeholders. Austrian MI activities are led by the **Federal Ministry of Climate Action, Environment, Mobility, Innovation and Technology (BMK)**. BMK installed an **expert advisory board**. This board meets in May 2021 the 5<sup>th</sup> time and gives advice to the Federal Minister on Austria's energy research and technology policy and its involvement in Mission Innovation. The **Climate and Energy Fund**, owned by BMK, is the most important institution funding national energy R&D and implementation projects. The Climate and Energy fund is currently leading the scoping process of the Industry Mission. The **Austrian Institute of Technology (AIT)** has a supporting role in the Austrian MI activities (contribution to Missions, supporting BMK and the Climate and Energy Fund and contribution to the MI Secretariat).

The **Austrian Research Promotion Agency (FFG)** is the national funding agency for industrial research and development in Austria. It provides funding for applied research. The **Kommunkredit Public Consulting (KPC)** provides management of funding initiatives for market and investment funding.

# CANADA

## 1. Clean Energy Innovation Strategy

### 1.1 Summary

Canada is working to address the threat of climate change by bringing together innovation from across the financial sector, businesses, and communities to exceed its current 2030 greenhouse gas reduction target and achieve net-zero emissions by 2050. In March 2022, the Government of Canada released the [2030 Emissions Reduction Plan: Canada's Next Steps for Clean Air and a Strong Economy](#). This plan is an ambitious and achievable sector-by-sector approach for Canada to reach its new climate target of cutting emissions by 40% below 2005 levels by 2030, and to put it on a pathway to achieve net-zero emissions by 2050. The 2030 Emissions Reduction Plan includes \$9.1 billion in new investments to cut pollution and grow the economy, a number of which relate to clean energy innovation. For example, the Government of Canada is helping industries to adopt clean technology and transition to net zero emissions, including through historic investments to enable industries to be clean and competitive and creating greater incentives for clean technologies and fuels, including carbon capture, utilization and storage (CCUS). Other investments and activities highlighted through the 2030 Emissions Reduction Plan include support to make Canada's electricity grid even cleaner, through a regulated Clean Electricity Standard and investments of about \$850 million in clean energy projects, to develop a strategy to strengthen federal coordination of clean tech and climate innovation measures, as well as greening Canada's homes and buildings through a national net-zero buildings plan and investments of around \$1 billion.

In addition to the 2030 Emissions Reduction Plan, a range of supporting strategy and policy frameworks all recognize the important role that clean energy innovation will have in enabling Canada to reach its energy and climate targets. These include: Canada's Strengthened Climate Plan (SCP) – [A Healthy Environment and a Healthy Economy](#), Canada's [Greening Government Strategy](#), the [Hydrogen Strategy for Canada](#), and the [Small Modular Reactor \(SMR\) Action Plan](#). The Government of Canada's Budget 2022

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provided funding to develop and implement additional strategies and measures that will contribute to energy innovation in Canada, including the Critical Minerals Strategy, the Green Buildings Strategy, and a federal innovation and investment agency. The Government of Canada is also developing a CCUS Strategy for the country.

Clean energy innovation is a crosscutting priority that helps to underpin Canada's efforts to achieve climate and energy goals and influence the pace and direction of energy systems transformation. The Government of Canada will continue to drive innovation by providing additional funding to trial pre-commercial clean technologies and de-risk large-scale pilot projects critical to net-zero transitions. Strategic investments are already targeting CCUS, electrification, and clean fuels, like hydrogen. The Office of Energy Research and Development (OERD) leads the Government of Canada's efforts in energy research, development, and demonstrating (RD&D), including through the delivery of energy innovation and cleantech programming. In order to maximize environmental and economic outcomes, OERD targets four key "missions" to realize a clean energy future: 1) Improve energy efficiency and processes to reduce emissions from energy end-use; 2) Accelerate electrification and maximize benefits of low-emitting heat and power; 3) Develop cleaner fuels pathways; and 4) Maintain safe and resilient energy systems to protect Canadians in the changing energy landscape. These priorities guide Canada's domestic and international efforts in support of clean energy innovation.



## 1.2 Methodology

The 2030 Emissions Reduction Plan uses economic modelling to show a pathway to achieving Canada's 2030 target, including the potential for each sector of the economy to reduce emissions by 2030. This modelling approach is widely used by other countries in charting their courses to net zero.

Broken down by sector, Canada's pathway to 2030 is based on today's understanding of the potential for each sector to reduce emissions by 2030. Given the economic interdependencies and interactions among sectors, the focus for further actions may shift in the future as Canada further decarbonizes, costs of abatement technologies change and other opportunities emerge.

The Government of Canada expects that the measures outlined in the 2030 Emissions Reduction Plan, together with complementary climate actions from the provinces and territories, municipalities, the financial community, Indigenous Peoples, innovators, and businesses—as well as with the acceleration of clean technology innovation and deployment—will lead to further emission reductions by 2030. Canada will continue to update its modelling projections, including in Canada's next Biennial Report in December 2022 and first 2030 Emissions Reduction Plan progress report expected in late 2023.

The *2030 Emissions Reduction Plan: Canada's Next Steps for Clean Air and a Strong Economy* reflects submissions from over 30,000 Canadians, provinces and territories, Indigenous partners, industry, civil society, and the independent Net-Zero Advisory Body. The plan represents a whole-of-society approach with practical ways to achieve emission reductions across all parts of the economy.

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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)
2030 Emissions Reduction Plan (ERP): Clean Air, Strong Economy	The 2030 Emissions Reduction Plan is an ambitious and achievable roadmap that outlines a sector-by-sector path for Canada to reach its emissions reduction target of 40 percent below 2005 levels by 2030 and net-zero emissions by 2050.	The 2030 Emissions Reduction Plan describes many of the actions that are already driving significant emission reductions as well as the new measures that will ensure Canada can meet its climate targets. The Plan includes \$9.1 billion in new investments, and reflects economy-wide measures such as carbon pricing and clean fuels, while also targeting actions sector by sector ranging from buildings to vehicles to industry and agriculture.	2022	<a href="https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview/emissions-reduction-2030.html?utm_campaign=not-applicable&amp;utm_medium=vanity-url&amp;utm_source=canada-ca_emissions-reduction-plan">https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview/emissions-reduction-2030.html?utm_campaign=not-applicable&amp;utm_medium=vanity-url&amp;utm_source=canada-ca_emissions-reduction-plan</a>
A Healthy Environment and Healthy Economy: Canada's Strengthened Climate Plan to Create Jobs and Support People, Communities, and the Planet	A Healthy Environment and a Healthy Economy is Canada's federal plan to build a better future with a healthier economy and environment. Canada's strengthened climate plan builds on continuing work with provinces and territories through the Pan-Canadian Framework on Clean Growth and Climate Change (PCF), which was released in 2016.	A Healthy Environment and a Healthy Economy is supported by an initial \$15 billion in investments across 64 new measures. The plan focuses on 5 pillars: making the places Canadians live and gather more affordable by cutting energy waste; making clean, affordable transportation and power available in every community; continuing to ensure pollution isn't free and households get more money back; and building Canada's clean industrial advantage.	2020	<a href="https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview/healthy-environment-healthy-economy.html">https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview/healthy-environment-healthy-economy.html</a>
Canada's Enhanced NDC	Canada's nationally determined contribution (NDC) under UNFCCC Paris Agreement	Sets a target of economy-wide greenhouse gas emissions reduction of 40–45% below 2005 levels by 2030, as well as Canada's commitment to net-zero emissions by 2050	2021	<a href="https://unfccc.int/sites/default/files/NDC/2022-06/Canada%27s%20Enhanced%20NDC.pdf">https://unfccc.int/sites/default/files/NDC/2022-06/Canada%27s%20Enhanced%</a>

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				<a href="#">20NDC%20Submission1_FINAL%20EN.pdf</a>
Pan-Canadian Framework on Clean Growth and Climate Change	The 2016 Pan-Canadian Framework on Clean Growth and Climate Change (PCF) is Canada's first-ever national climate plan that was developed with provinces and territories, and in consultation with Indigenous peoples. It is an important first step for Canada to achieve its Paris Agreement target, and is doing more to cut pollution in a practical and affordable way than any other climate plan in Canadian history.	The plan includes a pan-Canadian approach to pricing carbon pollution, and measures to achieve reductions across all sectors of the economy. It aims to drive innovation and growth by increasing technology development and adoption to ensure Canadian businesses are competitive in the global low-carbon economy.	2016	<a href="https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework/climate-change-plan.html">https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework/climate-change-plan.html</a>
Hydrogen Strategy for Canada	The Hydrogen Strategy for Canada is an ambitious framework that seeks to position Canada as a global hydrogen leader, cementing this low-carbon and zero-emission fuel technology as a key part of our path to net-zero carbon emissions by 2050.	The Strategy is underpinned by a federal investment of \$1.5 billion in a Low-carbon and Zero-emissions Fuels Fund to increase the production and use of low-carbon fuels, including hydrogen. The Strategy is designed to spur investment and partnerships to establish Canada as a global supplier of hydrogen, and to increase domestic production, which will transform our energy sector. The strategy will also be complemented by the Clean Fuel Standard, which will further drive investment and growth in Canada's fuels sector by incentivizing the development and adoption of clean fuels such as hydrogen.	2020	<a href="https://www.nrcan.gc.ca/sites/nrcan/files/environment/hydrogen/NRCan_Hydrogen%20Strategy%20for%20Canada%20Dec%2015%202200%20clean_low_accessible.pdf">https://www.nrcan.gc.ca/sites/nrcan/files/environment/hydrogen/NRCan_Hydrogen%20Strategy%20for%20Canada%20Dec%2015%202200%20clean_low_accessible.pdf</a>
Federal Sustainable Development Strategy 2022-2026	The draft 2022 to 2026 Federal Sustainable Development Strategy (FSDS, the draft strategy) is the first to be developed under a strengthened Federal Sustainable Development Act	It shows how 99 organizations across the Government of Canada will work together to promote a clean environment and tackle the crises of climate change and biodiversity loss, all while growing our economy and	2022	<a href="https://www.fdsd-sfdd.ca/en">https://www.fdsd-sfdd.ca/en</a>

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	(the Act). Taking a whole-of-government approach, it sets out Government of Canada sustainable development goals, targets, milestones and implementation strategies from an environmental perspective.	making sure that no one is left behind. It also shows how the Government of Canada is leading by example by transitioning to net-zero carbon and climate-resilient operations by 2050.  The Strategy focuses on the environmental aspects of the 17 Sustainable Development Goals of the 2030 Agenda for Sustainable Development.		
Small Modular Reactor Action Plan	Canada's Small Modular Reactor (SMR) Action Plan is Canada's plan for the development, demonstration and deployment of SMRs for multiple applications at home and abroad.	<p>The SMR Action Plan provides concrete actions for the Government of Canada to:</p> <ul style="list-style-type: none"> <li>• Ensure robust policy, regulatory and legislative frameworks are in place to protect people and the environment;</li> <li>• Accelerate innovation;</li> <li>• Continue meaningful engagement with Indigenous communities and all Canadians; and</li> <li>• Develop international partnerships and open up new markets.</li> </ul>	2020	<a href="https://smractionplan.ca/">https://smractionplan.ca/</a>

## 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, (include budget years where applicable)	Planned demonstration Investments (include budget years and indicate if domestic or international spending where possible)	Links to relevant reports or plans
Buildings and Energy Efficiency	<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 checked="" type="checkbox"/> Commercialisation Other:	<p>Develop a <a href="#">Canada Green Buildings Strategy</a>, to achieve net-zero buildings by 2050. Potential outcomes for the strategy could include building net-zero and climate resilient buildings from the start; accelerating climate-resilient, building retrofits; and transforming space and water heating.</p> <p>Ensure all new federal buildings are net-zero emissions and that major retrofits are low-carbon; ensure that, starting in 2030, 75% of domestic office new lease and lease renewal floor</p>	Various technologies for energy efficiency improvements; low-carbon construction materials.	<p>Total 2021-22 Budgeted Federal RD&amp;D spending (from select data submitted to IEA RD&amp;D Questionnaire):  <b>\$241,942,000</b></p> <p>Total 2022-23 Estimated Federal RD&amp;D spending (from select data submitted to IEA RD&amp;D Questionnaire):  <b>\$208,792,000</b></p> <p>Program Notes            RD&amp;D will be supported as a part of the \$874.5 million in support of the buildings sector</p>	<p>Total 2021-22 Budgeted Federal Demonstration spending (from select data submitted to IEA RD&amp;D Questionnaire):  <b>\$60,734,000</b></p> <p>Total 2022-23 Estimated Federal Demonstration spending (from select data submitted to IEA RD&amp;D Questionnaire):  <b>\$63,630,000</b></p> <p>Program Notes            \$33.2 million over 5 years for a Greener Neighbourhood Pilot</p>	<a href="https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview/emissions-reduction-2030.html?utm_campaign=not-applicable&amp;utm_medium=vanity-url&amp;utm_source=canada-">https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview/emissions-reduction-2030.html?utm_campaign=not-applicable&amp;utm_medium=vanity-url&amp;utm_source=canada-</a>

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		<p>space will be in net-zero carbon, climate resilient buildings; and supporting emerging clean technologies through procurement to reduce emissions from federal buildings.</p> <p><u>Emissions Estimates</u> Reduction of 37% from 2005 to 2030 levels in the buildings sector to achieve Canada's 2030 target.</p>		<p>announced as a part of Canada's 2030 Emissions Reduction Plan.</p> <p>RD&amp;D will be supported through NRCan's Office of Energy Research and Development's ongoing annual investments, including through the <a href="#">Energy Innovation Program</a>, <a href="#">Program for Energy R&amp;D</a>, <a href="#">Green Infrastructure Program – Energy Efficient Buildings</a> stream (\$48.4M), and others.</p> <p>Additional funding from <a href="#">Sustainable Development Technology Canada</a>, <a href="#">Innovation, Science and Economic Development Canada</a>, the <a href="#">Business Development Bank of Canada</a>, the <a href="#">National Research Council</a>, and other federal funders may support RD&amp;D in this area.</p>	<p>Program (Federal Budget 2022)</p> <p>Demonstrations will be supported through the NRCan <a href="#">Green Infrastructure Program – Energy Efficient Buildings</a> stream (\$48.4M), which will continue to 2026, as well as NRCan–OERD's ongoing annual investments through the <a href="#">Energy Innovation Program</a>, and others.</p> <p>Additional funding from <a href="#">Sustainable Development Technology Canada</a>, <a href="#">Innovation, Science and Economic Development Canada</a>, the <a href="#">Business Development Bank of Canada</a>, the <a href="#">National Research Council</a>, and other federal funders may support demonstrations in this area.</p>	<a href="#">ca_emissions-reduction-plan</a>
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Clean Electricity	<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 checked="" type="checkbox"/> Commercialisation Other:	Net Zero Electricity Grid by 2035, aligned with G7 goals, through the development of a Clean Electricity Standard  Phase out unabated coal-fired electricity by 2030.  <u>Emissions Estimates</u> Reduction of 88% from 2005 to 2030 levels in the electricity sector to achieve Canada's 2030 target.	Renewable energy technologies; smart grid and grid modernization technologies; energy storage; geothermal; tidal.  Regulatory and market innovation; business and customer solutions.  Interoperability standards of smart grid components.	Total 2021-22 Budgeted Federal RD&D spending (from select data submitted to IEA RD&D Questionnaire): <b>\$126,065,000</b>  Total 2022-23 Estimated Federal RD&D spending (from select data submitted to IEA RD&D Questionnaire): <b>\$118,106,000</b>  <u>Program Notes</u> RD&D will be supported through NRCan's Office of Energy Research and Development's ongoing annual investments through the <a href="#">Energy Innovation Program</a> , <a href="#">Program for Energy R&amp;D</a> , <a href="#">Green Infrastructure Programs</a> , and others.  Additional funding from <a href="#">Sustainable Development Technology Canada</a> , <a href="#">Innovation, Science and Economic Development Canada</a> , the <a href="#">Business Development Bank of</a>	Total 2021-22 Budgeted Federal Demonstration spending (from select data submitted to IEA RD&D Questionnaire): <b>\$41,450,000</b>  Total 2022-23 Estimated Federal Demonstration Spending (from select data submitted to IEA RD&D Questionnaire): <b>\$37,336,000</b>  <u>Program Notes</u> Demonstrations will be supported through NRCan's Office of Energy Research and Development's ongoing annual investments through the <a href="#">Energy Innovation Program</a> , <a href="#">Green Infrastructure Programs</a> , and others.  Additional funding from <a href="#">Sustainable Development Technology Canada</a> , <a href="#">Innovation, Science and Economic Development Canada</a> , the <a href="#">Business Development Bank of</a>	<a href="https://www.canada.ca/en/services/environment/weather/climate-tech/plan/climate-plan-overview/emissions-reduction-2030.html?utm_campaign=not-applicable&amp;utm_medium=anxiety-url&amp;utm_source=canada-ca_emissions-reduction-plan">https://www.canada.ca/en/services/environment/weather/climate-tech/plan/climate-plan-overview/emissions-reduction-2030.html?utm_campaign=not-applicable&amp;utm_medium=anxiety-url&amp;utm_source=canada-ca_emissions-reduction-plan</a>
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				Canada, the <a href="#">National Research Council</a> , and other federal funders may support RD&D in this area.	Canada, the <a href="#">National Research Council</a> , and other federal funders may support demonstrations in this area.	
Heavy Industry	<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 checked="" type="checkbox"/> Commercialisation	<p>Invest in industrial decarbonisation (e.g. CCUS RD&amp;D, Fuel Switching, clean fuels production, etc.) through key programs, including at Natural Resources Canada, Innovation, Science and Economic Development Canada, and others.</p> <p>Work with the Cement Association of Canada to support development of a <a href="#">roadmap to net-zero carbon concrete</a>.</p> <p>Cap oil and gas sector emissions at a pace and scale needed to achieve net-zero emissions by 2050.</p> <p><u>Emissions Estimates</u> Reduction of 39% from 2005 to 2030 levels in heavy industrial sectors to achieve Canada's 2030 target.</p>	<p>CCUS; fuel and feedstock switching in Industrial Processes; heat production and waste heat recovery, and increased resource efficiency.</p> <p>Data analytics and digital technologies to improve manufacturing processes, advance material use and development and enhance the industrial value chain.</p> <p>Advanced chemistry and separation technologies for lower energy use and GHG reduction.</p>	<p>Total 2021–22 Budgeted Federal RD&amp;D spending (from select data submitted to IEA RD&amp;D Questionnaire): <b>\$118,679,000</b></p> <p>Total 2022–23 Estimated Federal RD&amp;D spending (from select data submitted to IEA RD&amp;D Questionnaire): <b>\$107,180,000</b></p> <p><u>Program Notes</u> Announced in Budget 2021, the government is investing \$319M over 7 years for RD&amp;D to advance the feasibility &amp; commercial viability of CCUS technologies. This funding will be deployed through the <a href="#">Energy Innovation Program – Carbon Capture</a>,</p>	<p>Total 2021–22 Budgeted Federal Demonstration spending (from select data submitted to IEA RD&amp;D Questionnaire): <b>\$58,729,000</b></p> <p>Total 2022–23 Estimated Federal Demonstration Spending (from select data submitted to IEA RD&amp;D Questionnaire): <b>\$40,898,000</b></p> <p><u>Program Notes</u> Demonstration projects will be supported through the <a href="#">Energy Innovation Program – Carbon Capture, Utilization and Storage Stream</a> (\$319M/7 years).</p> <p>Demonstration projects supported through the Energy Innovation Program – <a href="#">Clean Fuels</a></p>	<a href="https://www.canada.ca/en/services/environment/weat-her/climate-change/climate-plan/climate-plan-overview/emissions-reduction-2030.html?utm_campaign=not-applicable&amp;utm_medium=vanity-url&amp;utm_source=canada-ca_emissions-reduction-plan">https://www.canada.ca/en/services/environment/weat-her/climate-change/climate-plan/climate-plan-overview/emissions-reduction-2030.html?utm_campaign=not-applicable&amp;utm_medium=vanity-url&amp;utm_source=canada-ca_emissions-reduction-plan</a>



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		Reduction of 31% from 2005 to 2030 levels in the oil and gas sector to achieve Canada's 2030 target.		<p><a href="#">Utilization and Storage Stream</a>.</p> <p>RD&amp;D supported through the Energy Innovation Program – <a href="#">Clean Fuels and Industrial Fuel Switching Stream</a> (\$53M/5 years), as well as other <a href="#">ongoing programs</a> at NRCan's OERD.</p> <p>RD&amp;D will be supported as a part of the <a href="#">Strategic Innovation Fund's Net Zero Accelerator</a> (\$8B/5 years), supporting industrial transformation and emission reduction among large emitting industries.</p> <p>Additional funding from <a href="#">Sustainable Development Technology Canada, Innovation, Science and Economic Development Canada</a>, the <a href="#">Business Development Bank of Canada</a>, the <a href="#">National Research Council</a>, <a href="#">Canada Infrastructure</a></p>	<p><a href="#">and Industrial Fuel Switching Stream</a> (\$53M/5 years), as well as other <a href="#">ongoing programs</a> at NRCan's OERD.</p> <p>Demonstration projects will be supported as a part of the <a href="#">Strategic Innovation Fund's Net Zero Accelerator</a> (\$8B/5 years).</p> <p>Additional funding from <a href="#">Sustainable Development Technology Canada, Innovation, Science and Economic Development Canada</a>, the <a href="#">Business Development Bank of Canada</a>, the <a href="#">National Research Council</a>, <a href="#">Canada Infrastructure Bank</a> and other federal funders may support demonstrations in this area.</p>	
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				Bank and other federal funders may support RD&D in this area.		
Hydrogen and Fuel Cells	<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 checked="" type="checkbox"/> Commercialisation	<p>Support GHG reductions of up to 45 Mt CO<sub>2</sub>e annually through production and use of low-carbon hydrogen by 2030; 190 Mt CO<sub>2</sub>e annually by 2050.</p> <p>Low-carbon hydrogen representing up to 6.2% of overall energy delivered in Canada; production of up to 4 Mt/year of low-carbon hydrogen by 2030; 30% of overall energy delivered in Canada; production of up to 20 Mt/year by 2050</p> <p>Achieve more than \$50 billion in direct hydrogen sector revenue for the domestic market and enable new industries as a result of low-cost hydrogen supply networks by 2050.</p> <p>Continue to advance technology development and innovation for core materials, end-use products, as well as</p>	<p>CCUS for steam-methane reformation and autothermal reforming; electrolysis and co-electrolysis; (physical &amp; chemical) hydrogen storage and distribution (i.e. Ammonia, or e.g. Methanol, Dimethyl Ether); fuel cells for medium and heavy duty vehicles; proton exchange membrane (PEM) technology; alternative catalysts for fuel cells; natural gas-hydrogen blending from 5% (up to 20%) hydrogen by volume in natural gas trunk lines/pipelines and high temperature water splitting.</p> <p>H<sub>2</sub> production for localized or centralized H<sub>2</sub> plants/utility units (cogeneration &amp; tri-generation of steam, power &amp; hydrogen).</p>	<p>Total 2021-22 Budgeted Federal RD&amp;D spending (from select data submitted to IEA RD&amp;D Questionnaire): <b>\$22,030,000</b></p> <p>Total 2022-23 Estimated Federal RD&amp;D spending (from select data submitted to IEA RD&amp;D Questionnaire): <b>\$22,002,000</b></p> <p><u>Program Notes</u> RD&amp;D supported through the Energy Innovation Program – <a href="#">Clean Fuels and Industrial Fuel Switching Stream</a> (\$53M/5 years); and as a part of <a href="#">the Program of Energy Research and Development (PERD)</a>.</p> <p>Additional funding from <a href="#">Sustainable Development Technology Canada, Innovation,</a></p>	<p>Total 2021-22 Budgeted Federal Demonstration spending (from select data submitted to IEA RD&amp;D Questionnaire): <b>\$2,851,000</b></p> <p>Total 2022-23 Estimated Federal Demonstration Spending (from select data submitted to IEA RD&amp;D Questionnaire): <b>\$971,000</b></p> <p><u>Program Notes</u> Demonstration projects supported through the <a href="#">Clean Fuels and Industrial Fuel Switching Stream of EIP</a> (\$53M/5 years).</p> <p>\$33.8 million for hydrogen trucking demonstration projects that address barriers to long-haul zero-emission trucking commercialization.</p>	<a href="https://www.nr.can.gc.ca/cli-mate-change-adapting-impacts-and-reducing-emissions/canadas-green-future/the-hydrogen-strategy/23080">https://www.nr.can.gc.ca/cli-mate-change-adapting-impacts-and-reducing-emissions/canadas-green-future/the-hydrogen-strategy/23080</a>

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		hydrogen production, storage, and distribution value chains.	Methane splitting (Methane Pyrolysis or Decomposition) that produces turquoise or grey hydrogen & <a href="#">carbon black</a> from biogas or natural gas at small scales	<a href="#">Science and Economic Development Canada</a> , the <a href="#">Business Development Bank of Canada</a> , the <a href="#">National Research Council</a> , and other federal funders may support RD&D in this area.	Additional funding from <a href="#">Sustainable Development Technology Canada</a> , <a href="#">Innovation, Science and Economic Development Canada</a> , the <a href="#">Business Development Bank of Canada</a> , the <a href="#">National Research Council</a> , and other federal funders may support demonstrations in this area.	
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 checked="" type="checkbox"/> Commercialisation	Advance utilisation of Canadian biomass resources, agricultural, forestry and municipal waste, towards net-zero in industrial (such as cement, steel, chemicals, oil & gas) and non-industrial (such as transportation, buildings) sectors in the medium and long term.	Biomass conversion technologies such as gasification; anaerobic digestion; second generation biofuels; pyrolysis; biorefinery; industrial and community applications of bioenergy	<p>Total 2021-22 Budgeted Federal RD&amp;D spending (from select data submitted to IEA RD&amp;D Questionnaire):  <b>\$37,423,000</b></p> <p>Total 2022-23 Estimated Federal RD&amp;D spending (from select data submitted to IEA RD&amp;D Questionnaire):  <b>\$27,151,000</b></p> <p><u>Program Notes</u>            RD&amp;D supported through the <a href="#">Forest Innovation Program</a> (\$5 million from 2017-23) and</p>	<p>Total 2021-22 Budgeted Federal Demonstration spending (from select data submitted to IEA RD&amp;D Questionnaire):  <b>\$5,197,000</b></p> <p>Total 2022-23 Estimated Federal Demonstration Spending (from select data submitted to IEA RD&amp;D Questionnaire):  <b>\$2,050,000</b></p> <p><u>Program Notes</u>            Demonstration projects supported through the <a href="#">Forest Innovation Program</a>, <a href="#">Clean Growth</a></p>	<a href="https://www.nrcan.gc.ca/our-natural-resources/energy-sources-distribution/renewable-energy/bioenergy-systems/7311">https://www.nrcan.gc.ca/our-natural-resources/energy-sources-distribution/renewable-energy/bioenergy-systems/7311</a>

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				<p>Investments in Forest Industry Transformation (IFIT) program. Other investments in RD&amp;D for bioenergy, biogas, and biorefining come through the <a href="#">Clean Growth Program</a>, <a href="#">Energy Innovation Program</a>, and <a href="#">Program on Energy research and Development</a>.</p> <p>Additional funding from <a href="#">Sustainable Development Technology Canada</a>, <a href="#">Innovation, Science and Economic Development Canada</a>, the <a href="#">Business Development Bank of Canada</a>, the <a href="#">National Research Council</a>, and other federal funders may support RD&amp;D in this area.</p>	<p><a href="#">Program</a>, and <a href="#">Energy Innovation Program</a>.</p> <p>Additional funding from <a href="#">Sustainable Development Technology Canada</a>, <a href="#">Innovation, Science and Economic Development Canada</a>, the <a href="#">Business Development Bank of Canada</a>, the <a href="#">National Research Council</a>, and other federal funders may support demonstrations in this area.</p>	
Transportation	<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 checked="" type="checkbox"/> Commercialisation	Mandatory target for 100% of new light-duty cars and passenger truck sales to be zero-emissions by 2035, with interim targets of at least 20% by 2026 and at least 60% by 2030.	Light, medium, and heavy duty zero-emission vehicles; zero-emission locomotives; sustainable aviation fuel; and marine sector technologies.	Total 2021-22 Budgeted Federal RD&D spending (from select data submitted to IEA RD&D Questionnaire): <b>\$96,631,000</b>	Total 2021-22 Budgeted Federal Demonstration spending (from select data submitted to IEA RD&D Questionnaire): <b>\$25,711,000</b>	<a href="https://www.canada.ca/en/services/environment/weat-her/climate-change/climate-plan/climate-">https://www.canada.ca/en/services/environment/weat-her/climate-change/climate-</a>

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		<p>35% of total medium and heavy duty vehicle sales to be zero emission vehicles by 2030, 100% by 2040 for a subset of vehicle types based on feasibility (a regulation will be developed to support the achievement of this target).</p> <p>Add 50000 EV chargers to Canada's charging network.</p> <p><u>Emissions Estimates</u> Reduction of 11% from 2005 to 2030 levels in transportation sectors to achieve Canada's 2030 target.</p>	<p>Electric vehicle infrastructure, including curbside charging; charging infrastructure for autonomous vehicles; bi-directional charging with energy storage; fast charging in the North; infrastructure standards and interoperability for electric bus overhead charging; repurposing used batteries for fast charging; grid impacts and vehicle-to-grid applications; and innovative charging hardware and software.</p>	<p>Total 2022-23 Estimated Federal RD&amp;D spending (from select data submitted to IEA RD&amp;D Questionnaire): <b>\$86,540,000</b></p> <p><u>Program Notes</u> RD&amp;D supported through the <a href="#">Green Infrastructure Program - Electric Vehicle Infrastructure Demonstration Program</a> (\$76 million); Transport Canada's <a href="#">Clean Transportation System R&amp;D Program</a>, which invests in clean aviation, rail, and marine R&amp;D; and other <a href="#">ongoing programs</a> at NRCan's OERD.</p> <p>Additional funding from <a href="#">Sustainable Development Technology Canada</a>, <a href="#">Innovation, Science and Economic Development Canada</a>, the <a href="#">Business Development Bank of Canada</a>, the <a href="#">National Research Council</a>, and other federal funders</p>	<p>Total 2022-23 Estimated Federal Demonstration Spending (from select data submitted to IEA RD&amp;D Questionnaire): <b>\$19,818,000</b></p> <p><u>Program Notes</u> \$33.8 million for hydrogen trucking demonstration projects that address barriers to long-haul zero-emission trucking commercialization.</p> <p>Demonstration projects supported through the <a href="#">Green Infrastructure Program - Electric Vehicle Infrastructure Demonstration Program</a> (\$76 million), Transport Canada's <a href="#">Clean Transportation System R&amp;D Program</a>; and other <a href="#">ongoing programs</a> at NRCan's OERD.</p> <p>Additional funding from <a href="#">Sustainable Development Technology Canada</a>, <a href="#">Innovation, Science and Economic</a></p>	<p><a href="#">plan-overview/emissions-reduction-2030.html?utm_campaign=not-applicable&amp;utm_medium=video&amp;utm_source=canada-ca_emissions-reduction-plan</a></p>
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				may support RD&D in this area.	<a href="#">Development Canada</a> , the <a href="#">Business Development Bank of Canada</a> , the <a href="#">National Research Council</a> , and other federal funders may support demonstrations in this area.	
CCUS	<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 checked="" type="checkbox"/> Commercialisation	Develop a comprehensive CCUS Strategy to guide the development and deployment of CCUS technologies to mitigate GHG emissions from a range of industrial sectors, such as steel, cement, chemicals, and oil and gas.	<p>Carbon Capture, Utilization, and Storage/Sequestration (CCUS) including a range of emerging or mature separation processes in CO<sub>2</sub> applications</p> <p>Carbon Dioxide Removal (CDR)/ Negative Emission technologies (NET) such as Direct Air Capture (DAC); Biomass Carbon Removal and Storage (BiCRS); and Enhanced Mineralization (EM).</p>	<p>Total 2021-22 Budgeted Federal RD&amp;D spending (from select data submitted to IEA RD&amp;D Questionnaire):  <b>\$33,562,000</b></p> <p>Total 2022-23 Estimated Federal RD&amp;D spending (from select data submitted to IEA RD&amp;D Questionnaire):  <b>\$28,055,000</b></p> <p><u>Program Notes</u>            Announced in Budget 2021, the government is investing \$319M over 7 years for RD&amp;D to advance the feasibility &amp; commercial viability of CCUS technologies. This funding will be deployed through the <a href="#">Energy Innovation Program –</a></p>	<p>Total 2021-22 Budgeted Federal Demonstration spending (from select data submitted to IEA RD&amp;D Questionnaire):  <b>\$9,768,000</b></p> <p>Total 2022-23 Estimated Federal Demonstration Spending (from select data submitted to IEA RD&amp;D Questionnaire):  <b>\$4,238,000</b></p> <p><u>Program Notes</u>            Demonstration projects to be supported through the <a href="#">Energy Innovation Program – Carbon Capture, Utilization and Storage Stream</a>. FEED Studies for CCUS projects are covered by this investment, supporting</p>	<a href="https://www.nrcan.gc.ca/our-natural-resources/energy-sources-distribution/carbon-capture-utilization-and-storage/4275">https://www.nrcan.gc.ca/our-natural-resources/energy-sources-distribution/carbon-capture-utilization-and-storage/4275</a>

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				<p><a href="#">Carbon Capture, Utilization and Storage Stream</a>.</p> <p>RD&amp;D will be supported as a part of the <a href="#">Strategic Innovation Fund's Net Zero Accelerator</a> (\$8B/5 years)</p> <p>Additional funding from <a href="#">Sustainable Development Technology Canada, Innovation, Science and Economic Development Canada</a>, the <a href="#">Business Development Bank of Canada</a>, the <a href="#">National Research Council</a>, <a href="#">Canada Infrastructure Bank</a> and other federal funders may support RD&amp;D in this area.</p>	<p>commercialization of CCUS technologies.</p> <p>A <a href="#">CCUS Investment Tax Credit</a> was also announced as a part of Budget 2021. This measure can help to enable large-scale demonstration and commercialization projects.</p> <p>Demonstration projects will be supported as a part of the <a href="#">Strategic Innovation Fund's Net Zero Accelerator</a> (\$8B/5 years)</p> <p>Additional funding from <a href="#">Sustainable Development Technology Canada, Innovation, Science and Economic Development Canada</a>, the <a href="#">Business Development Bank of Canada</a>, the <a href="#">National Research Council</a>, <a href="#">Canada Infrastructure Bank</a> and other federal funders may support</p>	
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					demonstrations in this area.	
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## 2.2 Tracking Progress

The [Canadian Net-Zero Emissions Accountability Act](#) enshrines in legislation the Government of Canada's commitment to achieve net-zero greenhouse gas emissions by 2050, and provides a framework of accountability and transparency to deliver on it. The Act establishes a legally binding process to set five-year national emissions-reduction targets as well as develop credible, science-based emissions-reduction plans to achieve each target. The 2030 Emissions Reduction Plan is the first released under this Act.

As part of Canadian Federal Government accountability requirements, Natural Resources Canada's energy innovation programs are required to report publicly on progress and results through a variety of mechanisms, including annual Departmental Results Reports and Departmental Results Framework indicators, horizontal initiatives such as, the Federal Sustainable Development Strategy, Canada's 2030 Emissions Reduction Plan, Strengthened Climate Plan, Clean Tech Data Strategy, Business Innovation and Growth Support (BIGS Review), as well as, reporting on international commitments such as Sustainable Development Goals. These reports generally require departments to report on progress towards pre-defined goals and targets using a combination of qualitative and quantitative data.

The Office of Energy Research and Development monitors the progress of energy innovation RD&D programs at multiple levels and units of analysis, including individual projects, individual technologies, technology areas, and by specific programs. OERD applies nested performance measurement frameworks that ensure that individual project and program objectives and outcomes align with key departmental and Government of Canada priorities. At the project level OERD energy innovation and clean growth RD&D projects submit annual project performance reports, a final project reports, and report on project outcomes for five years post project funding. Reporting requirements include financial information; narrative descriptions; supporting evidence such as technical reports; and reporting against project-specific indicators and common key performance indicators such as, development of intellectual property, advances in technological readiness levels (TRLs). Demonstration projects also required to report on actual and/or projected GHG emissions reductions. Data from project reports is analyzed and synthesized to help monitor technological advancement, inform planning and design of programs, and for reporting against performance measurement frameworks. Summary results are included in NRCan's annual Departmental Results Reports. For example, OERD's:

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- [Energy Innovation Program](#) is demonstrating early results, with 50% of project having advanced one or more levels, 27 patents or other IP, created 9 platforms or data tools, and influenced 28 codes, standards or regulations and reduced 2.21 Mt of GHG emissions in 2021-21.
- [Clean Growth Program](#) projects were successful in advancing innovation with 58% advancing one or more innovation levels. Projects also resulted in 1063 job years of employment per year and 42% projects had already achieved progress towards their 2027 economic goals. In 2021-22 projects had already reduced 14,131/ tonnes of CO<sub>2</sub>/year, 13,712,426 m<sup>3</sup> water/per year, and reduced waste by 70,896 tonnes/year and were on track for meeting or surpassing 2027 program targets.

OERD recently integrated mission-oriented and outcomes-based approaches to measurement to allow for more precise tracking of specific advances towards addressing concrete challenges or specific gaps in clean energy innovation technologies. For example, programs such as Impact Canada Clean Tech Initiative used prize-based challenges and outcomes-based approaches where innovators were awarded based on the results such as solutions to reduce GHG emissions in mines by 20% or production of the greenest and most cost-effective made-in Canada biojet fuel. Additionally, OERD piloted new tools for measuring the impact of RD&D investments. This included innovation system analysis and technological maturity analysis to inform program design, project selection and monitor progress towards addressing specific innovation gaps; measuring uptake, diffusion and use of knowledge, IP, new codes and standards, and technologies; exploring the use of taxation data for tracking economic, employment, and diversity outcomes; and longitudinal impact studies of investments in specific portfolio areas. Recent impact studies on investments in Carbon Capture, Use and Storage RD&D and energy efficiency standards and RD&D for new residential buildings found that, in addition to advancing new technologies, federal investments in energy RD&D play a critical role in convening expertise, supporting energy innovation eco-system development, and addressing non-technical barriers to the advancement and adoption of new technologies. These new approaches were identified as best practices in International Energy Association in 2022 In-Depth Review of Canada's Energy Policies.

### 3. Private Sector Engagement (Optional).

NRCan leverages public and private financing and expertise to support the advancement of Canadian clean tech while tackling difficult to solve problems and accelerating step-change reductions in GHG emissions. In one such example, NRCan partnered with Breakthrough Energy and the Business Development Bank of Canada (BDC) to deliver an initiative under the Energy Innovation Program, which provides Canadian companies with the support they need to bring their technologies to the global market. The Breakthrough Energy Solutions Canada (BESC) initiative selected 10 winning projects across electricity, transportation, buildings, and manufacturing sectors that are each targeting 500MT of annual GHG emissions reductions by 2050. In collaboration with the partners, NRCan provided other support to the companies to facilitate their growth and technology commercialization, including technical and business advice, annual accelerator sessions, and investor review.

In addition to NRCan and BDC funding, four of the companies within the cohort successfully raised funding through Series A funding rounds.

## 4. International Collaboration (Optional)

Natural Resources Canada engages with key bilateral partners and within multilateral fora such as the G7, G20, Glasgow Breakthroughs, the International Energy Agency, Clean Energy Ministerial, Mission Innovation, and the International Renewable Energy Agency to strengthen energy relationships and promote cooperation on key issues related to clean energy innovation. Canada's international collaboration on energy research, development and demonstration (RD&D) is mainly advanced through participation in the International Energy Agency's (IEA) Energy Technology Network, which includes the Committee on Energy Research and Technology (CERT), CERT Working Parties, and Technology Collaboration Programmes (TCPs).

Environment and Climate Change Canada engages internationally under existing multilateral and bilateral cooperation mechanisms, including Environmental Cooperation Agreements and environmental chapters of Free Trade Agreements, to advance clean technology innovation, deployment and scale up.

## 5. National Energy Innovation Ecosystem (Optional)

The Office of Energy Research and Development (OERD) at Natural Resources Canada leads the Government of Canada's efforts in energy research, development and demonstration, including delivery of energy innovation and cleantech programming. Focusing on influencing the pace and direction of energy system transformation, OERD targets the most impactful technologies and pays particular attention to program design and levers in order to maximize environmental and economic outcomes. All activities accord with one of four outcomes-oriented missions:

- Improve energy efficiency and processes to reduce emissions from energy end use;
- Accelerate electrification and maximize benefits of low-emitting heat and power;
- Develop cleaner fuels pathways; and
- Maintain safe and resilient energy systems to protect Canadians in the changing energy landscape.

Table 3 below details the roles of select clean energy innovation institutions within the Government of Canada, and particularly those within Natural Resources Canada. Other federal government institutions are also supporting clean energy research, development and demonstration, as are provincial and territorial governments and academic institutions. Other major federal organizations (including federal departments and crown corporations) that fund clean energy research, development and demonstration include, but are not limited to:

- [Innovation, Science and Economic Development Canada](#);
- [Sustainable Development Technology Canada](#);
- [Business Development Bank of Canada](#);
- [Export Development Canada](#); and
- [National Research Council of Canada](#).

Alongside OERD, these organizations represent the largest public funders of clean energy innovation in Canada. However, other federal organizations play a role. The [Clean Growth Hub](#), the Government of Canada's main source of information, resources and

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advice on federal supports for clean technology in Canada, is an interdepartmental initiative of 17 federal government departments and agencies supporting clean technology innovation.

More information on research facilities in Canada, including those focused on clean energy, can be [found here](#).

**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
Natural Resources Canada – Office of Energy Research and Development	The Office of Energy Research and Development (OERD) leads the Government of Canada's efforts in advancing energy research, development, and demonstration (RD&D), and is responsible for several funding programs in this space. With a focus on influencing the pace and direction of energy system transformation, OERD targets the most impactful technologies to maximize environmental and economic outcomes.	All	Grants and contributions to external projects, as well as co-investments with trusted partners, who focus on critical stages of technology development as well as specific industries/sectors of focus, enabling aligned priorities, shared risk, and minimized impact. OERD also coordinates energy R&D funding to federal laboratories, through the Program of Energy Research and Development (PERD) and the internal stream of Energy Innovation Program (EIP).	<a href="https://www.nrcan.gc.ca/science-and-data/funding-partnerships/funding-opportunities/office-energy-research-development-oerd/5711">https://www.nrcan.gc.ca/science-and-data/funding-partnerships/funding-opportunities/office-energy-research-development-oerd/5711</a>
Natural Resources Canada – CanmetENERGY-Devon	CanmetENERGY-Devon brings together scientists, engineers and technologists in a state-of-the-art research and development facility for innovation in energy technology. This research centre provides fundamental knowledge and innovative solutions that extract valuable hydrocarbon resources and reduce the	Heavy Industry, Hydrogen, Bioenergy, CCUS	Primarily an R&D organization focused on mid TRL levels.  Generates knowledge to provide solutions to industry, advice to government policy makers and regulators, and provides Canadians with relevant information on oil sands and heavy oil issues.	<a href="https://www.nrcan.gc.ca/science-and-data/research-centres-and-labs/canmetmaterials/22096">https://www.nrcan.gc.ca/science-and-data/research-centres-and-labs/canmetmaterials/22096</a>

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	environmental impacts of resource development.		Collaborates with industry, provincial/territorial governments, academic institutions and international organizations to develop and demonstrate new technologies	
Natural Resources Canada – CanmetMATERIALS	CanmetMATERIALS is a materials science laboratory which deploys unique expertise, equipment, and pilot-scale facilities to support the competitiveness and low carbon transition of Canadian industry. With research programs in energy transportation, production and end-use, this research centre focusses on developing and deploying the necessary materials technologies to enable the clean energy transition.	Clean electricity, Heavy Industry, Hydrogen, Bioenergy, Transportation, CCUS	<p>Primarily an R&amp;D organization focused on mid TRL levels.</p> <p>Generates knowledge to provide solutions to industry, advice to government policy makers and regulators.</p> <p>Collaborates with industry, provincial/territorial governments, academic institutions and international organizations to develop and deploy new technologies</p>	<a href="https://www.nrcan.gc.ca/science-and-data/research-centres-and-labs/canmetmaterials/canmetmaterials/8234">https://www.nrcan.gc.ca/science-and-data/research-centres-and-labs/canmetmaterials/canmetmaterials/8234</a>
TerraCanada Hamilton/Mississauga a Centre of Expertise (Natural Resources Canada & National Research Council of Canada)	The TerraCanada Hamilton/Mississauga Centre of Expertise is a world-class collaborative research facility, co-located in Canada's southwest Ontario industrial heartland, focused on substantially accelerating discovery and innovation in disruptive new materials that will underpin the nation's future net-zero carbon economy. This facility is the home of MI Innovation Platform Initiative: Materials For Energy (Collaborate Module).	Hydrogen, CCUS, Transportation	Leverages in-kind program, facility space, and infrastructure, this institution focuses on early-mid TRL scale research, in collaboration with national & international partners.	<a href="https://www.science.gc.ca/eic/site/063.nsf/eng/h_98241.html">https://www.science.gc.ca/eic/site/063.nsf/eng/h_98241.html</a>
Natural resources Canada – CanmetENERGY- Varennes	CanmetENERGY- Varennes is a science and technology leader in conducting innovative science and research activities to develop and implement different solution pathways for a sustainable energy future for Canada.	Industry, Buildings, Clean Electricity (particular focus on smart grid, remote microgrids)	<p>Primarily an R&amp;D organization focused on mid TRL levels.</p> <p>Generates knowledge to provide solutions to industry, advice to government policy makers and regulators, and provides Canadians with relevant</p>	<a href="https://www.nrcan.gc.ca/energy/energy-offices-and-labs/canmetenergy/canmetenergy-varennes/5761">https://www.nrcan.gc.ca/energy/energy-offices-and-labs/canmetenergy/canmetenergy-varennes/5761</a>

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	Over 200 research staff undertake applied R&D in industry energy systems optimisation, renewable energy integration into the grid,, resilient remote and northern distributed energy systems, affordable heating and cooling solutions in buildings, intelligent building controls and RETScreen clean energy decision making software.		information on industrial process optimisation, value chain in natural resource sector, smart grids, flexible and resilient buildings and affordable heating and cooling solutions for building stock.  Collaborates with industry, provincial/territorial governments, academic institutions and international organizations to develop and demonstrate new technologies	
Natural Resources Canada CanmetENERGY-Ottawa	The CanmetENERGY-Ottawa research complex conducts RD&D on a wide array of clean energy technologies; working to improve existing technologies and methods, while pioneering novel ones, with the goal of reducing greenhouse gas emissions, improving energy efficiency, and making clean energy technologies economically competitive. With over 200 scientists, engineers, technologists, managers, and support staff, CanmetENERGY-Ottawa leverages its unique pilot-scale facilities to accelerate the advancement of clean energy technologies, from the initial research stage through to commercialization.	All – Buildings, Clean Electricity, Heavy Industry, Hydrogen, Bioenergy, Transportation, CCUS	Primarily an R&D organization focused on mid TRL levels.  Generates knowledge to provide solutions to industry, advice to government policy makers and regulators.  Collaborates with industry, provincial/territorial governments, academic institutions and international organizations to develop, demonstrate and deploy new technologies.	<a href="https://www.nrcan.gc.ca/energy/offices-labs/canmet/ottawa-research-centre/5753">https://www.nrcan.gc.ca/energy/offices-labs/canmet/ottawa-research-centre/5753</a>



## 6. Further Supporting Evidence (Optional)

Natural Resources Canada's OERD delivers grants and contributions to energy RD&D projects, focusing on maximizing the leveraged impact of funds. This includes through **innovative program design**, such as the [Impact Canada prize-based cleantech innovation challenges](#). It also includes collaborative program delivery models such as [Breakthrough Energy Solutions Canada](#) (in partnership with Breakthrough Energy Ventures and the Business Development Bank of Canada), or the Science and Technology Assistance for Cleantech (STAC) program, that promote innovators' access to unique state-of-the-art national laboratory infrastructure.

Further, In January 2022, the International Energy Agency (IEA) released an In-Depth Review of Canada's energy policies that highlighted Natural Resources Canada's energy innovation activities as supporting global best practices, recognized OERD's efforts for innovative program design, and further recommended increased federal investment in energy RD&D to build on this success and accelerate innovation.

# CHILE

## 1. Clean Energy Innovation Strategy

### 1.1 Summary

Chile has achieved the target to be carbon neutral by 2050, according the Climate Change Law. Moreover, the NDC indicates that the peak for the national GHG emissions must be at last by 2025, among others important compromises. Nowadays, the energy sector is the major CO<sub>2</sub> emitter, with more than 70% of the total emissions. To reach the targets, a number of initiatives has been defined, such as the coal power plants phase out by 2040. All of the initiatives related to the energy sector –and its impacts– has been published as part of the Long Term Energy Planning.

Chile is aware that is not enough keep doing the same way. It is not time. Chile must accelerate the transition from a thermal and conventional energy matrix to a renewable energy based one. This is the main need to incorporate new and innovative solutions.

Chile has committed to increase in three times the public investment in R&D in the period 2022–2026, following the mission-oriented and people-centred approach. And one if the national challenges is already defined as the energy transition. It is from this challenge that Chile is designing its National Innovation Plan for the Energy Transition and selecting the missions to be faced in the short and medium term.

## 1.2 Methodology

A successful energy transition has been defined as a country priority. A number of official compromises are aligned with this priority. The energy transition is part of Climate Change Law and the the NDC; and is the main driver included in the Long Term Energy Policy 2050 and in the Long Term Energy Planning 2050, both already published. Chile has also defined a number of strategies for the medium term, such as the hydrogen, the electro mobility and the energy system flexibility strategies. Moreover, there is the Energy Agenda 2022–2026, where has been defined the short term priorities for the energy sector. All of these initiatives have been prepared based on an participative approach, including a wide range of stakeholders.

It is in the Energy Agenda 2022–2026 that the innovation is considered a key for both the energy transition and for a new development model for the country, based in knowledge.

The innovation in the Energy Agenda indicates that will be prepared a National Plan for the Energy Transition, based on the mission-oriented approach. The Plan will be designed in a participative way, including researchers, companies, entrepreneurs, related public agencies and civil society. The Plan will develop a wide portfolio with the opportunities and innovation projects needed for the short and medium term. It is based on this portfolio that will be prepared technological roadmaps, all of them oriented to achieve a successful energy transition.

Some of the innovation opportunities already detected, are related to: zero emissions electrical system, energy storage, green hydrogen, electromobility, digitalization and smart cities, sustainable heating ,among others.

## ALL MI MEMBER COUNTRIES – CHILE

**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)
NDC	Chilean nationally determined contribution ( NDC) under UNFCCC Paris Agreement	Sets the emissions peak by 2025	2021	<a href="https://cambioclimatico.mma.gob.cl/wp-content/uploads/2020/08/NDC_2020_Espanol_PDF_web.pdf">https://cambioclimatico.mma.gob.cl/wp-content/uploads/2020/08/NDC_2020_Espanol_PDF_web.pdf</a>
National Strategy for Science, Technology, Knowledge and Innovation for the Chilean Development	Chilean strategy developed by the National Science, Technology, Knowledge and Innovation Council	<ul style="list-style-type: none"> <li>- Focus of the R&amp;D on the main challenges of the country and in the citizens needs</li> <li>- Science, technology, knowledge and innovation as a key to achieve a sustainable development</li> </ul>	2022	<a href="https://www.consejocitci.cl/files/ugd/1296dd_5f4e394324614ef99dea042ef39710b4.pdf">https://www.consejocitci.cl/files/ugd/1296dd_5f4e394324614ef99dea042ef39710b4.pdf</a>
Long Term Energy Policy	National policy for the long term pathway of the energy sector	<ul style="list-style-type: none"> <li>- 100% of vehicle sells must be zero emission by 2035</li> <li>- 100% zero emissions electricity matrix by 2050</li> </ul>	2022	<a href="https://energia.gob.cl/sites/default/files/documentos/pen_2050_-_actualizado_marzo_2022_0.pdf">https://energia.gob.cl/sites/default/files/documentos/pen_2050_-_actualizado_marzo_2022_0.pdf</a>

## ALL MI MEMBER COUNTRIES – CHILE

Green Hydrogen Strategy	Chilean strategy for the development of a green hydrogen industry in the country	<ul style="list-style-type: none"> <li>- Top destination for green hydrogen investment in Latam by 2025</li> <li>- 5 GW electrolysis capacity operating and under development</li> <li>- 100 kton/year production in Chile</li> </ul>	2021	<a href="https://energia.gob.cl/sites/default/files/estrategia_h2_-_ingles2022.pdf">https://energia.gob.cl/sites/default/files/estrategia_h2_-_ingles2022.pdf</a>
National Electro mobility Strategy	Chilean strategy for the deployment of zero emissions transportation	<ul style="list-style-type: none"> <li>- 100% of new incorporations for urban public transportation zero emissions by 2035</li> <li>- 100% of light and medium weight vehicles sales zero emissions by 2035</li> </ul>	2022	<a href="https://drive.google.com/file/d/1rE_oSWxcfa_p5TY01fhB7AM9FADEtBPnt/view">https://drive.google.com/file/d/1rE_oSWxcfa_p5TY01fhB7AM9FADEtBPnt/view</a>

ALL MI MEMBER COUNTRIES – CHILE

## 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	Planned demonstration Investments (include budget years and indicate if domestic or international spending where possible)	Links to relevant reports or plans
<i>Decarbonization for a zero emissions system</i>	<input type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input checked="" type="checkbox"/> product development <input checked="" type="checkbox"/> Demonstration <input checked="" type="checkbox"/> Commercialisation Other:	Coal power plants phase out by 2040 and carbon neutrality by 2050	System stability with high variable energy generation and use of old coal infrastructure		
<i>High quality energy for all</i>	<input type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input checked="" type="checkbox"/> product development <input checked="" type="checkbox"/> Demonstration <input checked="" type="checkbox"/> Commercialisation Other:	100% of population with high quality energy access	Mix of technologies		

## ALL MI MEMBER COUNTRIES – CHILE

Hydrogen	<input type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input checked="" type="checkbox"/> product development <input checked="" type="checkbox"/> Demonstration <input checked="" type="checkbox"/> Commercialisation Other:	Hydrogen: The cheapest green hydrogen on the planet	Electrolysers Hydrogen storage Final uses	USD 50 MM in pilot projects	<a href="https://energia.gob.cl/sites/default/files/estrategia_h2_-_ingles2022.pdf">https://energia.gob.cl/sites/default/files/estrategia_h2_-_ingles2022.pdf</a>
<i>Electro mobility</i>	<input type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input checked="" type="checkbox"/> product development <input checked="" type="checkbox"/> Demonstration <input checked="" type="checkbox"/> Commercialisation Other:	100% of light and medium weight vehicles sales zero emissions by 2035	Inter operability and vehicle to grid solutions		<a href="https://drive.google.com/file/d/1rE_oSWxcfp5TY01fhB7AM9FADEtBPnt/view">https://drive.google.com/file/d/1rE_oSWxcfp5TY01fhB7AM9FADEtBPnt/view</a>
<i>Sustainable heating and cooling</i>	<input type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input checked="" type="checkbox"/> product development <input checked="" type="checkbox"/> Demonstration <input checked="" type="checkbox"/> Commercialisation Other:	– 80% of the energy used for heating and cooling must be sustainable by 2050	New technologies for heating and cooling		<a href="https://caloryfrio.minenergia.cl/descargable/Estrategia_calor_frio_v1.1.pdf">https://caloryfrio.minenergia.cl/descargable/Estrategia_calor_frio_v1.1.pdf</a>
<i>Digitalization and smart cities</i>	<input type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input checked="" type="checkbox"/> product development <input checked="" type="checkbox"/> Demonstration <input checked="" type="checkbox"/> Commercialisation Other:				

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Chile is a long and wide country, with different and extreme weather conditions. The geography of the country is highly diverse, including islands, mountains, coastal lines; and even forests, deserts and fertile valleys. The country has also a number of different renewable energy sources, such as solar irradiation, wind, wave and tidal and geothermal. The characteristics of the country mention above, together with a high quality researches and international energy companies, that become to Chile in a singular natural laboratory for testing new energy technology in real conditions.



## 2.2 Tracking Progress (Optional)

Nowadays the R&D and innovation tracking is led by the Ministry for Science, Technology, Knowledge and Innovation, according to international standard. The methodology is aligned with the Government budget allocations for R&D - GBARD, used by OECD and published in <https://observa.minciencia.gob.cl/indicadores/presupuesto-publico>

The Energy Agenda 2022-2026 establishes the creation of a National Innovation Observer, a web platform where will be included indicators related to public budget, patents, ecosystem, scientific publications, studies, public and international funds, among others.

### 3. Private Sector Engagement (Optional)

Chile has decided a mission-oriented approach for the innovation support from the public sector. Based on this approach, the R&D and innovation funds will be prioritized according the “missions”.

Chile has a number of support programs for the private sector. One of the programs is the R&D tax incentive law.

This tax incentive, allows a reduction in the Income Tax of 35% of the investment in R&D, by tax credit, with a maximum of USD 1.2 million. It also allows to consider the remaining 65% of R&D investment, as required expenses to deduct Income Tax. This tax benefit is complementary to other public programs and subsidies.

Other public support for private entrepreneurs is the StartUp Chile program. This is a public business accelerator program created by the Chilean Government for high-potential entrepreneurs to bootstrap their startups using Chile as a platform to go global. Up until today, its one of the biggest and most diverse accelerators in the world. Start-Up Chile has a large portfolio, receiving up to 180 startups per year.

Others public fundings are: innovation voucher, prototype and validation, high tech and consolidation and commercial expansion, among others.

## 4. National Energy Innovation Ecosystem (Optional)

Chile has a Ministry for Science, Technology, Knowledge and Innovation, leading and coordinating the public policies related. From this Ministry, emerges the National Agency for Research and Development (ANID), on charge of the implementation of most of the science and technology initiatives. Accordingly, the Ministry for Economy and Tourism is leading the applied technology developments, corporate innovation and entrepreneurship. For this purpose, the Ministry mandate to the Chilean Economic Development Agency (CORFO) to foster the innovation activity in Chile. Both agencies, ANID and CORFO, administrate public funds for the private sector engagement.

# DENMARK

## 1. Clean Energy Innovation Strategy

### 1.1 Summary

In one week, the Danish Government reached three agreements with parliament covering a green investment fund of 7.2 bio. EUR, a new unified carbon tax, and a renewable energy package that will quadruple the production of solar and land wind energy by 2030 and permit a fivefold increase of offshore wind power. Russia's invasion of Ukraine has left the EU in a new geopolitical situation and the need for sustainable solutions and more renewable energy is more urgent than ever. The Danish Government has taken several major decisions that will fast track the green transition. With a new renewable package, it is the ambition that all gas in Denmark should be green by 2030, and to completely phase out gas heating in Danish households from 2035. At the same time, Denmark will send a clear message to the private sector with an ambitious CO2 tax and new a green fund. With the green tax reform, Denmark's emissions of CO2 will be reduced with 4.3 million tons by 2030. The tax reform is thus the largest single contribution to Denmark's 2030 climate goals. More specifically this has materialised into three agreements:

1. Renewable energy package: A broad majority has agreed on a historic expansion of renewable energy. The parties agree to offer 4 GW of extra offshore wind by 2030 at the latest. In addition to 2 GW already agreed Denmark can now fivefold the production of offshore wind power over the next eight years. The agreement also aims for a quadrupling of the total electricity production from solar energy and onshore wind until 2030.
2. CO2 tax: The tax reform is the largest single contribution to Denmark's 2030 climate goals of reducing emissions by 70 % by 2030 compared to 1990. With the reform, Denmark's emissions of CO2 will be reduced by 4.3 million tons until 2030. The reform is a long-term decision that creates predictable framework conditions and allows companies to adapt. At the same time, there is agreement on targeted help for green conversion of the companies that are hit the hardest by the CO2 tax. The reform thereby minimizes the risk of emissions and jobs moving abroad.

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3. The new green fund: The fund will support the green transition of Denmark and the phasing out of fossil fuels. It covers 7.2 bio. EUR investments from 2024 to 2040

More initiatives are to be enacted in the coming to ensure that Denmark can fulfil its legally climate target of 70 percent reduction in 2030.

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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)
Danish Climate Act	Act to reduce Denmark's greenhouse gas emissions and establish a climate-neutral society to achieve the Paris Agreement	The purpose of this Act is for Denmark to reduce greenhouse gas emissions in 2030 by 70% compared to the level of emissions in 1990, and for Denmark to achieve a climate-neutral society by 2050 at the latest, taking into account the Paris Agreement target of limiting the global temperature rise to 1.5 degrees Celsius.	2020	<a href="https://en.kefm.dk/Media/1/B/Climate%20Act_Denmark%20-%20WEBTILG%C3%86NGELIG-A.pdf">https://en.kefm.dk/Media/1/B/Climate%20Act_Denmark%20-%20WEBTILG%C3%86NGELIG-A.pdf</a>
Danish Climate Agreement for Energy and Industry 2020	Denmark will show the world that climate action and economic recovery go hand in hand. A broad majority of the Danish Parliament has adopted a climate agreement on green transformation of industry and the energy sector. Combined with the Climate Agreement for Waste Management, the agreement will reduce emissions by 3.4 million tonnes of CO <sub>2</sub> equivalents in 2030.	<p>The agreement contains the following initiatives:</p> <ul style="list-style-type: none"> <li>• Establishment of the world's first energy islands</li> <li>• Transition to market-driven expansion of solar cells and onshore wind</li> <li>• Green technologies of the future – Power-to-X and capture of CO<sub>2</sub></li> <li>• Green transformation of the industry</li> <li>• Support for biogas and other green gases</li> <li>• Energy efficiency improvements</li> <li>• Green restructuring of heating taxes</li> <li>• Promotion of utilization of excess heat</li> <li>• Phasing out of individual oil and gas boilers</li> </ul>	2020	<a href="https://kefm.dk/Media/C/B/faktaark-klimaafale%20(English%20august%2014).pdf">https://kefm.dk/Media/C/B/faktaark-klimaafale%20(English%20august%2014).pdf</a>

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		<ul style="list-style-type: none"> <li>• Green district heating</li> <li>• Sustainability requirements of biomass for energy</li> <li>• Green transport pool</li> <li>• Transportation</li> <li>• Development of business accounts in agriculture</li> <li>• Green tax reform</li> </ul>		
<i>Follow-up agreement in relation to Climate agreement for energy and industry etc. Subsidy pools for phasing out oil and gas boilers and supporting measures.</i>	The parties agree that oil and gas boilers must be phased out and replaced with heat pumps, district heating, etc. It must be more attractive to choose green heating.	The agreement must ensure that a CO2 reduction of 0.7 million tonnes is achieved in 2030.	2020	<a href="https://kefm.dk/Media/2/3/Aftaletekst%20om%20tilskudspuljer%20og%20underst%C3%B8ttende%20tiltag%20-%20varme.pdf">https://kefm.dk/Media/2/3/Aftaletekst%20om%20tilskudspuljer%20og%20underst%C3%B8ttende%20tiltag%20-%20varme.pdf</a>
<i>Agreement on the future of oil and gas extraction in the North Sea</i>	Denmark introduces cut-off date of 2050 for oil and gas extraction in the North Sea and cancels all future licensing rounds.	A 2050 cut-off date for all oil and gas extraction, a cancellation of the 8th licensing round and all future licensing rounds, a commitment to lead a global campaign on the role of fossil fuel producing countries, a just transition initiative in the affected region to ensure development and employment, an analysis of the potential of electrification of current North Sea production, an initiative to explore the potential of carbon capture and storage, using old oil and gas wells	2020	<a href="https://en.kefm.dk/news/news-archive/2020/dec/denmark-introduces-cutoff-date-of-2050-for-oil-and-gas-extraction-in-the-north-sea-cancels-all-future-licensing-rounds">https://en.kefm.dk/news/news-archive/2020/dec/denmark-introduces-cutoff-date-of-2050-for-oil-and-gas-extraction-in-the-north-sea-cancels-all-future-licensing-rounds</a>

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Danish participation in an “Important Projects of Common European Interest” (IPCEI) regarding hydrogen	Denmark allots DKK 850 million to green hydrogen projects.	DKK 850 million is set aside, from which Danish projects that will be selected to be part of the IPCEI on hydrogen can be allocated support.	2021	<a href="https://kefm.dk/Media/637596033297952211/IPCEI%20aftale%20(webt).pdf">https://kefm.dk/Media/637596033297952211/IPCEI%20aftale%20(webt).pdf</a>
Investments in a continuously greener Denmark	The parties agree to prioritize DKK 247.8 million in 2022, DKK 397.3 million in 2023, DKK 328.1 million in 2024 and DKK 335.7 million in 2025 for targeted climate and environmental initiatives.	Initiatives: Expansion of renewable energy. CO <sub>2</sub> capture. Strengthen drinking water efforts. Better marine environment. Reestablishment of rock reefs in Denmark. Forest plan. Climate assistance. Strengthening of the Consumer Ombudsman.	2021	
DKK 100 million for green continuing education and upskilling	With the Finance Act for 2021, DKK 100 million was set aside annually in 2021-2022 for upskilling and further training in climate adaptation and green transition.	DKK 58.4 million is reserved for applications from providers of business and labour market education within the main areas 1) Agriculture and food and 2) Technology, construction and transport. DKK 39 million is reserved so that all providers of business and labour market education can apply for funds.	2021	<a href="https://www.uvm.dk/aktuelt/nyheder/uvm/2022/apr/220406-ny-aftale-100-millioner-kroner-til-groen-efteruddannelse-og-opkvalifice">https://www.uvm.dk/aktuelt/nyheder/uvm/2022/apr/220406-ny-aftale-100-millioner-kroner-til-groen-efteruddannelse-og-opkvalifice</a>
Green Fuels	Agreement to earmark DKK 1.25 billion to develop green fuels for aircraft, ships and trucks in Denmark and abroad within the Power-to-X Strategy.	The agreement sets out an ambition to build up an electrolysis capacity of 4 – 6 GW in Denmark by 2030. The Danish target of up to 6 GW is among the top three most ambitious national targets in Europe.	2022	<a href="https://en.kefm.dk/news/news-archive/2022/mar/broad-agreement-earmarks-billions-of-danish-kroner-towards-">https://en.kefm.dk/news/news-archive/2022/mar/broad-agreement-earmarks-billions-of-danish-kroner-towards-</a>



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				<a href="#">boosting-development-of-new-green-fuels</a>
Agreement on targeted heat checks and the phasing out of fossil heat	With the agreement on targeted heat checks and the phasing out of fossil heat, DKK 250 million has been set aside to ensure a faster phasing out of fossil heat sources in Danes' homes, especially to support more green district heating.	<p>DKK 40 million set aside to support energy saving activities.</p> <p>DKK 130 million set aside to support municipal effort to roll out district heating and smaller, shared heating solutions, etc.</p> <p>DKK 175 million set aside to support the costs of being disconnected from the gas network.</p>	2022	<a href="https://kefm.dk/Media/637889760408485776/Delafale%20om%20disponering%20af%20midler%20fra%20aftale%20om%20m%C3%A5lrettet%20varmecheck%20og%20udfasning%20af%20sort%20varme.pdf">https://kefm.dk/Media/637889760408485776/Delafale%20om%20disponering%20af%20midler%20fra%20aftale%20om%20m%C3%A5lrettet%20varmecheck%20og%20udfasning%20af%20sort%20varme.pdf</a>
<i>Renewable Energy Package</i>	The parties agree to offer 4 GW of extra offshore wind by 2030 at the latest. In addition to 2 GW already agreed Denmark can now fivefold the production of offshore wind power over the next eight years.	The agreement also aims for a quadrupling of the total electricity production from solar energy and onshore wind until 2030.	2022	<a href="https://en.kefm.dk/news/news-archive/2022/jun/a-green-reform-wave-in-denmark">https://en.kefm.dk/news/news-archive/2022/jun/a-green-reform-wave-in-denmark</a>
<i>CO2 tax</i>	The CO2 tax reform is a long-term decision creating framework conditions and allows companies to adapt. The reform is the largest single contribution to Denmark's 2030 climate goal.	With the reform, Denmark will reduce CO2 emissions by 4.3 million tons until 2030.	2022	<a href="https://en.kefm.dk/news/news-archive/2022/jun/a-green-reform-wave-in-denmark">https://en.kefm.dk/news/news-archive/2022/jun/a-green-reform-wave-in-denmark</a>
<i>The New Green Fund</i>	The fund supports the green transition in Denmark and the phase out of fossil fuels.	The fund covers 7.2 billion EUR investments from 2024-2040.	2022	<a href="https://en.kefm.dk/news/news-archive/2022/jun/a-green-reform-wave-in-denmark">https://en.kefm.dk/news/news-archive/2022/jun/a-green-reform-wave-in-denmark</a>
<i>Denmark can do more 2</i>	A proposal by the Danish government focused on green solutions and renewable energy,	The proposal aims to harvest the full potential of offshore wind and accelerate the production of renewable	2022	<a href="https://en.kefm.dk/news/news-archive/2022/apr/denma">https://en.kefm.dk/news/news-archive/2022/apr/denma</a>

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		energy on land to ensure Danish and European independence from Russian fossil fuels.		<a href="#">rk-set-to-build-more-energy-islands-and-accelerate-renewable-energy-production-to-secure-independence-from-russian-gas</a>
<i>International Energy Agency Conference in Sønderborg</i>	At the IEA's conference on energy efficiency in Sønderborg, climate leaders from all across the world did exactly that. At the ministerial roundtable chaired by Dan Jørgensen, Danish Minister for Climate, Energy and Utilities, the participants endorsed a joint statement containing the 'Sønderborg Action Plan'. The Sønderborg Action Plan contains strategic principles and policy-toolkits that illustrate available and energy efficient solutions for governments.	In the joint statement, Ministers for Energy stress the importance of energy efficiency as a central remedy towards many of the different challenges that we are facing today. It contains a number of strategic principles on energy efficiency as well as policy-toolkits to illustrate solutions for governments across the world.	2022	<a href="https://en.kefm.dk/news/news-archive/2022/jun/soenderborg-action-plan-a-global-promise-to-energy-efficiency-">https://en.kefm.dk/news/news-archive/2022/jun/soenderborg-action-plan-a-global-promise-to-energy-efficiency-</a>
<i>Agreement regarding development and enhancement of hydrogen and green fuels (Power-to-X Strategy)</i>	Strategy for PtX and CCU to create the necessary framework conditions for PtX in Denmark, which are intended to facilitate the contribution of these technologies to the objectives of the Danish Climate Act, the realisation of their commercial	1) Power-to-X must be able to contribute to the realisation of the objectives in the Danish Climate Act. 2) The regulatory framework and infrastructure must be in place to allow Denmark's strengths to be utilised and for the Power-to-X industry to operate on market terms in the long run.	2022	<a href="https://ens.dk/sites/ens.dk/files/ptx/strategy_ptx.pdf">https://ens.dk/sites/ens.dk/files/ptx/strategy_ptx.pdf</a>

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	potential and their integration into the Danish energy system.	<p>3) The integration between Power-to-X and the Danish energy system must be improved.</p> <p>4) Denmark must be able to export Power-to-X products and technologies.</p>		
<i>Framework conditions for CO<sub>2</sub> storage in Denmark</i>	CCS plays a significant role in meeting the national climate targets. Analyses from GEUS show that the Danish underground is particularly suitable for storing CO <sub>2</sub> , just as an increasing demand for CO <sub>2</sub> storage capacity is expected in Northern Europe towards 2030. However, there are currently no CO <sub>2</sub> stores in Denmark, and there is therefore a need for concrete initiatives.	<ul style="list-style-type: none"> <li>• A foundation must be created for safe and environmentally responsible storage of CO<sub>2</sub> in the underground.</li> <li>• Denmark must be able to import and export CO<sub>2</sub> to and from abroad</li> <li>• Further investigations of new storage locations in Denmark must be initiated.</li> </ul>	2022	<a href="https://kefm.dk/Media/637606718216961589/Principaftale%20om%20CO2-lagring.pdf">https://kefm.dk/Media/637606718216961589/Principaftale%20om%20CO2-lagring.pdf</a>
<i>Climate agreement on green electricity and heat 2022 – Denmark can do more 2</i>	Denmark and Europe must be safer and greener. This requires a significant expansion of renewable energy sources, where solar parks and onshore wind turbines can deliver cheap, green energy quickly in the years leading up to 2030. Denmark's large sea areas, with good wind and seabed conditions, provide ideal conditions for harvesting	It was agreed to ensure framework conditions that can enable a quadrupling of the total electricity production from solar energy and onshore wind towards 2030. The parties also agree to enable the tendering of at least 4 gigawatts (GW) of offshore wind for realization by 2030 at the latest, on the condition that the offshore wind does not negatively burden the state's finances over the project period.	2022	<a href="https://www.regeringen.dk/media/11470/klimaaftale-om-groen-stroem-og-varme.pdf">https://www.regeringen.dk/media/11470/klimaaftale-om-groen-stroem-og-varme.pdf</a>

ALL MI MEMBER COUNTRIES – DENMARK

	the sea wind and profits in the North Sea in the future as well, and the Danish waters have the potential to become a green power plant also for Europe.			
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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, (include budget years where applicable)	Planned demonstration Investments (include budget years and indicate if domestic or international spending where possible)	Links to relevant reports or plans
<i>Example 2:</i> Carbon capture and storage or utilisation (CCUS)	<input checked="" type="checkbox"/> Early-stage research <input type="checkbox"/> Applied research <input type="checkbox"/> product development <input checked="" type="checkbox"/> Product development <input type="checkbox"/> Demonstration <input type="checkbox"/> Commercialisation Other:					<a href="https://ufm.dk/en/publications/2020/filer/green-solutions-of-the-future">https://ufm.dk/en/publications/2020/filer/green-solutions-of-the-future</a>
<i>Example 3:</i> Green fuels for transportation and industry (Power-to-X etc.)	<input checked="" type="checkbox"/> Early-stage research <input type="checkbox"/> Applied research <input type="checkbox"/> product development <input checked="" type="checkbox"/> Product development <input type="checkbox"/> Demonstration <input type="checkbox"/> Commercialisation Other:					<a href="https://ufm.dk/en/publications/2020/filer/green-solutions-of-the-future">https://ufm.dk/en/publications/2020/filer/green-solutions-of-the-future</a>

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The commitment to investment in green technologies of tomorrow – carbon capture and Power-to-X – is a key part of the Danish Climate Agreement for Energy and Industry 2020. Achieving the goal of a 70% reduction in emissions in 2030 goal will require innovative new tools and investments in the green technologies of the future. The agreement allocates the equivalent of DKK 800 million annually, to be phased in from 2024, for carbon capture and storage. These funds will reduce emissions of CO2 equivalents by 0.9 tonnes in 2030 and will support the development and implementation of solutions that can capture carbon emissions from sources such as industry and put them to use. The agreement also includes a tender to support the establishment of large-scale Power-to-X plants with a total capacity of 100 MW. This is more than five times the capacity of the largest plants found in the world today.

### 3. National Energy Innovation Ecosystem (Optional)

**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
Ministry of Higher Education and Science Denmark	The Ministry is responsible for Science, Innovation and Higher Education. The Danish energy sector has a long tradition of close public-private sector partnerships in research, development and demonstration, not least through project financing via Innovation Fund Denmark under the Danish Ministry of Higher Education and Science and EUDP under the Danish Ministry of Energy, Utilities and Climate.	The key research needs that are expected to prove dominant in the next few years mainly cover the following headings: energy production; energy storage and conversion; intelligent, integrated and flexible energy systems; energy efficiency measures. The research effort must also help to make Denmark independent of fossil fuels by 2050.	Grants awarded by the Danish Parliament to strategic research priorities will be implemented as a general rule by Innovation Fund Denmark and typically through large and long-term investments. The funds will be distributed according to the arm's length principle in open competition, so that only the absolute best new research ideas are supported.	<a href="https://ufm.dk/en/the-ministry/mission-vision-and-strategic-objective">https://ufm.dk/en/the-ministry/mission-vision-and-strategic-objective</a> <a href="https://ufm.dk/en/publications/2018/filer/forsk25_katalog_eng_enkelt.pdf">https://ufm.dk/en/publications/2018/filer/forsk25_katalog_eng_enkelt.pdf</a>

# EUROPEAN COMMISSION

## 1. Clean Energy Innovation Strategy

### 1.1 Summary

In May 2022, in response to the global energy market disruption, the European Commission presented its **REPowerEU Plan**. It builds on the full implementation of the Fit for 55 proposals tabled last year without modifying the ambition of achieving at least -55 % net GHG emissions by 2030 and climate neutrality by 2050 in line with the European Green Deal. The REPowerEU plan puts forward an additional set of energy security of supply and storage actions to save energy, diversify supplies, quickly substitute fossil fuels by accelerating Europe's clean energy transition, and smartly combine investments and reforms.

#### **Energy savings**

Fit for 55 would lower EU gas consumption by 30% by 2030, with more than a third of such savings coming from meeting the EU energy efficiency target. A further reduction of energy consumption compared to the previous Energy Efficiency Directive proposal and higher renewable energy targets would enable the EU to fully meet the REPowerEU objectives, with other parts of the Fit for 55 package unchanged. The Commission therefore proposed to increase to 13% the binding target in the Energy Efficiency Directive.

In addition, the Commission invited to enable additional savings and energy efficiency gains in buildings through the Energy Performance of Buildings Directive, and to uphold the ambition of the Commission proposal for a Regulation on Ecodesign for Sustainable Products. The rapid deployment of it will lead to further energy savings through improved energy and resource efficiency of a broad range of products.

#### **Diversifying energy imports**



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With a full implementation of the REPowerEU plan, high prices, gas alternatives (sustainable biomethane, renewable hydrogen), further deployment of renewables, and structural demand measures such as energy efficiency, EU gas demand is expected to decrease at a faster rate than foreseen under Fit for 55.

**Substituting fossil fuels and accelerating Europe's clean energy transition**

To boost renewable energy, The Commission proposed to increase the target in the Renewable Energy Directive to 45% by 2030, up from 40% in last year's proposal. This would bring the total renewable energy generation capacities to 1236 GW by 2030, in comparison to 1067 GW by 2030 envisaged under Fit for 55 for 2030.

Solar photovoltaics (PV) is one of the fastest technologies to roll out. That is why the Commission set the REPowerEU target of over 320 GW of solar photovoltaic newly installed by 2025, over twice today's level, and almost 600 GW by 2030. As part of the increased ambition for solar, the Commission presented the EU solar strategy and introduced the European Solar Rooftop Initiative anchored around a legally binding EU solar rooftop obligation for certain categories of buildings.

Renewable hydrogen will be key to replace natural gas, coal and oil in hard-to-decarbonise industries and transport. Accelerated efforts are needed to deploy hydrogen infrastructure for producing, importing and transporting 20 million tonnes of hydrogen by 2030. REPowerEU sets a target of 10 million tonnes of domestic renewable hydrogen production and 10 million tonnes of renewable hydrogen imports by 2030. The Commission will top-up Horizon Europe investments on the Hydrogen Joint Undertaking (EUR 200 million) to double the number of Hydrogen Valleys in the EU by 2030. To facilitate the import of up to 10 million tonnes of renewable hydrogen, the Commission will support the development of three major hydrogen import corridors via the Mediterranean, the North Sea area and, as soon as conditions allow, with Ukraine.

To support hydrogen uptake and electrification in industrial sectors, the Commission will, in cooperation with the EIB, develop a technical advisory facility under the InvestEU Advisory Hub to support PPA-financed renewable energy projects. To unlock industrial investment, the Commission will double the funding available for the 2022 Large Scale Call of the Innovation Fund this autumn to around EUR 3 billion.

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The Commission called to align the sub-targets for renewable fuels of non-biological origin under the Renewable Energy Directive for industry and transport with the REPowerEU ambition (75% for industry and 5% for transport) and to rapidly conclude the revision of the Hydrogen and Gas Market package.

The Commission launched two public consultations on two delegated acts clarifying EU rules applicable to renewable hydrogen under the 2018 Renewable Energy Directive. Once adopted, these documents will complete the Commission's overall proposal for a regulatory framework for renewable hydrogen. The Commission also intends to complete the assessment of the first Important Projects of Common European Interest on hydrogen and calls on industry to accelerate the work on missing hydrogen standards, in particular for hydrogen production, infrastructure and end-use appliances. The Commission will regularly report, in close cooperation with the EU Member States, starting in 2025, on hydrogen uptake, and the use of renewable hydrogen in hard-to-abate appliances in industry and transport.

Boosting sustainable biomethane production to 35 bcm by 2030 is a cost-efficient path to achieve the ambition to reduce imports of natural gas from Russia. To increase the capacity of biogas production in the EU and promote its conversion into biomethane, the estimated investment needs amount to EUR 37 billion euro over the period.

Energy efficiency, fuel substitution, electrification, and an enhanced uptake of renewable hydrogen, biogas and biomethane by industry could save up to 35 bcm of natural gas by 2030 on top of what is foreseen under the Fit for 55 proposals.

**Smart investment**

REPowerEU entails additional investment of EUR 210 billion between 2022 and 2027, on top of what is needed to realise the objectives of the Fit for 55 proposals. Existing loans of EUR 225 billion from the Recovery and Resilience Facility (RRF) will be available for REPowerEU too. An additional EUR 20 billion in grants are proposed from the sale of allowances from the Market Stability Reserve of the EU Emission Trading System, to increase the financing available under the RRF. Implementing these efforts and new targets will save the EU EUR 80 billion in gas import expenditures, EUR 12 billion in oil import expenditures and EUR 1.7 billion in coal import expenditures per year by 2030.

National Innovation Pathway Round up

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## 1.2 Methodology

Different inputs for the planning of R&I:

- At a higher (political) level: the Group of Chief Scientific Advisors gives the Commission independent, high quality scientific advice on a variety of topics. The Projects for Policy (P4P) aims to use research and innovation project results to shape policy making.
- External stakeholder input through the SET Plan ETPs and IWGs. Through the research agendas by the EERA (European Energy research Alliance). Through the SRIA (strategic research agenda) of the CET Cofund.
- Internal input through studies by the JRC, such as the Clean Energy Technology Observatory and the annual Competitiveness Report. Modelling by Commission services (ENER, JRC) and in funded projects.
- Co-creation among different Commission services, specific R&I needs based on policy needs
- Official Comitology: the Programme Committee (MS/AC) in which the Horizon Europe R&I Work Programmes are scrutinised and finally adopted.

**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)
<i>REPowerEU Plan</i>	The European Commission's plan to rapidly reduce the EU's dependence on Russian fossil fuels by fast forwarding the clean transition and joining forces to achieve a more resilient energy system and a true Energy Union.	<p>Building on the Fit for 55 package of proposals and completing the actions on energy security of supply and storage, this REPowerEU plan puts forward an additional set of actions to:</p> <ul style="list-style-type: none"> <li>- save energy;</li> <li>- diversify supplies;</li> <li>- quickly substitute fossil fuels by accelerating Europe's clean energy transition;</li> <li>- smartly combine investments and reforms.</li> </ul> <p>Taken together, these actions will structurally transform EU's energy system. They require effective coordination between European regulatory and infrastructure measures, as well as national investment and reforms and joined-up energy diplomacy. They also require coordination between action on the demand side, to reduce energy consumption and transform industrial processes to replace gas, oil and coal with renewable electricity and fossil-free hydrogen, with action on the supply side to create the capacity and framework to roll out and produce renewable.</p> <p>Specific R&amp;I actions that will contribute to achieving the objectives of the REPowerEU Plan:</p> <ul style="list-style-type: none"> <li>- Additional €200 million to double the Hydrogen Valleys in the EU;</li> </ul>	2022	<a href="https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A230%3AFIN&amp;qid=1653033742483">https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A230%3AFIN&amp;qid=1653033742483</a>

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		<ul style="list-style-type: none"> <li>- Implementation of a joint strategic R&amp;I agenda on Green Hydrogen in the framework of the European Research Area;</li> <li>- Promoting a solar energy flagship initiative in the next Horizon Europe work programme;</li> <li>- Supporting an R&amp;I pillar in the proposed EU Solar Photovoltaics Industry Alliance;</li> <li>- Developing a joint strategic R&amp;I agenda on solar energy in the framework of the European Research Area;</li> <li>- Realising energy savings in buildings through the EU Cities Mission.</li> </ul>		
<i>European Green Deal</i>	A set of policy initiatives by the European Commission with the overarching aim of making the EU climate neutral in 2050.	<p>The European Green Deal focuses on 3 key principles for the clean energy transition, which will help reduce greenhouse gas emissions and enhance the quality of life of our citizens:</p> <ul style="list-style-type: none"> <li>- ensuring a secure and affordable EU energy supply;</li> <li>- developing a fully integrated, interconnected and digitalised EU energy market;</li> <li>- prioritising energy efficiency, improving the energy performance of our buildings and developing a power sector based largely on renewable sources.</li> </ul> <p>The European Commission's main objectives to achieve this are:</p> <ul style="list-style-type: none"> <li>- build interconnected energy systems and better integrated grids to support renewable energy sources;</li> <li>- promote innovative technologies and modern infrastructure;</li> <li>- boost energy efficiency and eco-design of products;</li> <li>- decarbonise the gas sector and promote smart integration across sectors;</li> </ul>	2020	<a href="https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en">https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en</a>

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		<ul style="list-style-type: none"> <li>- empower consumers and help EU countries to tackle energy poverty;</li> <li>- promote EU energy standards and technologies at global level;</li> <li>- develop the full potential of Europe's offshore wind energy.</li> </ul> <p>The European Commission adopted a set of proposals to make the EU's climate, energy, transport and taxation policies fit for reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels.</p>		
<i>Fit For 55</i>	The EU's plan for a green transition.	<p>As part of the European Green Deal, with the European Climate Law, the EU has set itself a binding target of achieving climate neutrality by 2050. This requires current greenhouse gas emission levels to drop substantially in the next decades. As an intermediate step towards climate neutrality, the EU has raised its 2030 climate ambition, committing to cutting emissions by at least 55% by 2030.</p> <p>The EU is working on the revision of its climate, energy and transport-related legislation under the so-called 'Fit for 55 package' in order to align current laws with the 2030 and 2050 ambitions. A number of new initiatives are also included in the package.</p>	2021	<a href="https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/">https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/</a>

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<i>Horizon Europe</i>	The EU's key funding programme for research and innovation with a budget of €95.5 billion for 2021 – 2027.	It tackles climate change, helps to achieve the UN's Sustainable Development Goals and boosts the EU's competitiveness and growth. The programme facilitates collaboration and strengthens the impact of research and innovation in developing, supporting and implementing EU policies while tackling global challenges. It supports creating and better dispersing of excellent knowledge and technologies. It creates jobs, fully engages the EU's talent pool, boosts economic growth, promotes industrial competitiveness and optimises investment impact within a strengthened European Research Area. Legal entities from the EU and associated countries can participate.	2021–2027	<a href="https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en">https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en</a>
<i>EU Hydrogen Strategy</i>	The strategy explores the potential for renewable hydrogen to help decarbonise the EU in a cost-effective way.	<p>It puts forward a vision for the creation of a European hydrogen ecosystem from research and innovation to scale up production and infrastructure to an international dimension.</p> <p>Specific R&amp;I actions that contribute to achieving the objectives of the EU Hydrogen Strategy:</p> <ul style="list-style-type: none"> <li>- EU Research and Innovation Framework Programmes invested more than EUR 1 billion over the period 2008–2021 into developing hydrogen technologies through two successive Fuel Cells and Hydrogen Joint Undertakings (FCH JU and FCH 2 JU). They leveraged an additional EUR 1 billion from the private sector and allowed the EU to become technology leader in the areas of electrolyzers, fuel cell buses and refuelling stations.</li> <li>- The Joint Undertakings designed the concept of Hydrogen Valleys: geographical or industrial clusters combining several hydrogen applications along the whole hydrogen value chain. There are now 23 Hydrogen Valleys in the EU.</li> </ul>	2020	<a href="https://energy.ec.europa.eu/topics/energy-systems-integration/hydrogen_en#eu-hydrogen-strategy">https://energy.ec.europa.eu/topics/energy-systems-integration/hydrogen_en#eu-hydrogen-strategy</a>



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		<ul style="list-style-type: none"> <li>- The new Clean Hydrogen Joint Undertaking, set up under Horizon Europe, will receive EUR 1 billion for 2021–2027, complemented by another EUR 1 billion from the industry. The coverage of the whole value chain, from production and storage to distribution and use, will be ensured by synergies between partnerships under Horizon Europe. Horizon Europe also contributes to the hydrogen policy through the European Innovation Council EIC and the European Institute of Technology EIT.</li> <li>- Cooperation between the European Commission and Member States on a 'green hydrogen Research and Innovation ERA pilot' and a related roadmap will drive the implementation of a strategic research agenda. The Commission's activities will focus on creating a common European Data Observatory on clean hydrogen, developing Open Innovation Test Beds as a first step towards a common open technology infrastructures network, and supporting the development of skills needed for the hydrogen economy.</li> <li>- The Commission has a leading role in the Clean Hydrogen Mission under Mission Innovation, which mobilises international cooperation to create a global hydrogen economy. It aims at setting up 100 Hydrogen Valleys across the world by 2030.</li> <li>- The Commission and Member States intend to work jointly with industry and academia to better link research and innovation programmes with deployment funding. A European ecosystem on clean hydrogen, which will cover the whole chain from research towards</li> </ul>		
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		market deployment, will also boost a world hydrogen economy, which is key to achieve our objectives for a clean planet.		
<i>EU Solar Energy Strategy</i>	The strategy takes a comprehensive approach to the solar energy sector, covering all technologies and demand. It identifies the barriers that are still preventing solar energy from fully playing its role in the energy transition and proposes measures to lift them.	<p>As part of the REPowerEU plan, this strategy aims to bring online over 320 GW of solar photovoltaic by 2025 (more than doubling compared to 2020) and almost 600 GW by 2030. These frontloaded additional capacities displace the consumption of 9 bcm of natural gas annually by 2027.</p> <p>The EU Solar Energy Strategy outlines a comprehensive vision to swiftly reap the benefits of solar energy, and presents four initiatives to overcome the remaining challenges in the short-term:</p> <ul style="list-style-type: none"> <li>- Promoting quick and massive PV deployment via the European Solar Rooftops Initiative.</li> <li>- Making permitting procedures shorter and simpler. The Commission will address this issue through the adoption of a legislative proposal, a recommendation and a guidance alongside this communication.</li> <li>- Ensuring the availability of an abundant skilled workforce to face up the challenge of producing and deploying solar energy all across the EU. In line with the call for stakeholders to establish an EU large-scale skills partnership for onshore renewable energy under the Pact for Skills, as part of the REPowerEU plan, this strategy will set out its relevance for the solar energy sector. This partnership will bring together all relevant stakeholders to take action on upskilling and reskilling to fill the gap.</li> </ul>	2022	<a href="https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A221%3AFIN&amp;qid=1653034500503">https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A221%3AFIN&amp;qid=1653034500503</a>

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		<ul style="list-style-type: none"> <li>- Launching a European Solar PV Industry Alliance that aims to facilitate innovation-led expansion of a resilient industrial solar value chain in the EU, in particular in the PV manufacturing sector.</li> </ul> <p>Specific R&amp;I actions that will contribute to achieving the objectives of the EU Solar Energy Strategy:</p> <ul style="list-style-type: none"> <li>- Through Horizon Europe programme, the EU will continue to support R&amp;I to reduce the cost of solar energy technologies, while increasing their energy efficiency and their sustainability, including in the manufacturing stage. These new technologies include heterojunction cells, perovskites and tandem cells, all of which achieve higher efficiencies than commercial technologies. Financial support is also needed for innovation in solar thermal or CSP technologies, as well as products tailored to innovative forms of deployment. The upcoming 2023–2024 work programme will include a flagship initiative to support solar energy research and innovation, focused inter alia on novel technologies, environmental and socio-economic sustainability, and integrated design.</li> <li>- Also under Horizon Europe, the European Partnership for Clean Energy Transition will crowd in support from EU Member States, the energy industry and public organisations for research and innovation in solar energy over the 2021–2027 period. The collaboration with Member States can be further expanded by developing a common solar energy research and innovation agenda in the framework of the European Research</li> </ul>		
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		<p>Area. This initiative will build on the ongoing work of the Strategic Energy Technology Plan.</p> <ul style="list-style-type: none"><li>- The space sector represents an additional innovation trigger. This strategic sector needs the development of high-performance solar cells, including multijunction cells. The Commission will continue to exploit synergies between the space and terrestrial sectors in all initiatives critical for the EU space programme, including research and development.</li><li>- To bridge the gap between research results and commercial development, the Innovation Fund will provide around EUR 25 billion of support over 2020-2030, depending on the carbon price, for the commercial demonstration of innovative low-carbon technologies, including solar energy. One of the seven large-scale projects selected in the first batch supports innovation in the solar sector. Finally, the European Regional Development Fund supports research and innovation in Member States and regions in priority areas identified through the local smart specialisation strategies.</li></ul>		
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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, (include budget years where applicable)
Clean Hydrogen	<input type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input type="checkbox"/> product development <input checked="" type="checkbox"/> Demonstration <input type="checkbox"/> Commercialisation Other:	Hydrogen: 80% cost reduction to \$1/kg by 2030	<p>The scope of the research and innovation activities of the Clean Hydrogen JU is related primarily to the production of clean hydrogen, as well as the distribution, storage and end use applications of low carbon hydrogen in hard to abate sectors.</p> <p>Priorities:</p> <ul style="list-style-type: none"> <li>• Hydrogen production</li> <li>• Hydrogen storage and distribution</li> <li>• Hydrogen Valleys</li> <li>• Hydrogen end uses – transport</li> <li>• Hydrogen end uses – clean heat and power</li> <li>• Hydrogen Supply Chains</li> <li>• Cross-cutting (sustainability; education and public awareness; safety, pre-normative research and regulations, codes and standards)</li> </ul>	EUR 1200 million for the period 2021-2027

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Sustainable, secure and competitive energy supply	<input checked="" type="checkbox"/> Early-stage research <input type="checkbox"/> Applied research <input type="checkbox"/> product development <input type="checkbox"/> Demonstration <input type="checkbox"/> Commercialisation Other:		Activities in the areas of renewable energy; energy system, grids and storage; as well as Carbon Capture, Utilization and Storage (CCUS).	Horizon Europe, Cluster 5 “Climate, Energy and Mobility”
Efficient, sustainable and inclusive energy use	<input type="checkbox"/> Early-stage research <input type="checkbox"/> Applied research <input type="checkbox"/> product development <input type="checkbox"/> Demonstration <input type="checkbox"/> Commercialisation Other:		Activities targeting the energy demand side, notably a more efficient use of energy as regards buildings and industry.	Horizon Europe, Cluster 5 “Climate, Energy and Mobility”
Cross-sectoral solutions for the climate transition	<input type="checkbox"/> Early-stage research <input type="checkbox"/> Applied research <input type="checkbox"/> product development <input type="checkbox"/> Demonstration <input type="checkbox"/> Commercialisation Other:		This covers thematic areas that are crosscutting by nature and can provide key solutions for climate, energy and mobility applications. Such areas are batteries, hydrogen, communities and cities, early-stage breakthrough technologies as well as citizen engagement.	Horizon Europe, Cluster 5 “Climate, Energy and Mobility”

The European R&I Framework Programme Horizon Europe Cluster 5 “Climate, Energy and Mobility” aims to accelerate the twin green and digital transitions and associated transformation of our economy, industry and society with a view to achieving climate neutrality in Europe by 2050. This encompasses the transition to greenhouse gas neutrality of the energy and mobility sectors by 2050 at the latest (as well as that of other sectors not covered by this cluster), while boosting their competitiveness, resilience, and utility for citizens and society.

Activities will contribute to:

- **Promoting an open strategic autonomy by leading the development of key digital and, enabling and emerging technologies, sectors and value chains** to accelerate and steer the digital and green transitions through human-centred technologies and innovations;
- **Restoring Europe’s ecosystems and biodiversity, and managing sustainably natural resources** to ensure food security and a clean and healthy environment;
- **Making Europe the first digitally enabled circular, climate-neutral and sustainable economy** through the transformation of its mobility, energy, construction and production systems;
- **Creating a more resilient, inclusive and democratic European society**, prepared and responsive to threats and disasters, addressing inequalities and providing high-quality health care, and empowering all citizens to act in the green and digital transitions.

## 2.2 Tracking Progress (Optional)

The Strategic Technology Information System (SETIS) website is the open-access information, knowledge management and dissemination system for the European strategic energy technology plan. The European Commission's Joint Research Centre (JRC) operates SETIS with contributions from DG Energy and DG Research and Innovation (Clean Energy Transition unit). SETIS data sources include data submitted by EU Member States in the context of their National Energy and Climate Plans.



### 3. Private Sector Engagement (Optional)

The **EU-Catalyst Partnership** serves as a good example of public-private cooperation on the clean energy transition. With the European Investment Bank, using EU budget resources from Horizon Europe and the Innovation Fund, and Breakthrough Energy Catalyst matching EU grants and financial investments, EU aims to mobilise up to EUR 820 million (USD 1 billion) for innovative projects until 2027. The European Commission and Breakthrough Energy Catalyst will invest in a portfolio of high-impact EU-based projects, initially in four sectors: green hydrogen, sustainable aviation fuels, long-duration energy storage, and direct air capture. The EU contribution comes from Horizon Europe (EUR 200 million) and the Innovation Fund (EUR 200 million). The EU-Catalyst-Partnership contributes significantly to the approach of REPowerEU, bridging the crucial intersection between TRL 7 and 9. Breakthrough Energy issued a first Request for Proposals (RFP) in early January 2022, and the first projects will be selected in 2022 already.

Besides the already established **industrial alliances**, i.e. the European Battery Alliance and the European Clean Hydrogen Alliance, to enhance industry's contribution to REPowerEU and reinforce its competitiveness, the Commission will set up **the EU Solar PV Industry Alliance**. It will map the availability of financial support at national, EU and private levels, attract private investment and facilitate match-making between producers and off-takers. These industrial alliances are an important tool to identify technology needs, investment opportunities and regulatory barriers and enablers at all stages of the value chain.

In 2021, the European Union launched the first 37 Horizon Europe institutionalised/ co-programmed/ co-funded public-private **European partnerships**. Clean energy issues are fully or partially addressed in 12 of those partnerships, in which the EU commits to contribute up to EUR 8 billion with the partners adding at least almost EUR 13 billion more. Following are the examples of Horizon Europe's strong focus on partnerships with industry and Member States:

- Clean Hydrogen JU (EUR 1 billion EU contribution, 1 billion EUR private investment),
- Partnerships on transport (road, waterborne, aviation) and clean steel,
- Co-funds with EU Member States / Associated Countries with 1:2 leverage (EU contributes 30%): Clean Energy Transition, Driving Urban Transitions.

**Institutionalised partnerships:**

**Clean Hydrogen Joint Undertaking (JU)**

Total estimated budget: At least EUR 2 bn

EU commitments: Up to EUR 1 bn

Partners' commitments: At least EUR 1 bn

The focus of Clean Hydrogen JU's research and innovation activities will primarily be the production of clean hydrogen, as well as the distribution, storage and end-use applications of low-carbon hydrogen in hard to abate sectors.

**Clean Aviation Joint Undertaking (CAJU)**

Total estimated budget: EUR 4.1 bn

EU commitments: Up to EUR 1.7 bn

Partners' commitments: At least EUR 2.4 bn

The partnership will develop disruptive new aircraft technologies to support the European Green Deal and climate neutrality by 2050. These technologies will deliver net greenhouse gas (GHG) reductions of no less than 30%, compared to 2020 state-of-the-art.

**Europe's Rail (EU-Rail) Joint Undertaking**

Total estimated budget: EUR 1.2 bn

EU commitments: Up to EUR 600 m

Partners' commitments: EUR 600 m

The Europe's Rail (EU-Rail) Joint Undertaking will contribute to the achievement of the Single European Railway Area, to a fast transition to a more attractive, user-friendly, competitive, affordable, efficient and sustainable European rail system, and to the development of a strong and globally competitive European rail industry.

### **Partnership with EIT\* InnoEnergy**

Total estimated budget: EUR 43 m (2021); EUR 36.58 m (2022)

EIT InnoEnergy defines its mission as ‘to build and manage a sustainable, long-lasting operational framework amongst the three actors of the knowledge triangle in the energy sector: industry, research, and higher education, while ensuring that the integration of the three is more efficient and has a higher impact on innovation (talent, technology, companies) than the three standing alone’.

\* European Institute of Innovation and Technology

### **Co-programmed partnerships:**

#### **European Partnership for Batteries (BATT4EU)**

Total estimated budget: EUR 1.85 bn

EU commitments: EUR 925 m

Partners’ commitments: EUR 925 m

The vision of the European Partnership for Batteries (BATT4EU) is to establish by 2030 in Europe the best-in-the-world innovation ecosystem to boost a competitive, sustainable and circular European battery value chain and to drive the transformation towards a carbon-neutral society.

#### **Zero-emission Waterborne Transport (ZEWT) partnership**

Total estimated budget: EUR 3.8 bn

EU commitments: EUR 530 m

Partners’ commitments: EUR 3.3 bn

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The partnership will provide and demonstrate zero-emission solutions for all main ship types and services before 2030, which will enable zero-emission waterborne transport before 2050.

**Towards Zero-emission Road Transport (2Zero) partnership**

Total estimated budget: EUR 1.23 bn

EU commitments: EUR 615 m

Partners' commitments: Up to EUR 900 m

The partnership will set an ambitious research programme to accelerate the development of zero tailpipe-emission road transport in Europe with a system approach. It will develop a common vision and deliver a multi-stakeholders roadmap for a climate-neutral and clean road transport system. It will improve air quality, the mobility safety of people and of goods.

**People-centric Sustainable Built Environment (Built4People) partnership**

Total estimated budget: EUR 780 m

EU commitments: EUR 380 m

Partners' commitments: EUR 400 m

The partnership brings together the whole value chain to accelerate people-centric innovation in the built environment towards sustainability.

**The Clean Steel Partnership (CSP)**

Total estimated budget: EUR 1.7 bn

EU commitments: EUR 700 m

Partners' commitments: Up to EUR 1 bn

The partnership will develop lean CO<sub>2</sub> technologies, and test these at large scales until 2030. These technologies are required to reduce CO<sub>2</sub> from EU steel production by 80–95% compared to 1990 levels, ultimately leading to climate neutrality.

### **Processes4Planet partnership**

Total estimated budget: EUR 2.6 bn

EU commitments: Up to EUR 1.3 bn

Partners' commitments: Up to EUR 1.3 bn

Processes4Planet is a cross-sectorial R&I partnership that aims at transforming the European process industries to achieve the overall climate neutrality at the EU level by 2050 by developing and deploying climate neutral solutions and bringing technological and non-technological innovations to readiness for subsequent deployment.

### **Co-funded partnerships:**

Public-public partnerships between the European Union and EU Member States/Associated Countries represent a peculiar instrument in the EU funding landscape.

### **Clean Energy Transition (CET) partnership**

Total estimated budget: EUR 791.2 m

EU commitments: EUR 210 m

Partners' commitments: EUR 581.2 m

This public-public partnership is a transformative research, development and innovation joint programming and funding programme between the European Union and 32 Member States and Associated Countries fosters the acceleration of the clean energy transition in all its dimensions.

The CET Partnership (CETP) encourages international cooperation beyond the EU/EEA. It collaborates with other international initiatives, such as Mission Innovation (MI) through the MI Calls and by actively connecting the thematic work to the MI Missions. The upcoming MICall22 will be hosted jointly by the CETP and Driving Urban Transitions towards a Sustainable Future (DUT) partnership.

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CETP calls are open to applicants from third countries. However, funding is limited to non-EU/EEA applicants eligible for funding from either Associated Partners to the CETP or Partners that have concluded a funding commitment with the CETP. The US and Canada have already concluded a funding commitment for the 1st joint call of the CETP in the spirit of MI to set up joint research.

**Driving Urban Transitions towards a Sustainable Future (DUT) partnership**

Total estimated budget: EUR 435 m

EU commitments: EUR 130 m

Partners' commitments: EUR 305 m

This public-public partnership between the European Union, Member States and Associated Countries addresses the urban dimension across all SDGs with SDG 11 (sustainable cities and communities) and its subgoals as the main entry point. More information can be found in JPI Urban Europe (2019:12) Strategic Research and Innovation Agenda 2.0.

## 4. International Collaboration (Optional)

Multilateral cooperation under Mission Innovation is the focus of EU's international cooperation in clean energy research and innovation.

In line with the EU Hydrogen Strategy, and building on the existing EU Flagship with Africa on renewable energy, the Commission will also focus on extending the international cooperation with the Southern Neighbourhood countries and continuing the dialogue with the African Hydrogen Partnership\*.

The Cluster 5 'Africa-EU CO-FUND action', to be funded in 2024, now aims to establish links with the Clean Hydrogen Joint Undertaking topic 'Research & Innovation cooperation with Africa on hydrogen' to be funded in 2022.

The Commission will explore the development of joint hydrogen research and development programmes in the context of the EU Stabilisation and Association Agreements with the Western Balkans and the Association Agreements with Neighbourhood countries.

\* The project LEAP-RE, a long-term EU-Africa Partnership for R&I actions in the area of renewable energy with 83 consortium partners from Europe and Africa, has started in January 2021. In addition, five projects resulting from the Green Deal call on energy solutions for Africa have started in October 2021 and will contribute to the present R&I Partnership on Climate Change and Sustainable Energy of the EU/AU High-Level Policy Dialogue on Science, Technology and Innovation.

# FINLAND

## 1. Clean Energy Innovation Strategy

### 1.1 Summary

Clean Energy Innovation Strategy of Finland is presented as integrated part of the national Climate and Energy Strategy.

Summary of the strategy includes strategic priorities, such as:

- Finland aims at 4 % spending to RDI of GDP. The target is not sector specific.
- Clean innovations and solutions are developed and used on a wide scale and to enable a technology-neutral, carbon-neutral economy.
- Priorities of the development of new technology and the commercialization of innovations include, among others, energy infrastructure, new energy technologies, hydrogen and power-to-X solutions, electrification and circular economy.
- We actively participate in selected international cooperation forums, such as Clean Energy Ministerial (CEM) and Mission Innovation. The focus areas of influence and cooperation are
- matters related to energy system integration, hydrogen and the circular economy.



## 1.2 Methodology

The strategy was prepared by the government officials based on various other reports and working group's work including stakeholder engagement.

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**Table 1: RELEVANT DOCUMENTS AND POLICIES**

<b>Document or policy name</b>	<b>Description of the document or policy</b>	<b>Specific outcomes, goals or targets identified in the document or policy</b>	<b>Year</b>	<b>Web Link(s)</b>
National Climate and Energy Strategy	Defining climate and energy related policy targets and measures as well as background information.	The define activities to achieve climate neutrality by 2035.	2022	<a href="https://valtioneuvosto.fi/paatokset/paatokset?decisionId=0900908f807c35c1">https://valtioneuvosto.fi/paatokset/paatokset?decisionId=0900908f807c35c1</a>

## 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, (include budget years where applicable)	Planned demonstration Investments (include budget years and indicate if domestic or international spending where possible)	Links to relevant reports or plans
<i>Example 1:</i> Hydrogen	R Early-stage research R Applied research R product development R Demonstration R Commercialisation Other:	1000 MW electrolyzers by 2030	Electrolysers Hydrogen storage	Years 2022–2023: - 300 MEUR hydrogen specific funding - approx. 1000 MEUR energy technology funding including hydrogen	Total investment pipeline is approx. 1000 MEUR	<a href="https://valtioneuvosto.fi/paatokset/paatokset?decisionId=0900908f807c35c1">https://valtioneuvosto.fi/paatokset/paatokset?decisionId=0900908f807c35c1</a>
Renewable energy and	R Early-stage research R Applied research R product development	Share of renewable energy 51 % by 2030,	New energy technologies	years 2022–2023 - approx. 1000 MEUR energy		<a href="https://valtioneuvosto.fi/paatokset/paatokset?decisionId=bfa9bd08-e83a-470d-9894-">bfa9bd08-e83a-470d-9894-</a>

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energy technology	R Demonstration R Commercialisation Other:	measured of final consumption.		technology funding including hydrogen		<a href="#">c4c4be9f7a8e.pdf (ecnu.edu.cn)</a>
<i>Batteries</i>	R Early-stage research R Applied research R product development R Demonstration R Commercialisation Other:	The national battery strategy's vision is that the Finnish battery cluster in 2025 will be a pioneer that produces know-how, innovations, sustainable economic growth, well-being and jobs in Finland.	Batteries	Year 2022: 50 MEUR		<a href="https://julkaisut.valtioneuvosto.fi/handle/10024/162684">https://julkaisut.valtioneuvosto.fi/handle/10024/162684</a>

### 3. National Energy Innovation Ecosystem (Optional)

**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
Ministry of Science and Technology of the People's Republic of China	Prepares and supervises the implementation of major national science and technology projects, coordinates the R&D and innovation of key common technologies, cutting-edge leading technologies, modern engineering technologies and disruptive technologies, and take the lead in organizing major technology research and application demonstration of achievements.		Takes the lead in establishing a unified national science and technology management platform and a fund coordination, evaluation and supervision mechanism for scientific research projects. Coordinates and manages the central financial science and technology plan (special projects, funds, etc.) and supervise the implementation.	<a href="https://service.most.gov.cn/kjh_tztg_all/20220303/4868.html">https://service.most.gov.cn/kjh_tztg_all/20220303/4868.html</a>

# FRANCE

## 1. Clean Energy Innovation Strategy

### 1.1 Summary

The France 2030 plan presented by the President of the Republic in October 2021 has one ambition: to prepare the France of tomorrow. It is a tool that enables France to develop the industries and create the jobs that will allow us to respond together to the major ecological and energy transitions.

This plan is structured around major societal objectives, which include the decarbonisation of our production methods (energy, industry) and the improvement of the quality of life (sustainable cities, innovative buildings, energy efficiency).

With €10.3 billion in the energy sector, this is an unprecedented effort for research, innovation and industry that will make it possible to support both capacity investments and highly innovative and disruptive projects in areas where France is already at the technological frontier.

The France 2030 plan absorbs the previous investment programme for the future. In addition to strengthening investment in innovation and R&D, this plan aims to support manufacturers in critical segments of the industry. Thus, France 2030 supports investment along the entire technology development continuum (low TRL to high TRL).

## 1.2 Methodology

The governance principles at the heart of France 2030 are disruptive innovation, trust in emerging actors, efficiency and transformation of territories, evaluation and agility.

The France 2030 plan dedicates

- 50% of its expenditure on decarbonising the economy,
  - 50% to innovative emerging players, with no environmentally unfavourable expenditure (in the sense of the Do No Significant Harm principle),
  - Accepting risk-taking and failure with the application of the "Fail fast, learn fast" principle,
  - Compared to previous plans and to the logic of the 4 previous investment programmes (PIA), based essentially on innovation, the France 2030 plan proposes a vision of industry for 2030,
  - France 2030 is intended to be flexible, with close steering and monitoring tools to adjust the course as the work progresses,
  - The France 2030 plan is managed interministerially, in particular by strategy coordinators attached to the General Secretariat for Investment.
- 
- For more information, please visit our website:  
[www.gouvernement.fr/presse-et-reseaux-sociaux](http://www.gouvernement.fr/presse-et-reseaux-sociaux)

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**Table 1: RELEVANT DOCUMENTS AND POLICIES**

<b>Document or policy name</b>	<b>Description of the document or policy</b>	<b>Specific outcomes, goals or targets identified in the document or policy</b>	<b>Year</b>
France 2030 : Focus on renewable energy	The renewable energy strategy consists of developing innovative solutions in the field of photovoltaics, floating wind power and energy networks and facilitating and accelerating the development of new technologies.	<p>Production of several GW of solar panels per year in France</p> <p>Objective of deploying 40 GW of offshore wind turbines in France by 2050</p> <p>Develop a flexible and massively digitalized energy network industry</p> <p>Target of 33% renewable energy in the energy mix by 2030 with a 40% share of renewable electricity in electricity production.</p>	2030
France 2030 – Focus on decarbonising industry	<p>The strategy on decarbonisation of industry is structured around 3 objectives:</p> <ul style="list-style-type: none"> <li>- Industrialise existing low-carbon solutions while continuing to innovate;</li> <li>- Strengthen the links and synergies between the players in the sector</li> <li>- Train more young people and professionals in decarbonisation-related professions,</li> </ul>	support the development of decarbonised processes to achieve our commitment to reduce greenhouse gas emissions in this sector by 35 % between 2015 and 2030	2030



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	particularly those that are not very attractive at present		
France 2030 – Focus on nuclear	The strategy is to strengthen innovation in the nuclear sector on SMR, waste management and multi-recycling	By 2030 : Launch a preliminary project for an SMR reactor, finance a prototype of an innovative nuclear reactor allowing for better management of radioactive substances, develop multi-recycling solutions	2030
France 2030 – Focus on decarbonated hydrogen	The strategy consists of supporting the production of decarbonised hydrogen until it becomes competitive, supporting the industrial equipment sectors	Decarbonising industry by developing a French electrolysis industry  Develop heavy mobility with decarbonised hydrogen  Supporting research, innovation and skills development in order to promote the uses of tomorrow	2030

## 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	Planned demonstration Investments (include budget years and indicate if domestic or international spending where possible)
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: <u>deploying hydrogen industry</u>	<p>Hydrogen:</p> <p>To change scale to reach profitability and to reinforce the industrial character of the French offer</p> <p>to create a French electrolysis industry</p> <p>to decarbonise industry by replacing hydrogen of fossil origin</p> <p>to develop hydrogen mobility with key technological bricks</p> <p>to develop large-scale territorial projects on the national territory by encouraging the sharing of uses of tomorrow by supporting R&amp;D and innovation to reduce costs and develop equipment for these new uses.</p>	<p>All the technological building blocks necessary to achieve the objective : Electrolysers, Hydrogen storage,...</p>	<p>€ 3,7 bn of which € 3.2 bn IPCEI.</p>

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Renewable energy	<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: <u>deploying renewable industry</u>	New high efficiency and high stability solar cell with efficiency  deploying a floating wind energy industry  developing a flexible and massively digitalised energy network industry	Next generation PV  Floating wind turbine Flexible energy network industry  Support the industrialisation of renewable energies	€ 1 bn .100% domestic
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 Other:	To launch a preliminary project for an SMR reactor,  to finance a prototype of an innovative nuclear reactor allowing for better management of radioactive substances  to develop multi-recycling solutions	Small modular reactor, Multi-recycling, Waste management	€ 1 bn .100% domestic
Decarbonising industry	<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:	Industrialise existing low-carbon solutions while continuing to innovate;  Strengthen the links and synergies between the players in the sector  Train more young people and professionals in decarbonisation-related professions, particularly those that are not very attractive at present	improving energy efficiency  use of renewable energy  tuse of waste as a source of energy or material  Carbon Capture, Utilization, and Storage	€ 5 bn .100% domestic

## 2.2 Tracking Progress (Optional)

2021 and 2022 were marked by the announcement of the France 2030 Investment Strategy. One of the main contributions of this new strategy is the possibility of financing industrialisation, in addition to the innovation aspects already covered by the future investment plans.

Steering the France 2030 plan requires an appropriate organisation. To this end, national coordinators are responsible for coordinating action and establishing roadmaps and indicators.

### 3. International Collaboration (Optional)

International collaboration is possible in the France 2030 plan. Projects with international actors are considered on a case-by-case basis.

Europe is one of the fundamental building blocks of larger innovation projects via its tools such as PIIEC (Hydrogen, Battery...), the Innovation Fund and Horizon Europe.

## 4. National Energy Innovation Ecosystem (Optional)

### **SGPI :**

The General Secretariat for Investment (SGPI) is responsible, under the authority of the Prime Minister, for ensuring the consistency and monitoring of the State's investment policy through the deployment of the France 2030 plan.

The SGPI works closely with the ministries responsible for the themes of the France 2030 investment programme. The Ministry of Energy Transition is responsible for the strategy for decarbonised energy, hydrogen and the decarbonisation of industry.

### **France 2030 is being implemented by 4 operators:**

The National Research Agency (ANR), The Agency for Ecological Transition (ADEME), The Public Investment Bank (Bpifrance) and the Caisse des Dépôts. The operators are responsible for implementing the calls for projects, carrying out project appraisals and proposing funding arrangements to the governance.

[www.gouvernement.fr/presse-et-reseaux-sociaux](http://www.gouvernement.fr/presse-et-reseaux-sociaux)

### **CEA :**

The French Alternative Energies and Atomic Energy Commission (CEA) is a key player in research, development and innovation especially in low carbon energies (nuclear and renewable energies) and technological research for industry. The CEA participates in the implementation of collaborative projects with many academic and industrial partners.

<https://www.cea.fr/english>

### **IFPEN :**

IFP Energies nouvelles (IFPEN) is a major research and training player in the fields of energy, transport and the environment. From research to industry, technological innovation is central to all its activities.

<https://www.ifpenergiesnouvelles.com/>

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**ITE :**

The Institutes for Energy Transition (ITE) are interdisciplinary platforms in the field of decarbonised energies, bringing together the skills of industry and public research in a logic of public-private co-investment and close collaboration between all the players, which should make it possible to strengthen the ecosystems formed by the competitiveness clusters.

We have 7 ETIs:

- **Efficacity** (energy and ecological transition of cities) : <https://efficacity.com/>
- **Supergrid** (high voltage, transmission, power conversion and direct current sector) : <https://www.supergrid-institute.com/>
- **Vedecom** (sustainable mobility : ecological, automated and shared) : <https://www.vedecom.fr/?lang=en>
- **IPVF** (photovoltaic cells) : <https://www.ipvf.fr>
- **INES2S** (develop an industrial sector in France for the integration of photovoltaic solar energy) : <https://www.ines-solaire.org/>
- **FEM** (offshore renewable energies) : <https://www.france-energies-marines.org/en/the-institute/>
- **Nobatek INEF4** (Energy and Environmental Transition in Construction) : <https://www.nobatek.inef4.com/en/>

# GERMANY

## 1. Clean Energy Innovation Strategy

### 1.1 Summary

German government's Energy Concept and the decisions of the Bundestag serve as the compass for steering the energy transition. The German government has tightened climate protection targets and anchored the goal of greenhouse gas neutrality by 2045. The German Federal Ministry for Economic Affairs and Climate Action (BMWK) sets the course for this in its energy research policy. The higher ambitions also affect the CO<sub>2</sub> reduction targets by 2030 in the individual sectors: energy, industry, transport, buildings and agriculture. Emissions are to be reduced by 65 % by 2030 compared with 1990. Germany is one of the few countries to phase out coal-fired power generation in addition to nuclear power, while at the same time massively driving forward the restructuring of the energy industry, the expansion of renewable energies and, for example, the expansion of the hydrogen economy along the entire value chain with a total of nine billion euros.

By 2030 at least 80% of German gross electricity consumption is to be covered by renewables. The expansion of renewable energy on land and at sea will be raised to an entirely new level. The ministry funds more than 1,300 new, application-oriented research projects each year that support the energy and climate policy goals: from photovoltaic systems on lakes to sustainable heat supply for entire city districts. The German government has agreed on a substantial expansion of photovoltaic plants by 200 GW up to 2023.

At the international level, the focus is on close cooperation in climate policy. Climate change is expected to have a particular impact on supply chains, infrastructures, value creation models and sales markets. The Federal Ministry for Economic Affairs and



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Climate Action (BMWK) therefore plans to intensify dialog with companies and associations in order to face the new challenges within German companies and to address the necessary adaptation strategies in this context.

## 1.2 Methodology

The Federal Government's 7th Energy Research Programme supports German companies in further developing their competitive edge on modern energy technologies.

Since 2014, the German Federal Ministry for Economic Affairs and Climate Action has been engaged in initiating energy research networks in important areas of energy research involving intensive technical exchange with research institutions, universities and research-based industry. In addition to promoting participation and transparency, the aim of the networks is to accelerate the transfer of results and ensure the quality of research findings. There are currently ten networks on central topics of the energy transition, such as hydrogen, renewable energies or climate-neutral buildings and neighbourhoods. In these networks experts discuss, agree on technical positions and make recommendations on funding strategies. The results of the networks' activities are incorporated into the ministry's strategic considerations for future energy research policy. The open expert networks bring together more than 4,000 experts (as of October 2021). Through their exchange, they help to transfer the results of energy research directly to the stakeholders of the energy transition, to discuss practical funding strategies in a topic-focused manner and to propose new measures.

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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)
7th Energy Research Programme	Innovations for the energy transition	Focus on technology and innovation transfer, in particular through the Living Labs of the Energy Transition as a new funding pillar for preparing innovative solutions for the market on an industrial scale.	2021	<a href="https://www.bmwk.de/Redaktion/EN/Dossier/energy-research-and-innovation.html">https://www.bmwk.de/Redaktion/EN/Dossier/energy-research-and-innovation.html</a>
National Hydrogen Strategy	Coherent framework for the generation, transport and use of hydrogen, encouraging the relevant innovations and investment. The Strategy sets out the steps that are needed to meet the German climate targets, create new value chains for the German economy and foster energy policy cooperation at international level.	The Federal Government expects that around 90 to 110 TWh of hydrogen will be needed by 2030. In order to cover part of this demand, Germany plans to establish up to 10 GW of generation capacity including the offshore and onshore energy generation facilities needed for this. This corresponds to 14 TWh of green hydrogen production.	2020	<a href="https://www.bmwk.de/Redaktion/EN/Publikationen/Energie/the-national-hydrogen-strategy.html">https://www.bmwk.de/Redaktion/EN/Publikationen/Energie/the-national-hydrogen-strategy.html</a>

## 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, (include budget years where applicable)	Planned demonstration Investments (include budget years and indicate if domestic or international spending where possible)	Links to relevant reports or plans
7th Energy Research Programme	<input checked="" type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input type="checkbox"/> product development <input checked="" type="checkbox"/> Demonstration <input type="checkbox"/> Commercialisation Other:	Contribution to the federal government's energy policy goals	Various technologies for energy conversion, transport and distribution and end-use	1.3 billion € (2021)	Investments not an independent part of this programme	<a href="https://www.bmwk.de/Redaktion/DE/Publikationen/Energie/bundesbericht-energieforschung-2022.html">https://www.bmwk.de/Redaktion/DE/Publikationen/Energie/bundesbericht-energieforschung-2022.html</a> (English version will be available in Autumn 2022)
National Hydrogen Strategy	<input type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input type="checkbox"/> product development <input checked="" type="checkbox"/> Demonstration	Increase generation capacity by 10 GW until 2030	Electrolysers Alternative processes: Photoelectrochemical/	7 billion € (national) 2 billion € (international)	The focus is on private investment for the production, transportation and use of hydrogen	<a href="https://www.bmwk.de/Redaktion/EN/Publikationen/Energie/the-national-hydrogen-strategy.html">https://www.bmwk.de/Redaktion/EN/Publikationen/Energie/the-national-hydrogen-strategy.html</a>

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	<input type="checkbox"/> Commercialisation Other:		Photocatalytic, Solar Thermochemical, Photobiological. Use of biomass and biogenic residues: Fermentation, Reforming, Gasification, Plasmalysis.			
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Germany intends to be climate neutral by 2050, in line with the wider European ambition to become the first climate neutral continent. Innovation plays an important role in reaching this goal. In June 2020 Germany launched its National Hydrogen Strategy (<https://www.bmwk.de/Redaktion/EN/Publikationen/Energie/the-national-hydrogen-strategy.html>). The National stimulus package for the COVID-recovery provides 7 billion euros for the implementation of the National Hydrogen Strategy domestically, and another 2 billion euros for fostering international cooperation in the field of hydrogen. Under the scope of the National Hydrogen Strategy Germany established the National Hydrogen Council as well as the Innovation Commissioner for Green Hydrogen at the Federal Ministry of Education and Research (BMBF).

## 2.2 Tracking Progress (Optional)

The 7th Energy Research Programme is subjected to an external evaluation accompanying the programme as well as an ex-post evaluation after the end of the programme. Aspects of the evaluation are e.g. the contribution of the programme to the higher-order goals of the energy transition, the impact on companies and the economic efficiency of the measures. The evaluation process includes the development of a set of indicators to monitor success as well as an analysis of the funding budget, for example according to the type of funding recipient.

### 3. Private Sector Engagement (Optional)

A cross-departmental and theme-oriented programme structure was chosen for the 7th Energy Research Programme. The departmental responsibilities are assigned in project funding based on the Technology Readiness Level. The Federal Ministry for Economic Affairs and Climate Action (BMWK) is responsible for project funding in the application-oriented field of energy research. The so-called Living Labs of the Energy Transition located here address primarily the private sector. The majority of research, development and demonstration of energy and efficiency technologies is supported by companies. In the area of project funding alone, companies provided a total of 744 million euros for their own funding in 2021.

## 4. International Collaboration (Optional)

The Federal Ministry for Economic Affairs and Climate Action (BMWK) promotes energy research at national as well as European and international level. Germany is committed to fostering innovation for a climate-friendly energy supply worldwide and contributes to the European Union's goal of making Europe the world's first climate-neutral continent by 2050. The importance of international research cooperation is increasing constantly. The research cooperation the Federal Ministry for Economic Affairs and Climate Action engages in is based on three pillars: i) Energy research in the European Union, ii) Energy research in the International Energy Agency, and iii) Multilateral energy research initiatives.



# JAPAN

## 1. Clean Energy Innovation Strategy

### 1.1 Summary

Japan aims to reduce GHGs to net-zero, that is, to realize carbon neutrality by 2050. In addition, Japan aims to reduce its GHG emissions by 46 percent in FY 2030 from its FY2013 levels, setting an ambitious target which is aligned with the long-term goal of net-zero by 2050, while continuing strenuous efforts in its challenge to meet the lofty goal of cutting its emission by 50%.

Toward two ambitious goals, namely, carbon neutrality by 2050 and GHG reduction by 46% in FY2030, future directions have been stipulated in the Green Growth Strategy, the Strategic Energy Plan, the Plan for Global Warming Countermeasures, and the Long-Term Strategy under the Paris Agreement.

Realizing carbon neutrality by 2050 will require an enormous effort. We need to significantly accelerate structural changes in the energy and industry sectors, and bold investment to make innovation. Changing from the conventional mindset, to take measures positively to tackle climate change heralds transformation in the industrial structure and social economy, and leads to the next strong growth. The Green Growth Strategy is a set of industrial policies to create a “virtuous cycle of the economy and the environment”.

In the Green Growth Strategy, we set high goals for the 14 industrial fields (\*) that are expected to grow. We will produce and direct all available policies, including budget, taxation, finance, regulatory reforms/standardization, and international cooperation, towards that goal. For example, we have established an unprecedented 2 trillion yen fund (Green Innovation Fund) to provide continuous support for companies that take on the challenge of ambitious innovation for the next 10 years. This will support the

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forward-looking challenges of companies, such as making bold investments to make innovation, and realize transformation in the industrial structure and social economy.

(\*)1. Offshore wind/solar/geothermal power; 2. Hydrogen/Fuel Ammonia; 3. Next-generation heat energy; 4. Nuclear; 5. Automobile/battery; 6. Semiconductor/information and communication; 7. Shipping; 8. Logistics, people flow, and civil engineering infrastructure; 9. Food, Agriculture, forestry and fisheries; 10. Aircraft; 11. Carbon recycling/material; 12. Housing and Building/ next-generation power management; 13. Resource circulation-related; 14. Life style-related

## 1.2 Methodology

To formulate policies and measures on energy and climate change, leaders from various sectors, including academia, industry and financial sector, contribute to scientific-knowledge based discussion for the Government. Based on such discussion, the policies and measures are approved by the Government of Japan, through the consensus-building process among related ministries. Such policy making process includes modeling and simulations (e.g. RITE Global model, described below), analysis of industry activities and review of innovations.

RITE Global model for Energy and Climate Change Assessment: DNE21+

RITE built a model that can assess cost-efficient global warming countermeasures for the period of up to 2030 while dividing world into 77 regions, in order to analyze and assess global warming framework beyond second commitment period while reflecting regional difference well in itself.

DNE21+ is a dynamic linear programming model that optimizes multiple time-points concurrently. It also features a capability of explicit assessment of global warming countermeasures by bottom-up modeling of energy supply (electricity generation, etc.) and CCS technologies. For an assessment of bottom-up reduction target, it has a capability of explicit assessment of energy-saving/global warming countermeasure technologies in energy-intensive sectors such as iron-and-steel or cement by bottom-up modeling of individual technologies, while top-down approach is adopted to assess energy demand side technologies.

Based on detailed technology data of every sector around the world, this model serves as a leading-edge analysis tool and enables detailed assessment of global and sectoral approach.

Main parts of this model was based on work undertaken for the “Assessment of Mitigation Framework after 2013” (Beyond 2010).

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In June 2008, IEA published Energy Technology Perspectives (ETP) 2008. By comparing scenarios analyzed with DNE21+ and IEA ETP2008, we have clarified features of DNE21+ more explicitly and examined common terms regarding projection of energy and global warming countermeasures.

<https://www.rite.or.jp/system/en/global-warming-ouyou/modeltodata/overviewdne21/outline-dne21plusmodel/>

**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)
Environment Innovation Strategy	Based on the Long-term Strategy under the Paris Agreement (Cabinet Decision in June 2019; hereinafter referred to as the “Longterm Strategy” ) and the Integrated Innovation Strategy 2019, this Environment Innovation Strategy is formulated in order to create innovations in the fields of energy and environment, where Japan has a strength, to realize a feasible level of cost for adoption of such technologies in the society and to apply them globally. This strategy will contribute to significant reduction in Japan’ s GHG (Greenhouse Gas) emissions and to the reduction in GHG emissions worldwide as much as possible.	This Environment Innovation Strategy aims to establish innovative technologies that enable global carbon neutrality and, further, reduction of the accumulated stock of CO2 in the earth’ s atmosphere ( “Beyond Zero” ) by 2050.	January 21, 2020	<a href="https://www8.cao.go.jp/cstp/tougosenryaku/kankyoen.pdf">https://www8.cao.go.jp/cstp/tougosenryaku/kankyoen.pdf</a>

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RITE Global model for Energy and Climate Change Assessment: DNE21+	RITE built a model that can assess cost-efficient global warming countermeasures for the period of up to 2030 while dividing world into 77 regions, in order to analyze and assess global warming framework beyond second commitment period while reflecting regional difference well in itself.	DNE21+ is a dynamic linear programming model that optimizes multiple time-points concurrently. It also features a capability of explicit assessment of global warming countermeasures by bottom-up modeling of energy supply (electricity generation, etc.) and CCS technologies. For an assessment of bottom-up reduction target, it has a capability of explicit assessment of energy-saving/global warming countermeasure technologies in energy-intensive sectors such as iron-and-steel or cement by bottom-up modeling of individual technologies, while top-down approach is adopted to assess energy demand side technologies.	August, 2008	<a href="https://www.rite.or.jp/system/en/global-warming-ouyou/modeltodata/overviewdne21/outline-dne21plusmodel/">https://www.rite.or.jp/system/en/global-warming-ouyou/modeltodata/overviewdne21/outline-dne21plusmodel/</a>
Green Growth Strategy	Gone are the days when countermeasures to global warming are considered as a cost or constraint to the economic growth, the world has entered a new era to grasp them as a great opportunity for further prosperity. Changing from the conventional mindset, to take measures positively to tackle climate change heralds transformation in the industrial structure and social economy, and leads to the next strong growth. The Green Growth			

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	<p>Strategy is a set of industrial policies to create a “virtuous cycle of the economy and the environment” .</p> <p>the Japanese government will set high goals and muster all possible and necessary policies for the thus-determined industries (14 industrial fields) that are expected to grow. The role of the government is to provide full support to private companies in conducting their forward-looking challenges, such as a bold investment to make innovation.</p>			
Strategic Energy Plan	<p>In the new Strategic Energy Plan, the key theme is to show the path of the energy policy to realize carbon neutrality by 2050, and reduce greenhouse gas emissions by 46% in FY 2030 from its FY 2013 levels, while continuing strenuous efforts in its challenge to meet the lofty goal of cutting its emission by 50%.</p> <p>At the same time, another important theme is to overcome the challenges Japan’ s energy supply-demand structure faces. On the major premise of safety, efforts will be made for energy security and economic efficiency</p>			

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	<p>of energy while promoting climate change countermeasures (S+3E). Strategic Energy Plan mainly consists of parts of (1) Progress in the past decade after the accident at TEPCO's Fukushima Daiichi Nuclear Power Station, (2) Challenges and responses for achieving carbon neutrality by 2050, and (3) Policy responses towards 2030 looking ahead to 2050.</p>			
Plan for Global Warming Countermeasures	<p>The Plan for Global Warming Countermeasures is the Government's comprehensive plan based on the Act on Promotion of Global Warming Countermeasures. This plan, revised in October 2021, stipulates the Japan's new reduction target, which is that Japan aims to reduce greenhouse gas emissions by 46 percent by fiscal 2030 from fiscal 2013 levels as an ambitious target aligned with its long-term goal of achieving net-zero by 2050 and will continue strenuous efforts in its challenge to meet the lofty goal of cutting its emission by 50 percent. It also includes a set of measures and policies for</p>	<p>Japan aims to reduce greenhouse gas emissions by 46 percent by fiscal 2030 from fiscal 2013 levels as an ambitious target aligned with its long-term goal of achieving net-zero by 2050 and will continue strenuous efforts in its challenge to meet the lofty goal of cutting its emission by 50 percent.</p>	<p>October 22, 2021 (Cabinet decision)</p>	<p><a href="https://www.env.go.jp/en/headline/2551.html">https://www.env.go.jp/en/headline/2551.html</a></p>

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	achieving it, describing a pathway toward the target.			
Long-Term Strategy under the Paris Agreement	<p>The Long-Term Strategy under the Paris Agreement is formulated in accordance with the provision of the Paris Agreement.</p> <p>This strategy shows the basic concept, visions, and measures for net zero GHG emissions by 2050.</p> <p>The basic concept is that global warming countermeasures do not weigh on economic growth, rather, these measures are the keys to transforming the industrial structure and producing robust growth by dramatically changing our economy and society, promoting investments, and enhancing productivity.</p>	The Long-Term Strategy under the Paris Agreement shows the basic concept, visions, and measures for net zero GHG emissions by 2050.	October 22, 2021 (Cabinet decision)	<a href="https://www.env.go.jp/en/headline/2551.html">https://www.env.go.jp/en/headline/2551.html</a>



## 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, (include budget years where applicable)	Planned demonstration Investments (include budget years and indicate if domestic or international spending where possible)	Links to relevant reports or plans
Offshore wind /solar/geothermal power	<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 checked="" type="checkbox"/> Commercialisation Other:	<ul style="list-style-type: none"> <li>· In 2040, 30–45 GW projects [Offshore wind].</li> <li>· In 2030, power generation cost of 14 yen/kWh by next generation solar cells [Solar]</li> </ul>	<ul style="list-style-type: none"> <li>· Cost Reduction for Offshore Wind Power Generation</li> <li>· Next-Generation Solar Cell Development</li> </ul>	<ul style="list-style-type: none"> <li>· Cost Reduction for Offshore Wind Power Generation : 119.5 billion yen (Green Innovation Fund)</li> <li>· Next-Generation Solar Cell Development : 49.8 billion yen (Green Innovation Fund)</li> </ul>		<a href="https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/01_offshore.pdf">https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/01_offshore.pdf</a>
Hydrogen/fuel ammonia	<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 checked="" type="checkbox"/> Commercialisation Other:	<ul style="list-style-type: none"> <li>· In 2030, about 3 million tons introduced in Japan [Fuel Ammonia]</li> <li>· In 2030, target cost: Upper 10 yen range (per Nm<sup>3</sup>-H<sub>2</sub>) [Fuel Ammonia]</li> </ul>	<ul style="list-style-type: none"> <li>· Large-scale Hydrogen Supply Chain Establishment Project</li> <li>· Hydrogen Production through</li> </ul>	<ul style="list-style-type: none"> <li>· Large-scale Hydrogen Supply Chain Establishment Project : 300 billion yen (Green Innovation Fund)</li> </ul>		<a href="https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/p">https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/p</a>

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		<ul style="list-style-type: none"> <li>· In 2050, about 20 million tons introduced [Hydrogen].</li> <li>· In 2050, about 30 million tons introduced in Japan [Fuel Ammonia].</li> <li>· In 2050, about 100 million tons introduced in the world [Fuel Ammonia]</li> <li>· In 2050, about 1.7 trillion yen market in the world [Fuel Ammonia].</li> </ul>	Water Electrolysis Using Power from Renewables · Fuel Ammonia Supply Chain Establishment Project	· Hydrogen Production through Water Electrolysis Using Power from Renewables : 70 billion yen (Green Innovation Fund) · Fuel Ammonia Supply Chain Establishment Project : 68.8 billion yen (Green Innovation Fund)		<a href="https://www.nedo.go.jp/content/100940967.pdf">df/02_hydrogen.pdf</a> <a href="https://www.nedo.go.jp/content/100940967.pdf">https://www.nedo.go.jp/content/100940967.pdf</a> <a href="https://www.nedo.go.jp/content/100940968.pdf">https://www.nedo.go.jp/content/100940968.pdf</a>
Next-generation heat energy	<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 checked="" type="checkbox"/> Commercialisation Other:	<ul style="list-style-type: none"> <li>· In 2050, injecting synthetic Methane (e-methane) by 90% into existing gas pipeline infrastructure.</li> </ul>	· Technology Development of Producing Recycled Carbon Fuel.	· Technology Development of Producing Recycled Carbon Fuel. : 24.22 billion yen (Green Innovation Fund)		<a href="https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/03_next_gen_heat.pdf">https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/03_next_gen_heat.pdf</a>
Automobile/batteries	<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 checked="" type="checkbox"/> Commercialisation Other:	<ul style="list-style-type: none"> <li>· In 2035, electrified vehicles accounting for 100% of new passenger car sales.</li> </ul>	· Next-Generation Storage Battery and Motor Development · Development of In-Vehicle Computing and Simulation Technologies for Energy Efficiency of Electrified Vehicles and Other Vehicles	· Next-Generation Storage Battery and Motor Development : 151 billion yen (Green Innovation Fund) · Development of In-Vehicle Computing and Simulation Technologies for Energy Efficiency of Electrified Vehicles and Other Vehicles : 42 billion yen (Green Innovation Fund)		<a href="https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/05_automobile.pdf">https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/05_automobile.pdf</a>

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Semiconductor/ information and communication	<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 checked="" type="checkbox"/> Commercialisation Other:	<ul style="list-style-type: none"> <li>· In 2040, semiconductor/information and communication industries achieving carbon neutrality.</li> </ul>	<ul style="list-style-type: none"> <li>· Next-generation Digital Infrastructure Construction</li> </ul>	<ul style="list-style-type: none"> <li>· Next-generation Digital Infrastructure Construction : 141 billion yen (Green Innovation Fund)</li> </ul>		<a href="https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/06_semi_conductor.pdf">https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/06_semi_conductor.pdf</a>
Shipping	<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 checked="" type="checkbox"/> Commercialisation Other:	<ul style="list-style-type: none"> <li>· Before the conventional target year of 2028, realizing the commercial operation of zero-emission ships.</li> </ul>	<ul style="list-style-type: none"> <li>· Next-generation Ship Development</li> </ul>	<ul style="list-style-type: none"> <li>· Next-generation Ship Development : 35 billion yen (Green Innovation Fund)</li> </ul>		<a href="https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/07_shipping.pdf">https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/07_shipping.pdf</a>
Logistics, people flow, and civil engineering infrastructure	<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 checked="" type="checkbox"/> Commercialisation Other:	<ul style="list-style-type: none"> <li>· In 2050, carbon-neutral ports realizing decarbonization of ports and construction work.</li> </ul>	<ul style="list-style-type: none"> <li>· Smart Mobility Society Construction</li> </ul>	<ul style="list-style-type: none"> <li>· Smart Mobility Society Construction : 113 billion yen (Green Innovation Fund)</li> </ul>		<a href="https://www8.cao.go.jp/cstp/tougosenryaku/kankyo_gaiyo_en.pdf">https://www8.cao.go.jp/cstp/tougosenryaku/kankyo_gaiyo_en.pdf</a>
Aircraft	<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 checked="" type="checkbox"/> Commercialisation Other:	<ul style="list-style-type: none"> <li>· Starting from 2030, installing core technologies such as batteries in stages.</li> </ul>	<ul style="list-style-type: none"> <li>· Next-generation Aircraft Development</li> </ul>	<ul style="list-style-type: none"> <li>· Next-generation Aircraft Development : 21.08 billion yen (Green Innovation Fund)</li> </ul>		<a href="https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/10_aircraft.pdf">https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/10_aircraft.pdf</a>
Carbon recycling/material	<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 checked="" type="checkbox"/> Commercialisation Other:	<ul style="list-style-type: none"> <li>· In 2050, artificial photosynthesis plastics on par with existing products [CR].</li> <li>· Realizing zero carbon steel [Material].</li> </ul>	<ul style="list-style-type: none"> <li>· Hydrogen Utilization in Iron and Steelmaking Processes</li> <li>· Development of Technology for Producing Raw</li> </ul>	<ul style="list-style-type: none"> <li>· Hydrogen Utilization in Iron and Steelmaking Processes : 193.5 billion yen (Green Innovation Fund)</li> <li>· Development of Technology for Producing</li> </ul>		<a href="https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/11_carbon_recycle.pdf">https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/11_carbon_recycle.pdf</a>

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			<p>Materials for Plastics Using CO2 and Other Sources</p> <ul style="list-style-type: none"><li>· Technology Development of Producing Recycled Carbon Fuel.</li><li>· Development of Technology for Producing Concrete and Cement Using CO2</li><li>· Development of Technology for CO2 Separation, Capture, etc.</li></ul>	<p>Raw Materials for Plastics Using CO2 and Other Sources : 126.2 billion yen (Green Innovation Fund)</p> <ul style="list-style-type: none"><li>· Technology Development of Producing Recycled Carbon Fuel : 24.22 billion yen (Green Innovation Fund)</li><li>· Development of Technology for Producing Concrete and Cement Using CO2 : 56.78 billion yen (Green Innovation Fund)</li><li>· Development of Technology for CO2 Separation, Capture, etc. : 38.23 billion yen (Green Innovation Fund)</li></ul>		
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# THE NETHERLANDS

## 1. Clean Energy Innovation Strategy

### 1.1 Summary

In line with the European Fit For 55 package, the Netherlands increased its CO<sub>2</sub> reduction target from 49% to 55% reduction in 2030 compared to 1990. The Netherlands is targeting CO<sub>2</sub>-reduction on a sectoral level with the Dutch Climate Agreement of 2019 for the Electricity Sector, Industry, Mobility, the Built Environment and Agriculture & Land-use. In 2019, the knowledge and innovation challenges for these sectoral Missions have been translated into the Integrated Knowledge and Innovation Agenda on Climate and Energy (IKIA) and 13 Multi-Year Mission-Driven Innovation Programs (MMIPs). Through sectoral Mission teams – composed of end-users, private actors, knowledge institutes and government agencies – all Dutch innovation efforts concerning Climate and Energy across all TRL-levels are guided towards the Missions and MMIPs of the Climate Agreement. Our international innovation efforts are also in line with the IKIA, so that the various initiatives contribute to the Missions of the Climate Agreement.

In 2020, the Knowledge and Innovation Covenant (KIC) has been signed by private and public parties. This KIC gives insight in and commitment of foreseen financial means for RD&D. In the years between 2020–2023, the financial means for climate and energy are about €1 billion per year. About €320 mln public funding and €590 mln private funding for RD&D.

This spring, the policy agenda of our national climate policy for the coming ten years has been published. Besides that, a €35 billion Climate Fund is being developed. The Climate Fund is one of the main instruments of the Coalition Agreement to enable financing for measures that contribute to the goal of at least 55% CO<sub>2</sub> reduction by 2030. Between 2024 and 2030, the Climate Fund will invest in large scale innovation projects related to, amongst others, the following topics: energy infrastructure, converting gas plants to green hydrogen plants, heat transition, nuclear energy, and early phase upscaling of new energy technologies.

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## 1.2 Methodology

The Dutch government is using the knowledge and creativity of the Dutch business community and knowledge institutions to achieve our climate goals. The focus is on the realization of the Integrated Knowledge and Innovation Agenda on Climate and Energy (IKIA) and Multi-Year Mission-Driven Innovation Programs (MMIPs). By involving the private sector and the demand-side of innovation in aligning our energy innovation investments (from fundamental research to demonstration/implementation), policies, regulations, market conditions and international efforts, we aim to create focus and mass in clean energy investments. This provides a more predictable and focussed framework for investors to invest in low-carbon innovations. The MMIPs allow to develop calls for proposals to stimulate fundamental research and grant schemes to support pilot and demonstration projects. Multi-year collaborations between companies, knowledge institutions and other parties are encouraged.

In 2019, the content of the MMIPs was determined in consultation with the private sector and knowledge institutes. This year, the IKIA and MMIPs will be recalibrated together with industry, knowledge institutions and governments. With this, we determine the required innovation effort and commitment to meet the targets of the Coalition Agreement and the EU Fit For 55 package.

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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)
National Climate Agreement – The Netherlands	The English translation of the National Climate Agreement of the Netherlands, presented to the House of Representatives on the 28th of June, 2019.	By 2030, the Dutch government wants to reduce the Netherlands' greenhouse gas emissions by 49% compared to 1990 levels, and a 95% reduction by 2050.  Note that this year (2022) the 49% reduction target was increased to 55% – in line with the EU Fit For 55 package. In 2050, we aim to be climate neutral.	2019	<a href="#">National Climate Agreement – The Netherlands   Publicatie   Klimaatakkoord</a>
Draft Climate Policy Programme	The draft Climate Policy Programme describes the main lines of climate policy for the period up to 2030. It provides an overview of the main policy instruments per sector with which the government intends to achieve the target of at least 55% CO2 reduction by 2030.	55% CO2 reduction by 2030, climate neutral in 2050.	2022	<a href="#">Ontwerp Beleidsprogramma Klimaat   Publicatie   Rijksoverheid.nl</a>
The Integral Knowledge and Innovation Agenda (IKIA) for the energy transition	The Integral Knowledge and Innovation Agenda (IKIA) consists of 13 multi-year mission-driven innovation programs (MMIPs) that give direction to specific development goals, and thereby contribute to the perspective that	<ul style="list-style-type: none"> <li>- A completely CO2-free electricity system in 2050</li> <li>- A CO2-free built environment in 2050</li> <li>- A climate-neutral industry with the reuse of raw materials and products in 2050</li> </ul>	2019	<a href="https://www.klimaatakkoord.nl/themas/kennis--en-innovatieagenda/documenten/publicaties/2019/03/12/innoveren-met-een-missie">https://www.klimaatakkoord.nl/themas/kennis--en-innovatieagenda/documenten/publicaties/2019/03/12/innoveren-met-een-missie</a>



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	is needed in the construction, installation and energy sector to invest in the development of innovation.	<ul style="list-style-type: none"> <li>- Emission-free mobility for people and goods in 2050</li> <li>- A net climate-neutral agriculture and nature system in 2050</li> </ul>		
Knowledge and Innovation Covenant 2020-2023 (KIC)	In the KIC, the private sector, knowledge institutes and governments confirm their commitments to important innovation themes – Energy Transition & Sustainability being one of them.	Invest 4.9 billion euros per year in knowledge and innovation (€2.05 billion of private investments and €2.85 billion of public investments) for the period 2020-2023.	2019	<a href="https://www.nwo.nl/sites/nwo/files/documents/Kennis%20en%20innovatieconvenant%202020-2023.pdf">https://www.nwo.nl/sites/nwo/files/documents/Kennis%20en%20innovatieconvenant%202020-2023.pdf</a>

## 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, (include budget years where applicable)	Planned demonstration Investments (include budget years and indicate if domestic or international spending where possible)	Links to relevant reports or plans
<b>A completely carbon free electricity system in 2050</b>	<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 checked="" type="checkbox"/> Commercialisation  <i>The Innovation Missions focus on all TRL levels, from fundamental research to demonstration and implementation</i>	Intermediate targets 2030: - On a yearly basis, at least 35 TWh of electricity will be produced by onshore wind and solar installations > 15 kW - At least 49 TWh of electricity will be produced by offshore wind	- Offshore wind - Onshore wind - (Next generation) PV - System integration	We track investments in RD&D in a different way, see table below.		<a href="https://www.klimaatatkoord.nl/the-mas/kennis--en-innovatieagenda/documenten/publicaties/2019/03/12/innoveren-met-een-missie">https://www.klimaatatkoord.nl/the-mas/kennis--en-innovatieagenda/documenten/publicaties/2019/03/12/innoveren-met-een-missie</a>
<b>A carbon-free built environment in 2050</b>	<input checked="" type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input checked="" type="checkbox"/> Product development <input checked="" type="checkbox"/> Demonstration	Intermediate targets 2030: - 200,000 existing homes per year off natural gas (1.5 million homes in total)	- Electrification - Heat pumps - District heating - System integration			<a href="https://www.klimaatatkoord.nl/the-mas/kennis--en-innovatieagenda/">https://www.klimaatatkoord.nl/the-mas/kennis--en-innovatieagenda/</a>

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	<input checked="" type="checkbox"/> Commercialisation  <i>The Innovation Missions focus on all TRL levels, from fundamental research to demonstration and implementation</i>	- 15 percent of utility buildings and social real estate off natural gas - At least 20% of local energy consumption (including EV) will be produced locally (in the built environment) in an sustainable way				<a href="https://documenten/publ/2019/03/12/innoveren-met-een-missie">documenten/publ/2019/03/12/innoveren-met-een-missie</a>
<b>A climate neutral industry with the re-use of raw materials and products in 2050</b>	<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 checked="" type="checkbox"/> Commercialisation  <i>The Innovation Missions focus on all TRL levels, from fundamental research to demonstration and implementation</i>	Intermediate targets 2030: - Using 50% less primary raw materials - Greenhouse gas emissions from production processes and the waste sector are reduced to around 36 Mton CO2 equivalent - Electrification and CO/CO2 reuse are achieved - CCS is being used cost-efficiently - Sustainable hydrogen is on its way to implementation - Biobased raw materials are seen as the standard	- CCU/CCS - Electrification in industry - Biorefinery - Hydrogen			<a href="https://www.klimaatkoord.nl/the-mas/kennis--en-innovatieagenda/documenten/publ/2019/03/12/innoveren-met-een-missie">https://www.klimaatkoord.nl/the-mas/kennis--en-innovatieagenda/documenten/publ/2019/03/12/innoveren-met-een-missie</a>
<b>Emission-free mobility for people and goods in 2050</b>	<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 checked="" type="checkbox"/> Commercialisation  <i>The Innovation Missions focus on all TRL levels, from fundamental research to demonstration and implementation</i>	- 1.9 million electric vehicles - 1/3 of energy consumed in mobility is renewable - 8 billion fewer business (car) kilometres made on a yearly basis - At least the 32 largest municipalities have zero-emission zones for urban logistics	- EV - Electrification - Biofuels			<a href="https://www.klimaatkoord.nl/the-mas/kennis--en-innovatieagenda/documenten/publ/2019/03/12/innoveren-met-een-missie">https://www.klimaatkoord.nl/the-mas/kennis--en-innovatieagenda/documenten/publ/2019/03/12/innoveren-met-een-missie</a>

**This table shows our public RD&D spending, divided into different categories according to the IEA questionnaire.**

	2019	2020	2021
A1. Energy efficiency: industry	€ 31,1	€ 106,9	€ 75,0
A2. Energy efficiency: residential and commercial buildings	€ 28,4	€ 14,0	€ 2,5
A3. Energy efficiency: mobility	€ 41,4	€ 2,3	€ 77,9
A4. Energy efficiency: other	€ 23,8	€ 11,9	€ 18,9
B1. Oil and gas	€ 1,5	€ 0,5	€ 0,5
B3. CO2 capture and storage	€ 7,0	€ 5,9	€ 10,1
C1. Solar energy	€ 15,5	€ 18,1	€ 21,2
C2. Wind energy	€ 46,5	€ 15,5	€ 14,1
C3. Ocean energy	€ 0,0	€ -	€ -
C4. Biofuels	€ 8,2	€ 7,2	€ 13,3
C5. Geothermal energy	€ 10,9	€ 3,6	€ 4,7
C6. Hydroelectricity	€ -	€ -	€ -
C7. Other Renewable Energie Sources	€ 0,2	€ -	€ -
D1. Nuclear Fission	€ 7,0	€ 7,0	€ 7,7
D2. Nuclear Fusion	€ -	€ -	€ -
E1. Hydrogen	€ 14,3	€ 14,4	€ 56,4
E2. Fuel cells	€ -	€ 0,5	€ 5,3

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F1. Electric power generation	€ -	€ 0,2	€ -
F2. Electricity transmission and distribution	€ 2,3	€ 13,3	€ 17,4
F3. Energy storage	€ 20,2	€ 8,4	€ 9,9
G1. Energy system analysis	€ 11,7	€ 4,5	€ 13,2
G2. Basic (not-specific) energy research	€ 0,9	€ -	€ 0,5
G3. Other	€ -	€ 8,2	€ 12,2
<b>Total</b>	<b>€ 271,0</b>	<b>€ 242,4</b>	<b>€ 360,7</b>

We work with governments, knowledge institutes and the private sector on the innovations that are needed to achieve the Missions as formulated in Table 2. The Topsector Energy (TSE) plays an important role in this. The TSE consist of various Top Consortia for Knowledge and Innovation (TKIs) in which governments, knowledge institutes and Dutch organizations come together. TKIs are formed around the themes of the Missions. On a yearly basis, we decide together with the TSE and TKI's what the priorities for RD&D are to achieve the targets formulated in the Missions and the underlying MMIPs. Together we launch new programs and mobilize public and private funding for RD&D projects across all TRL-levels.

## 2.2 Tracking Progress (Optional)

We set up an Innovation Monitoring Unit (IMU) that measures progress towards addressing our energy innovation priorities as formulated in the Integrated Knowledge and Innovation Agenda on Climate and Energy (IKIA). The IKIA consists of 5 Missions (Electricity Sector, the Built Environment, Industry, Mobility, Agriculture & Land Use). These Missions again consists of 13 Multi-Year Mission Driven Innovation Programmes (MMIPs). For each MMIP, the knowledge and innovations that need to be developed to complete the missions have been worked out.

The IMU investigates the efforts made within the Missions of the IKIA. Information is provided on:

- Deployment at the Missions and MMIPs level (quantitative)
- Deployment to sub-programs within MMIPs (qualitative, based on expert judgement)

The Progress Report made by the IMU shows if we are on track to meet the targets formulated in the IKIA. Besides that, it provides information on the distribution of type of innovation activities; the deployment of public funds; the distribution between public/private investments; and the type of organisations that made the investments.

### 3. Private Sector Engagement (Optional)

The Netherlands supports public-private collaboration through various policies:

- General policies, such as the [public-private allowance](#), which facilitates private contributions for public-private partnerships for research and innovation within the Top Sectors.
- Energy-innovation policies, requiring a private contribution (in-cash or in-kind). For example the Renewable Energy Scheme (HER) (on average 50%), the DEI+ (on average 75%), the MOOI (on average 40%). In 2021, the Dutch government has invested €181 million euros in energy innovation through various subsidy schemes, with €298 million euros in private contributions. This means that on average, 62% of the investments are private contributions.
- Private actors are part of the Mission Teams, prioritizing innovation efforts within MMIPs. By involving the private sector and the demand-side of innovation in aligning our energy innovation investments (from fundamental research to demonstration/implementation), policies, regulations, market conditions and international efforts we aim to create focus and mass in clean energy investments. This provides a more predictable and focussed framework for investors to invest in low-carbon innovations.
- A dedicated investment agency – [Invest-NL](#) – aims to invest in innovative, low-carbon technologies with a higher risk profile. This venture capital should trigger new investments from the private sector to bring innovative technologies onto the market.
- In the Knowledge and Innovation Covenant (KIC) both public and private actors specify their intended contribution to the Dutch mission oriented Topsector policy. This amounts to roughly €355 mln public funds and €590 mln private funds per year (2020–2023) on climate and energy innovation.
- The [Dutch National Growth Fund](#) was created to enhance the structural growth of the Dutch economy. This investment fund will invest €20 billion between 2021 and 2025 in large-scale investment projects and programs with a minimum subsidy

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amount of €30 million per proposal. Each proposal requires a private contribution of at least 50%. Subsidy will be made available in three rounds. In April it was announced that €4,5 billion of the €6,3 billion that the government is making available in the second round is earmarked for projects relevant to the agreements in the Climate Agreement. Hundreds of millions will go, for example, to hydrogen, heat networks and a future-proof living environment. This money will be doubled with private money.



# NORWAY

## 1. Clean Energy Innovation Strategy

### 1.1 Summary

Development of Clean Energy technologies and solutions is a central part of the Norwegian Governments Energy Policy. Most recently this is described in the Government White Paper to the Parliament (Storting), “Meld. St. 11 (2021-22)”. In this document the Government describes the national and international energy situation, with a particular view to climate and energy security challenges, and their policies and measures to meet these challenges. Research, development and market introduction of new clean energy technologies and solutions is an important part of the policy, and the Government has a special focus on CCS, Hydrogen and offshore floating wind power.

The Ministry of Petroleum and Energy established a national energy advisory R&D strategic board in 2008. This body was tasked with developing a national energy R&D strategy. Energy21 is hence the national strategy for climate-friendly energy technology. The strategy presents recommendations to industry, research institutions and allocating authorities. The Energy21-strategy shall support Norwegian energy policy by contributing to increased value creation and secure, cost-effective and sustainable utilisation of Norwegian energy resources. The strategy is revised every fourth year and developed by a board constitutive of industry representatives appointed by the Minister of Petroleum and Energy.

The fifth revision of the strategy was announced June 2022. The updated strategy’s vision is to develop “Europe’s best energy system”. In the strategy, three major challenges were identified: 1) Decarbonisation of transport and industry; 2) Secure, competitive and environmentally friendly energy supply and 3) The development of new, green industries and marine energy technologies. The strategy includes eight priority areas: Hydropower, offshore wind, solar energy, batteries,

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hydrogen and CCS, as well as two core priority areas that are cross-sectoral: Integrated and effective energysystems and energy markets and regulations.

## 1.2 Methodology

The Energy21-strategy has been formulated through an iterative process. In the process, 19 areas of strategic interest within the energy- and transport system have been evaluated. The process can be simplified into three steps:

1. The areas of strategic interest are compared with regards to their respective potential to contribute to the strategy's goals.
2. The areas of strategic interest are compared with regards to their respective potential for innovation and research needs. EU's associated research activities and Norway's potential role within these research areas are also being evaluated in this step.
3. The areas of strategic interest are evaluated altogether with regards to their potential to contribute to the strategy's goals (i.e. the governments long-term energy and climate goals)

Work meetings and ongoing dialogues have been held throughout the process with representatives from authorities, industry actors and research environments. Around 600 participants have contributed to the strategic process for the fifth revision of the strategy. Studies and reports, in addition to the collective competency of the board also plays an important role.



## 2. Clean Energy Innovation Priorities

### 2.1 Overview of Clean Energy Innovation Priorities

**Table 2: CLEAN ENERGY INNOVATION PRIORITIES**

Innovation priority	Focus of national innovation activity (tick all that apply)	Targets/Goals (if applicable) *	Technologies or topics of interest	Total R&D funding allocated (include budget years where applicable)  Numbers in thousands of USD	Planned demonstration investments (include budget years and indicate if domestic or international spending where possible)	Links to existing strategy, roadmap, plans or analysis
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 checked="" type="checkbox"/> Commercialisation Other:	The Norwegian Government will contribute to the development of a coherent valuechain where production, distribution and use of hydrogen are developed in parallel. A Roadmap has been developed for Hydrogen with signposts for the production, distribution and use of hydrogen in 2025/2030 and 2050.	Clean hydrogen production, distribution and utilisation	2018: USD 22 700 2019: USD 19 100 2020: USD 49 400 2021: USD 66 800 committed	Examples of demonstration investments:  2021: NOK 1.6 billion granted three industry projects.  2022: NOK 1.12 billion granted five production plants	<a href="#">Norway 2022 – Analysis - IEA:</a> see page 47 to 49 for a summary of Norwegian hydrogen policy.  <a href="#">Grants to hydrogen projects   Heilo   Enova</a> (in Norwegian)

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					for renewable hydrogen and seven pioneering hydrogen and ammonia-powered vessels.	<a href="#">Enova grants more than 1 billion NOK to three industrial projects.</a> <a href="#">Hydrogen is the climate solution in all three projects   Enova SF</a>  <a href="#">Enova supports hydrogen projects in the maritime sector with NOK 1.12 billion   Enova SF</a>
Offshore wind, with a particular emphasis on floating installations	<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 checked="" type="checkbox"/> Commercialisation Other:	The Norwegian Government aim to open up areas for offshore wind power production that will generate 30 000 MW of power in Norway by 2040. This is nearly equivalent to the amount of electricity currently produced in Norway and will require around 1 500 turbines.	Offshore wind	2018: USD 3 268 2019: USD 2 655 2020: USD 3 087 2021: USD 5 766 2022: USD 10 240 committed	Examples of demonstration investments:  2018: NOK 2.3 billion granted the Hywind Tampen project to establish 11 floating wind	<a href="#">Offshore wind - time line - regjeringen.no</a>  <a href="#">Enova supporting pioneer project - equinor.com</a>

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					turbines at 8,6 MW capacity each. The project will contribute to reductions of about 200 000 tonnes CO <sub>2</sub> -emissions per annum by replacing the gas used to power 5 oil- and gas platforms on the fields of Gullfaks and Snorre.	
CCS	<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 checked="" type="checkbox"/> Commercialisation Other:	The CCS project “Longship”, which is currently under construction, is a key part of the Government’s CCS policy and part of Norway’s contribution to the development of necessary climate technologies. The Government will facilitate commercial CO <sub>2</sub> storage on the Norwegian continental shelf. The Government will contribute to promote CCUS as an important tool in reaching the goals set out by the Paris Agreement.	CCS	2018: USD 16 910 2019: USD 21 400 2020: USD 17 560 2021: USD 17 560 2022: USD 20 240 committed	Examples of demonstration investments:  2021: The Government will grant a total of NOK 16,8 billion to the Longship project.	<a href="https://regjeringen.no/en/tema/Carbon+capture+and+storage-CCS-/regjeringen.no">Carbon capture and storage - CCS - regjeringen.no</a>  <a href="https://regjeringen.no/en/tema/Meld.St.33(2019-2020)/Report+to+the+Storting+(white+paper)/regjeringen.no">Meld. St. 33 (2019–2020) Report to the Storting (white paper) (regjeringen.no)</a>

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Hydrogen

There are many projects under development in Norway with funding from the allocating authorities that plan to produce, distribute and use hydrogen produced with low to zero emissions. Two new research centres for environmentally friendly energy was announced in 2022 on hydrogen and ammonia: [HYDROGENi](#) led by SINTEF and [HyValue](#) led by NORCE. The centres' research will cover the whole hydrogen valuechain and will run from 2022-2030.

Offshore wind

A framework have been established for opening the areas of Utsira North and Southern North Sea II for offshore renewable energy production. The Government plans to carry out the next licensing round for new offshore wind areas in 2025. A new research centre for environmentally friendly energy on offshore wind became operational in 2021, [NorthWind](#). NorthWind is led by SINTEF and will run from 2021-2029.

CCS

The Longship projects includes carbon capture at Norcem's cement factory in Brevik planned operational in 2024, and carbon capture at Hafslund Oslo Celsio's waste incineration facility in Oslo planned operational in 2026. Northern Lights, a collaboration between Equinor, Shell and Total, are building the CO<sub>2</sub> transport and storage part of Longship. Phase one of Northern Lights is to be completed mid-2024 with a capacity of up to 1,5 million tonnes of CO<sub>2</sub> per year.

The research centre for environmentally friendly energy, [NCCS](#) is led by SINTEF and was established in 2016. NCCS has as goal to fast-track CCS deployment through industry-driven, science-based innovation that addresses major barriers identified in CCS demonstration and industry projects. The research centre will operate for eight years from 2016 to 2024.



## 2.2 Tracking Progress (Optional)

The Norwegian Ministry of Petroleum and Energy conducts evaluations on a regular basis focusing on research outcomes concerning in particular new energy production, increased energy efficiency and emission reductions. The number of research publications, PhD- and postdoctorates employed-, and the funding of new research projects are amongst the parameters included in annual reviews of the relevant R&D programmes.

### 3. Private Sector Engagement (Optional)

The SkatteFUNN R&D tax incentive scheme is a Government program designed to stimulate research and development (R&D) in Norwegian trade and industry. The incentive is a tax credit and comes in the form of a deduction from a company's payable corporate tax. To be eligible for the program, companies need to be based in Norway and liable to pay corporate tax to Norway. Furthermore, the company must seek to develop a new or improved product, service or production through a dedicated R&D project that will generate new knowledge, skills and capabilities within the company. Most of the projects that utilises the scheme are small- and medium enterprises. The largest thematic area is the energy system and utilization of energy sources. Most of the projects that is focused on utilizing energy sources are concentrated on offshore wind. Hydropower and solar power are also large areas, and there has been an increased growth in projects within batteries and hydrogen.

## 4. International Collaboration (Optional)

Participation in international programmes for RD&D is considered an important way for Norwegian research- and technology environments to access networks, infrastructure, markets, capital and world-leading competency that goes beyond what national programmes can offer. Particularly important is participation in the Horizon Europe Framework Programme and the European Research Area (ERA). Norway has an ambition to capture 2,8% of the Horizon Europe Framework Programme funding and provides support to contribute to high-quality projects and applications to the programme. Norway also hosts European research infrastructures, including ECCSEL ERIC which is the European Research Infrastructure for CO<sub>2</sub>-capture, utilisation, transport and storage (CCUS). Norway also engages in cooperation with third countries that share similar research priorities, particularly concerning CCS, but also offshore wind and hydrogen.

## 5. National Energy Innovation Ecosystem (Optional)

**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
The Research Council of Norway	The Research Council of Norway is an administrative agency with special powers under the Ministry of Education and Research. It manages research funding from all the Norwegian ministries, and allocates funds to basic and applied research and innovation within all fields and disciplines.	<p>The Norwegian Research Council is responsible for managing most of the public funding available for energy research. The funding is allocated to various programmes and funding schemes that together cover the entire energy field, including energy efficiency, renewable energy and carbon capture and storage.</p> <p>The most important initiatives in the energy field are the research programme ENERGIX and the Centres for Environment-friendly Energy Research (FME scheme).</p>	The programmes employ funding instruments that cover long-term basic and applied research, technology development, small-scale pilot projects and social science research. Public funding is available to cover 100% of the costs of the basic research. Private actors are required to provide at least 50% of the funding for projects further along the innovation chain.	<a href="https://forskingsradet.no/en/energy-transport-and-low-emissions-portfolio">Energy, transport and low emissions - portfolio (forskingsradet.no)</a>
Gassnova	Gassnova SF is a state-owned enterprise owned by the Ministry of Petroleum and Energy. Gassnova SF works to ensure that capture, transport and storage of CO <sub>2</sub> (CCS) can become a relevant solution in mitigating climate change. The main	CLIMIT is a national programme for research, development and demonstration of technologies for capture, transport and storage of carbon.	CLIMIT supports projects in all stages of the development chain, from long-term basic research to build expertise to demonstration projects for CCS technologies. The main focus is on technology development, but it is also considered important to identify	<a href="#">About the CLIMIT programme and the funding opportunities</a>

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	goal is to promote cost-effective and future-oriented solutions for CCS. By facilitating technology development and sharing experience from developing the “Longship” CCS Project in cooperation with the industry players.	The CLIMIT programme involves collaboration between Gassnova SF and the Research Council of Norway. The Research Council manages research and development, while Gassnova manages piloting and demonstration activities. The board for the CLIMIT programme makes decisions on funding awards.	opportunities for future commercialisation and value creation in Norwegian industry.	
Enova	Enova SF is a state enterprise owned by the Ministry of Climate and Environment. Its task is to promote a shift towards more environmentally friendly energy consumption and production, as well as the development of energy and climate technology.	Enova supports companies in the public and private sector with necessary capital expenditure for implementing energy- and climate friendly solutions. Enova contributes to the wider utilisation of well-known technologies.	The funding covers projects from the pilot phase to commercialisation, assisting companies with testing out the technology and demonstrating that it works under ordinary conditions.	<a href="#">About Enova – Learn about our work   Enova</a>
Innovation Norway	Innovation Norway is a state-owned enterprise owned by the Ministry of Trade, Industry and Fisheries and county municipalities. It promotes nationwide industrial development to both the business economy and Norway’s national economy, and helps release the potential of different districts and regions by contributing towards innovation, internationalisation and promotion.	Under the Environmental Technology Scheme Innovation Norway provides grants for development and demonstration of innovative products or processes that solve an environmental problem. The scheme provides grants for innovation projects. The purpose of an innovation project is to develop or significantly improve a new product, process or services. At the core of the project are research and development activities. Grants for innovation projects are	Funding provided by Innovation Norway will be based on an overall assessment of the enterprise and project. The grant will only partially cover project costs; additional funding must be obtained from other sources.	<a href="#">Grants for Environmental Technology (innovasjon.no)</a>

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		intended to strengthen the enterprise’s competitiveness and trigger the potential for sustainable growth. The overarching goal is lasting value creation in Norway.		
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# REPUBLIC OF KOREA

## 1. Clean Energy Innovation Strategy

### 1.1 Summary

Korea is pursuing clean energy innovation based on its 4th Energy Technology Development Plan (2019–2028), which comprises the nation's R&D strategy to meet the national basic energy plan's policy targets and the Carbon Neutral Industry/Energy R&D Strategy aimed at achieving its NDC. In October 2021, Korea confirmed its GHG emissions target for 2030 at a 40% reduction from the 2018 amount.

**1. The 4th Energy Technology Development Plan (2019):** Make focused investments in 16 major technologies to nurture the new energy industry, supply clean and safe energy, innovate into a high efficiency/low consumption structure, and spread distributed-type energy. The 16 major technologies include solar energy, wind power, hydrogen, advanced energy materials, nuclear power, clean power generation, resource development, recycled resources, energy safety, energy efficiency of buildings, industrial efficiency, transportation efficiency, big data, smart grid, energy storage, and cyber security.

**2. Carbon-neutral Industries/Energy R&D strategy (2021):** Korea also announced focused areas for carbon neutrality R&D to achieve its NDC. The strategy was established to transform the structure of carbon neutral industry/energy, supply/spread carbon neutral technology, and create new industries/jobs related to carbon neutrality.

**3. 2050 Carbon Neutral Energy Technology Roadmap (2021):** Korea established a roadmap for the 13 energy fields to achieve its 2030 GHG reduction target (NDC) and Carbon Neutral Industry/Energy R&D Strategy. The 13 technologies include photovoltaic, wind, clean fuel power generation, green hydrogen, energy storage, power system, sector coupling, industrial complex/buildings, energy

facility, resource circulation, oil refining, and CCUS.



## 1.2 Methodology

When establishing the 2050 Carbon Neutral Energy Technology Roadmap, subcommittees composed of experts from companies, research centers, and universities by major energy technology area were established and reviewed the entire process from technology development to commercialization, including technology development strategy, international cooperation, talent-nurturing, standardization, and certification, etc. Technologies that should be developed with priority were identified, and the areas required for successfully commercializing technologies to achieve the national policy targets were developed and solutions were prepared. Contents from each subcommittee were reviewed by the steering committee and finally confirmed through public hearings.

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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
<b>4th Energy Technology Development Plan</b>	R&D strategy to achieve the policy targets of the national basic energy plan	Nurturing the new energy industry, supplying clean and safe energy, innovating into a high-efficiency/low consumption structure, spreading distributed-type energy	2019
<b>Carbon-neutral Industry / Energy R&amp;D strategy</b>	Developing core technologies in the 17 focused areas of carbon neutral industry/energy R&D, dividing them into technologies to achieve NDC in 2030 and technologies to realize carbon neutrality in 2050, and presenting the development timeline by stage	Selecting carbon-free power generation, renewable energy, hydrogenation, system advancement, energy storage, and high energy efficiency as major areas for carbon neutrality and providing focused support for technology development	2021
<b>2050 Carbon Neutral Energy Technology Roadmap</b>	short-, mid-, long-term technology Acquisition strategy to achieve 2050 carbon neutrality	Roadmap presented the development schedule and securing of 197 key technologies in 13 areas (clean fuel power generation, fuel cell, solar power, power system, sector coupling, energy storage, green hydrogen, industrial buildings, resource circulation, CCUS, energy facilities, oil refining)	2021

## 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, (include budget years where applicable)
<b>Clean fuel power generation</b>	<input type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input checked="" type="checkbox"/> Product development <input checked="" type="checkbox"/> Demonstration <input checked="" type="checkbox"/> Commercialisation Other:	Commercialize hydrogen and ammonia based carbon free power generation technology replacing LNG gas turbines	Technologies to improve the efficiency of hydrogen turbine combined power generation  Ammonia turbine technology	To be decided
<b>Fuel cells</b>	<input 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:	Develop a MW scale combined power generation system based on fuel cells with over 65% generation efficiency	Commercial fuel cell-based combined power generation system in over MW scale Technologies to maximize the operating ratio of fuel cell system based on renewable energy	To be decided
<b>PV</b>	<input type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input checked="" type="checkbox"/> Product development <input checked="" type="checkbox"/> Demonstration <input checked="" type="checkbox"/> Commercialisation	Overcome the marginal efficiency in the mass production of c-Si (30%), develop innovative technologies to diversify PV installation environment	c-Si based tandem PV module  Deployment of PVs through innovative diversification of installation site	To be decided

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	Other:	(floating, offshore, agro, building		
<b>Wind power</b>	<input type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input checked="" type="checkbox"/> Product development <input checked="" type="checkbox"/> Demonstration <input checked="" type="checkbox"/> Commercialisation Other:	Commercialize floating offshore wind as a main business, scale up wind power generation platforms and develop large-scale wind farm	Commercialize the full-scale floating offshore wind power system  Integrate power grid to GW offshore wind farms and develop energy conversion technologies	To be decided
<b>Green hydrogen</b>	<input type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input checked="" type="checkbox"/> Product development <input checked="" type="checkbox"/> Demonstration <input checked="" type="checkbox"/> Commercialisation Other:	100MW scale green hydrogen production and secure hydrogen liquefaction system capable of long - distance, high-volume transportation	Mass production of green hydrogen from renewable energy  Develop a liquid hydrogen system capable of long-distance and high-volume transportation	To be decided
<b>Energy storage</b>	<input type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input checked="" type="checkbox"/> Product development <input checked="" type="checkbox"/> Demonstration <input checked="" type="checkbox"/> Commercialisation Other:	Develop ESS for large capacity/long-period, and for short-period power stabilization, develop ESS for distributed power grid	Large capacity energy storage hub system  Ultra speed, long ESS for EV charging	To be decided
<b>Electricity Grid</b>	<input type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input checked="" type="checkbox"/> Product development <input checked="" type="checkbox"/> Demonstration <input checked="" type="checkbox"/> Commercialisation Other:	Build grid network flexible to the renewable energy volatility, inter-national grid network, optimal integrated operation of flexible power sources	Develop AC/DC hybrid electrical power system and operating technologies DSO-based technologies for flexible and integrated operation of power sources	To be decided
<b>Sector coupling</b>	<input type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input checked="" type="checkbox"/> Product development <input checked="" type="checkbox"/> Demonstration <input checked="" type="checkbox"/> Commercialisation Other:	X2P with renewable energy, regenerative heat from non-electric energy, large scale hydro power and compressed air energy storage system	Carnot battery thermal energy storage technology  Next-gen Fuel-Emissions Free CAES (Compressed Air Energy Storage) system	To be decided

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<b>Building/ Factory</b>	<input type="checkbox"/> Early-stage research <input checked="" type="checkbox"/> Applied research <input checked="" type="checkbox"/> Product development <input checked="" type="checkbox"/> Demonstration <input checked="" type="checkbox"/> Commercialisation <input type="checkbox"/> Other:	Strengthen digital demand management, optimize energy supply and use, introduce DC distribution and optimize its design	Develop technologies to improve the real-time operation efficiency based on data  Interactive energy community technologies	To be decided
<b>Industrial Facility</b>	<input 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 <input type="checkbox"/> Other:	Electrify/decarbonize high energy-consuming devices, optimum use and supply of thermal energy, sustainable energy supply management	Develop technologies to improve the efficiency of industrial motors and motor inverters  Increase the supply temperature range of heat pump	To be decided
<b>Resource recycle</b>	<input 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 <input type="checkbox"/> Other:	Expand and advance remanufacturing industry and related technologies, maximize industrial use of recycled resources, build infrastructure for low carbon based circular economy	Remanufacturing/industrial materials technologies  LCI DB development technologies	To be decided
<b>Refinery</b>	<input 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 <input type="checkbox"/> Other:	Produce zero carbon fuels available to use in refinery process, bio crude oil manufacturing technologies by using the existing infrastructure	Carbon free heat source (hydrogen, etc.) alternative technologies  Next-gen bio crude oil manufacturing technologies	To be decided
<b>CCUS</b>	<input 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 <input type="checkbox"/> Other:	Develop low cost carbon capture technologies, develop CO2storage in-house technologies and carry out integrated demonstration, commercialize CCU products and process early	CO2 capture technologies emitted by power generation facilities and industry CO2 offshore/underground storage construction and operating technologies	To be decided

## 2.2 Tracking Progress (Optional)

- Every year, detailed execution plans, including on current status diagnosis, basic direction on energy R&D, implementation strategies, and initiatives, etc., are prepared through establishing the implementation plan (draft) on energy technology development.
- The comprehensive evaluation (interim evaluation) is conducted every three years by the Ministry of Science and ICT (MSIT), which generally manages national R&D, for the efficient implementation of the national energy technology development projects.

### 3. Private Sector Engagement (Optional)

- Consulting support to strengthen business development capabilities and to supply/spread technology development results of energy companies
- Establishing business models, supporting patents and technologies, and financing, etc.
- Technology valuation, prototype-making, and market entry consulting, etc

## 4. International Collaboration (Optional)

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).

- Korea is working on joint international energy research projects with the US, Norway, Germany, Australia, China, and India among MI member states. Some of the projects participated in by institutions from the US, Norway, Australia, China, and India are being pursued based on MOUs signed between the respective governments. Korea is also participating in joint international energy research projects with non-members of MI including Singapore, Palau, Spain, the Czech Republic, the Philippines, Vietnam, Thailand, Mongolia, and Malaysia.
- Establishing opportunities to build diverse cooperation systems through participating in multilateral cooperative bodies and multilateral cooperative meetings including IEA and CSLF, etc.



## 5. National Energy Innovation Ecosystem (Optional)

**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
<b>Korea Institute of Energy Technology Evaluation and Planning</b>	<ul style="list-style-type: none"> <li>·Energy R&amp;D funding agency under Ministry of Trade, Industry and Energy in Korea, which undertakes roles in planning, evaluating, and managing national energy R&amp;D Projects.</li> <li>·Main function vary from Energy Technology Policy Planning, Project Planning, Evaluation and Management, International Cooperation and to Education and Training for undergraduate.</li> </ul>	·R&D support for overall energy technology	government grants, subsidy, where in tech development cycle focused	<a href="http://www.ketep.re.kr">www.ketep.re.kr</a>
<b>Korea Energy Agency</b>	·Korea Energy Agency was established to reduce GHG emission and to contribute to the healthy economic development through efficient implementation of energy use rationalization projects.	·From energy audit service, identifying energy saving potential in energy intensive businesses, to systematical optimization of building and industrial energy consumption pattern using ICT	government grants, subsidy, where in tech development cycle focused	<a href="http://www.energy.or.kr">www.energy.or.kr</a>
<b>Korea Institute of Energy Research</b>	·It aims to contribute to the creation of national growth engines and the development of the national economy through R&D and spread of achievements in the energy technology area	<ul style="list-style-type: none"> <li>·Renewable Energy R&amp;D</li> <li>·Hydrogen Energy R&amp;D</li> <li>·Convergence &amp; Complex R&amp;D</li> <li>·Carbon-based Clean Energy Utilization R&amp;D</li> <li>·Energy Efficiency R&amp;D</li> </ul>	government grants, private funding	<a href="http://www.kier.re.kr">www.kier.re.kr</a>

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<b>Korea Electrotechnology Research Institute</b>	·Korea Electrotechnology Research Institute (KERI) has been playing a central role in the advancement of scientific technology and industrial development in Korea by leading R&Ds and testing in the electric power, electricity and electric utility fields.	·R&D of power technologies and power systems of renewable energy ·R&D of electrical apparatus ·R&D of electrical parts and materials ·R&D of convergence technology based on electro-medical device and electrical technology	government grants, private funding	<a href="http://www.keri.re.kr">www.keri.re.kr</a>
<b>Korea Institute of Machinery &amp; Materials</b>	·KIMM is paving the way in turning the imaginary technologies - such as sustainable energy technology, environment-friendly technology for the Earth, or the safe and reliable mechanical technology - into real practical technologies	·Advanced manufacturing systems ·Nano and machinery meet to lay the foundation to a new industry ·Energy systems ·Environment system ·Mechanical systems safety	government grants, private funding	<a href="http://www.kimm.re.kr">www.kimm.re.kr</a>
<b>Korea Institute of Industrial Technology</b>	·Implementing technology transfers and dissemination to SMEs ·Providing technology support utilizing its technology, human resources, and infrastructure ·Developing technologies to overcome common technological hardships experienced by SMEs ·Conducting in-depth research for demand-oriented production technologies	KITECH focuses on three key research areas: root industry technology, clean manufacturing system technology, and industry convergence technology. KITECH strives to strengthen the fundamentals of Korean industries by carrying out demand-oriented R&D and application activities and securing original technologies for the future.	government grants, private funding	<a href="http://www.kitech.re.kr">www.kitech.re.kr</a>
<b>Korea Research Institute of Chemical Technology</b>	·the Korea Research Institute of Chemical Technology (KRICT) has played a leading role in the advancement of the nation's chemical industry, namely, developing technology in chemistry and related fields, transferring chemical technology to industries, fostering	·Chemical & Process Technology ·Advanced Materials ·Therapeutics & Biotechnology ·Specialty and Bio-based Chemical Technology ·Chemical Platform Technology ·Center for Low-Chemical Progress	government grants, private funding	<a href="http://www.kRICT.re.kr">www.kRICT.re.kr</a>

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	experts and leaders, and providing a wide range of infrastructure supporting services.			
<b>Korea Institute of Geoscience and Mineral Resources</b>	<ul style="list-style-type: none"> <li>·Geo-information &amp; Geotechnology for public safety &amp; awareness</li> <li>·Mineral resources utilization &amp; recycling technology for the mining industry</li> <li>·Original technology for petroleum &amp; gas resources to secure energy in the future</li> <li>·New geo-technology on global climate change</li> </ul>	KIGAM emphasizes on research in five fields: Geology, Mineral Resources, Petroleum & Marine, Geologic Environment and Geoscience platform.	government grants, private funding	<a href="http://www.kigam.re.kr">www.kigam.re.kr</a>
<b>Korea Institute of Science and Technology</b>	<ul style="list-style-type: none"> <li>·Preemptive response to the super-aging era by developing technologies to overcome brain diseases and disabilities</li> <li>·Establishment of the foundation for the 4th industrial revolution by preoccupying advanced robot and big data-based technologies</li> <li>·Continuous discovery of innovative growth engines by leading the source technology of next-generation computing and composite materials</li> <li>·Leading the realization of a sustainable society by developing technologies for climate, disaster, and safety</li> </ul>	<ul style="list-style-type: none"> <li>·Brain science</li> <li>·Post-silicon semiconductor</li> <li>·Artificial Intelligence and Robot</li> <li>·Climate and Environmental Research</li> <li>·Biomedical research</li> <li>·Advanced materials research</li> <li>·Clean energy research</li> <li>·Research Resources</li> </ul>	government grants, private funding	<a href="http://www.kist.re.kr">www.kist.re.kr</a>

# SAUDI ARABIA

## 1. Clean Energy Innovation Strategy

### 1.1 Summary

**Innovation is a priority for many developed economies as lever for socio-economic growth, global leadership, and achieving national ambitions.** As a result, **a framework for developing an effective innovation ecosystem** throughout the stages of the innovation journey **was developed**. We have identified two components in the **energy innovation ecosystem to be successful in KSA:**

- 1) Identifying **innovation focus areas** that support energy sector ambitions and address its challenges
- 2) Developing an innovation **enablement ecosystem** that catalyzes deploying innovative ideas
- 3)

The Innovation initiatives will include both **long-term (“develop-to-ready” the strategic focus areas that require longer-term research & development) and short-term (“ready-to-deploy” the mature innovative ideas requiring a push for commercialization) efforts** in the innovation focus areas and prioritized using defined criteria. An **Energy Innovation Steering Committee** with stakeholders from government, industry, and research **will govern the energy innovation** agenda to ensure alignment and effective delivery.

1. Defining an effective focused innovation requires having clear KSA energy sector strategic directions and priorities. A model was designed to analyse energy sector priorities, address challenges and mitigate risks, the model is utilized through engagements with energy pillars which are oil, gas, Refining and petrochemicals, power, renewables and nuclear, hydrogen and carbon.

2. We have created a functional innovation framework by defining the role of innovation in the energy ecosystem, identifying innovation focus areas and alignment with all energy pillars on projects and priorities and Establishing a robust innovation enablement system. We are also working to resolve pressing energy sector challenges and risks, increase the level of collaboration within the ecosystem, bridge R&D and industry gaps to create value, enable ecosystem entrepreneurship & embed innovation culture in the energy ecosystem.

## 1.2 Methodology

The innovation strategy was developed and adopted by implementing several steps. One of the most important steps is to benchmark and embrace the best practices that were implemented globally by developed countries. Leading the innovative countries, we have created an integrated framework supporting focused innovation journey along four dimensions, knowledge, Resources & Policies, Users & Market, Network & Value Chain. Different elements of innovation framework dimensions were combined resulting in a successful innovation outcome. Secondly, we have integrated the four dimensions into the country frame work and we have assessed the country strengths and weaknesses in each dimension. After that we have implemented a model where we will reinforce our strengths and eliminate our weaknesses by identifying and expediting the implementation of our strategic priorities, resolving our challenges and mitigating the risks. Moreover, the KSA energy ecosystem set several ambitious national targets that will require innovation solutions which are oil, gas, Refining and petrochemicals, power, renewables and nuclear, hydrogen and carbon. Finally, we have defined the energy innovation focus areas that follows a **“develop-to-deploy”** methodology via two types of innovation approaches, the first is **Develop-to-Ready** and the second is **Ready-to-Deploy**. This methodology will engage key stakeholders in workshops focused on integrated energy strategy, draft innovation focus areas jointly with all related stakeholders from the energy ecosystem, identify ideas/projects under each focus areas from different platforms and review with energy ecosystem leadership for alignment and endorsement, prioritize ideas/projects based on set criteria and develop execution plans and define key enablers needed for success.

ALL MI MEMBER COUNTRIES – SAUDI ARABIA

**Table 1: RELEVANT DOCUMENTS AND POLICIES**

<b>Document or policy name</b>	<b>Description of the document or policy</b>	<b>Specific outcomes, goals or targets identified in the document or policy</b>	<b>Year</b>	<b>Web Link(s)</b>
KSA. NDC	Saudi Arabia nationally determined contribution (NDC) under UNFCCC Paris Agreement	The Kingdom aims at reducing, avoiding, and removing GHG emissions by 278 million tons of CO <sub>2</sub> eq annually by 2030 – a more than two-fold increase versus the previous ambition as outlined in the Kingdom's INDC (130 million tons of CO <sub>2</sub> eq). Thus, ambition represents progression and the highest possible ambition. Furthermore, by supporting mitigation efforts in other countries (e.g., Middle East Green Initiative), Saudi Arabia's efforts extend beyond its borders.	2021	<a href="https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/United%20States%20of%20America%20First/United%20States%20NDC%20April%2021%202021%20Final.pdf">https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/United%20States%20of%20America%20First/United%20States%20NDC%20April%2021%202021%20Final.pdf</a>

## ALL MI MEMBER COUNTRIES – SAUDI ARABIA

<i>Saudi Arabia Green Initiative (SGI)</i>	<p>SGI works with entities and organizations across the Kingdom to amplify their existing climate actions and create opportunities for new initiatives. SGI also bridges the gap between public and private sustainability efforts, identifying opportunities for collaboration and innovation.</p>	<p>SGI brings together environmental protection, energy transformation and sustainability programs to work towards three overarching targets to achieve a common goal of a green future.</p> <ol style="list-style-type: none"> <li>1- Reducing Emissions: Reduce carbon emissions by more than 278 mtpa by 2030.</li> <li>2- Greening Saudi: Plant 10 billion trees across Saudi Arabia</li> <li>3- Protecting land and sea: Raise protected areas to more than 30% of total marine and terrestrial area</li> </ol> <p>Protect at least 30% of the global ocean in Marine Protected Areas (MPAs) and Other Effective area-based Conservation Measures (OECMs) by 2030.</p> <p>Contribute to UNFCCC climate action by supporting and guiding sports actors in achieving global climate change goals and displaying climate leadership.</p>	2021	<a href="https://www.saudigreeninitiative.org/about-saudi-green-initiative/">https://www.saudigreeninitiative.org/about-saudi-green-initiative/</a>
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## ALL MI MEMBER COUNTRIES – SAUDI ARABIA

		Cut global methane emissions by 30% by 2030 through the six-sector solution proposed by UNEP.		
<i>Medial East Green initiative (MGI)</i>	MGI is a catalyst for global impact, creating an economy of scale for climate action.	<p>There are 3 pillars that defines MGI strategic environmental aims:</p> <ol style="list-style-type: none"> <li>1- Knowledge Transfer.</li> <li>2- Environmental Stewardship.</li> <li>3- Forward-thinking innovative climate solutions.</li> </ol> <p>Plant 50 billion trees across the Middle East (including 10 billion at home in Saudi Arabia). Restore an area equivalent to 200 million hectares of degraded land, helping reduce CO2 by 2.5% of global levels.</p> <p>To enable the achievement of the Middle East Green Initiative goals,</p>	2021	<a href="https://www.saudigr eeeninitiative.org/about-middle-east-green-initiative/">https://www.saudigr eeeninitiative.org/about-middle-east-green-initiative/</a>



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		<p>the Kingdom of Saudi Arabia announced during the summit that it will establish the following:</p> <ul style="list-style-type: none"><li>• Co-operative Platform to accelerate implementation of the Circular Carbon Economy (CCE)</li><li>• Regional Hub for Climate Change</li><li>• Regional Center for Carbon Extraction Use and Storage</li></ul> <p>The Kingdom additionally announced a regional initiative for clean fuel solutions for cooking for that will benefit more than 750 million people worldwide, and the establishment of a Regional Investment Fund for Circular Carbon Economy (CCE) technology solutions. The total investment in these two initiatives is approximately SAR 39 billion and the Kingdom will contribute to financing approximately 15% of it.</p>		
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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, (include Budget years where applicable)	Planned demonstration Investments (include budget years and indicate if domestic or international spending where possible)	Links to relevant reports or plans
CCE Abatement: CCUS & 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 checked="" type="checkbox"/> Commercialisation Other:	CCUS: Total Co2 managed by 4R's which is reduce, reuse, recycle & remove is going to be 531 MtCO2 by 2040. Volume reduced of CO2 by 278 MtCO2 by 2030. Hydrogen: Total clean H2 production capacity 4 Mtpa by 2030.		Carbon Capture Tech. Carbon utilization. Sequestration. H2 production (e.g. Electrolysers) H2storage H2 transport H2 utilization		<a href="https://www.cce.org.sa/">https://www.cce.org.sa/</a>
CCE Avoidance & Removal: Renewable energy: Solar, Wind, Direct Air Capture	<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 checked="" type="checkbox"/> Commercialisation Other:	Energy mix, installed generation capacity up to 50 % by 2030 of the total energy generated.	Renewable generation and integration. Energy Storage. Direct Air Capture			<a href="https://www.kapsarc.org/research/publication/">https://www.kapsarc.org/research/publication/</a>

### 3. Private Sector Engagement (Optional)

The Saudi Arabia Ministry of Energy is coordinating and closely monitoring the following projects:

- **Geothermal Energy Exploration:**  
Some recent reports on geothermal energy show that Saudi Arabia is rich in terms of different geological characteristics and geothermal activity and is qualified to contribute effectively to the domestic energy supply. This geothermal exploration project aims to have a better understanding of the subsurface conditions in Al-Lith area and assess the possibility of having a geothermal reservoir. This project involves Preliminary and Geoscientific studies (Geological, geophysical, and geochemical studies) in collaboration with TAQA.
- **Cryogenic Carbon Capture Technology:**  
An internal study showed that an emerging technology that has not yet been commercially developed in global markets, and owned by one of the world's leading companies in the field of carbon management, the American Company Chart, is based on capturing and reusing cryogenic CO<sub>2</sub> more efficiently than traditional techniques, and its estimated cost is lower up to \$ 34 per ton of carbon dioxide. For this reason, the Ministry, in partnership with King Abdullah University of Science and Technology, the NEOM project and the American Company Chart, has adopted the development of a plan for a pilot plant with a lifespan of up to 5 years in a power plant adjacent to the industrial areas on the West Coast, with the aim of designing and constructing a 30- tons CO<sub>2</sub> capture unit and a cryogenic CO<sub>2</sub> production.
- **Direct Air Capture technology development in collaboration with ARAMCO and KAUST:**  
As part of KAUST Circular Carbon Initiative (CCI), the CO<sub>2</sub> Capture thrust focuses on the demonstration of direct air capture (DAC) technology encompassing metal-organic-framework (MOF) developed at KAUST and will collaborate with Aramco on the development and upscaling of new adsorbents to process design, cost estimation, environmental analysis and small-scale demonstration.

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- Membrane-based CO<sub>2</sub> capture study in collaboration with ARAMCO:  
Carbon Dioxide is being emitted as a Tail Gas of Sulfur Recovery Units (SRU). A membrane carbon capture unit is proposed on this stream which contains approximately 22% CO<sub>2</sub> by mole (wet basis). A typical carbon capture system design consists of a two-stage membrane process that, based on preliminary calculations, can produce a CO<sub>2</sub> product stream of at least 98% purity at a capture rate of approximately 90%. The introduced Membrane Carbon Capturing Technology is currently at TRL 6 where the technology needs to be assessed to determine its feasibility for this particular application before demonstration in a relevant environment.

## 4. International Collaboration (Optional)

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).

Saudi Arabia has joined the mission innovation believing that the mission innovation will act as catalyst to excel the investment in research, development and demonstration to make clean energy affordable, attractive and accessible to all this decade. The kingdom is an active member in three missions, the clean hydrogen mission and the green powered future mission (GPFM), along with co-leading the carbon dioxide removal mission (CDR), the CDR mission will catalyse the advancement in research and development in CDR technologies such as the direct air capture which is promising and important technology for Saudi Arabia.

Saudi Arabia has established a global collaboration with a variety of different world-wide countries, from the far East with Japan, Korea and China to the far west with Canada and USA. All the collaborations are directly working to protect the climate while sustaining the global energy security. The collaboration varies from one country to another. On the other hand, many collaboration opportunities are common between all countries. One of the most important collaborations is the circular carbon economy where we can collaborate on infrastructure development projects for carbon circular economy applications (such as CCUS, and DAC), also to identify areas of cooperation in relation to clean hydrogen technologies in relation to hydrogen transportation and storage, and exchange expertise and experiences to apply best practices in the field of hydrogen projects more over to develop policy, legislation and build awareness of the hydrogen economy. cooperation and exchange of experiences to promote innovation and the use of artificial intelligence in the field of energy

## 5. National Energy Innovation Ecosystem (Optional)

**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
KFUPM KAUST KSU KAU	Execute & coordinates the R&D and innovation of key common technologies, cutting-edge leading technologies, modern engineering technologies and disruptive technologies, and take the lead in organizing major technology research.	CCE: CCUS & Hydrogen CCE : Renewable energy: Solar, Wind		1- <a href="http://www.kfupm.edu.sa/Default.aspx">http://www.kfupm.edu.sa/Default.aspx</a> 2- <a href="https://www.kaust.edu.sa/en">https://www.kaust.edu.sa/en</a> 3- <a href="https://ksu.edu.sa/">https://ksu.edu.sa/</a> 4- <a href="https://www.kau.edu.sa/Home.aspx">https://www.kau.edu.sa/Home.aspx</a>
KACST	Providing support for scientific research and technological development. Conducting applied scientific research and technological development. Coordinating national activities in the fields of science, technology and innovation. Strengthening local and international partnerships for technology transfer, localization and development. Providing	CCE: CCUS & Hydrogen CCE : Renewable energy: Solar, Wind		1- <a href="https://www.kacst.edu.sa/">https://www.kacst.edu.sa/</a>

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	consultations, services and innovative solutions. Investing in technology development and its commercial processes.			
KAPSARC	Advance the understanding of energy economics and to act as a catalyst for dialogue, charting a path to better welfare for societies, locally and globally.	CCE: CCUS & Hydrogen		<a href="https://www.kapsarc.org/research/publications/">https://www.kapsarc.org/research/publications/</a>
K.A.CARE	conducts applied research to serve sustainable development and provide recommendations regarding renewable energy and atomic energy on the national scale.	CCE : Renewable energy: Solar, Wind		<a href="http://www.kacare.gov.sa">www.kacare.gov.sa</a>
ARAMCO SABIC SEC ACWA POWER	Execute & coordinates the R&D and innovation of key common technologies, cutting-edge leading technologies, modern engineering technologies and disruptive technologies, and take the lead in organizing major technology research. and application demonstration of achievements.	CCE: CCUS & Hydrogen CCE : Renewable energy: Solar, Wind		1- <a href="https://www.aramco.com/?utm_source=googleads&amp;utm_medium=ppc&amp;utm_campaign=GO_KSA_Brand_EX&amp;gclid=Cj0KCQjwlemWBhDUARIsAFpIrLUsWFD6QMj8b-JaiG2zCLWyJEOHzZd2bdEU_BanGShrmYDXIMa5lcaArSMEAL">https://www.aramco.com/?utm_source=googleads&amp;utm_medium=ppc&amp;utm_campaign=GO_KSA_Brand_EX&amp;gclid=Cj0KCQjwlemWBhDUARIsAFpIrLUsWFD6QMj8b-JaiG2zCLWyJEOHzZd2bdEU_BanGShrmYDXIMa5lcaArSMEAL</a>

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				<a href="#">w_w cB</a> 2- <a href="https://www.sabic.com/en">https://www.sabic.com/en</a> 3- <a href="https://www.se.com.sa/en-us/Pages/home.aspx">https://www.se.com.sa/en-us/Pages/home.aspx</a> 4- <a href="https://www.acwapower.com/en/">https://www.acwapower.com/en/</a>
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# SWEDEN

## 1. Clean Energy Innovation Strategy

### 1.1 Summary

Government bills stating the resources, activities and goals for Energy R&I are presented regularly to Parliament (Riksdag). The national clean energy innovation strategy is currently set out in the Government bill 2016/17:66 “Research and innovation in the energy area for ecological sustainability, competitiveness and security of supply” and the resulting decision by Parliament . The implementation is also given detailed instructions in the annual Letter of appropriation.

The overall goal of the Energy R&I strategy is to contribute to reaching established goals on energy and climate, the long-term energy and climate policy and energy related environment policy goals. Focus should be on areas that can contribute to economic growth and international trade.

To accomplish this, energy R&I should:

- build scientific and technological knowledge and competence to enable the transition to a sustainable energy system,
- develop technologies and services that can be implemented in Sweden or elsewhere, and to
- contribute to and make use of international energy cooperation.

The main current goals established by Parliament are

- 50 % more efficient energy use by 2030 in relation to 2005 .
- 100 % renewable electricity production by 2040, while not excluding nuclear production<sup>2</sup>.
- No net greenhouse gas emissions by 2045 .

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The main activity of the clean energy research and innovation efforts is a broad programme of research, development, pilot- and demonstration projects, as well as commercialisation and product development that is implemented by the Swedish Energy Agency.

In addition, there are also the following support mechanisms:

- The Industrial Leap programme supports pilot studies, research, demonstration, and investment to decrease greenhouse gas emissions from industry, to achieve net-zero emissions and strategic industry projects contributing to climate mitigation. The 2022 budget has increased from 750 million SEK in 2021 to 909 million SEK.
- The national strategy for electrification of industry and transport has been launched by the Government. Implementation is being initiated and a number of tasks are given to government agencies to carry out.
- The Swedish Energy Agency supports a special R&I effort for aviation biofuels or electric aviation with a funding of 50 million SEK 2021 and 50 million SEK 2022.
- A system of state credit guarantees for green investments is in operation.
- The investments of the Almi Invest GreenTech Fund continue to back Swedish early-stage start-ups that significantly reduce greenhouse gas emissions.

## 1.2 Methodology

Different initiatives of intervention are formulated through the overall methodology of Swedish governance, e.g., through Government bills to Parliament, through the Budget bill or through special tasks given to Government agencies. Preparation is done through e.g., the work of a committee, through public consultations, etc. as appropriate in relation to the dignity of the proposal.

Regarding the periodic Government Bills on the programme on Energy Research and Innovation, these are based on input from the Swedish Energy Agency, as well as the six main research funding agencies, and overall evaluations of the work in the programme.

The detailed strategy for the Energy Research and Innovation Programme is then developed by the Swedish Energy Agency.

In general, the strategy evolves through extensive consultations with the research community, industry, and society in various energy system areas. Key challenges and thematic areas are identified.

The funding is both top down and bottom up.

Much of the R&D is implemented using R&D Programmes, consortia, or centres of different kinds. To launch such an effort, “Programme” decisions are taken that spell out

- Programme Vision
- Goals and their relation to political goals, environmental goals, or the UN SDGs.
- Programme goals: i.e., what the programme activities are to result in during the active phase, and
- Indicators to follow progress

There are of course also time plans, budgets and a description of scope and activities eligible for funding. In general, an external advisory committee leads the programme implementation.

Support for demonstration, business and product development and commercialisation are to a great extent bottom up, depending on applications from small and medium sized businesses.

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**Table 1: RELEVANT DOCUMENTS AND POLICIES**

<b>Document or policy name</b>	<b>Description of the document or policy</b>	<b>Specific outcomes, goals or targets identified in the document or policy</b>	<b>Year</b>	<b>Web Link(s)</b>
Government Bill Research and innovation in the energy area for ecological sustainability, competitiveness and security of supply”	Decision on goals and guidelines for the funding of energy Research and Innovation by the Swedish Energy Agency	As described in Summary	2016/17	<a href="#">Forskning och innovation på energiområdet för ekologisk hållbarhet, konkurrenskraft och försörjningstrygghet Proposition 2016/17:66 – Riksdagen</a>
The Industrial Leap	Support to pilot studies, research, demonstration, as well as investment to decrease greenhouse gas emissions from industry, etc	R&I and investment projects to decrease climate impact of industry.	2022	<a href="#">The Industrial Leap (energimyndigheten.se)</a>
Government Bill on Energy Policy	Decisions on energy policy and goals	Sets out the energy policy of Sweden	2017/18	<a href="#">Energipolitikens inriktning Proposition 2017/18:228 – Riksdagen</a>

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Government Bill on Climate Policy Framework	Decisions on climate policy and goals	Sets out the climate policy of Sweden	2016/17	<a href="#">Ett klimatpolitiskt ramverk för Sverige Proposition 2016/17:146 – Riksdagen</a>
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## 2. Clean Energy Innovation Priorities

### 2.1 Overview of Clean Energy Innovation Priorities

The clean energy innovation priorities of the energy research and innovation programme are carried out in a framework of thematic areas, viz.: 1) Energy in the Transport System, 2) Energy in Buildings, 3) Energy in Industry, 4) Bioenergy, 5) Electricity Production and the Electricity System, 6) Sustainable Society, 7) Energy Systems Studies, 8) Business Development and Commercialisation, and 9) International Collaboration.

In these areas, there are more than 55 different programmes, centra or consortia, each with their specific scope, approach, and goals. In addition, there are individual projects as well as clusters.

In all these R&I activities, the type of projects is determined by the specific challenges of the project/programme topic: basic energy related research, research, applied research, development, pilot- and demonstration studies, business development and commercialisation.

In the Industrial Leap, it is also possible to support investments. The GreenTech fund invests in start-ups that can reduce climate impact.

It is not possible to list all these goals, scopes, and activities in a table as suggested; there would be hundreds of table rows.

The Swedish Energy Agency maintains a publicly accessible database of all funded activities; unfortunately, only in Swedish.

## 2.2 Tracking Progress (Optional)

Overall progress of the Energy R&I programme is reported annually by the Swedish Energy Agency to Government.

Progress of individual programmes, centres and consortia are regularly measured against the indicators adopted for each one. External evaluations are carried out regularly, e.g., at mid-term or end of programme/centra/consortia.

Evaluation of effects is sometimes carried out for larger groups of activities, after sufficient time has elapsed.

General indicators include indicators for **Input, Activities, Results, Outcomes** and **Effects**.

**Input:** Funding provided; strategic goals etc.

**Activities:** Funding per thematic area, per type of grant recipient, per type of activity, cofounding, gender of project leaders, etc

**Results:** Direct results like exams and degrees, numbers of scientific publications, citation index data etc

**Outcomes:** Reporting by project leaders on contributions to overall goals, patents, further use of results, external evaluation results, etc.

**Effects:** Special evaluations to document long-term effects and developments due to the R&I funded. Also, good examples of R&I projects etc.

The business development and commercialisation activities are followed up with indicators for number of employees, revenue, collaborations, stock exchange listings, subsequent investments etc.

### 3. Private Sector Engagement (Optional)

The different activities in the Swedish Energy Agency R&I Programme are to varying degrees co-funded by industry. The overall co-fund is slightly more than 50 percent.

Industry is the recipient of in excess of 30 percent of the R&I funding. In addition, approximately 10 percent of funding is allocated to industry associations and centres.

Strategies etc are developed in consultation with researchers, industry, and society.

Programmes etc. are generally implemented with the help of advisory committees etc. with industrial representation.

The Industrial Leap is in entirety aimed at supporting industry in decreasing their climate footprints

The system of state credit guarantees for green investments is a de-risking instrument to promote large green industrial investments.

Funding for Demonstration projects are given to industry

The business development and commercialisation activities are meant for Small and Medium Sized Enterprises or start-ups.



## 4. International Collaboration (Optional)

One of three priority activities of the Swedish Energy Agency's Research and Innovation Programme is to "Contribute to and benefit from international co-operation".

In general, SE gives priority to multilateral collaborations.

First among these is, obviously for us, the European Union and its different energy R&I related instruments: The framework programme Horizon Europe and its different initiatives like Missions and Partnerships, the Innovation Fund, the Strategic Energy Technology Plan, some Important Projects of Common European Interest (IPCEI), and others.

We also give priority to different activities in the Nordic co-operation like the Nordic Energy Research, as well as the collaboration under the International Energy Agency, the IRENA, the Clean Energy Ministerial and the Mission Innovation.

There are also several bilateral collaborations; some more research focused and other more targeted on innovation.

The Swedish Energy Agency has defined a number of priority countries for bilateral co-operation.

## 5. National Energy Innovation Ecosystem (Optional)

Government decisions are all taken in plenum. Government bills are then sent to parliament for discussion and decision.

The overall research and innovation policy of Sweden is the responsibility of the Ministry of Education and Research. The **Energy research and innovation programme** is, however, the responsibility of the Minister for Energy, currently part of the Ministry of Infrastructure.

Actual funding is the task of a number of government agencies. For the Energy and Innovation programme, this is the Swedish Energy Agency. Other agencies are

- The Swedish Research Council, a government agency under the Ministry of education and Research, supports research of the highest quality within all scientific fields. Funding is 8 billion SEK per year.
- The Swedish Innovation Agency, Vinnova, is a government agency under the Ministry of Enterprise and Innovation. It funds research, development, and demonstration to make Sweden competitive and to meet the societal challenges.
- The Swedish Research Council for Sustainable Development, Formas, is a government agency under the Ministry of the Environment that funds research and innovation on the environment, agricultural sciences, and spatial planning.

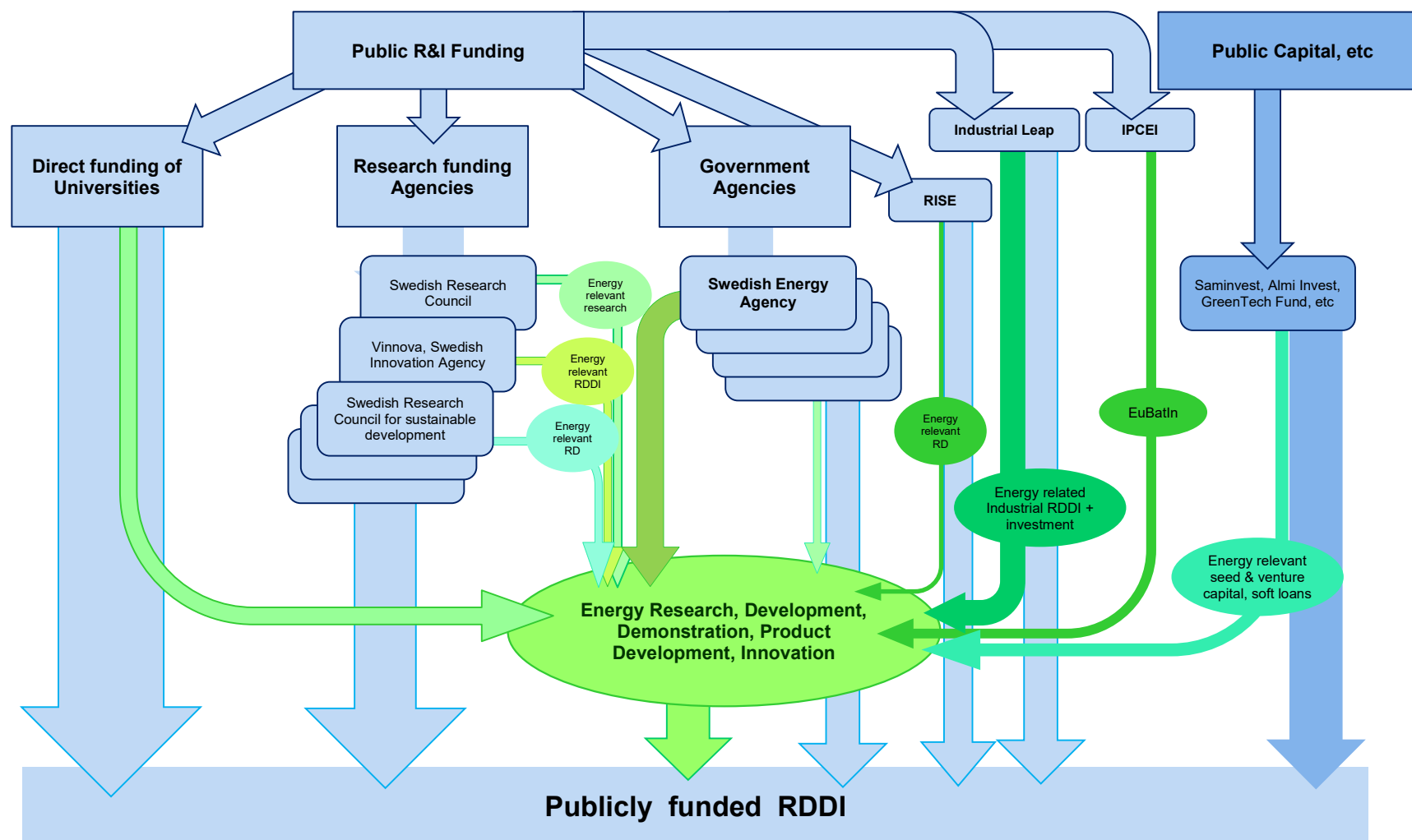
Energy related R&I funding includes activities carried out in collaboration between the Swedish Energy Agency, the Swedish Research Council (energy related basic research), Vinnova and Formas.

Together, the Swedish Energy Agency, Vinnova and Formas for instance fund seventeen Strategic Innovation Programmes (SIP).

The SIPs aim at providing sustainable solutions to global societal challenges and increased international competitiveness. Within the programmes, companies, academia, and organizations together develop sustainable products and services of the future. A number of these SIPs are energy related.

RISE, the Research Institutes of Sweden AB, is an independent, state-owned research institute supporting sustainable growth and strengthening the competitiveness and capacity for renewal of Swedish industry, as well as promoting the innovative development of society as a whole. Parts of the activities of RISE are energy related.

## ALL MI MEMBER COUNTRIES – SWEDEN



Schematic picture of some main components of the energy related research and innovation effortys in Sweden. The arrows are not showing funding sizes in any formal or quantitative way but only indicate contributions. Measures for deployment are not shown.

# UNITED KINGDOM

## 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.

### 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	<a href="https://www.gov.uk/government/publications/british-energy-security-strategy">https://www.gov.uk/government/publications/british-energy-security-strategy</a>
<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"> <li>our decarbonisation pathways to net zero by 2050, including illustrative scenarios.</li> <li>policies and proposals to reduce emissions for each sector.</li> <li>cross-cutting action to support the transition.</li> </ul>	2021	<a href="https://www.gov.uk/government/publications/net-zero-strategy">https://www.gov.uk/government/publications/net-zero-strategy</a>
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 <a href="#">Net Zero Innovation Board</a> , 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	<a href="https://www.gov.uk/government/publications/net-zero-research-and-innovation-framework">https://www.gov.uk/government/publications/net-zero-research-and-innovation-framework</a>

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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"> <li>the role of different technologies in the UK's future energy system.</li> <li>potential domestic and export growth opportunities.</li> <li>where innovation support and investment for those technologies could deliver the greatest benefits.</li> </ul>	2019	<a href="https://www.gov.uk/government/publications/energy-innovation-needs-assessments">https://www.gov.uk/government/publications/energy-innovation-needs-assessments</a>
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



## 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"> <li>Breeding</li> <li>Planting</li> <li>Cultivating</li> <li>Hydrogen from biogenic feedstocks combined with CCS</li> </ul>	Part of BEIS's £1bn Net Zero Innovation Portfolio (NZIP) as well as research and innovation delivered through UKRI	NZIP will support domestic demonstration.	<a href="https://www.gov.uk/government/collections/net-zero-innovation-portfolio">https://www.gov.uk/government/collections/net-zero-innovation-portfolio</a>
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"> <li>Cost reduction for CCUS in power, industrial and waste sectors.</li> <li>Feasibility and design of DAC and GGR technologies.</li> </ul>	Part of BEIS's £1bn Net Zero Innovation Portfolio as well as research and innovation delivered through UKRI	NZIP will support domestic demonstration.	<a href="https://www.gov.uk/government/collections/net-zero-innovation-portfolio">https://www.gov.uk/government/collections/net-zero-innovation-portfolio</a>

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		which provide incentives for investors.	<ul style="list-style-type: none"> <li>5 Demonstrators of land based GGR technologies.</li> </ul>			
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"> <li>Technologies for heating and cooling buildings including food cold chain.</li> <li>Innovation in Green Lending market.</li> <li>Innovative retrofit technologies and installation processes, including heat pumps.</li> <li>100% hydrogen for heating trials.</li> </ul>	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.	<a href="https://www.gov.uk/government/col-lections/net-zero-innovation-portfolio">https://www.gov.uk/government/col-lections/net-zero-innovation-portfolio</a>
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"> <li>Low Carbon Hydrogen supply solutions including production, transport, and storage. Enabling technologies for a wider hydrogen economy.</li> </ul>	Part of BEIS's £1bn Net Zero Innovation Portfolio as well as research and innovation delivered through UKRI	NZIP will support domestic demonstration.	<a href="https://www.gov.uk/government/col-lections/net-zero-innovation-portfolio">https://www.gov.uk/government/col-lections/net-zero-innovation-portfolio</a>
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"> <li>Development of UK Small Modular Reactor design.</li> </ul>	£385m through the Advanced Nuclear Fund (ANF)	ANF will support domestic demonstration	<a href="https://www.gov.uk/government/col-lections/net-zero-innovation-portfolio">https://www.gov.uk/government/col-lections/net-zero-innovation-portfolio</a>

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	Other:	addition to longer-term fusion research.	<ul style="list-style-type: none"> <li>Development of High Temperature Gas Reactor technology.</li> </ul>			
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"> <li>Lightweight composites for turbines.</li> <li>Floating Offshore Wind technologies.</li> <li>Mitigating impact on radar.</li> <li>Wave energy technologies.</li> <li>Combining offshore wind with hydrogen production.</li> </ul>	Part of BEIS's £1bn Net Zero Innovation Portfolio as well as research and innovation delivered through UKRI	NZIP will support domestic demonstration.	<a href="https://www.gov.uk/government/col-lections/net-zero-innovation-portfolio">https://www.gov.uk/government/col-lections/net-zero-innovation-portfolio</a>
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"> <li>Bi-directional electric vehicle charging technologies.</li> <li>Automated secure data exchange.</li> <li>Interoperable Demand Side Response systems.</li> <li>Smart Meter based Internet of Things sensor devices.</li> <li>Smart Meter energy data repository.</li> <li>Longer duration energy storage</li> </ul>	Part of BEIS's £1bn Net Zero Innovation Portfolio as well as research and innovation delivered through UKRI	NZIP will support domestic demonstration.	<a href="https://www.gov.uk/government/col-lections/net-zero-innovation-portfolio">https://www.gov.uk/government/col-lections/net-zero-innovation-portfolio</a>

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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.

## 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)

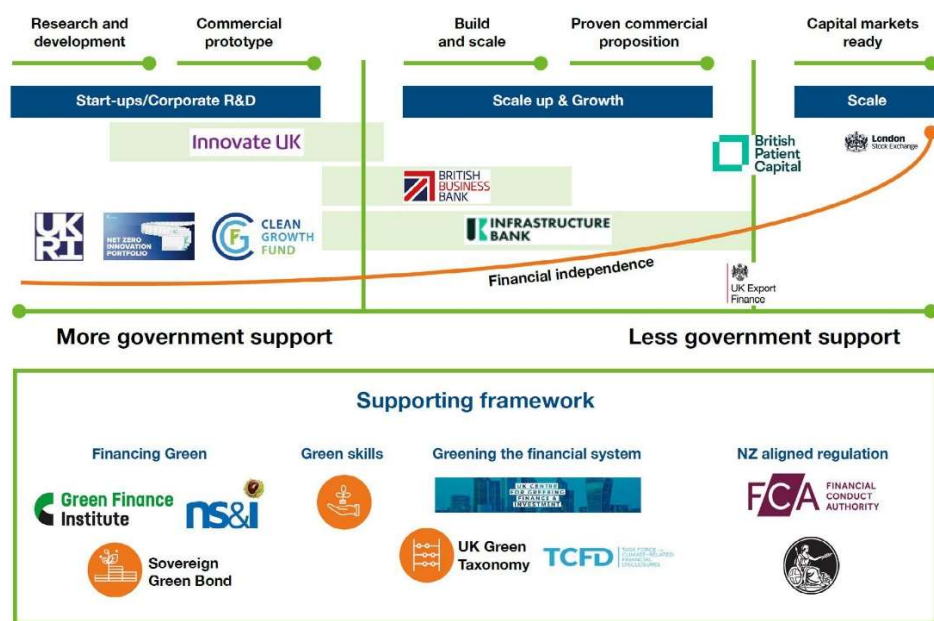
International co-operation and collaboration, including access to research and innovation infrastructure, the sharing of experience and lessons learned and input to standards setting will also be important to supporting the UK's ability to meet its net zero target.

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.

## 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**

<b>Institution name</b>	<b>Description of role</b>	<b>Innovation priority(ies) that they contribute to (taken from Table 2)</b>	<b>Description of funding modalities (e.g. grants, co-investment, where in tech development cycle focused)</b>	<b>Links</b>
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.	<a href="https://gov.uk/beis">Gov.uk/beis</a>
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.	<a href="https://gov.uk/fcdo">Gov.uk/fcdo</a>
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	<a href="https://gov.uk/dft">Gov.uk/dft</a>
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	<a href="https://ukri.org">ukri.org</a>
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	<a href="https://ukri.org/councils/innovate-uk">ukri.org/councils/innovate-uk</a>

## National Innovation Pathway Round up

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# 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.

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**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 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