

# MISSION INNOVATION **COUNTRY HIGHLIGHTS**

4<sup>TH</sup> MI MINISTERIAL 2019



**MISSION  
INNOVATION**

accelerating the clean energy revolution

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# INTRODUCTION

Mission Innovation (MI) Members<sup>1</sup> agreed to provide information on strategies and plans for their respective governmental and/or state-directed clean energy research and development investment over five years. New investments are focused on transformational clean energy technology innovations that can be scaled to varying economic and energy market conditions that exist in participating countries and in the broader world.

Information-sharing promotes transparency and integrity. It allows for broad stakeholder engagement, gives rise to opportunities for collaboration, and can inspire and inform investment decisions by the private sector.

Accordingly, MI Members have shared narratives, available on the MI website, describing the nature of their clean energy research, development, and demonstration (RD&D) investments; current strategies and priorities for engagement in Mission Innovation.

MI Members initially submitted narrative and funding information prior to the Inaugural MI Ministerial in June 2016. They submitted updated information in November 2016, at the one-year anniversary of the MI launch in Paris then prior to the Second MI Ministerial (June 2017) and Third MI Ministerial (May 2018). Once again, MI members have submitted information prior to the Fourth MI Ministerial in Vancouver, Canada in May 2019. This updated information focuses on key highlights over the past year including recent developments in members plans, policies and strategies, innovation successes, activities delivered in support of the Innovation Challenges, public sector RD&D investment and new collaborations.

This document provides a compilation of the most recent information that has been submitted by each of the 24 MI Members. In addition to promoting transparency and integrity, it is hoped that the information shared in the document will facilitate collaboration among Members and encourage further private sector engagement.

All data is based on information submitted by members. Baselines are determined independently by each member based on national priorities and relevant activity under Mission Innovation, it therefore differs by member and, for International Energy Agency (IEA) member countries, is often a subset of the IEA datasets<sup>2</sup>. All funding amounts presented in this report are in USD using a single set of foreign exchange rates<sup>3</sup>. There may be small differences in USD amounts compared to previous MI country books. Numbers denoted by “zero” in the following tables may indicate that no information has been provided for spend in that category.

<sup>1</sup> Mission Innovation Members, as of May 2019, include 23 countries and the European Commission on behalf of the European Union. A complete list is provided at: <http://mission-innovation.net/countries/>

<sup>2</sup> Please see Annex A for full data set

<sup>3</sup> The exchange rates used were taken from the OECD Monthly Monetary and Financial Statistics [https://stats.oecd.org/Index.aspx?DataSetCode=MEI\\_FIN#](https://stats.oecd.org/Index.aspx?DataSetCode=MEI_FIN#).



# AUSTRALIA

## Mission Innovation impact case study

Australia led the establishment of the Renewable and Clean Hydrogen Innovation Challenge (IC8), in partnership with the European Commission and Germany, to address the need for further technology improvements to enable hydrogen to be cost-competitive in the energy system.

The Challenge is supporting this objective by getting like-minded countries to work together to identify and overcome key technology barriers to the production, distribution, storage and use of hydrogen at scale.

It provided a forum to connect a diverse range of hydrogen stakeholders including the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE), the Hydrogen Council, the World Economic Forum and the International Energy Agency Technology Collaboration Programmes. It renewed a global conversation about the hydrogen supply chain, and has been a catalyst for subsequent hydrogen related activity in the International Energy Agency, G20 and Clean Energy Ministerial.

The Challenge has 17 members who teleconference regularly. It has hosted workshops involving industry, government, academics and partners in Berlin (October 2018) and Antwerp (March 2019).

IC8 members have reached broad agreement on the value and main elements of an information sharing platform for hydrogen demonstration. The objective of the platform is to consolidate the learnings of the first emerging integrated hydrogen projects (hydrogen valleys) in order to accelerate the shift towards large-scale multi-application hydrogen projects. The European Commission is in the process of engaging a provider to build the platform for delivery in September 2019.

The Challenge has agreed on a set of focus areas for research and development (R&D) collaborations and expects to hold its first technical workshop on hydrogen in the gas grid in September 2019.

## Update on clean energy innovation policies and strategies

- The Council of Australian Governments (COAG) Energy Council established a Working Group, led by Australia's Chief Scientist, Dr Alan Finkel, to deliver a National Hydrogen Strategy by the end of 2019. The strategy will examine hydrogen exports; hydrogen for transport; hydrogen in the gas network; hydrogen for industrial users; hydrogen to support electricity systems; and cross-cutting issues that affect all sectors, such as safety, R&D and innovation, and environmental impacts.
- The Commonwealth Scientific and Industrial Research Organisation's (CSIRO) Hydrogen Roadmap published in August 2018 provides a blueprint for the development of a hydrogen industry in Australia. The Roadmap identified priorities for policy and regulatory development, commercial investment, research development and deployment, and social acceptance.
- The Australian Government has developed the Trajectory for Low Energy Buildings, a national plan that sets a trajectory towards zero energy (and carbon) ready buildings for Australia. The plan considers opportunities for new buildings and measures to transition existing buildings.

## Major innovation initiatives in 2018/19

- In August 2018, the Australian Government, through the Australian Renewable Energy Agency (ARENA), provided AUD\$22 million to 16 research and development projects to propel innovation in exporting renewable hydrogen to the world. The projects include the development of a wide range of hydrogen-related technologies including concentrating solar thermal, electrolysis, biotechnology, carrier synthesis, thermochemical processes, fuel cell development and energy generation.

- The Australian Government invested over AUD\$26 million in the Future Fuels Cooperative Research Centre to undertake research and development to transition energy infrastructure to a low-carbon economy using future fuels such as hydrogen and biogas. The Research Centre will adapt existing infrastructure for the production, transport and storage of sustainable future fuels.
- The Australian Government invested AUD\$50 million in the Hydrogen Energy Supply Chain (HESC) pilot project, a collaboration with a Japanese consortium led by Kawasaki Heavy Industries and the Japanese Government. The four-year pilot project will demonstrate the feasibility of a hydrogen supply chain from Australia to Japan.
- The Australian Government approved Snowy 2.0, an expansion of Australia's existing pumped-hydro energy storage project, as part of its plan to support new renewable energy for Australia's future energy mix. Snowy 2.0 will increase generation capacity and provide large-scale storage capability.

## Major activities in support of the Innovation Challenges in 2018/19

- Australia is the interim Operating Agent (being confirmed) of a new international collaboration in the Affordable Heating and Cooling Innovation Challenge (IC7) priority area of 'Predictive Maintenance and Control Optimization'. In April 2019, a planning workshop was held in Delft, Netherlands, attended by 27 delegates from 10 countries.
- A consortium of over 30 Australian industry, government and academic partners are collaborating on a project to support engagement in IC7 activities. The project involves:

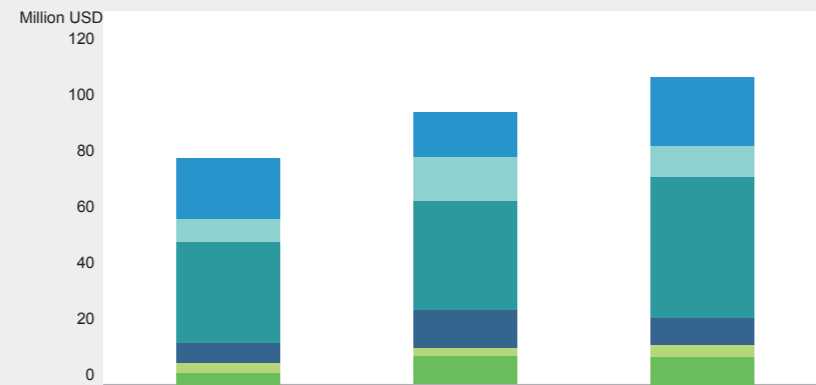
<b>1</b> Establishment of Living Laboratories for validating emerging Heating, Ventilation, and Air Conditioning (HVAC) products and services	<b>2</b> Establishment of a new Integrated Design Studios process for building design innovation	<b>3</b> Development of an Open Data Platform for driving innovation and commercialisation of HVAC-as-a-Service applications.
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- Australia and the UK are leading work on the Storage Integration work stream under the Smart Grids Innovation Challenge (IC1) and co-organised an MI member workshop on energy storage safety in February 2019.
- Australia successfully attracted the International Conference on Integration of Renewable and Distributed Energy Resources to Australia for 2020. This will be used to showcase MI deliverables.
- The CSIRO's Renewable Energy Integration Facility was accepted as part of the International Energy Agency Smart Grid International Research Facility Network, an international smart grid laboratory collaboration initiative.

## Other Mission Innovation related activity in 2018/19

- The Australian Government has committed AUD\$25 million to support the development of the Future Battery Industries Cooperative Research Centre. The Centre will address industry-identified gaps in the battery industries value chain, in collaboration with 58 industry, academic and government partners.
- Australia has developed the 'Best Practice Guide: Battery Storage Equipment – Electrical Safety Requirements', with input from industry, consumers, electrical safety regulators and Australia's scientific research organisation, the CSIRO. The document provides robust standards and guidelines for safe installation of battery systems.

Public sector RD&D investment



\*All amounts are in million USD

	Baseline	First Year	Second Year
Energy Efficiency	21.54	16.04	24.11
CCS	8.14	15.27	10.87
Renewables	36.08	39.11	50.22
Nuclear Fission & Fusion	6.81	13.11	9.63
Hydrogen & Fuel Cells	3.10	2.91	4.09
Other Power & Storage Technologies	4.45	10.19	9.68
Other Cross-cutting Technologies/ Research	-	-	-
Unallocated	-	-	-
<b>TOTAL</b>	<b>80.1</b>	<b>96.6</b>	<b>108.6</b>

Australia's MI baseline includes research and development, but not demonstration.

New Collaborations

Collaborators	Name of Collaboration	Brief Description	Sectors	Type of Collaboration	Duration	Funding amount	Additional information
Japan	Hydrogen Energy Supply Chain (HESC) pilot project	The project aims to demonstrate the feasibility of a hydrogen supply chain from Australia to Japan.	Public-public and public-private	Demonstration	2017 to 2021	AUD\$50 million	<a href="https://hydrogenenergysupplychain.com/">https://hydrogenenergysupplychain.com/</a>

AUSTRIA

Update on clean energy innovation policies and strategies

Climate and Energy Strategy #mission2030<sup>4</sup>

In June 2018 the Climate and Energy Strategy #mission2030 was concluded by the Austrian government. It defines objectives and fields of action to follow a decarbonisation path with target years 2030 and 2050 with the central goal to reduce greenhouse gas emissions and increase the share of renewable energy. By 2030, Austria will reduce its CO<sub>2</sub> emissions by 36% compared to 2005.

This will be achieved by increasing the share of renewable energy in gross final energy consumption from 33.5% (2018) to 45-50% by 2030. Austria has set itself the target of covering 100% of its total electricity consumption (national balance) from renewable energy sources in Austria by 2030. Today, around 72% of electricity already comes from renewable sources. To achieve this goal, investments in energy efficiency measures as well as the expansion of renewable energy sources, infrastructure and storage facilities are necessary. The transformation to an efficient and climate-neutral energy, mobility and economic system must encompass the entire energy value chain (generation, transport, conversion and consumption), including all related products and services. Energy research and technology development play a key role in this far-reaching process.

To implement the Climate- and Energy Strategy two flagships, with respect to research and innovation were drafted, flagship 9 "Building blocks of the energy systems of the future and the flagship 10 "Programme Mission Innovation Austria".

- In Flagship 9 the programme activities of the Federal Ministry of Transport, Innovation and Technology (BMVIT) and the Climate and Energy Fund (KLIEN) will be targeted on following mission oriented focal areas: Plus Energy Areas, Integrated regional energy systems, Break-Through Technologies for Industry and Energy-efficient mobility systems of the future.
- Flagship 10 will focus on the further development of the programme "Flagship Regions Austria".

Energy Research Initiative Implementation Plan

BMVIT is currently working on an implementation plan for the national energy research initiative of #Mission2030. This implementation plan will concretise Flagships 9 and 10 of the national Climate and Energy Strategy. Four stakeholder groups in the field of Buildings and Urban Systems, Break-through Technologies for Industry, Energy Systems and Grids and Mobility Systems are developing innovation goals and innovation activities and measures. The outcome of this process will feed into further Research, Development and Innovation (RDI) planning procedures.

Major innovation initiatives in 2018/19

Launch of Flagship Region Energy (national)

- In 2018 the 8-years Initiative was launched. It focuses on an efficient interaction of energy production, consumption, system management and storage. The programme combines research and development and demonstration funding instruments for the testing of integral solutions in real time. 3 Regions have been selected: In the "Green Energy Lab", part of Austria becomes a test region for the future energy system with a significantly great share of renewable energies. The focus is placed on more flexibility and digitalisation of the energy system to support energy supply security. The purpose of "NEFI" (New Energy for Industry) is to show that 100% renewable energy supply of industrial sites is possible with energy technologies developed in Austria. The aim of "WIVA P&G" (hydrogen initiative) is to demonstrate the shift of the Austrian economy to an energy system which is largely based on hydrogen. The focus is on the production, storage, distribution and application of renewable hydrogen in the fields of energy supply, industry and mobility. In the first year, 21 projects were funded with more than €30 million inducing a total investment of €57 million.

- A 14 min film describes the Flagship Region Energy (general Introduction and explanation of all 3 labs) <sup>5</sup>

<sup>4</sup> [https://mission2030.info/wp-content/uploads/2018/10/Klima-Energiestrategie\\_en.pdf](https://mission2030.info/wp-content/uploads/2018/10/Klima-Energiestrategie_en.pdf)

<sup>5</sup> <https://www.youtube.com/watch?v=OLmp7nqImDM>

Transnational/International

- The strategic research and innovation agenda of JPI Urban Europe<sup>6</sup> has the goal, by coordinated city research and development to develop European solutions for sustainable, live-able and economically strong cities of tomorrow. Since 2012 8 transnational call for proposals has been performed in the network of 20 participating countries (total funding >€100 million). Austria is leading the Strategic Energy Technology Plan working group on “Smart Cities and Communities” and has started an activity for “100 European Plus-Energy quarters”.
- The Joint Programming Platform ERA-NET Smart Energy Systems<sup>7</sup> is an important instrument, to support transnational RDI cooperation in the field of energy systems. The platform contributes substantially to the Implementation plan of the Action 4 of the European Strategic Energy Technology Plan – “Increasing the resilience and security of the energy systems”. Austria is leading the joint programming platform, with 30 funding agencies from 23 countries. The goal is to initiate and fund concrete transnational RDI-projects in participating countries. Up to now 58 projects with more than €100 million were funded. Project consortia involve in total 225 project partners, 50 from business enterprises (60% SMEs).
- International Energy Agency (IEA) research cooperation – Austria has funded 20 new participations in tasks and annexes with a total budget of €3 million. The Austrian Technology Collaboration Programmes (TCP) portfolio is consistent with national priorities. Austria participates in 88 of total 185 activities, 48 in the End-Use, 35 in the Renewables and 5 in Fossil Fuels. In 2018/2019 Austria has joined 3 TCPs – the Clean Energy Education and Empowerment C3E TCP, the Hydrogen TCP and the Energy Conservation through Energy Storage (ECES) TCP. Austria participates in 21 TCPs and one expert Group (EGRD).

Major activities in support of the Innovation Challenges in 2018/19

**Initiation of Mission innovation Pilot Multilateral Call for cooperative RDI Projects.** This initiative, led by Austria, will enable financing of multilateral cooperative RDI Projects from research and industry within the framework of MI. It is based on a well-established model and leveraging on the existing Joint Programming Platform Smart Energy Systems (JPP SES) with currently 30 public funding partners from 23 European countries. The funding mechanism and the topic of storage system and storage integration were presented to MI Innovation Challenges IC1, IC6, IC7 and IC8. MI Innovation Challenges have two important roles to play in the MICall19:

- To comment on call focus and requested research areas
- As matchmaking platforms to start project consortia together with industry partners

Collaboration with the Innovation Challenges

<ul style="list-style-type: none"> <li>• IC1 Workshop in Rome, November 2018: Presentation of MI Multilateral Pilot Joint call and discussion on opportunities for IC1</li> </ul>	<ul style="list-style-type: none"> <li>• IC7: Austria is joining the Comfort Climate Box (International Energy Agency Annex Energy Conservation through Energy Storage/Heat Pumping Technologies) in collaboration with IC7</li> </ul>
<ul style="list-style-type: none"> <li>• IC8: Austria participated in a meeting of IC8 and contributed to the workplan</li> </ul>	<ul style="list-style-type: none"> <li>• IC7 and IC8: invitation to support the pilot joint call (telephone calls)</li> </ul>
<ul style="list-style-type: none"> <li>• IC6: Presentation of the MI Pilot Multilateral Call at IC6 Workshop in India, New Delhi, February 2019</li> </ul>	<ul style="list-style-type: none"> <li>• Austria participated in a Hydrogen Ministerial Meeting in October 2018 initiated by Japan</li> </ul>

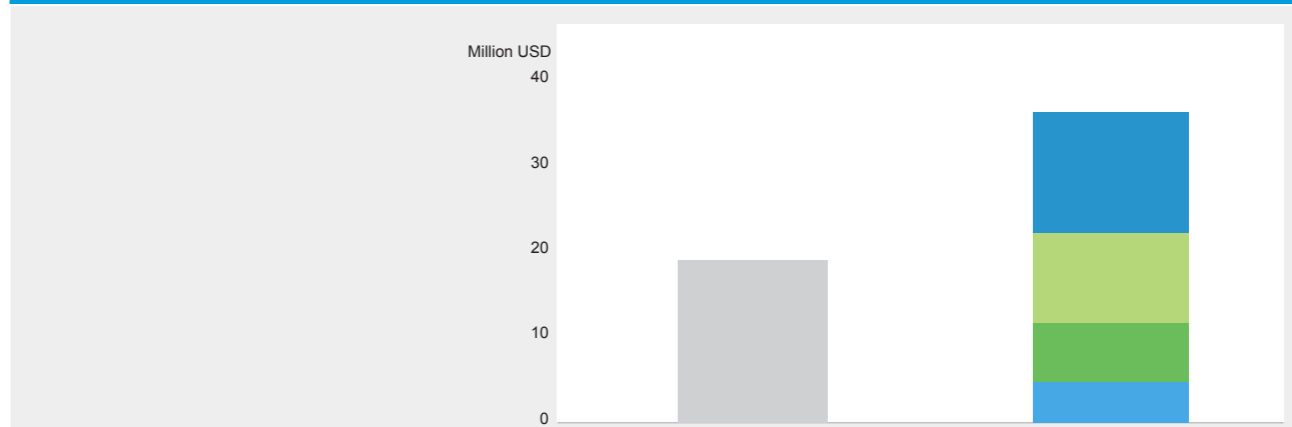
<sup>6</sup> <https://jpi-urbaneurope.eu/>  
<sup>7</sup> [www.eranet-smartenergysystems.eu](http://www.eranet-smartenergysystems.eu)

Other Mission Innovation related activity in 2018/19

**Mission Innovation Week Austria:** In the first “Mission Innovation Austria Week 2019” (Stegersbach and Oberwart, south of Vienna May 2019), current developments will be presented and discussed in a series of parallel events. Topics such as PV self-consumption, local energy communities and municipal contributions to energy system transformation will highlight the role of local practices and scope for action. In workshops and pitches, the innovative power and chances of success of start-ups as well as the recipes for success of scale-ups will be outlined. In deep dive sessions, experts will present the state of the art and discuss energy future issues with participants in small groups. The rapidly advancing artificial intelligence research and its application possibilities in the energy sector will be addressed, as well as blockchain technology, 5G and future telecommunication standards. Furthermore, innovation activities for renewable hydrogen or the system integration of electromobility will be addressed. In the course of the conference, high-level speakers will shed light on the Austrian innovation landscape and the role of international research cooperation. The Mission Innovation Austria Week will provide the possibility for the innovation Challenges to present themselves to the Austrian stakeholders from industry and research as well as to network among the different innovation Challenges.

**Private Sector Engagement: Mission Innovation Austria board:** The private sector has been involved in Austrian MI activities from the beginning. In preparation for joining MI, Austria has established a national governance structure, ensuring a broad involvement of Austrian industry and RDI stakeholders. Key element is an Advisory Board (Mission Innovation Austria Beirat) made up of industry representatives and international energy experts who provide strategic advice to the Technology minister. The advisory board meets twice a year.

Public sector RD&D investment



*All amounts are in million USD	Baseline	First Year
Energy Efficiency	-	14.03
CCS	-	-
Renewables	-	-
Nuclear Fission & Fusion	-	-
Hydrogen & Fuel Cells	-	10.40
Other Power & Storage Technologies	-	6.84
Other Cross-cutting Technologies/ Research	-	4.64
Unallocated	18.89	-
<b>TOTAL</b>	<b>18.9</b>	<b>35.9</b>

The baseline is calculated by averaging the budget for project funding of the Flagship Projects in the national programmes for energy research (City of Tomorrow and Energy Research Programme). On average €16 million funding have been granted each year between 2014 and 2016 for flagship projects. An allocation of R&D expenditures was not foreseen in the calculation of the baseline.

## New Collaborations

Collaborators	Name of Collaboration	Brief Description	Sectors	Type of Collaboration	Duration	Funding amount	Additional information
~40 IEA and partner countries	IEA Research Cooperation Call 2018	Funding of collaborations in Tasks and Annexes and Executive Committees of IEA Technology Collaborations Programmes, research & development, dissemination and networking	Public-public	Research	2018 to 2021	2.8 M€	<a href="https://nachhaltigwirtschaften.at/en/iea/">https://nachhaltigwirtschaften.at/en/iea/</a>
23 European Countries including MI members: Austria, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Sweden	ERA-NET Smart Energy Systems Call 2018 – Integrated regional Energy Systems	A Transnational Joint Programming Platform to Initiate Co-Creation and Promote Energy System Innovation	Public-public	Research, development and demonstration	2018 to 2021	6 M€	<a href="https://www.eranet-smartenergy systems.eu/">https://www.eranet-smartenergy systems.eu/</a>
14 European Countries including MI Members: Austria, Denmark, Finland, France, Italy, Netherlands, Norway, Sweden, UK	JPI Urban Europe Call 2018 - Sustainable and Liveable Cities and Urban Areas	JPI Urban Europe was created in 2010 to address the global urban challenges of today with the ambition to develop a European research and innovation hub on urban matters and create European solutions by means of coordinated research.	Public-public	Research, development and demonstration	2018 to 2021	2.5 M€	<a href="https://jpi-urbaneurope.eu/calls/sustainable-urbanisation-china-europe/">https://jpi-urbaneurope.eu/calls/sustainable-urbanisation-china-europe/</a>
7 European countries including MI members: Austria, Finland, Germany, Netherlands, Sweden.	ERA-NET Bioenergy	A transnational cooperation of programme owners and programme managers in the area of bioenergy R&D.	Public-private	Research, development	2018 to 2022	1 M€	<a href="https://www.eranetbioenergy.net/">https://www.eranetbioenergy.net/</a>
18 European Countries and Regions including MI members: Austria, Finland, France, Germany, Italy, Netherlands, Sweden, UK	SOLAR-ERA.NET Cofund 2	A European network of national and regional funding organisations in the field of solar electricity generational.	Public-public	Research, development	2018 to 2022	1 M€	<a href="http://www.solar-era.net/">http://www.solar-era.net/</a>



## BRAZIL

## Mission Innovation impact case study

Participation in MI has provided an inspiring environment for improving Brazil's database on clean energy innovation investments. The existing experiences have helped accelerate the design of more effective reporting and use it as a tool for improving policies and strategies. One example is the collaboration between Brazil and the International Energy Agency (IEA) aiming at capacity building and methodological development to support a national platform for clean energy innovation spending reports and indicators. Various collaborators have joined this initiative since the last Ministerial Meeting. Third MI Ministerial (MI-3) side events and networking were useful to create links that proved effective to help Brazil build a strategy for improving the data governance on innovation investments for advancing clean energy.

In Brazil the governmental support for research and development activities in the energy sector is fragmented between several institutions. There are programs managed by regulatory agencies, investments by public banks, funding agencies and different public funds. It is understood that the design of a tool capable of concentrating information and classifying it according to international best practices is fundamental to optimize the use of resources and enable greater integration between research and development (R&D) activities with other countries. This is expected to improve the quality of investments, boost public-private collaboration, strengthen innovation networks and accelerate development of clean energy technologies.

## Update on clean energy innovation policies and strategies

- According to the IEA (2018), Brazil has the greenest energy mix amongst large economies. In 2017, the proportion of renewables in the Brazilian energy matrix is around 43% and 80% in its electricity mix. In line with its goal to expand the use of renewable energy sources, it is expected to reach a share of 47% from renewable sources (electricity and biofuels) by 2027, according to the latest Ten Year Energy Expansion Plan.
- In the transportation sector, Brazil has strong biofuels mandates (27.5% ethanol mix in gasoline and 10% biodiesel mix in diesel). It aims to increase biofuels in the energy mix to 18% by 2030 (RenovaBio)<sup>8</sup>. The Rota 2030 programme, announced in 2018, requires vehicle manufacturers to increase energy efficiency of their fleet by 11% by 2022, and grants tax cuts on the purchase and import of electric and hybrid vehicles.
- The Science, Technology and Innovation Plan for Renewable Energies and Biofuels 2018-2022<sup>9</sup> is a strategic orientation document of the Ministry of Science, Technology, Innovation and Communications to operate in the areas of renewable energies and biofuels, being part of the National Science, Technology and Innovation Strategy (ENCTI 2016-2022)<sup>10</sup>.

## Major innovation initiatives in 2018/19

- A successful webinar with seven Brazilian institutions, including the Energy Research Office and the Ministry of Mines and Energy last October presented IEA's data work on tracking energy R&D budgets, as well as on national clean energy innovation policies and strategies. This was a kick-off to a set of programmed activities in 2019, including joint work on the development of a data management tool to support tracking clean energy R&D and innovation spending in the Brazil and a fact-finding mission.

<sup>8</sup> <http://epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/renovabio>

<sup>9</sup> <https://www.mctic.gov.br/mctic/export/sites/institucional/tecnologia/tecnologiasSetoriais/Plano-de-Ciencia-Tecnologia-e-Inovacao-Para-Energias-Renovaveis-e-Biocombustiveis.pdf>

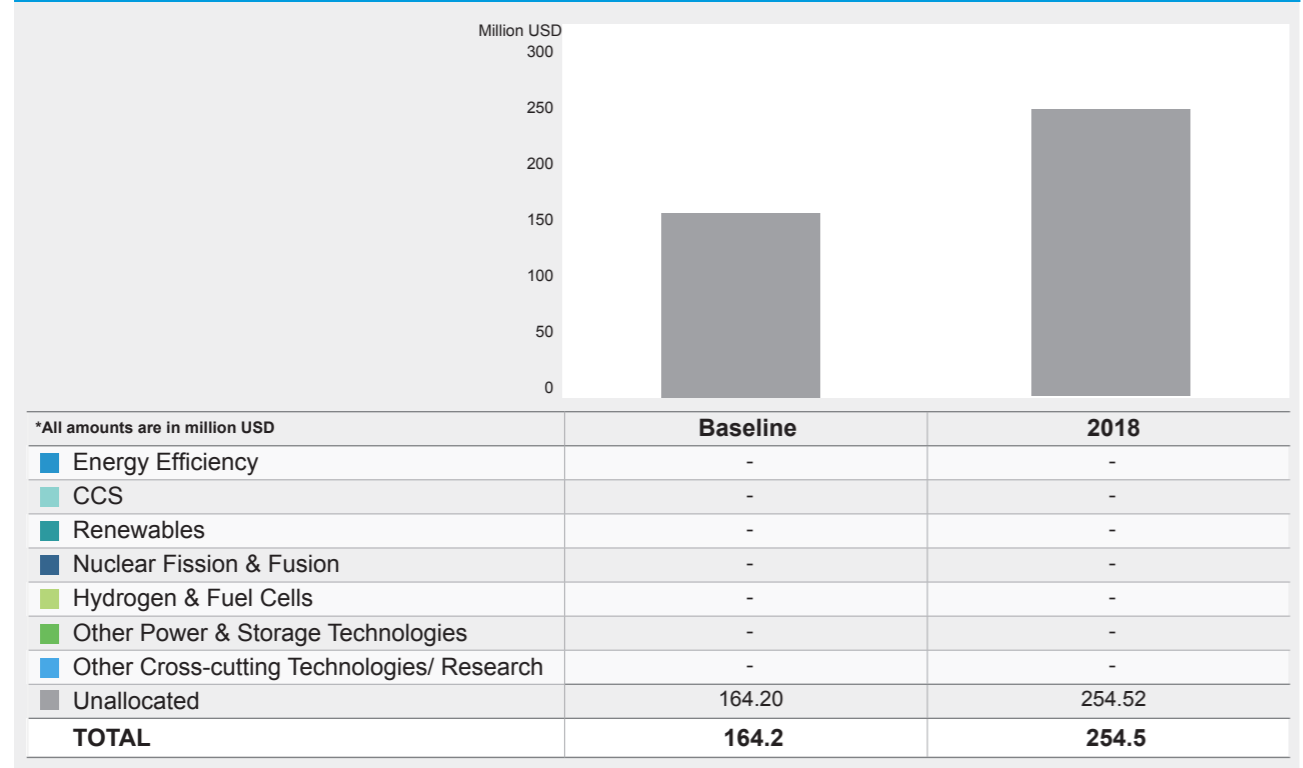
<sup>10</sup> [http://www.mctic.gov.br/mctic/export/sites/institucional/ciencia/SEPED/Arquivos/PlanosDeAcao/PACTI\\_Sumario\\_executivo\\_Web.pdf](http://www.mctic.gov.br/mctic/export/sites/institucional/ciencia/SEPED/Arquivos/PlanosDeAcao/PACTI_Sumario_executivo_Web.pdf)

- The National Agency for Petroleum, Natural Gas and Biofuels (ANP) and the National Electric Energy Agency (ANEEL), responsible for sector regulation, have been active in supporting energy innovation, supervising legal obligations of investments for private companies in research, development and innovation projects in the energy sector.
- Other public institutions have been active in financing or offering grants for R&D in clean energy, including the National Development Bank (BNDES) and FINEP (that manages a national fund for R&D, including energy).

**Major activities in support of the Innovation Challenges in 2018/19**

IC4 (Sustainable Biofuels): Three main instruments support RenovaBio operations: Annual Carbon Intensity Reduction Targets, Biofuels Certification and Decarbonisation Credits (CBIO). On March 15, 2018, Presidential Decree No. 9,308 established the RenovaBio Committee. On June 5, 2018, the National Council for Energy Policy (CNPE) approved, in Resolution No. 5, the annual compulsory targets for greenhouse gas (GHG) emissions reduction for fuel trade, as defined by the RenovaBio Committee. In addition, ANP started a program called "RenovaBio Itinerante" in September 2018, which explains the RenovaBio operation for biofuel producers. In November 2018, through Resolution No. 758, the National Agency for Petroleum, Natural Gas and Biofuels (ANP) established the accreditation requirements for Inspection Companies, the Biofuel Producer eligibility criteria and the Biofuels Efficient Production Certification. In January 2019, ANP accredited two Inspection Companies. On March 1, 2019, ANP put to public consultation the resolution draft that provides the individualization of the annual compulsory GHG emission reduction targets. Contributions will be presented on 16 April 2019. In second half of 2019 ANP will publish the resolution that determines the rules to prove CBIO acquisition.

**Public sector RD&D investment**



This is the result of an effort to consolidate and organize investment data about public and public-oriented projects in clean energy. This database includes all projects approved by ANP and ANEEL in 2018 under the investment mandates, as well as BNDES public financing.

For cross-cutting power sector themes, they were allocated only partially as clean energy investments, adopting the % of renewable energy in the Brazilian electricity mix as a proxy.



**CANADA**

**Mission Innovation impact case study**

MI was a key driver for increased Government of Canada programming in clean energy innovation, and led to a number of new funding programs being established. In addition, closer ties with international colleagues led to the development of some activities that certainly would not have occurred without MI. This includes the advancement of materials acceleration platforms as a result of IC6 and the Canada-UK Power Forward Challenge.

Emphasising the key role MI plays in spurring increased public investments, Budget 2017 specifically stated: "The Government of Canada has made a commitment under Mission Innovation to double its 2014-15 baseline expenditures of \$387 million for clean energy and clean technology research, development and demonstration by 2020. Budget 2017 proposes a number of measures, including in the areas of green infrastructure and clean technology, that will help to meet this commitment while generating more good, well-paying jobs in the clean growth economy."

These investments are intended to make Canada a world leader in innovation: as the world increasingly seeks out more sustainable and renewable sources of energy, as well as new technologies to improve the quality of air and water, Canadian companies can lead the way. In 2019, 12 Canadian firms made the Global Cleantech List<sup>11</sup> and three Canadian companies are among the 10 finalists for the \$20M Carbon XPRIZE<sup>12</sup>.

**Update on clean energy innovation policies and strategies**

The Government of Canada continues to implement and support programs related to the Pan-Canadian Framework on Clean Growth and Climate Change<sup>13</sup> (PCF), Canada's plan to meet our emissions reduction targets, grow the economy and build resilience to a changing climate. The PCF includes a focus on driving innovation and growth by increasing technology development and adoption to ensure Canadian businesses are competitive in the global low-carbon economy.

In Budget 2017, Canada's federal government announced the Innovation and Skills Plan<sup>14</sup>, a new vision for Canada's economy as a global leader in innovation. An investment of over \$2.3 billion for clean technology was announced in the Budget as part of this vision, supporting the implementation of the PCF. At Natural Resources Canada (NRCan), all Budget 2017 initiatives are now implemented; the programs proved very popular, with many more high-quality applications received than funding allowed.

These measures are helping to foster Canada's vibrant clean technology ecosystem. In 2019, 12 Canadian firms made the Global Cleantech List<sup>15</sup> and three Canadian companies are among the 10 finalists for the \$20M Carbon XPRIZE<sup>16</sup>.

<sup>11</sup> <https://i3connect.com/gct100>

<sup>12</sup> <https://carbon.xprize.org/prizes/carbon>

<sup>13</sup> <https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework.html>

<sup>14</sup> <https://www.budget.gc.ca/2017/docs/bb/brief-bref-en.html#section1>

<sup>15</sup> <https://i3connect.com/gct100>

<sup>16</sup> <https://carbon.xprize.org/prizes/carbon>

## Major innovation initiatives 2018/19

The **Clean Growth Program**<sup>17</sup>, launched in 2017 by NRCan, provides \$155 million over three years for the co-funding of 50 clean technology research, development and demonstration (RD&D) projects with provinces and territories in Canada's energy, mining and forestry sectors, and is expected to lead to an annual reduction of 0.3-0.7 megatonnes (Mt) of greenhouse gas (GHG) emissions by 2026. The first approved project, at Goldcorp Canada Inc.'s Borden Mine<sup>18</sup>, was announced on October 29, 2018 and focuses on replacing diesel equipment with battery electric vehicles, making this Canada's first all-battery electric underground mine. Other approved projects will be announced in 2019-20.

In 2019, as part of the **Impact Canada Initiative**<sup>19</sup>, NRCan launched five Clean Technology Challenges<sup>20</sup>:

- **The Generating New Opportunities:** Indigenous Off-Diesel Initiative: \$20 million to help remote Indigenous communities move away from using diesel by developing cleaner community-led energy projects.
- **The Women in Cleantech Challenge:** \$6 million to promote greater representation of women in Canada's cleantech sector by supporting the creation of six new, highly impactful and globally significant women-led clean technology companies.
- **The Power Forward Challenge:** \$20 million (\$10 million from each country) to design better smart grids in a joint initiative between NRCan and the United Kingdom's Department for Business, Energy and Industrial Strategy, announced at the third MI Ministerial (MI-3).
- **The Sky's the Limit Challenge:** \$14 million to develop a cost-competitive sustainable aviation fuel that meets or exceeds international aviation fuel standards.
- **The Crush It! Challenge:** \$10 million to develop a new clean technology solution that transforms how energy is used for crushing and grinding rocks in the mining industry.

The 53 projects funded under NRCan's **Energy Innovation Program**<sup>21</sup>(EIP) focus on addressing innovation gaps and opportunities to significantly reduce GHG emissions in key priority areas such as renewable energy, smart grids, reducing diesel dependency, oil and gas and energy efficient buildings. Building on the success of funding in Budget 2016 for the EIP, in Budget 2017 the Government of Canada provided an additional \$211.6 million of funding over five years, plus ongoing funding of \$52.9 million per year. The program is expected to result in 10-16 Mt carbon dioxide equivalent (CO<sub>2</sub>e) total combined indirect and direct reductions per year by 2030. As an example, building on a successfully demonstrated prototype pilot that can capture 1 T of atmospheric CO<sub>2</sub> per day, British Columbia based Carbon Engineering<sup>22</sup> has received \$1.5 million in funding from the EIP to pioneer a scalable technology to capture CO<sub>2</sub> from the air and combine it with hydrogen atoms released from other clean energy sources to turn it into liquid fuels for transportation.

The RD&D component of the **Green Infrastructure**<sup>23</sup>(GI) suite of programs includes: Smart Grids (\$35 million over four years for 13 projects), Net-Zero Buildings (\$48.4 million over eight years for 13 projects), Remote Communities (\$59.4 million over four years for 12 projects), and Electric Vehicle Infrastructure Demonstrations (\$30 million over four years for 28 projects). As an example, thanks in part to \$6.7 million in GI funding, AddEnergie is developing the next generation of fast-charging stations for electric vehicles (EVs), to serve the greater variety of EV models that will be available to Canadian consumers in the next five years.

<sup>17</sup> <https://www.nrcan.gc.ca/cleangrowth/20254>

<sup>18</sup> <https://www.canada.ca/en/natural-resources-canada/news/2018/10/minister-sohi-announces-funding-for-borden-mine-of-the-future.html>

<sup>19</sup> <https://impact.canada.ca/en>

<sup>21</sup> <https://impact.canada.ca/#challenges>

<sup>20</sup> <https://www.nrcan.gc.ca/energy/funding/icg/18876>

<sup>22</sup> <http://carbonengineering.com/about-a2f/>

<sup>23</sup> <https://www.nrcan.gc.ca/cleangrowth/19780>

Regarding nuclear energy, through **Atomic Energy of Canada Ltd.**<sup>24</sup> (AECL), Canada is investing \$1.2 billion over ten years, beginning in 2016, to renew the science and infrastructure at the Chalk River Laboratories. The renewal will transform the site into a modern, world-class nuclear science and technology campus. In addition, through AECL's Federal Nuclear Science and Technology Work Plan<sup>25</sup>, Canadian Nuclear Laboratories is working on hydrogen technologies that offer low-carbon solutions for the energy and transportation sectors as well as research to advance the deployment of small modular reactors (SMRs) in Canada as a clean energy solution. NRCan provided also provided \$224,000 in funding under the EIP for the development of a roadmap which will help drive SMR development and deployment in Canada.

## Major activities in support of the Innovation Challenges in 2018/19

Canada participates in all eight Innovation Challenges and co-leads IC4 and IC6.

### IC1: Smart Grids

In May 2018 at CEM9/MI-3, IC1 launched the work programs of six high-priority RD&D tasks. Canada co-wrote and is leading Task #4 on flexibility options. Canada actively participated in the 4<sup>th</sup> IC1 workshop held in Rome in November 2018 where, as the liaison between the CEM International Smart Grid Action Network (ISGAN) initiative and IC1, Canada oversaw the signing of the Letter of Intent between ISGAN and IC1 to undertake collaborations to advance the market uptake of smart grid technologies. Canada also co-authored (with India) a fact sheet on smart grid flexibility options and contributed to a Country Report 2019 volume highlighting the status of smart grids in 16 countries plus the European Commission.

### IC4: Sustainable Biofuels

Under IC4, a Canada-US-Mexico Trilateral Biojet Collaboration Workshop was held at the United States Department of Energy's Pacific Northwest National Laboratories in May 2018. The workshop, attended by 64 leading experts from the three countries, identified key areas for international collaboration and provided input into Canada's *The Sky's the Limit* sustainable aviation fuel challenge.

### IC6: Clean Energy Materials

As co-lead for IC6, Canada has taken a leadership role by organizing several international meetings over 2018-19, bringing together stakeholders from academia, government and business to continue exploring the potential for accelerated materials discovery to drive clean energy innovation. Canada also announced funding for two major initiatives: the National Research Council's Novel Materials for a Clean and Sustainable Energy program as well as an \$8 million investment in the University of British Columbia's Autonomous Discovery Accelerator (ADA). ADA combines robotics and artificial intelligence (AI) to accelerate discoveries of clean energy materials and is remotely controlled from an AI accelerated operating system, ChemOS, at the University of Toronto.

## Other Mission Innovation related activity in 2018/19

Canada is taking a leadership role within MI by hosting the fourth Ministerial, MI-4, in Vancouver in May 2019. As host, Canada developed an inclusive, dynamic and engaging programme that opens up dialogue beyond Ministers and the private sector, to include industry, innovators, investors and youth.

Canada is one of five MI governments working with the Breakthrough Energy Coalition<sup>26</sup>(BEC), an initiative led by Bill Gates that includes over 30 influential investors from around the world.

Canada is a key participant in MI's governance, chairing the Steering Committee (2018-19), co-leading the Analysis and Joint Research Sub-Group, chairing the Ministerial Planning Team (2018-19), participating in the Business and Investor Engagement Sub-Group, and supporting the Secretariat (leading the Communications workstream and participating in the Ideas and Innovators workstream).

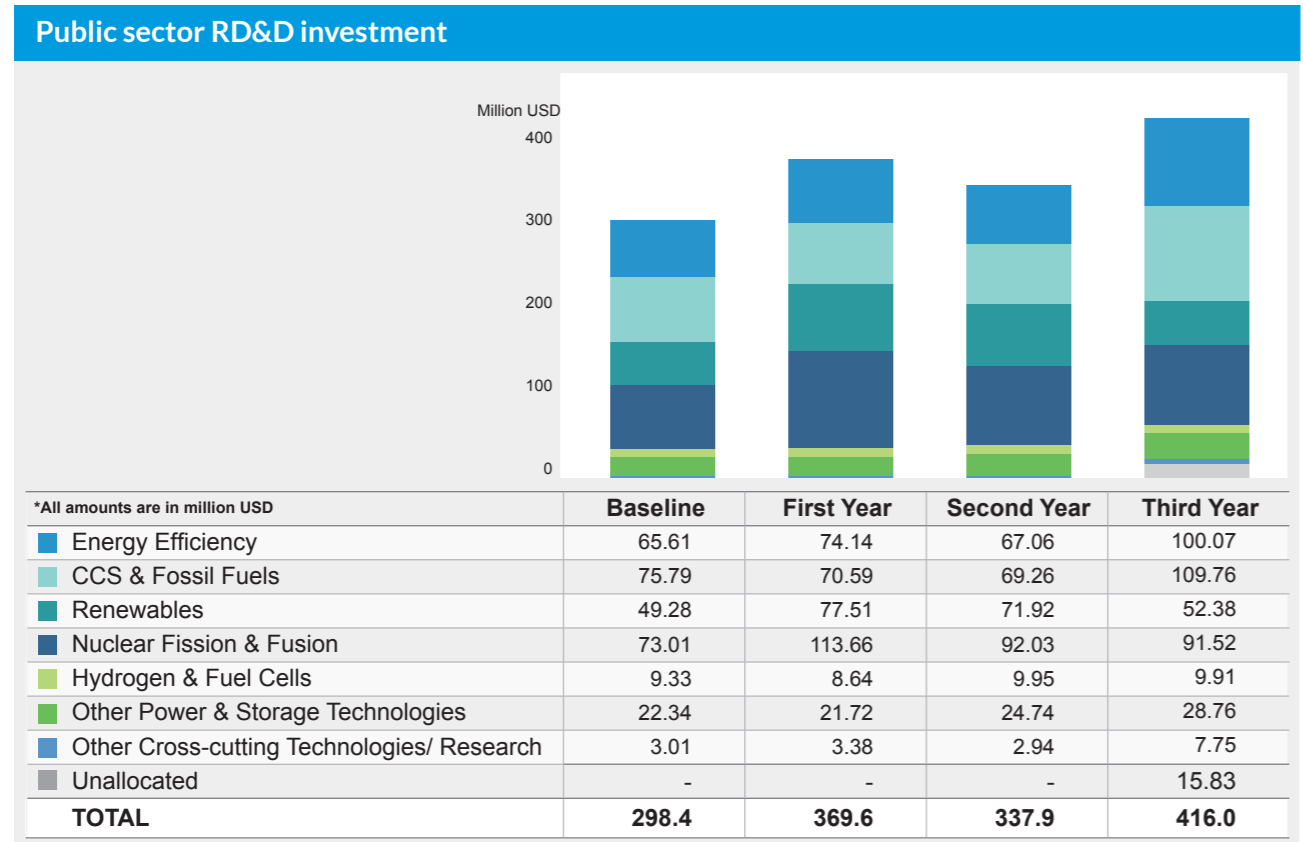
<sup>24</sup> <https://www.aecl.ca/>

<sup>25</sup> <https://www.aecl.ca/science-technology/federal-science-and-technology-work-plan/>

<sup>26</sup> <http://www.b-t.energy/coalition/>



To improve MI's recognition and impact within the clean energy innovation ecosystem, Canada commissioned and launched a new visual identity and a new website for MI. The website provides a modernized, dynamic communication platform and is designed to grow with MI into the future.



Canada is on track to meet or exceed our doubling target. Data on Canada's expenditures in Fiscal Year 2018-19 are not yet available, but are expected to show a significant further increase in spending as the initiatives announced in Budget 2017 continue to be implemented.

Statistics Canada administers an annual survey of private sector spending on energy research and development (excluding demonstration), the Industrial energy research and development expenditures by area of technology, by industry group<sup>27</sup>.

### New Collaborations

Collaborators	Name of Collaboration	Brief Description	Sectors	Type of Collaboration	Duration
Canada, US, Mexico	Canada-US-Mexico Trilateral Biojet Workshop	Held at the United States Department of Energy's Pacific Northwest National Laboratories and attended by 64 leading experts from the three countries, the workshop identified key areas for international collaboration on sustainable biofuels (Innovation Challenge 4) and provided input into the design of Canada's The Sky's the Limit sustainable aviation fuel challenge.	Public-private	Research, development	May 15-16, 2018

<sup>27</sup> <https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2710034701>



## CHILE

### Mission Innovation impact case study

In 2019 Chile is going to launch an international call for an Institute for clean energy research, where national and international collaboration is expected in order to develop new solutions with high value for the Chilean energy and mining industry. In this case, MI will be a platform to promote the initiative and to engage leading organizations from MI members. Moreover, as Chile is part of the group IC5 "Converting Sunlight", all the related experience shared in the group were considered.

Even though the call was designed according to national energy and mining priorities, the discussions and innovation focus of the MI members provided key insight to identify the research focuses and to promote public-private engagement and fostering international cooperation.

The impact of the Institute for Clean Energies is expected as follows: development of new materials and innovations that add value to lithium, salts and other materials in the supply chain of electromobility and green growth; the development of photovoltaic and solar concentration energy technologies adapted to extreme desert conditions at competitive costs; the development of a set of technologies for the mining industry in order to produce zero emissions fuels as a competitive energy.

### Update on clean energy innovation policies and strategies

In 2017 the Chilean Ministry of Energy launched a short-term Energy Roadmap, a strategy for the period 2018-2022 which includes the modernization of the sector and a de-carbonization process together with the increase of the energy efficiency and the improve of renewable generation.

The Energy Roadmap was made on the basis of the changes in this sector. It recognises that scientific and technological progress will not come about on its own. It is necessary to keep up with the times and put in the effort needed to get on board with the modernizing trend, clearing and preparing the road ahead to take advantage of the new opportunities and solutions linked to technological development and innovation, such as the new sources of electricity generation, distributed generation and storage alternatives, electro mobility, electricity demand side management, and a number of options that will be available to contribute to Chile's economic and social progress.

The strategy is to continue with the most relevant energy innovations programs, such as the development of a new photovoltaic solar panel specially designed for desert conditions and fostering new innovation opportunities oriented to explore new opportunities, as the hydrogen as an energy carrier.

### Major innovation initiatives in 2018/19

One of the key Chilean innovation initiatives is the development of a new photovoltaic system so-called AtaMoS-TeC (Atacama Module and System Technology Center). The AtaMoS-TeC brings together the government and in partnership national and international companies and technology centres, a portfolio of research, development and innovation projects, to adapt a new photovoltaic system designed specifically for desert conditions, covering a gap between the knowledge of its own features for solar power generation and the needs of the Chilean Desert. The goal of AtaMoS-Tec is to adapt and develop new materials, components and operation and maintenance services for photovoltaic systems, ensuring their durability and performance under desert climate conditions.

Another initiative is a public-private Technology Development Program. It started by 2018 to take advantage of the opportunity for using hydrogen as an energy vector, produced by clean sources as wind and solar power. Two international consortiums are undertaking research focused on the development of new low emissions mining extraction trucks powered by mixing hydrogen and diesel; and by powering others mining vehicles incorporating fuel cells to strongly decrease the Diesel consumption. The two consortiums include national and international universities and companies experienced on hydrogen applications.

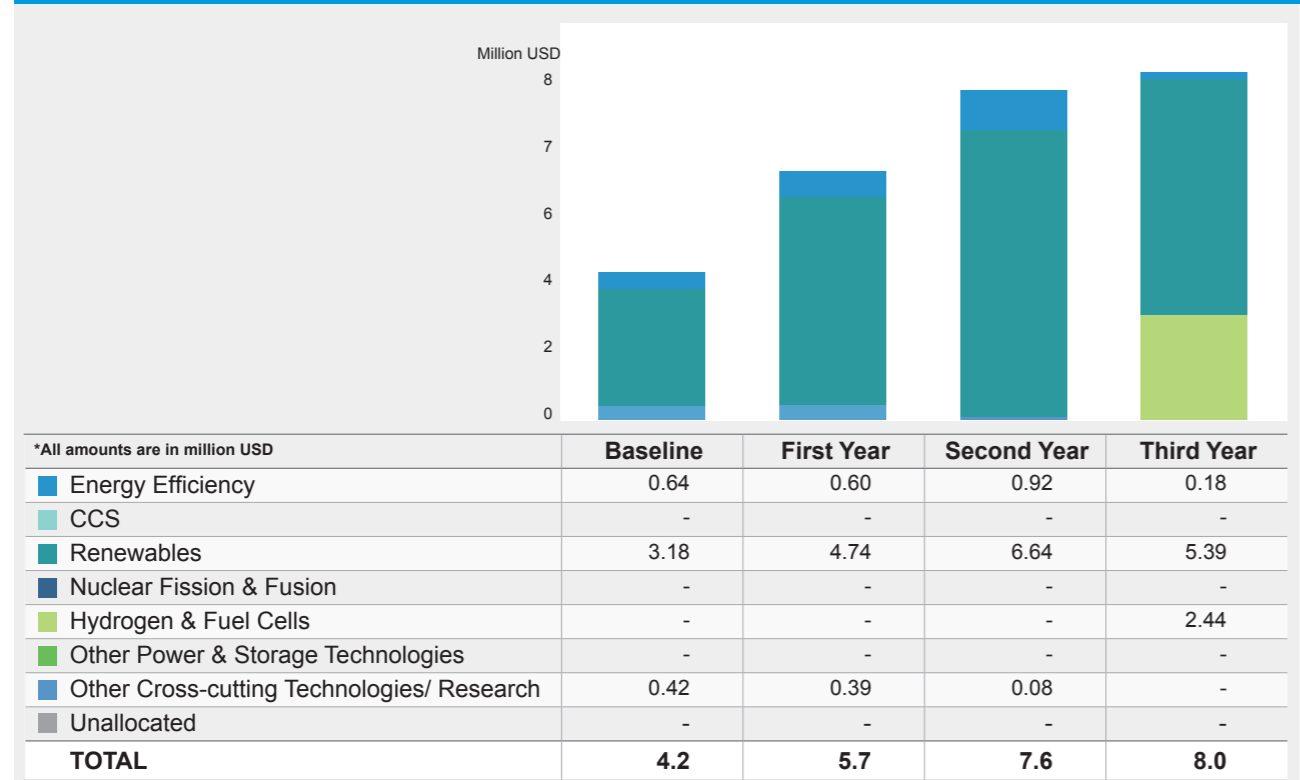
**Major activities in support of the Innovation Challenges in 2018/19**

The Chilean Ministry of Energy will announce an open call for a “Chilean Technological Institute for solar energy, low emissions mining and advanced materials of lithium and other materials” in the context of MI-4 and related to the IC5 Converting Sunlight where Chile is a member.

The Technological Institute should develop industrial research and technological development, provide technological services, collaborate with the development and strengthening of human capacities, execute actions of diffusion, extension and promotion of entrepreneurship and technology-based innovation and open innovation.

The areas of interest are solar energy, low emissions mining and advance materials of lithium and other minerals for electromobility and energy storage. It is expected a project with a time scope of at least ten years and funds for more than USD 10 million per year.

**Public sector RD&D investment**



**CHINA**

**Mission Innovation impact case study**

**Research on Key Technologies of the Microgrid System concerning Comprehensive Utilization of Multi-Renewable Energy Resources Based on Solar Energy**

To respond to the demand for a reliable and environmentally friendly process of urbanisation in China, the research and demonstration is taking place on a new type of integrated multi-energy micro-grid system based on solar energy. The key elements of system planning and design, intelligent control/inversion, energy efficiency and demand response are combined to result in 60% of supply from renewables, heat storage and electricity storage demonstration.

Relating to the sub tasks of IC1, advanced models, mechanisms and related policies of multi-energy complementary integrated application systems have been studied.

The implementation of new megawatt-level Combined Cooling Heat & Power micro-grids in rural communities will inform a set of strategies for the promotion and application in urbanization in western provinces and regions of China. It will promote the extensive utilization of renewable energy, and promote the construction of intensive, intelligent, green and low-carbon urbanization in China.

**Update on clean energy innovation policies and strategies**

From 2016 to 2018, China's Ministry of Science and Technology successfully launched a number of key state research and development programs in the areas of clean and high efficiency utilization of coal and new types of energy saving technology, new energy vehicles, smart grid, renewable energy and hydrogen energy, and provided active support to such research, development and demonstration (RD&D) in the field of clean energy.

In April 2017, a number of government agencies including the state Ministry of Science and Technology (MOST), National Development and Reform Commission and the Ministry of Education jointly published the “Plan for State Technological Innovation Project during the ‘Thirteenth Five-year Plan’ Period”. The Plan defined that the key areas of clean energy deployed by the State Technological Innovation Center included nuclear energy, smart grid and clean and high efficiency utilization of coal. The Plan put forward the general objective of the achievement of an enterprise-centered, market-oriented technological innovation system with combined resources from industry, academy and research and development (R&D), improvement of enterprises’ independent innovation capability and core industrial competitiveness, and strengthening of the transformation of technological achievements and the perfection of an innovation and start-up business service system.

**Major innovation initiatives in 2018/19**

From 2016 to 2018, the “Smart Grid and Equipment” Project was launched by the state Ministry of Science and Technology (MOST) to support 120 innovation projects, with total public support of 1.5 billion RMB.

In 2018, the “Renewable Energy and Hydrogen Energy Technology” Project was launched by MOST to support 31 innovation projects, with total public support of 0.5 billion RMB.

**Major activities in support of the Innovation Challenges in 2018/19**

- IC1 members are going to release the Country Report 2019 and China is one of the three co-leads of this report.
- At the 4<sup>th</sup> Workshop on Smart Grid Innovation Challenge in November 2018, the Institute of Electrical Engineering of the Chinese Academy of Sciences (IEE CAS) signed a letter of intent with the International Smart Grid Action Network (ISGAN) to promote close cooperation and mutual support between international groups.

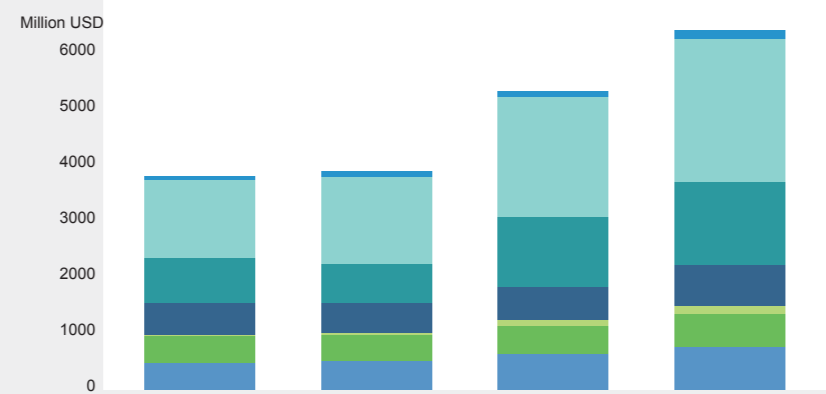
- Led by IEE CAS, the participants in IC1 Task 6 attended the IC1 Smart Grid Industry Working Group Forum and prepared a keynote report on the application of block-chain technology in the smart grid.
- In accordance with the mandate of MI, the 2nd International Conference on Sustainable Biofuels was held in Yantai, Shandong Province, China during April 2-4, 2019. A conference report on progress of IC4 development will be published by co-lead countries.

Other Mission Innovation related activity in 2018/19

Entrusted by the Department of International Cooperation of the Ministry of Science and Technology, the Chinese Secretariat of MI is established under the Renewable Energy Power Generation System Research Department of the Institute of Electrical Engineering. It is responsible for the cooperation and communication of all the Chinese organizations that are participating in the Innovation Challenges.

In January 2019, in Beijing, there was a plenary meeting for all participants in the MI ICs in China to report on their achievements and future plans under the frame of the MI ICs.

Public sector RD&D investment



\*All amounts are in million USD

	Baseline	First Year	Second Year	Third Year
Energy Efficiency	78.60	92.20	122.43	146.61
Cleaner Fossil Fuels	1,381.50	1,526.60	2,116.08	2,539.30
Renewables	798.07	695.28	1,224.30	1,469.17
Nuclear Fission & Fusion	550.18	529.02	604.59	725.51
Hydrogen & Fuel Cells	18.14	45.34	105.80	126.96
Other Power & Storage Technologies	480.65	453.45	483.68	580.41
Other Cross-cutting Technologies/ Research	471.58	512.39	633.31	760.28
Unallocated	-	-	-	-
<b>TOTAL</b>	<b>3,778.7</b>	<b>3,854.3</b>	<b>5,290.2</b>	<b>6,348.2</b>

New Collaborations

Collaborators	Name of Collaboration	Brief Description	Type of Collaboration	Duration
Denmark	Student and researcher exchange	Institute of Electrical Engineering of the Chinese Academy of Sciences and the Danish Technical University developed a cooperation intention and further exchanges with senior researchers	Research development	2018



DENMARK

Mission Innovation impact case study

A collaboration between the Center for Electric Power and Energy, the Danish association Intelligent Energi (iEnergi) and the Climate Knowledge and Innovation Community was formed with the purpose of further strengthening the Danish participation in IC1 in the period 2019-2020. It is the first project supporting MI activities to receive funding from the Danish Energy Technology Development and Demonstration Program (EUDP). The collaboration was initiated through IC1.

Update on clean energy innovation policies and strategies

In June 2018, the Danish government signed an energy agreement with the unanimous support of all parties in the Danish parliament.

The agreement establishes a professional and efficient energy sector as the basis for the transition to a sustainable green society, and focus on renewable energy, energy efficiency improvements, research, and energy regulation.

The agreement provides for significant investments to realise the ambition of a low-emission society by the year 2050. It also establishes the framework for a cost-effective green transition, taking into account the costs for society and individuals, as well as the rapidly advancing technology.

Major innovation initiatives in 2018/19

In 2018 Innovationfund Denmark invested 103 million DKK more than was earmarked for energy research and innovation through the MI doubling commitment.

Major activities in support of the Innovation Challenges in 2018/19

As part of the official CEM and MI activities in Copenhagen and Malmö in May 2018 Denmark hosted a public workshop on MI IC1 (Smart Grids). At the workshop a Joint Statement and Recommendations were handed over to the Ministerial representatives from India, Italy, Sweden and Denmark present at the workshop. In the Joint Statement it is stressed that the IC1 working group continue its commitment to strongly supporting the ongoing fruitful joint collaboration within IC1.

A collaboration between the Center for Electric Power and Energy, the Danish association Intelligent Energi (iEnergi) and the Climate Knowledge and Innovation Community was formed with the purpose of further strengthening the Danish participation in the MI IC1 in the period 2019-2020. It is the first project supporting MI activities to receive funding from the Danish Energy Technology Development and Demonstration Program (EUDP).

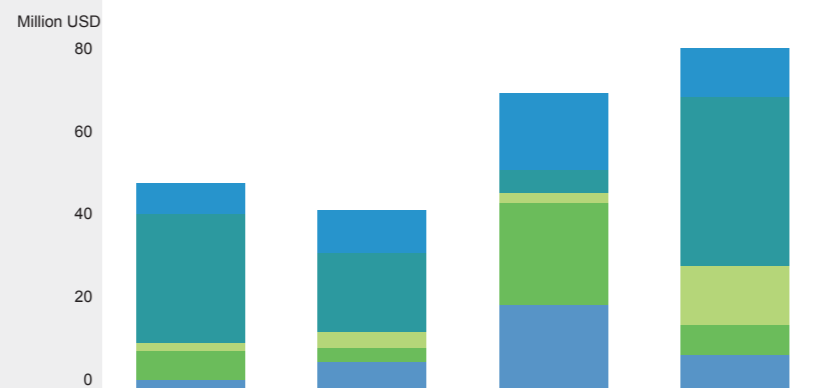
The research collaboration SDC (Sino Danish Center), which the Technical University of Denmark is part of, has a new theme on 'Sustainable Energy'. The collaboration supports PhD-scholarships and the purpose is to achieve international excellence in research and education in sustainable energy systems and deliver high quality candidates to the energy sector.

In 2019 EUDP, the Danish energy research, development and demonstration program, has included MI activities as part of their funding scheme.



## EUROPEAN COMMISSION

### Public sector RD&D investment



\*All amounts are in million USD

	Baseline	First Year	Second Year	Third Year
Energy Efficiency	6.86	9.60	17.22	10.69
CCS	-	-	-	-
Renewables	28.82	17.56	5.43	38.60
Nuclear Fission & Fusion	-	-	-	-
Hydrogen & Fuel Cells	2.09	3.98	2.42	13.26
Other Power & Storage Technologies	6.59	3.07	22.63	7.00
Other Cross-cutting Technologies/ Research	1.87	5.99	19.13	7.43
Unallocated	-	-	-	-
<b>TOTAL</b>	<b>46.2</b>	<b>40.2</b>	<b>66.8</b>	<b>77.0</b>

### Mission Innovation impact case study

In October 2018, the European Commission and Breakthrough Energy<sup>28</sup> announced their intention to create a €100 million joint pilot investment fund - Breakthrough Energy Ventures - Europe (BEV-E). This pilot fund will invest in and develop economically-viable breakthrough clean energy technologies and companies established in the EU. It will pioneer a new European public-private co-investment vehicle and its investments will target the five key areas that reflect the major energy- and greenhouse gas (GHG)-related challenges where efforts are essential to combat climate change: (1) electricity, (2) transportation, (3) agriculture, (4) manufacturing, and (5) buildings. It is expected to be operational by mid-2019.

Breakthrough Energy Coalition, spearheaded by Bill Gates, was launched simultaneously with MI. It is an international group of private investors, prominent companies, funds, institutional investors and banks that share a commitment to accelerate the commercialization of new clean energy technologies and building new tools to address climate change. Breakthrough Energy Ventures (BEV) is the first investor-led fund created by Breakthrough Energy in December 2016 with more than US\$1 billion in committed capital to build new, cutting-edge energy companies around the world.

Half of the equity of BEV-E will come from Breakthrough Energy and the other half from InnovFin - risk-sharing financial instruments funded through Horizon 2020, the EU's current research and innovation program.

The public-private breakfast session at the 3<sup>rd</sup> MI Ministerial during which 'bold ideas' (developed by the World Economic Forum to boost private engagement in supporting and financing deep-tech energy innovations) were discussed, helped raise the value and need for such public-private co-investment vehicles.

In the pilot phase, the impacts are anticipated on numerous fronts:

- New innovative solutions and technologies that reduce greenhouse gas emissions and technology cost reach early commercialization
- Growth of early-stage companies in Europe delivering breakthrough energy innovations (i.e. job creating)
- Increased number of investors in Europe providing patient capital (risk-tolerant)

### Update on clean energy innovation policies and strategies

The governance of the Energy Union (the main policy strategy for energy and climate of the European Union [EU]) entered in to force, requiring EU member states to develop National Energy and Climate Plans (NECPs)<sup>29</sup>. These covered the five different dimensions of the Union, including research, innovation and competitiveness. The reinforced governance of the Energy Union will help monitor the Energy Union's objectives.

The Strategic Energy Technology (SET) Plan<sup>30</sup>, which is the main instrument to structure national and EU programmes around shared objectives and to strengthen cooperation among European countries in the sector of energy, has endorsed all its fourteen Implementation Plans. These Implementation Plans intend to trigger public and private investments in the key energy research and innovation priorities<sup>31</sup> of the Energy Union. Following the launch of the EU Battery Alliance in 2017, the European Commission (EC) also adopted a Strategic Action Plan for Batteries.

<sup>28</sup> <http://www.b-energy/>

<sup>29</sup> Draft NECPs were submitted by EU Member States by the end of 2018, whilst final versions are to be submitted by end 2019 - see <https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/governance-energy-union> and <https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/governance-energy-union/national-energy-climate-plans>

<sup>30</sup> <https://ec.europa.eu/energy/en/topics/technology-and-innovation/strategic-energy-technology-plan>

<sup>31</sup> <https://publications.europa.eu/en/publication-detail/-/publication/a3b22c5b-ed41-11e8-b690-01aa75ed71a1/language-en/format-PDF/source-803647918>

Furthermore, the Accelerating Clean Energy Innovation (ACEI) strategy continued to be implemented as a dimension of the Energy Union policy. A second report was produced presenting the progress achieved in the 20 actions outlined in the strategy<sup>32</sup>.

Lastly, the EC presented its strategic long-term vision for a climate-neutral Europe by 2050, launching the debate on EU's long-term climate ambition and strategy. Research, innovation and international cooperation feature among the top priorities of this proposal<sup>33</sup>.

### Major innovation initiatives in 2018/19

The 2018-2020 work programme of the Societal Challenge "Secure, Clean and Efficient Energy" of the Horizon 2020 (H2020) framework research programme was approved, securing about €1,900 million for research activities related to clean energy. This included a budget allocation of about €250 million towards research and innovation on electric batteries and about €400 million for research in thematic areas related to the Innovation Challenges of MI (additional budget on projects with relevance to clean energy will also be spent in other programme parts, e.g. European Research Council, Marie Skłodowska-Curie Actions).

The EC published its proposal for Horizon Europe, the €100 billion research and innovation programme running from 2021 to 2027 that will succeed Horizon 2020 and will continue supporting European clean energy innovation research<sup>34</sup>. The EC proposed that 35% of research funding be dedicated to climate-related research and €15 billion for the Climate/Energy/Transport cluster.

The InnovFin Energy Demonstration Programme (EDP)<sup>35</sup> achieved significant momentum, with more than €140 million mobilised by the European Investment Bank as loans for four innovative flagship First-of-its-kind commercial-scale demonstration projects in strategic sectors for clean energy.

### Major activities in support of the Innovation Challenges in 2018/19

The EU has increased its support to the Innovation Challenges (IC) by introducing as many as 15 new research initiatives relevant to ICs in its 2018-2020 Work Programme of Horizon 2020, such as:

- 7 new calls relevant to five ICs (1, 2, 4, 5, and 7).
- The project SUNRISE, relevant to IC5, under the Future Emerging Technology programme (budget: €1 million).
- The inducement prize "RESponsible Island - Prize for a renewable geographic energy island" (relevant to IC2).
- A second call for ACT<sup>36</sup>(relevant to IC3) was published on 4th June 2018. The budget for the Call is up to €30 million.
- 6 new calls relevant to IC8 in the Work Programme of the Fuel Cells and Hydrogen Joint Undertaking.

<sup>32</sup> [https://ec.europa.eu/commission/sites/beta-political/files/swd-progress-accelerating-clean-energy-innovation-april2019\\_en.pdf](https://ec.europa.eu/commission/sites/beta-political/files/swd-progress-accelerating-clean-energy-innovation-april2019_en.pdf)

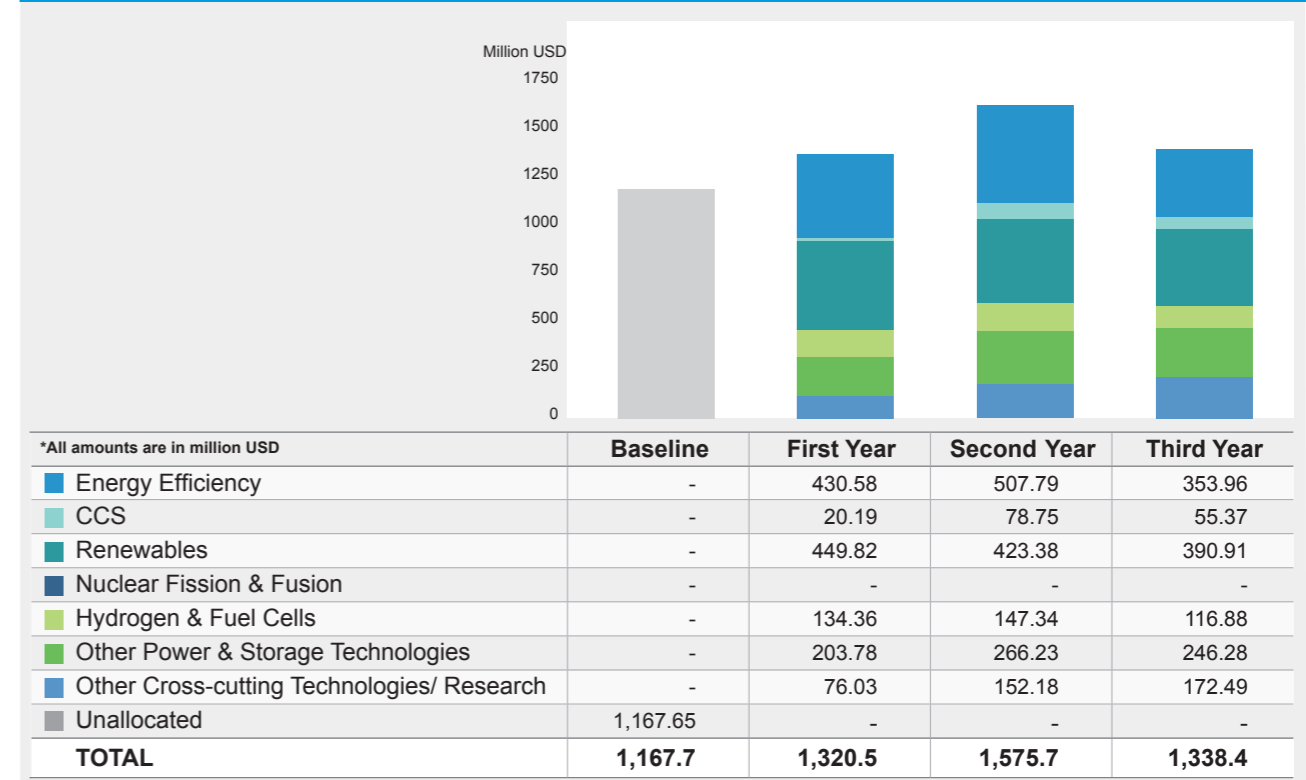
<sup>33</sup> COM(2018) 773 final

<sup>34</sup> [https://ec.europa.eu/info/designing-next-research-and-innovation-framework-programme/what-shapes-next-framework-programme\\_en#whatshapethecommissionsproposal](https://ec.europa.eu/info/designing-next-research-and-innovation-framework-programme/what-shapes-next-framework-programme_en#whatshapethecommissionsproposal)

<sup>35</sup> The InnovFin EDP facility provides loans, loan guarantees or equity-type financing between EUR 7.5 Million and 75 Million to first-of-a-kind commercial-scale demonstration projects in the fields of energy system transformation, including but not limited to renewable energy technologies, smart energy systems, energy storage, carbon capture and storage or carbon capture and use. The four new projects signed by the European Investment bank in 2018 were for (a) the manufacturing of innovative battery cells for use in transport, energy storage and industry (Northvolt, Sweden); (b) for a floating wind farm (WindFloat Atlantic, Portugal); (c) for a network of ultra-fast charging stations for electrical vehicles in Central and Eastern Europe (GreenWay, Slovakia); and (d) for an innovative 50 MW/year automated manufacturing plant of reversible fuel cells and stack systems (Elcogen, Estonia). See <https://www.eib.org/en/infocentre/publications/all/innovfin-energy-demo-projects.htm>

<sup>36</sup> ACT is an international initiative to facilitate RD&D and innovation, particularly through joint calls, within CO2 capture, utilisation and storage. ACT is managed by a consortium of 10 participants, of which 9 from Europe and one from the US, which joined this network in 2018 bringing its own resources (EUR 10 Million). See <http://www.act-ccs.eu/about-us>

### Public sector RD&D investment



Based on CORDA data, extracted on 1 April 2019. At this time only partial data is available for 2018 because the signature of projects, based on 2018 global commitments, is continuing throughout 2019.

### New Collaborations

Collaborators	Name of Collaboration	Brief Description	Sectors	Type of Collaboration	Duration	Funding amount	Additional information
Mexico, Argentina, Uruguay	BABET-REAL5 (project)	The objective of the project is to develop an alternative solution for the production of 2G bioethanol to the current model requiring high capital investment and huge amounts of biomass. This solution will be competitive at smaller scale, processing 30,000 tons dry biomass per year. It will be applicable to many countries, rural areas, feedstocks.	Open to both public and private sector	Research and development	2016 to 2020	6M€ total - EU contributes 5.5M€ and Mexico 0.4M€	<a href="https://cordis.europa.eu/project/rcn/199585/factsheet/en">https://cordis.europa.eu/project/rcn/199585/factsheet/en</a>
Norway (coordinator), France, Germany, The Netherlands, UK, United States, EU (Romania: Greece, Spain	ACT-ERANET 2nd Call 2018-2019 3rd Call 2020 (Accelerating CCS Technologies)	ACT is an international initiative to facilitate RD&D and innovation within CO2 capture, utilisation and storage (CCUS). The ambition is to fund world class RD&D innovation that can lead to safe and cost effective CCUS technology.	Calls open to both public and private sector	ACT is an ERA NET Cofund, which is a tool established by the European Commission under the Horizon 2020 programme for research and innovation. The idea behind ERA NET Cofunds is that European countries should join forces when it comes to funding RD&D and innovation on subjects of high European interest. ACT is one of many ERA NET Cofunds, but ACT is the only ERA NET Cofund addressing CCS. The ACT-ERANET are targeted to the identified Priority Research Directions (PRDs) under Mission Innovation Challenge 3-CCUS.			



## FINLAND

## Mission Innovation impact case study

The Smart Otaniemi Innovation Ecosystem has been initiated, supporting innovation of new smart energy solutions through collaboration between industry and research actors. The ecosystem is currently running 11 pilots in real living lab circumstances. Today the ecosystem already has about 60 partners, companies and research organisations, focusing on new energy services. An important basis for the ecosystem is set by the open Internet of Things platform utilizing 5G and other new technologies.

The strategic visibility of smart energy initiatives has increased as a result of the ecosystem.

MI has provided the platform for finding partners for the strategic initiatives.

The Smart Otaniemi ecosystem is strongly integrated with Finnish MI activities. The activities within ecosystem feed the Finnish agenda for MI challenge activities. MI also helps to facilitate networking and information exchange with similar centers or ecosystems globally. It enables a global dimension for cooperation of the ecosystem through:

- Joint calls helped to find good partners
- Collaboration with other MI members

The Smart Otaniemi ecosystem has been recently initiated. It develops principles for sharing data and controllability across different actors. It will thus allow access of new players developing new energy services. The resulting impacts will be in emission reduction, reducing costs, stimulating companies activities for employment and export, etc.

## Update on clean energy innovation policies and strategies

Finland's clean energy innovation policies are based on the Government reports on the National Energy and Climate Strategy for 2030 and the Medium-term Climate Change Plan for 2030 submitted to Parliament, they include inter alia:

In the existing national energy and climate strategy it is stated that Finland will continue to make major investments in developing new technologies and commercialising innovations. Full use will be made of the international MI cooperation. Since the strategy was launched in 2016 several actions have been taken to fulfil the goals of the strategy.

In addition to innovation initiatives several recent policy actions in Finland's energy market framework will spur clean energy innovations.

With minor exceptions, Finland will phase out the use of coal for energy. The share of transport biofuels will be increased to 30 per cent, and an obligation to blend light fuel oil used in machinery and heating with 10 per cent of bioliquids will be introduced. The minimum aim is to have 250 000 electric and 50 000 gas-powered vehicles on the roads. The electricity market will be developed at the regional and the European level. The flexibility of electricity demand and supply and, in general, system-level energy efficiency will be improved. Technology neutral tendering processes will be organised in 2018–2020, on the basis of which aid will be granted to cost-effective new electricity production from renewable energy.

## Major innovation initiatives in 2018/19

- In 2017, a four year program, Smart Energy Finland, was launched, the budget of the program is €100 million.

- In 2018, a three year activity, Batteries from Finland and a four year program, Smart Mobility, were launched. The budget of these programs is over €100 million.

- In 2018 several test and innovation platforms were initiated as part of Smart Energy Finland:

<sup>1</sup> The Smart Otaniemi platform<sup>37</sup> involves over 60 companies. At Smart Otaniemi, we are renewing the way research and development is done, and pushing the boundaries of new energy technology. With Finnish hi-tech excellence the foundations of future standards will be built. We create more sustainable world through pilots involving everything from AI and blockchain, to aggregator business models, smart EV charging infrastructure, and 5G and IoT services.

<sup>2</sup> Åland Island Smart Energy Platform, over 20 companies and research entities are involved. The project aims to create a piloting area for new smart energy technologies on Åland Islands. It has now entered the implementation phase. Based on smart electricity networks and innovative energy storage solutions utilization of 100% renewable energy is becoming reality. Key elements in the system are its ability to integrate decentralized production of renewable energy and to control simultaneous fluctuations in demand and production. It is also important to allow consumers to operate actively as part of the system. The area is a unique place for companies to test new energy solutions, and it will also act as a reference for Finnish export industry. In addition, it can provide a unique piloting platform attracting international investments and operators.

<sup>3</sup> SolarX large joint project of 4 universities and over 10 companies. The aim of the consortium is to remove the technical barriers to extensive solar power integration into the electric power systems and distribution networks, as well as to enable easy access to the electricity markets for the new prosumers having local PV generation. Novel solutions will be investigated for the energy storage applications on various system levels, control and operation of micro grids, power balance and grid stability, as well as control and operation of PV inverters. Enabling technologies investigated will be AI for energy analysis and forecasting, 5G for connectivity, digital platforms for integration and block chains for exchanging energy and related data. In addition, novel primary components will be studied for medium and low voltage networks in order to enhance PV hosting capacity of these networks.

- Batteries/energy storages Battery Recycling ecosystem, BatCircle, was created in the end of 2018. 30 companies, universities and research Institutes are involved. This ecosystem was recognized by EU Commission and Finland was asked to lead the Battery Recycling sub working group under the Battery Implementation plan.

- In 2019, the Power to X, Blue electricity initiative was launched. Lappeenranta University of Technology and VTT are preparing the ecosystem at the moment. Discussions with 20 companies have been held and they are looking for international partners. The aim of the Blue Electrification Innovation Ecosystem project is to produce an operating model for a dynamic ecosystem based on clean, affordable and unlimited resource of electricity. The cornerstone of the ecosystem is the rapid electrification of society, including Power to X to Power solutions combined with maximum utilization of digitalization. In addition to the ecosystem theme, the project aims to produce a road map for the commercialization and research activities of the topic for coming years.

## Major activities support of the Innovation Challenges in 2018/19

- Finland has been actively involved in the operation of the EU Strategic Energy Technology Plan (SET-Plan). The SET-Plan combines the promotion and better coordination of energy technology in the EU and the EEC countries. A total of 14 implementation plans have been prepared in the SET-Plan between 2016 and 2018. Finland has participated actively in the preparation and introduction of these implementation plans.

- SET-Plan key action no 7. "Batteries for e-Mobility and Stationary Storage" where Finland is leading the Working Group on battery recycling. Finland has launched an ecosystem type of consortium named BatCicle, where over 30 companies, universities and research institutes are involved.

- Finland – China (Business Finland – MoST) joint call for clean energy collaboration was opened in the end of 2018.

- A Joint Call in the Smart Energy theme with Germany was launched and 10 joint projects were funded.

<sup>37</sup> <https://smartotaniemi.fi/>



## FRANCE

### Mission Innovation impact case study

The involvement of France in IC2 as co-lead has had a significant impact for the launching of support activities in the field of off-grid energy access. It enabled or at least accelerated the launch of the call for projects completed in 2018, making possible the funding of 9 projects targeting energy innovation on the African continent. It has also allowed a close cooperation between France and India on off-grid access to energy innovation programs sharing objectives and projects accomplishments.

The international dimension of MI gives strong emphasis to all the activities performed under its umbrella. As an example, the calls for projects launched in the frame of IC2 obtained international visibility and the project nominees could have access to a worldwide audience (pitch at MI-3, presentation of the projects at the IC2 international workshops).

Projects are currently in progress, they will stand as demonstration solutions to be widely deployed in the frame of a scale-up process to follow. These projects, if successful have the potential to dramatically improve the life of the populations, by bringing viable and locally climate compatible energy solutions in the African off-grid territories.

### Update on clean energy innovation policies and strategies

To face climate change challenges and be collectively able to limit global warming under 2°C, innovation will be key. It will enable us to act simultaneously towards three major goals: reduction of greenhouse gas emissions, economic development and job creation, and energy security. These goals are at the heart of French energy transition for green growth act, which was passed in August 2015, a few months before COP21 and the Paris Agreement.

In July 2017 the Minister for the Ecological and Inclusive Transition presented the Government's Climate Plan. Drawn up at the request of the President and Prime Minister, this calls on all government departments across the board to step up the pace of the energy and climate transition and of the Paris Agreement's implementation, throughout the five-year term.

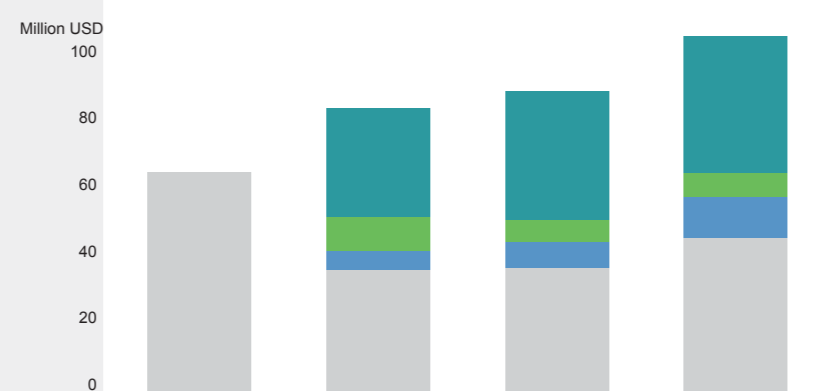
As a follow-up to those political corner stones which the green growth act and the climate plan represent, France published in January 2019 its multi-annual energy plan (MEP), covering all aspects of energy policy and all forms of energy. The MEP sets out two fundamental priorities: reducing energy consumption, particularly fossil fuel consumption, and developing renewable energy sources. These will be the central tenets of our energy system as it evolves to meet the demands of the low-carbon economy.

In the same time frame, France published its National Low-Carbon Strategy (SNBC), which defines the trajectory to reduce greenhouse gas (GHG) emissions at the national level and orchestrates the implementation of the transition towards a low-carbon economy. This strategy defines over three periods of time (2015-2018, 2019-2023, 2024-2028) the upper limits for greenhouse gas emissions that should not be exceeded on average at the national level (carbon budget) and sets targets by sectors of activity.

Regarding research and innovation, France published its National Energy Research Strategy in December 2016, focusing on key transformational themes for energy transition (energy efficiency and integration of renewable sources, increased flexibility, digitization and decentralization of systems). It also emphasizes the need to support cross disciplinary research, to foster innovation in relation to territories and the industrial network, in particular small businesses, and to develop skills and knowledge for and through R&D.

In June 2018, the French Minister for an ecological and solidary transition announced a national hydrogen plan aiming at an accelerated deployment of green hydrogen production facilities. Among other measures, the plan foresees a support of €100 million to fund innovation projects which will make the scaling-up of green hydrogen solutions possible.

### Public sector RD&D investment



\*All amounts are in million USD

	Baseline	First Year	Second Year	Third Year
Energy Efficiency	-	-	-	-
CCS	-	-	-	-
Renewables	-	31.88	37.78	33.77
Nuclear Fission & Fusion	-	-	-	-
Hydrogen & Fuel Cells	-	-	-	-
Other Power & Storage Technologies	-	9.68	6.26	6.97
Other Cross-cutting Technologies/ Research	-	5.31	7.44	18.65
Unallocated	64.82	36.84	37.31	50.30
<b>TOTAL</b>	<b>64.8</b>	<b>83.7</b>	<b>88.8</b>	<b>109.7</b>

### New Collaborations

Collaborators	Name of Collaboration	Brief Description	Sectors	Type of Collaboration	Duration	Funding amount	Additional information
China	Joint call	Energy related joint call	Public-private	R&D&I	2018	2M€	Held every year

Major innovation initiatives in 2018/19

Regarding the actual financing of clean energy innovation projects, a new round of the French programme of investments for the future was launched by the end of 2016, with a total amount of funding of €10 billion over 2017-2025. Around two thirds of this sum will be dedicated to the ecology and energy transition in general, including clean energy innovation in particular.

In this framework, the different actions operated by the French environment & energy management agency (ADEME) supported since 2010, 745 projects with a total amount of support of €2.5 billion (budget overall projects: €7.22 billion). The targeted sectors were energy transition, transportation for the future, circular economy, eco-efficient buildings, industry and agriculture.

The third strand of the future investment programme (Programme d'investissements d'avenir (PIA)), launched early last year, has provided ADEME with a funding envelope of €1 billion for the energy transition. Among which, namely:

- €300 million State aids (grants and repayable advances) for the action demonstrators of the energy and ecological transition,
- €400 million in equity for innovative infrastructure investments of the "First Of A Kind" commercial type,
- 150 M€ for the so-called Innovation Contest, a call for projects dedicated to SME's and start-ups.

In addition, ADEME launched this year two calls for projects to enhance hydrogen innovation and its scale up, targeting two sectors, transportation and mobility and industrial processes.

In parallel, the programme of investments for the future enabled the setting-up of the Energy transition institutes (ITE), multi-disciplinary platforms addressing topics focussed on the energy transition. They bring together the know-how of the industry and the academic world and are based on a public-private co-investing partnership. Ten ITE's were recognized, covering various sectors, namely: green chemistry and bio-sourced materials, renewable marine energy, solar energy, geothermal energy, smart electric grids, energy efficiency, sustainable buildings, decarbonised vehicles and innovative mobility. The whole programme is provided with a budget envelope amounting to circa €450 million, financing up to 50% of the activities of the institutes.

Major activities in support of the Innovation Challenges in 2018/19

France participates in the 8 innovation challenges. All are considered very relevant to contribute to accelerate the deployment of innovative low-carbon solutions. Among all the activities performed may be highlighted several specific actions. Namely:

**IC2:** Among the 8 Challenges identified by MI, the Challenge on "innovation for off-grid electricity access from renewable" is co-led by France and India.

- France launched a call for proposals (CFP) on innovative solutions for off-grid access to energy, enabling the selection of 9 projects in March 2018. The global budget of these 9 projects amounted €5.8 million with a support amounting €1.8 million. The selected projects address various innovative technologies (hybrid electricity production, solar, river stream generator), different uses of electricity enhancing economic development (irrigation, agriculture, desalination, mobility) and electricity payment issues (pay as you go, leasing).
- A workshop was held in India at the beginning of March 2019 organised by the Indian Department of Science and Technology with French participation. This event gave the opportunity to gather stakeholders, government representatives, entrepreneurs and researchers and exchange on projects selected by French and Indian CFP on innovation for off-grid energy access.a

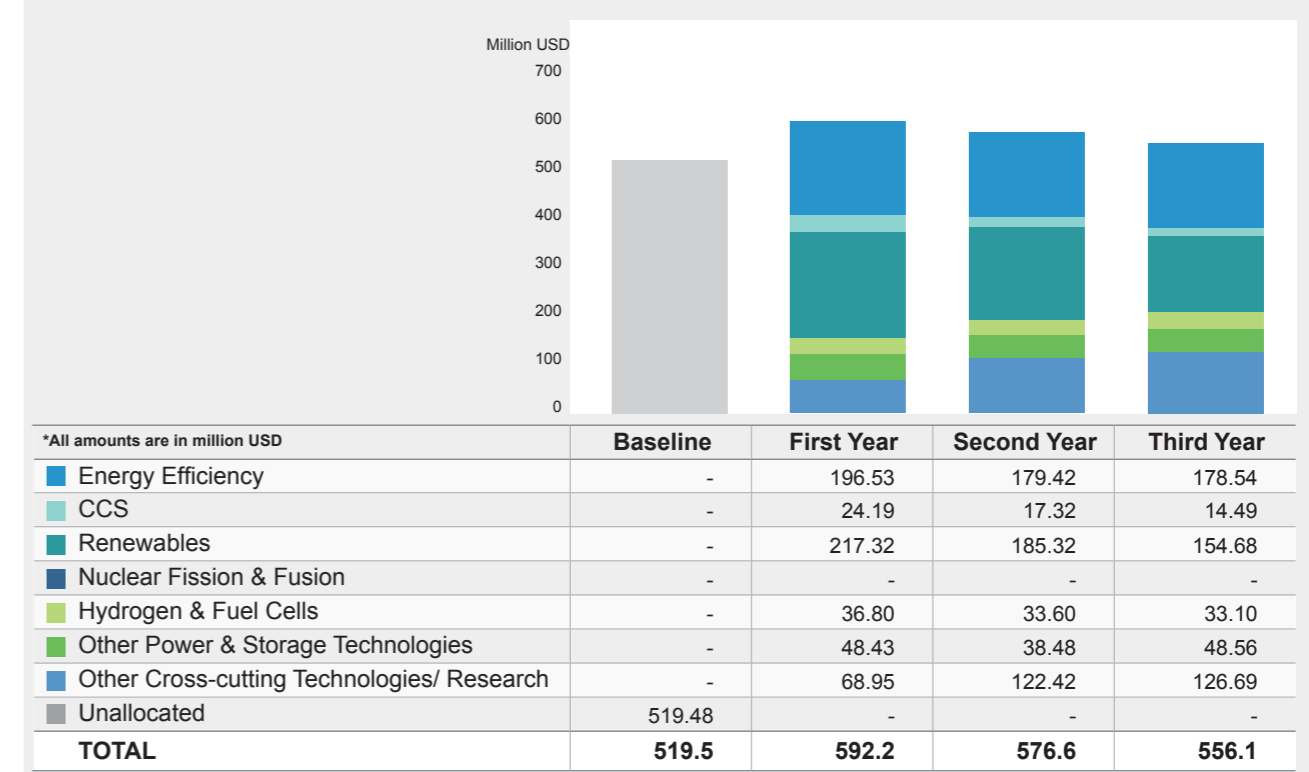
**IC3:** France joined the CCUS (CO<sub>2</sub> capture, utilisation and storage) innovation challenge from its foundation in 2016. This topic is addressed by the French low-carbon national strategy as one of the levers to reach the goal of neutrality carbon (e.g. coupling CCUS with biomass combustion). Hence, France:

- Participates to the ERANET ACT CCUS (European funding programme), which aims at supporting projects dealing with the priorities set by this innovation challenge.
- Contributes to the definition of the action plan of the challenge in co-operation with the challenge co-leads, UK, Mexico and Saudi Arabia and is involved in the organisation of an event planned for June 2019, aiming at identifying collaboration between industries and laboratories to work on the major topics identified from the "CCUS Experts Workshop".

**IC8:** France joined the hydrogen innovation challenge from its foundation in 2018, this topic being considered as a major lever of the energy transition

- France actively participates to the events organized by the challenge (workshops of Berlin and Antwerpen).
- Among others, France is looking forward to contributing to the actions which will be performed in the frame of the "Hydrogen valleys" initiative launched by the EC. The Zero Emission Valley (Auvergne Rhône-Alpes Region) was selected to participate to the international cluster of hydrogen valleys.

Public sector RD&D investment



From 2015 (Year 1), Fundamental research is integrated in the calculation of the French R&D public funding in the field of new technologies for energy.

In addition to the figures here-above, it shall be stressed that a significant public support is as well brought by France to nuclear R&D (approximately €500 million). However, the financing of these activities is not part of the French financial commitments taken under MI.



**New Collaborations**

Collaborators	Name of Collaboration	Brief Description	Sectors	Type of Collaboration	Duration	Funding amount	Additional information
EU	ERANet Geothermica	Combination of 17 geothermal energy research and innovation programme owners and managers from 14 countries and their regions.	Public-private	Demonstration and technology development projects to accelerate geothermal energy deployment	2 <sup>nd</sup> call is currently in preparation	20M€	<a href="http://www.geothermica.eu/">http://www.geothermica.eu/</a>
EU	ERANet Smart Energy Systems	The initiative deals with the key challenges and topics of the future energy system:	Public-private	A Transnational Joint Programming Platform to Initiate Co-Creation and Promote Energy System Innovation			<a href="http://www.eranet-martenergy-systems.eu/">http://www.eranet-martenergy-systems.eu/</a>



**GERMANY**

**Mission Innovation impact case study**

**Including artificial photosynthesis in the 7th Energy Research Programme of the Federal Government**

Artificial photosynthesis research in Germany used to be funded primarily as part of the support for basic research. The international expert group established within IC5 and their development of the IC5 work programme contributed to raising awareness about this topic in Germany. Together with the consultative procedure in preparation of the new research programme and a publication by the German Academies of Sciences, the thinking of this expert group was instrumental in shaping the new programme focus and aligning it with other activities in Europe and worldwide.

By supporting research, development and demonstration of artificial photosynthesis technologies as part of applied energy research, Germany is supporting IC5 as well as IC8. International cooperation within MI is explicitly mentioned in the 7th Energy Research Programme. The impact to date has been, to put applied research on artificial photosynthesis in the spotlight and contributing to the ongoing discussion on the feasibility of importing renewable energy in the form of chemical energy carriers.

In future, it is anticipated that increased funding and increased international collaboration will lead to a more rapid technological development in this area. Several projects are already being discussed. In the long run, this might afford opportunities for Germany for exporting high-quality plant technology and importing solar fuels and other valuable substances from regions with higher solar irradiation (particularly desert regions).

**Update on clean energy innovation policies and strategies**

In September 2018 Germany launched the 7th Energy Research Programme of the Federal Government (available in English). The programme focuses on technology and innovation transfer and introduces “living labs for the energy transition” as a new funding instrument. These industrial-scale demonstration projects will investigate the systemic interplay of energy technologies that are already close to market. New emphasis is also being put on start-ups (and SMEs) as important facilitators of innovation transfer. Furthermore, the program significantly broadens the scope of energy research by including and emphasizing system-integration (grids, storage and sector-coupling) and cross-system research topics like digitisation, resource efficiency and societal aspects of the energy transition. International cooperation will be strengthened under the new programme. This includes enhanced cooperation within MI, with an emphasis on hydrogen and solar fuels. In keeping with the motto, ‘efficiency first’, a major fraction of the funding will be directed on the efficient use of energy and the reduction of energy consumption. Renewable energy generation will remain a major focus of energy research.

**Major innovation initiatives in 2018/19**

- Energy Research Networks bring together experts from research, business and industry. At the beginning of 2019 these had grown to accommodate about 3900 members. These networks provide expert support to the Research and Innovation Platform which is the central discussion forum for high-level actors from policymaking, science, business, industry and civil society.
- Living labs for the energy transition: €100 million per year have been set aside to support these large scale demonstration projects in the years 2019-2021.
- Energy transition in the transport sector: A major research initiative was implemented in 2018, with a focus on the renewable production of synthetic fuels. About 150 individual projects have been launched.

- Carbon2Chem: Steel mill gases are now turned into ammonia and methanol during full operation. 20 million tons of CO<sub>2</sub> can be potentially saved per year in Germany.
- The Kopernikus-Projects are one of the largest funding initiatives for the energy transition in Germany and are about to enter the 2<sup>nd</sup> funding phase in 2019. The four projects will have received about €120 million of funding between 2016 and 2019.
- A call for proposals on the digitisation of the energy transition was launched in early 2019.

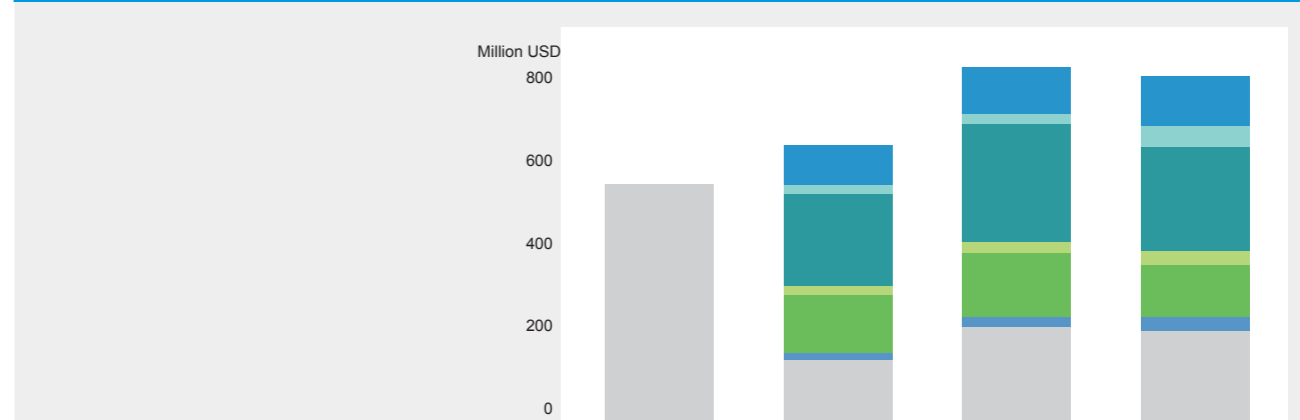
### Major activities in support of the Innovation Challenges in 2018/19

Germany is participating in the development of IC1, IC3, IC6 and IC7 by providing information, supporting researchers in participating at IC events and participating in discussions on further developments. In addition, Germany is co-leading IC5 and IC8, corresponding to the strategic focus on the inherently global topics of hydrogen and solar fuels. In support of IC8 Germany hosted the first IC8 Workshop in Berlin and conducted and participated in many more meetings and workshops with the goal to advance this challenge as quickly as possible. In support of both IC5 and IC8 Germany announced a funding opportunity within the framework of the new 7th Energy Research Programme, including a special emphasis on international collaboration within the scope of IC5 and IC8. Furthermore, Germany will be joining the MICall19, which supports several innovation challenges. Finally, the German Federal Government is promoting MI within the scientific community in Germany and supports scientists in participating in the development of Innovation Challenges. Large-scale and often unique research infrastructure present at major scientific research institutions in Germany can be made available to international researchers as part of international cooperation within the framework of MI.

### Other Mission Innovation related activity in 2018/19

- Germany is participating in the MI Champions Programme and will support the MI Champion from Germany in taking part at MI-4 as well as further engaging in the Innovation Challenges.
- With the focus on better participation of Startups within the energy research programme, Germany is supporting innovation transfer and private sector engagement.
- Germany is promoting MI within its research communication activities, for example the 2018 Federal Government Report on Energy Research.
- Germany is supporting international cooperation on energy research within the Technology Collaboration Programmes of the IEA Energy Technology Network.

### Public sector RD&D investment



\*All amounts are in million USD

	Baseline	First Year	Second Year	Third Year
Energy Efficiency	-	85.71	106.13	112.98
CCS	-	20.54	22.08	50.07
Renewables	-	212.63	266.65	233.43
Nuclear Fission & Fusion	-	-	-	-
Hydrogen & Fuel Cells	-	18.18	25.88	32.56
Other Power & Storage Technologies	-	128.57	147.10	116.62
Other Cross-cutting Technologies/ Research	-	17.71	21.45	32.67
Unallocated	531.64	137.07	210.35	202.26
<b>TOTAL</b>	<b>531.6</b>	<b>620.4</b>	<b>799.6</b>	<b>780.6</b>

Within the MI framework Germany reports project funding on clean energy technologies. In comparison to the data Germany reports to the International Energy Agency (IEA), this does not include institutional funding and project funding for nuclear safety research. It does include some programmes on clean energy technology (specifically SINTEG, EnEff.Gebäude.2050 and Wärmenetze 4.0) that were launched after the start of MI and that are not included in the data reported to the IEA, as these programmes are not part of the Energy Research Programme of the Federal Government.

## New Collaborations

Collaborators	Name of Collaboration	Brief Description	Sectors	Type of Collaboration	Duration	Funding amount	Additional information
23 European Countries including MI members: Austria, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Sweden	ERA-NET Smart Energy Systems Call 2018 – Integrated regional Energy Systems	A transnational Joint Programming Platform to Initiate Co-Creation and Promote Energy System Innovation.	Public-public	Research, development and demonstration	2018 to 2021	6M€	<a href="https://www.eranet-smartenergy-systems.eu/">https://www.eranet-smartenergy-systems.eu/</a>
7 European countries including MI members: Austria, Finland, Germany, Netherlands, Sweden	ERA-NET Bioenergy	A transnational cooperation of programme owners and programme managers in the area of bioenergy R&D.	Public-private	Research, development	2018 to 2022		<a href="https://www.eranetbioenergy.net">https://www.eranetbioenergy.net</a>
18 European Countries and Regions including MI members: Austria, Finland, France, Germany, Italy, Netherlands, Sweden, UK	SOLAR-ERA.NET Cofund 2	A European network of national and regional funding organisations in the field of solar electricity generational.	Public-public	Research, development	2018 to 2022		<a href="http://www.solar-era.net/">http://www.solar-era.net/</a>
Norway, France, Germany, The Netherlands, UK, United States, EU (Romania: Greece, Spain)	ACT-ERANET 2nd Call 2018-2019 3rd Call 2020 (Accelerating CCS Technologies)	ACT is an international initiative to facilitate RD&D and innovation within CO2 capture, utilisation and storage (CCUS).	Calls open to both public and private sector	ACT is an ERA NET Cofund, which is a tool established by the European Commission under the Horizon 2020 programme for research and innovation. The idea behind ERA NET Cofunds is that European countries should join forces when it comes to funding RD&D and innovation on subjects of high European interest. ACT is one of many ERA NET Cofunds, but ACT is the only ERA NET Cofund addressing CCS. The ACT-ERANET are targeted to the identified Priority Research Directions (PRDs) under Mission Innovation Challenge 3-CCUS.			
EU	ERANet Geothermica	Combination of 17 geothermal energy research and innovation programme owners and managers from 14 countries and their regions.	Public-private	Demonstration and technology development projects to accelerate geothermal energy deployment	2 <sup>nd</sup> call is currently in preparation		<a href="http://www.geothermica.eu">http://www.geothermica.eu</a>
SE, EU Com, IT, UK, NL, FR, US, NO, KR, CH, JP, FI, AT, DE, DK, CA, BE, IEA HPT & ECES collaboration with IC7	Comfort & Climate Box	The goal of this Combined Annex is to develop and disseminate knowledge, evaluate prototypes and coordinate field tests involving HP/storage-packages in existing buildings.	Public-private	Research and innovation	Q4 2018 to Q2 2021		<a href="https://heatpumpingtechnologies.org/annexes/ideas-and-proposals/">https://heatpumpingtechnologies.org/annexes/ideas-and-proposals/</a>
IC5 project through H2020 with 8 MI countries.	SUNRISE	EU Large-scale Research Initiative on the production of fuel and chemicals from sunlight.	Public-public	Large-Scale, Long-Term Research	2019 to 2020 (first step)	1M€ from the EC	<a href="https://docs.wixstatic.com/ugd/8993fb_d548a65940774debabf4645423c6f83a.pdf">https://docs.wixstatic.com/ugd/8993fb_d548a65940774debabf4645423c6f83a.pdf</a>

## INDIA

## Mission Innovation impact case study

## Initiating large scale activity in the areas of Carbon Dioxide Capture/ Utilisation, Sustainable Biofuels and in Storable Sun Fuels

By funding large number of projects in close association with MI members a strong research base and trained human resources will be established. These areas will get a boost because of MI activities.

India, as co-lead in IC1, launched 9 smart grids research and development (R&D) projects under the umbrella of MI in collaboration with the nine MI IC1 members by investing 5 million USD to financially support activities towards research, development and deployment. The 9 projects helped to bring academia, utilities and industry into a single platform in their respective topics. 17 Indian institutes, 22 foreign institutes and 25 industrial organisations are involved in these multilateral collaborations. India also collaborated with several MI members for off grid challenges. This could happen only because of the MI platform.

This funding will create necessary and essential infrastructure for R&D in these areas. Close interaction with scientists from MI members will provide a boost and avoid duplication of research efforts. MI helps to enlarge the research networks and with increased dissemination of Information, there is enhancement of interest in academic institutions to become the knowledge partners in on-going intervention.

A trained pool of more than 100 scientists has been created in these advanced areas of research. The Clean Energy solutions that are developed will have a significant effect on development of clean energy technologies. More researchers are now being attracted to working in the clean energy sector. Specific funding programmes have assisted in bridging the gap "from the lab to the market ". Exchange of best practices and sharing of information on existing and perspective collaborative projects. Technology development through knowledge sharing among 9 MI IC1 members. The involvement of Industry/utilities from its initiation have a practical impact of deployment of these developed technologies for social welfare. We expect a collaborative framework and network of researchers, innovators and industries to be developed as a result of these endeavours.

## Update on clean energy innovation policies and strategies

- The Government of India revisited its Biofuel policy with a view to provide financial support to second generation Biofuel commercialisation. The policy was formulated with full consultation of industry, investors and technology providers. The policy also provides for enlarging the scope of feed stock which could be used for production of fuel grade ethanol for blending into ethanol. The policy has set aside about 700 million USD for viability gap funding of new cellulosic ethanol plants.
- Kisan Urja Surksha Utthan Mahaabhiyan or the KUSUM YOJANA<sup>38</sup>: Under this arrangement, the Central Govt. desires to assist as many farmers as possible to install new and improved solar pumps on their farms. The main aim of this scheme is to provide the farmers with advanced technology to generate power. The solar pumps will not only assist to irrigate the farms but also allow to generate clean energy. During the first phase of the program, the power department, in association with other wings of the government will work towards the successful distribution of solar powered pumps. The scheme will result in setting up of additional power capacity of 25750MW. The government has also come up with the government produce scheme for setting up 1200 MW capacity in public building owned by government. The installed capacity for solar energy in the country is 24750MW with 38130MW additional capacity installation.
- Wind Solar Hybrid Policy to Strengthen Energy Security of India: The Government has formulated the draft National Wind-Solar Hybrid Policy with the objective to provide a framework for promotion of large grid connected wind-solar PV system for optimal and efficient utilization of transmission infrastructure and land, reducing the variability in renewable power generation and thus achieving better grid stability. Further, the policy aims to encourage new technologies, methods and solutions involving combined operation of wind and solar PV plants.

<sup>38</sup> <https://kusum.online/home/>

## Major innovation initiatives in 2018/19

### Collaborative RD&D Support Initiatives:

- In 2018-19, India (through the Ministry of Science and Technology) launched the Funding Opportunity Announcement for Carbon Capture (IC3), Sustainable Biofuels (IC4) and Converting Sunlight (IC5) to provide an opportunity for Indian researchers to collaborate with researchers from MI members with a total budget of 17 million USD. A total of 47 projects under the above mentioned three Funding Opportunity calls have been recommended for financial support.
- In 2018-19, 18 Smart Grids and off grids projects were officially announced at the 3rd Mission Innovation Ministerial. Both France and India have financially supported field projects in India and African countries for affordable off grid. A partnership has been built with the International Solar Alliance (ISA) for deployment of off grid technology options.
- India has taken the lead in developing a framework which is promoting the clean energy technologies with the active participation of scientists, researchers, universities, industries, utilities as well as private organisations across the world through the MI platform.
- To promote clean energy by addressing the issues in smart grids technologies in India the Department of Science and Technology (DST, India) has allocated USD 5 million through nine smart grids programs in collaboration with nine different MI members. 9 MI members are involved Australia, Canada, China, Germany, Italy, Norway, USA, UK, France.
- Based on the identified smart grid R&D priority areas, 6 Smart Grids R&D Tasks are established in collaboration with MI IC1 members, India is establishing a national smart grid consortium including experts from industry, utility and academics to address the identified R&D tasks.
- Materials on Energy Storage (MES) 2018 supports R&D activities aimed at innovative materials for energy storage and to build energy storage device with enhanced output for multifunctional applications.
- Materials for Energy Conservation and Storage Platform (MECSP) 2017: A theme-based initiative to support R&D for the entire spectrum of energy conservation and storage technologies from early stage research to technology breakthroughs in materials, systems and scalable technologies to maximize resource use efficiency has resulted in setting up of 4 technology platforms.
- Hydrogen and Fuel cell 2018 program focused to develop transformational technologies that reduce the cost of hydrogen production, distribution & Storage, diversify the feedstock available for economic hydrogen production, enhance the flexibility of the power grid, reduce emissions through novel uses of low-cost hydrogen.

### National and International Meetings: Ministry of Science and technology (DBT & DST)

- India hosted the Second MI Indian Stakeholders meeting on Clean Energy Innovations 2019 on 3<sup>rd</sup> May 2019 in New Delhi. The event was attended by various international agencies (International Energy Agency, World Economic Forum, World Bank, AEF Sweden), senior advisors, technical experts, industry representatives, investors and broader public participation.
- India hosted the second international stakeholder meeting on MI Challenge "Off Grid Access to Electricity" on 1-2<sup>nd</sup> March 2019 at the Indian Institute of Technology in Delhi. The event was attended by the various international agencies, Senior advisors, Technical experts, Industry representatives, investors and broader public participation. More than 66 participants from 40 organisations around the globe participated in deliberations.
- The National Smart Grids stakeholder conclave was organized on 27<sup>th</sup> August at the Indian Institute of Technology Delhi, India to bring together researchers, industrialists, entrepreneurs and business investors to enhance public and private partnerships via engagement, knowledge sharing, collaborative programmes and investments. This Smart Grids Conclave brought together 177 participants with 86 participants from 22 academic institutions, 43 participants from 32 Industries who are actively engaged in R&D and 22 participants from 18 utilities companies.
- The second International meeting on Clean Energy Material Innovation Challenge was held on 21<sup>st</sup> and 22<sup>nd</sup> February 2019 which aimed to bring together leaders and visionaries from government, scientific community, and the private sector.
- A workshop on MI IC1 smart grids (on 28<sup>th</sup> December 2018) was organized to enhance the public-private partnership in the identified R&D tasks in MI IC1 which will result in future collaboration opportunities.

### Engaging and Supporting the Public Private partnerships

- The Department of Biotechnology (DBT), Ministry of Science and Technology, Government of India and its Public Sector Undertaking, Biotechnology Industry Research Assistance Council, have joined forces with Tata Trusts, to set up the first "Clean Energy International Incubation Centre (CEIIC)" in Delhi under MI.
- India has partnered with Sweden for a Sustainable Future, Avoided Emissions Framework. A challenge call was announced, and eight successful case studies are ready to be shared as an MI-4 deliverable.
- A joint Memorandum of Understanding (MoU) between the Ministry of Science and Technology, Government of India, and the International Energy Agency on Enhancing Innovation for the Clean Energy Transition has been signed. A one-day round table meeting: "Enhancing Innovation for the Clean Energy Transition" was organized by Department of Biotechnology, Ministry of Science & Technology, Government of India.
- Pursuant to this, a template for Information sharing has been developed jointly by the Ministry of Science and Technology and the International Energy Agency pertaining to Research, Development and Demonstration (RD&D) Data Tracking methodologies for Clean Energy Spending.

### Prizes and other Initiatives:

- India has actively supported applications for MI Champions program and one of the applicants has been selected to represent India at the 4<sup>th</sup> MI Ministerial. Additionally, Four National Clean Energy Champions will be supported via Research Innovation grants.
- A Global Cooling Prize - an innovation challenge to develop a cooling technology with 5X less climate impact was formally launched by Dr Harsh Vardhan, Hon'ble Union Minister of Science and Technology, Environment, Forest and Climate Change, and Earth Sciences, Government of India.
- Department of Biotechnology has supported 4 demonstration plants to convert Municipal Solid Waste to Energy using innovative technologies.

### New Policy Support Initiative:

Wind Solar Hybrid Policy to Strengthen Energy Security of India: The Government has formulated a draft National Wind-Solar Hybrid Policy with the objective to provide a framework for promotion of large grid connected wind-solar PV system for optimal and efficient utilization of transmission infrastructure and land, reducing the variability in renewable power generation and thus achieving better grid stability. Further, the policy aims to encourage new technologies, methods and way-outs involving combined operation of wind and solar PV plants.

## Major activities in support of the Innovation Challenges in 2018/19

### Collaborative projects:

India launched the Funding opportunity announcement for Carbon Capture (IC3), Sustainable Biofuels (IC4) and Converting Sunlight (IC5) MI Challenge. The special feature of these calls was mandatory participation of one or more MI members. Provision has been made for scientist exchange between India and the participating MI members. For three Innovation Challenges viz: Carbon Capture: 20, Sustainable Biofuels: 14, Converting Sunlight: 13 projects have been recommended for financial support from the Ministry of Science and Technology (DBT & DST).

### Global Cooling Prize, India:

To incentivize development of a residential cooling solution that will have at least five times less climate impact than today's standard Refrigeration and Air Conditioning units. This technology could prevent up to 100 gigatons (GT) of CO<sub>2</sub>-equivalent emissions by 2050 and put the world on a pathway to mitigate up to 0.5°C of global warming by 2100, all while enhancing living standards for people in developing countries around the globe. India is pleased to commit financially and technically to the Global Cooling Prize<sup>39</sup>.

<sup>39</sup> <http://www.dst.gov.in/global-cooling-prize-launched-awarding-breakthrough-innovations-cooling-technology>

**IC7 Priority Area: Physiological Studies for thermal comfort:**

India is taking an active role in the IC7 priority area “Physiological studies for thermal comfort” (IC7: PS). IC7: PS involves the appropriate understanding about human comfort needs, depending upon physiological, psychological and behavioural conditions. Research, Development and Deployment will develop pathways for technologies and policies to save considerable amount of energy, meeting MI objectives. A status report of research and technology readiness has been prepared. Further, specific subgroups involving research and industry leaders from MI members will be created which will set a road map and outlay for technical and financial support.

**Technology Demonstration projects**

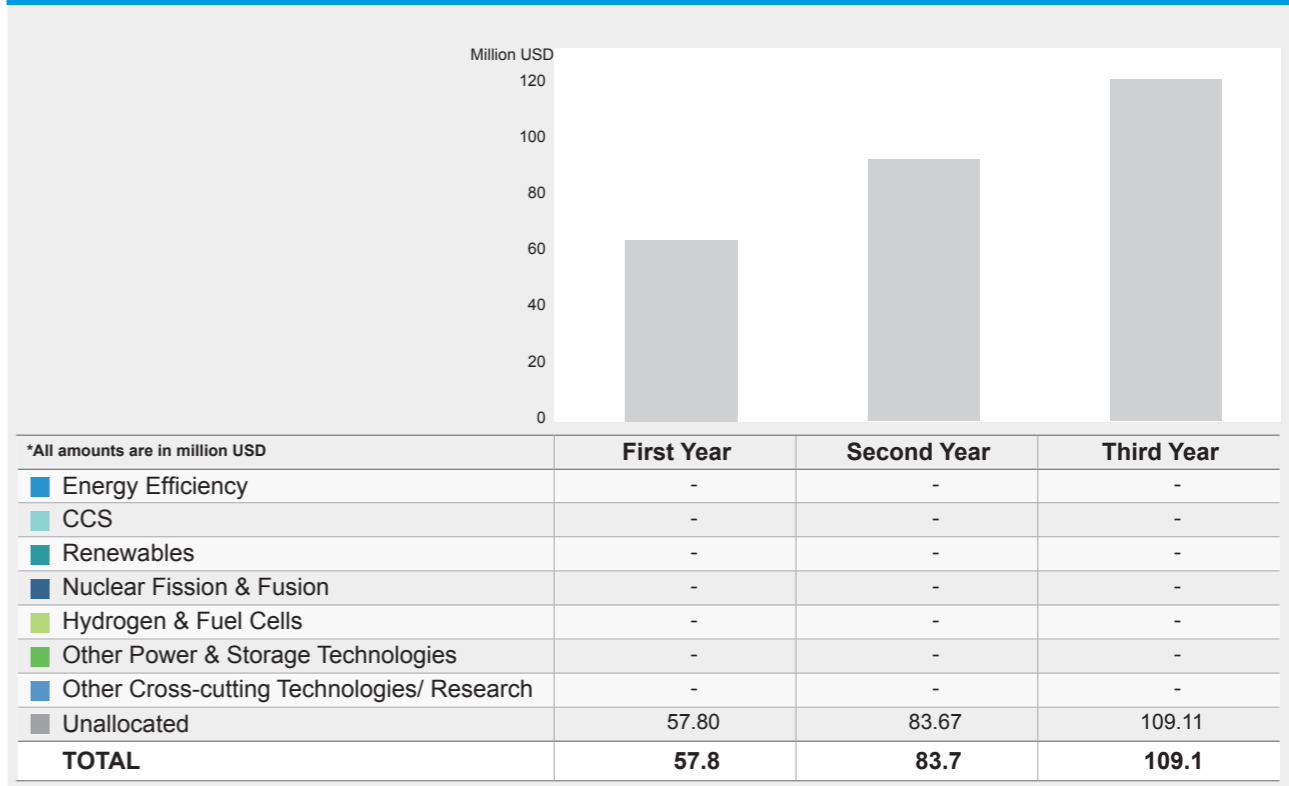
- Department of Biotechnology (DBT), Department of Science and Technology (DST) of Government of India have funded major RD&D projects in areas of clean energy covered by all MI challenges.
- DBT has funded projects on conversion of Municipal solid waste (MSW)/Liquid Waste to Energy.
- On a DBT funded project, Indian Oil Bioenergy centre has developed enzyme technology, for 2G ethanol, at 5000 litre scale.
- A continuous pilot plant for conversion of CO2 to algae rich in omega fatty acids has been established at DBT-IOC Bioenergy centre.
- DST has launched 9 Smart Grids projects at the 3rd MI Ministerial, IC1 event on May 2018 in Sweden.
- DST has established 6 Smart Grid R&D tasks team to facilitate the progress on smart grids R&D tasks.
- DST has financially supported 9 projects in the area of off- grid access to electricity with knowledge partners from MI members.
- DST: Materials on Energy Storage (MES) 2018 supports R&D activities - 29 proposals (Research and Technology Stream) were approved for funding with an approximate cost of USD 250 million for 3 years.
- DST: Materials for Energy Conservation and Storage Platform - 4 Proposals were approved for funding with a total cost of USD 400 million for 5 years.
- DST: Hydrogen and Fuel Cell 2018 - 31 proposals (Research and Technology Stream) were approved for funding with an approximate cost of USD 250 million for 3 years.
- India established a dedicated MI Resource Centre (MIRC) at Indian Institute of Technology Roorkee, India which is playing a key role in fostering the MI IC1 activities.
- India established a dedicated MI Resource Centre (MIRC) at Indian Institute of Technology Delhi for MI IC7 activities.

**Other Mission Innovation related activity in 2018/19**

- A joint Memorandum of Understanding (MoU) between the Ministry of Science and Technology, Government of India, and the International Energy Agency on Enhancing Innovation for the Clean Energy Transition has been signed. A one-day round table meeting: “Enhancing Innovation for the Clean Energy Transition” was organized by Department of Biotechnology, Ministry of Science & Technology, Government of India.
- Pursuant to this, a one-day round table meeting: “Enhancing Innovation for the Clean Energy Transition” was organized by the Department of Biotechnology, Ministry of Science & Technology, Government of India, which has helped develop working relationships between key staff from International Energy Agency and relevant Government of India Ministries, particularly Ministry of Science and Technology. The proposed investment data will help policy planners to address the areas of clean energy development in more pragmatic manner.
- The Ministry of Science and Technology (DBT & DST) is jointly working with the International Energy Agency in preparing a template for Data Collection to track the Public and Private Sector Clean Energy RD&D Spending.
- 2<sup>nd</sup> Stakeholders Meeting on Public Private Cooperation for Clean Energy Innovations is proposed for 26<sup>th</sup> April 2019. focusing on greater Private sector engagement for bringing technologies to a commercial stage and accelerate public private partnerships via engagement learning networking and investment to accelerate clean energy innovations.

- “Synthesis Document: Off-Grid Access to Electricity” is published to provide information about initiatives taken by different MI members to develop Off Grid solutions. The report would be useful for individual scientists, institution and stakeholders in MI members and beyond working in the area of off grid access to electricity and help to accelerate to build more collaboration.
- India Country Status Report on Clean Energy Materials Innovation Challenge IC6: The report includes institutional framework and current research scenario for clean energy materials with focus on materials for energy storage and also provides India’s research landscape for energy storage materials.

**Public sector RD&D investment**



These are only direct research costs incurred in the implementation of project and do not include man-hour costs of regular scientists employed (which are also funded by public funds) in the institutions. Overheads for implementation of projects are only partially supported (15%).

The Ministry of Science and technology (DBT & DST) is jointly working with International Energy Agency in preparing a template for Data Collection to track the Public and Private Sector Clean Energy RD&D Spending.

**New Collaborations**

Collaborators	Name of Collaboration	Brief Description	Sectors	Duration	Additional information
Sweden	Avoided Emission Framework	Sweden-India Innovation Partnership for a Sustainable Future, Avoided Emissions Framework	Public-Public	2018	<a href="http://pib.nic.in/newsite/PrintRelease.aspx?relid=178749">http://pib.nic.in/newsite/PrintRelease.aspx?relid=178749</a>



# INDONESIA

Please view Indonesia's full narrative on the Mission Innovation website.

## Public sector RD&D investment



*All amounts are in million USD	Baseline	First Year
Energy Efficiency	-	-
CCS	-	-
Renewables	-	-
Nuclear Fission & Fusion	-	-
Hydrogen & Fuel Cells	-	-
Other Power & Storage Technologies	-	-
Other Cross-cutting Technologies/ Research	-	-
Unallocated	16.70	30.40
<b>TOTAL</b>	<b>16.7</b>	<b>30.4</b>



# ITALY

## Mission Innovation impact case study

### Mission Innovation has:

- allowed the development of new bilateral agreements of Scientific and Technological Cooperation among international public research centres (i.e. Italy/India Cooperation agreement on Joint application for Strategic key programme for international scientific technological cooperation – RSE - Roorkee);
- facilitated the interaction among the National Research Centres involved in the development of cleantech technologies;
- favoured the synergy among the various Ministries involved in research activities support;
- given substance and resources to the Italian research and innovation (R&I) activities planned under the National Plan for Energy and Climate (NPEC) in the frame of the European Governance of the Energy Union, together with the participation in the European Strategic Energy Technology Plan (SET-Plan);
- focused the attention of all stakeholders on the opportunities that hydrogen can offer as an energy carrier.

MI stimulated this activity through the organization of high-level common initiatives open to the participation of international experts active in the cleantech sector both at public and private level.

The main impacts are related to the development of Smart Grids, the strengthening of international technical cooperation activities within the framework of MI IC1 and the encouragement of national research activities towards research priorities and development jointly identified.

This activity has also highlighted the importance of private sector and investors involvement to accelerate the adoption of innovative smart grid solutions, in particular in the SMEs area where Italy has a well-known leadership.

## Update on clean energy innovation policies and strategies

**The National Energy Strategy (NES)** is the ten-year plan issued by the Ministry of Economic Development (MiSE) and the Ministry of Environment and Protection of Land and Sea (MATTM) on November 2017, which has defined the national energy and climate targets to drive the change of the national energy system towards the targets set by policy makes.

The strategy has been updated and modified by the proposal of the **National Energy and Climate Plan (NECP)**, that has been presented by MiSE and MATTM to the European Commission in December 2018, according to the Governance of the Energy Union and Climate Action. The Plan sets out measures to ensure the creation of a secure, sustainable and competitive energy system in order to achieve sustainable growth, promote fundamental role of research and innovation in the cleantech sector and reach the 2030 environmental targets at European level.

The targets for renewable energy systems (RES) are very significant and assume to cover more than 55% of the demand in the electricity field, 33% of the demand in the thermal sector and more than 21% in the transport sector, for an overall target of 30% of the gross energy consumption. Additional efforts are expected in the increase of energy efficiency as well as in the dramatic reduction of greenhouse gas (GHG) emissions.

One of the five dimensions of the NECP proposal is represented by the research, innovation and competitiveness pillar. The dimension includes and refers to the national participation in MI which is committed to **double public funds** for R&D for clean energy from **€222 million in 2013 to €444 million in 2021**. The Italian participation in MI therefore constitutes an opportunity for the national research centres and industry to participate in highly innovative research projects in an international cooperation context, by adopting an innovative approach to contribute at the development of clean technologies at global level.

## Major innovation initiatives in 2018/19

- a) The Ministry of Economic Development is soon to approve the 2019-2021 3 year-plan of the National Electric System Research Fund. The resources allocated will amount to approximately €210 million. The Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), the National Research Council (CNR) and Ricerca sul Sistema Energetico (RSE) are the leading public research institutions involved. A call for proposals for the private sector is also foreseen on a cofunding basis. The activities are aimed at innovating and improving the performance of the system in terms of economics, safety and the environment. The programme's coverage ranges from system governance to research and development (R&D) and deployment of renewable technologies, smart grids and end-use. It is financed through a specific component of the end-user electricity tariff.
- b) The Ministry of Education, Universities and Research (MIUR) has launched in 2018 the National Energy Technology Cluster which supports research, development and demonstration (RD&D) as well as technology transfer in the Energy Area. The Cluster aims at combining the demand for innovation from the industrial sector with the offer of innovation coming from the research structures of the country, supporting the achievement of the expected targets in terms of research planning from the SET-Plan and the participation in MI. Two project lines are foreseen: the development of innovative technologies for energy transformations and storage, in particular for Concentrated Solar Plants (CSP), and Smart grids. The leading Agency is ENEA with more than 80 stakeholders involved from industries, R&D organisations and universities. The cluster is currently in the start-up phase and the activities to be carried out are being defined.
- c) The Ministry of Environment, Land and Sea has completed in 2018 a €4.7 million call for proposals for funding energy efficiency lighting systems R&D in religious buildings and a €3.7 million funding programme for tests, and R&D activities for the environmental impact of the biofuels emissions in the aviation sector. This funding programme has already been published under the "highlights 2017" Italy section of MI website.
- d) In late 2018 the Basilicata Region has launched a tender under the Cohesion Funds worth around €10 million that has been awarded by ENEA, with the final goal to strengthen and expand the integrated platform for biorefinery and green chemistry (PIBE) active at the ENEA Research Centre in Trisaia (Matera).

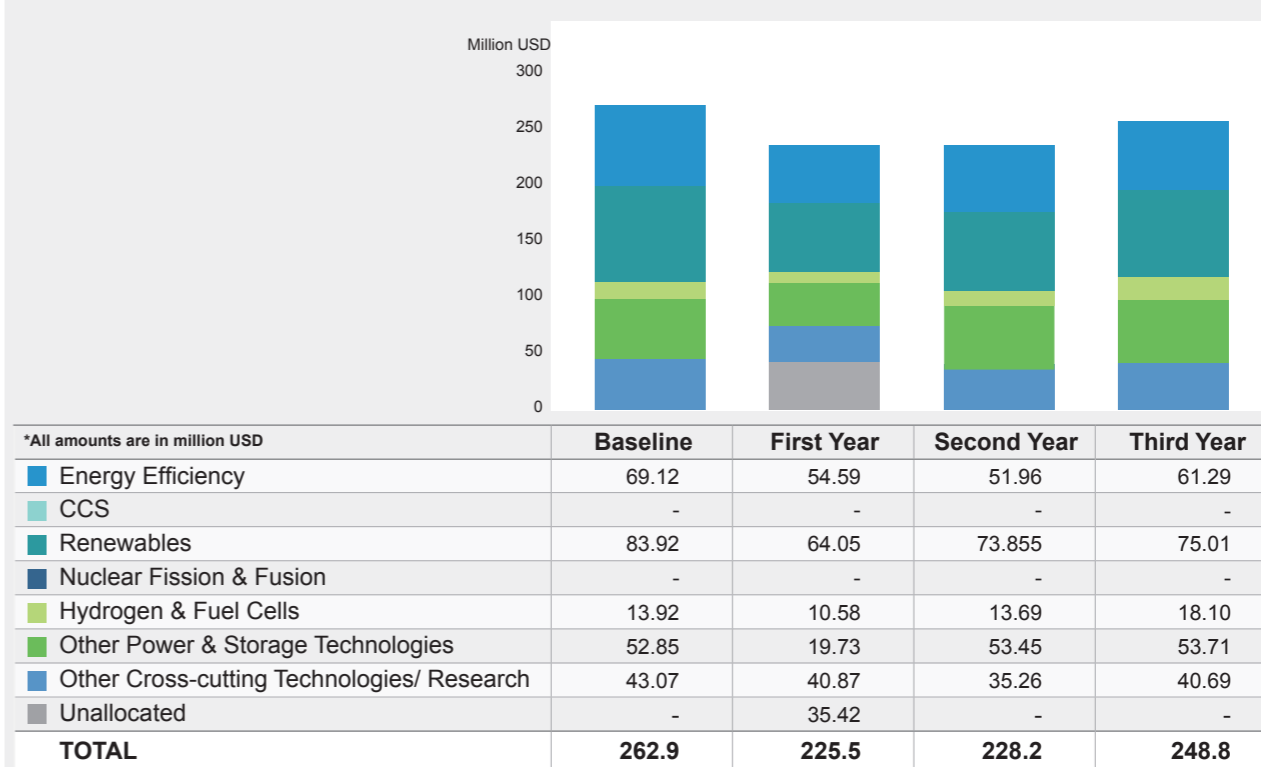
## Major activities in support of the Innovation Challenges in 2018/19

- **MI IC1:** Italy as MI IC1 co-lead, hosted the 4<sup>th</sup> **Deep-Dive Workshop IC1 Smart Grid**. The workshop was held on 21-23 November 2018 in Rome and gathered IC1 representatives from 17 countries, the European Union, International Organizations and Government representatives, smart grids experts and industry leaders to address smart grids research and innovation and the main challenges towards smart grids full development and deployment.
- **MI IC6:** Italy, as part of MI IC6 activity, hosted the "**Workshop Mission Innovation: Clean Energy Materials Innovation Challenge: a European Meeting**" in Rome on 25 October 2018 bringing together sectorial experts from all over the world.
- **MI IC8:** Italy took part actively in the MI "**Hydrogen Valleys**" workshop organized in Antwerp in March 2019 involving research and development national actors. Moreover, during the workshop Italy presented its national "Hydrogen Valley" located in Bolzano, South Tyrol.

## Other Mission Innovation related activity in 2018/19

- In line with the MI Action Plan goals and IC1's willingness to involve the private sector, Italy and other IC1 co-leads presented the **Smart Grids Innovation Accelerator (SGIA) Platform** during the 4<sup>th</sup> deep-dive workshop hosted in 2018 in Rome and the MI Gathering 2019 in Santiago. The SGIA will serve as a suitable tool to enable sharing technical results and best practices, **catalyzing the public and private sectors** joint efforts towards IC1 goals to accelerate the development and deployment of innovative smart grids technologies worldwide.
- Italy will promote the private sector participation in the **Public-Private Roundtables and the Innovation Showcase** initiatives organized during the MI-4 in Vancouver.

## Public sector RD&amp;D investment



First Year - the overall total includes the €30 million budget of a 100% State Owned Company.

Second Year is provisional data.

Third Year is estimated data.

It is worth noting that the amount of spending indicated in the graphics for the second and third years represents around 80% of the actual overall amount spent in R&D in the energy sector since it does not include other R&D Institutions whose expenses accounting is still in progress by the Italian Statistical Institute (ISTAT). For example, in 2018 (Third Year) the Italian Ministry for Education, Universities and Research allocated other **€48.7 million for research activities in this field that are not yet officially accounted for in the 2018 data.**

For the activities of MI the **Budget Law 2018 has approved €15 million, for the period 2019-2021, and with the new Budget Law 2019 further financing of up to €40 million has been approved for the same period 2019-2021. A further financing of €345 million is foreseen in the near future up to the year 2021 in order to reach the doubling target.**



## JAPAN

## Mission Innovation impact case study

“Mitou” challenge 2050 programme has been launched, inspired by the activity of MI. “Mitou” means unexplored in Japanese. This programme is also promoted to industry-academia collaboration and limited to researchers aged 40 or younger in academia.

We have come to realize that it is important to promote long-term, challenging but high-impact research and development (R&D).

Although there is no impactful outcome yet, the motivation of young researchers has been improving.

## Update on clean energy innovation policies and strategies

The Government of Japan formulated the Strategic Energy Plan in order to show to the public the basic direction of Japan's energy policy under the Basic Act on Energy Policy in July 2018. The new Strategic Energy Plan is the basis for the orientation of Japan's new energy policy towards 2030 and further towards 2050, considering the changes in energy environments inside and outside Japan. Efforts to achieve an optimal energy mix are only partly accomplished. The new plan emphasizes the strengthening of such efforts to ensure continued, concrete results towards 2030. Towards 2050, the new plan seeks to achieve energy transitions and decarbonization, in light of the global momentum in this direction and in enforcement of the Paris Agreement, and to pursue all tenable options toward this end.

The Paris Agreement calls on countries to submit to the UN a long-term strategy in order to steadily reduce GHG emissions. Currently, we are working hard to formulate a long-term strategy for submission in summer 2019.

## Major innovation initiatives in 2018/19

The existing Strategic Roadmap for Hydrogen and Fuel Cells was renewed in March 2019. The renewed roadmap defines:

- (i) new targets on the specification of basic technologies and the breakdown of costs;
- (ii) necessary measures for achieving these goals; and
- (iii) that Japan will convene a working group consisting of experts to review the status of implementation in each area stipulated by the roadmap.

In 2019, Japan will invest 20.4 billion yen in R&D on clean hydrogen.

Japan hosted the Hydrogen Energy Ministerial Meeting in October 2018. More than 20 countries got together and shared the view that hydrogen can be a key contributor to the energy transitions. We confirmed the value of collaborating on these agendas in the “Tokyo Statement”.

- (i) Harmonization of Regulation, Codes and Standards,
- (ii) International Joint R&D emphasizing Safety,
- (iii) Study and Evaluation,
- (iv) Communication, Education, and outreach.

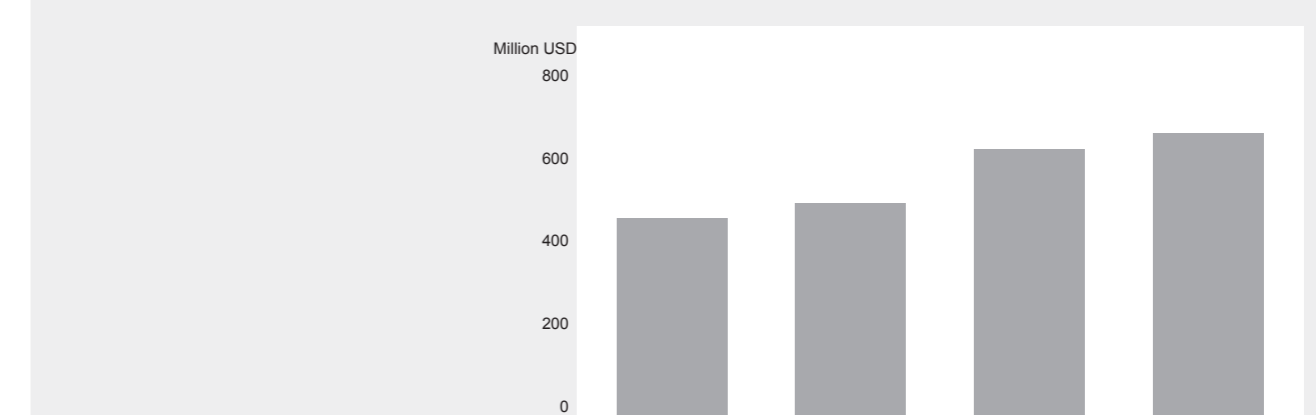
Japan considers the concept of “carbon recycling” as recognizing CO<sub>2</sub> as a source of carbon, capturing and recycling it as carbon compounds in industries, then utilizing it as fuel or a raw material or even in the growing of vegetables. To promote technological innovations involving capture, storage and utilization of CO<sub>2</sub>, the “Carbon Recycling Promotion Office” was established in the Agency for Natural Resources and Energy.

## Major activities in support of the Innovation Challenges in 2018/19

Japan joined the IC8 Deep Dive and Hydrogen Valleys workshops to provide the knowledge and information obtained from previous research, development, and demonstration (RD&D) projects. Furthermore, Japan held the First Hydrogen Energy Ministerial Meeting in Tokyo in October 2018. IC8 was invited to the meeting to present their activities and future plans.

Prof. Kodama from Niigata University collaborated with prof. Gus Nathan (The Univ. of Adelaide, Australia), Commonwealth Scientific and Industrial Research Organisation's and the Australian Renewable Energy Agency to establish an international collaboration "Converting Sunlight to Fuels" as a part of IC5 activity.

## Public sector RD&amp;D investment



*In Million USD	Baseline	First Year	Second Year	Third Year
<b>TOTAL</b>	<b>407.5</b>	<b>575</b>	<b>661</b>	<b>684.5</b>

The figures in the table below include overlapping areas therefore the sum is not equal to the total amount of public R&D investment.

*In Billion Japanese Yen	Baseline	First Year	Second Year	Third Year
Production process	9.1	16.1	16.3	18.1
Structural material	21.2	31.6	32.7	29.6
Storage Battery	9.8	14.4	19.0	21.6
Hydrogen	12.2	16.4	20.7	20.4
Photovoltaic	6.9	11.5	14.3	15.6
Geo-thermal	1.6	3.5	4.1	4.6
CCUS	11.1	18.1	22.0	24.1
Core technologies for Systems	16.3	29.3	33.6	40.5

Japan registered the FY 2016 as its base year and 45 billion yen as its baseline amount. Further, Japan will try to allocate as much budget as possible to the fields of innovative technologies looking ahead to the year of 2050 in NESTI2050. Even if there are financial constraints, the aim is to double the budget in five years.

In addition, Japan compiled a report called the Long-term Energy Supply and Demand Outlook for FY2030 (the “Energy Mix”). Tackling climate change issues requires finding a balance between mitigation measures and economic growth. To achieve this, Japan is committed to:

- 1** Promoting energy-saving measures
- 2** Expanding the use of renewable energy sources, and
- 3** Increasing investments aimed at establishing a new energy system to improve the efficiency of energy use.

In particular, the total share of renewable energy is set to double from 12% in 2013 to 22-24% (Solar 7.0%, Wind 1.7%, Biomass 3.7-4.6%, Geothermal 1.0-1.1%, Hydropower 8.8-9.2%) in 2030.

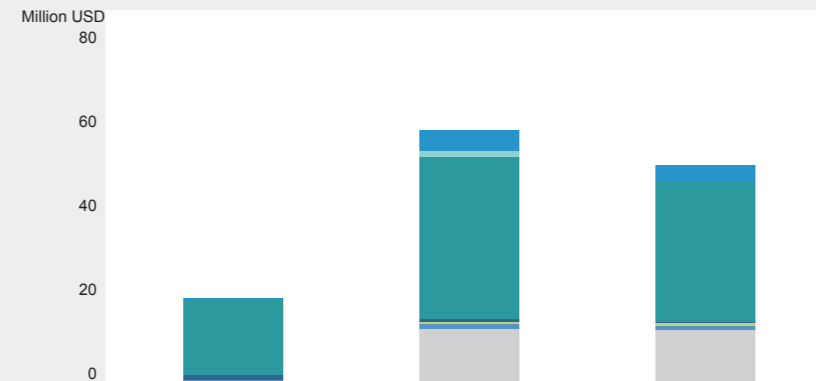




# MEXICO

Please view Mexico's full narrative on the Mission Innovation website.

## Public sector RD&D investment



\*All amounts are in million USD

	Baseline	First Year	Second Year
Energy Efficiency	0.26	4.81	3.42
CCS	0.13	1.53	0.11
Renewables	17.22	37.24	32.42
Nuclear Fission & Fusion	0.90	0.39	0.07
Hydrogen & Fuel Cells	0.13	0.74	0.76
Other Power & Storage Technologies	-	-	-
Other Cross-cutting Technologies/ Research	0.19	0.91	0.80
Unallocated	-	11.94	11.74
<b>TOTAL</b>	<b>18.8</b>	<b>57.6</b>	<b>49.3</b>



# NETHERLANDS

## Mission Innovation impact case study

Activities that would not have occurred without MI are the development of a prototype for a Comfort Climate Box (the active cooperation between the International Energy Agency Technology Collaboration Programmes and MI (IC7)), the expanding of the Accelerating CCS Technologies ERA-net cofund<sup>40</sup> to non-EU MI-members (contributes to the goals of IC3), Biofuture platform report (IC4) and reinforced cooperation within the hydrogen challenge (IC8).

MI stimulated these activities by creating a platform for countries through which they can more easily collaborate. Also, adding the MI Innovation Challenges to the projects/collaborations, the country members have more leverage to make things happen.

### Comfort Climate Box (CCB)

**Impact:** shared costs research and development, integration of components at system level and with that a 'plug & play system' for affordable heating & cooling.

The Netherlands aims at establishing further private engagement in the CCB, and also to discuss this further in the Business & Investor Engagement subgroup.

### Accelerating CCS Technologies ERA-net cofund call

26 proposals were received for the second call, selected projects will start in September 2019. A new call is planned in 2020. The focus of the MI IC3 workshop in Trondheim, June 20<sup>th</sup> 2019, will be on strengthening private-public collaboration by identifying research, development and innovation gaps of common interest in higher Technology Readiness Level technologies.

### Biofuture Platform report

Strengthened collaboration with existing international initiatives (Biofuture Platform, MI Sustainable Biofuels Innovation Challenge (IC4), among other initiatives). A call in the Horizon 2020 work program for advanced biofuels which can contribute to the objectives of IC4.

The cooperation within the hydrogen challenge is reinforced. All topics are open to international cooperation with the aim to bring costs down (3-4 times), performances up and accelerate development of a global hydrogen market.

## Update on clean energy innovation policies and strategies

The Netherlands has set an ambitious CO<sub>2</sub>-reduction target of 49% in 2030, with a view to increasing the European Union target for CO<sub>2</sub>-emission reduction to 55% in 2030 compared to 1990. The Netherlands is targeting CO<sub>2</sub>-reduction on a sectoral level within the Dutch Climate Agreement for the Electricity sector, Industry, Mobility, the built environment and Agriculture & land-use. For this purpose, sectoral consultations were organised with all relevant stakeholders, including industry and non-governmental organisations to discuss options and concrete measurements.

The draft of the Climate Agreement has been completed and with that a Mission Oriented Knowledge and Innovation Agenda ("IKIA") for Climate and Energy has been developed. In this agenda all the relevant knowledge and innovation challenges to reach the sectoral CO<sub>2</sub>-reduction targets have been translated in to 13 mission-oriented innovation programs. These innovation programs are designed to stimulate (fundamental) research, the development and market-introduction of effective CO<sub>2</sub>-reduction technologies, taking to account social circumstances and preferences. The definitive Climate Agreement is foreseen before summer 2019.

The cabinet has assigned an additional €300 million per year, starting in 2018, to execute the national Climate Agreement focussing on pilots and demonstration projects. With this additional budget the Netherlands has met the MI doubling targets.

<sup>40</sup> <http://www.act-ccs.eu/>

### Major innovation initiatives in 2018/19

The Netherlands supports energy-innovation projects through a variety of programs and collaborations. Among the most successful national programs are:

- The Topsector Energy Program: €41.8 million in 2018, €33 million in 2019
- The demonstration program for climate & energy-innovation that supports pilots and the demonstration of CO<sub>2</sub>-reduction projects: €40 million in 2018, €35 million in 2019
- The renewable energy program that supports early technologies to achieve cost reductions: €50 million in 2018, €50 million in 2019

New themes and budget have been added to the national programs this year and in 2018 in accordance with the extra budget that the cabinet has assigned for the upcoming National Climate Agreement (in total €300 million/year). The additional available budget amounts to €36.4 million in 2018 and €91.5 million in 2019. With that extra budget research & innovation projects are stimulated on for example CO<sub>2</sub>-reduction in the industry including CO<sub>2</sub> capture, utilisation and storage CC(U)S and recycling, flexibilization of the electricity system, hydrogen, spatial integration of large-scale renewable energy production (wind or solar), and phasing out of natural gas in the built environment for heating/cooking. An example is the development of a sustainable low temperature heating network for existing buildings with photovoltaic thermal systems and ground fittings.

### Major activities in support of the Innovation Challenges in 2018/19

#### Comfort Climate Box (IC7)

The Netherlands has provided project-leadership to develop a prototype for a comfort climate box. Cooperation with MI members of the International Energy Agency Heat Pumping Technologies /Energy Conservation through Energy Storage network including UK, Austria, Sweden, Canada etc

#### ACT ERA-net cofund call (IC3)

Second call of €30 million to internationally accelerate CCUS technologies, with a reference to the MI IC3 report on Priority Research Directions. Start of projects in September 2019. MI members: NO, DE, FR, NL (€4 million), UK, USA. Other: CH, ES, GR, RO, TR.

#### Biofuture platform report 'state of the Low Carbon Bio-economy' (IC4)

Successful cooperation between Biofuture Platform members (the Netherlands and 11 other MI members) and MI members (EU, Mexico and Norway).

#### Reinforced cooperation within the hydrogen challenge (IC8)

The Netherlands joined IC8 and is helping to develop the work program. Dutch priorities include: Hydrogen Valleys, working technologies at scale, (Green) H<sub>2</sub> in industry, feedstocks, transport/ maritime, gas turbines in powerplants, admixture into natural gas networks, underground storage, enabling global market, suitable carriers.

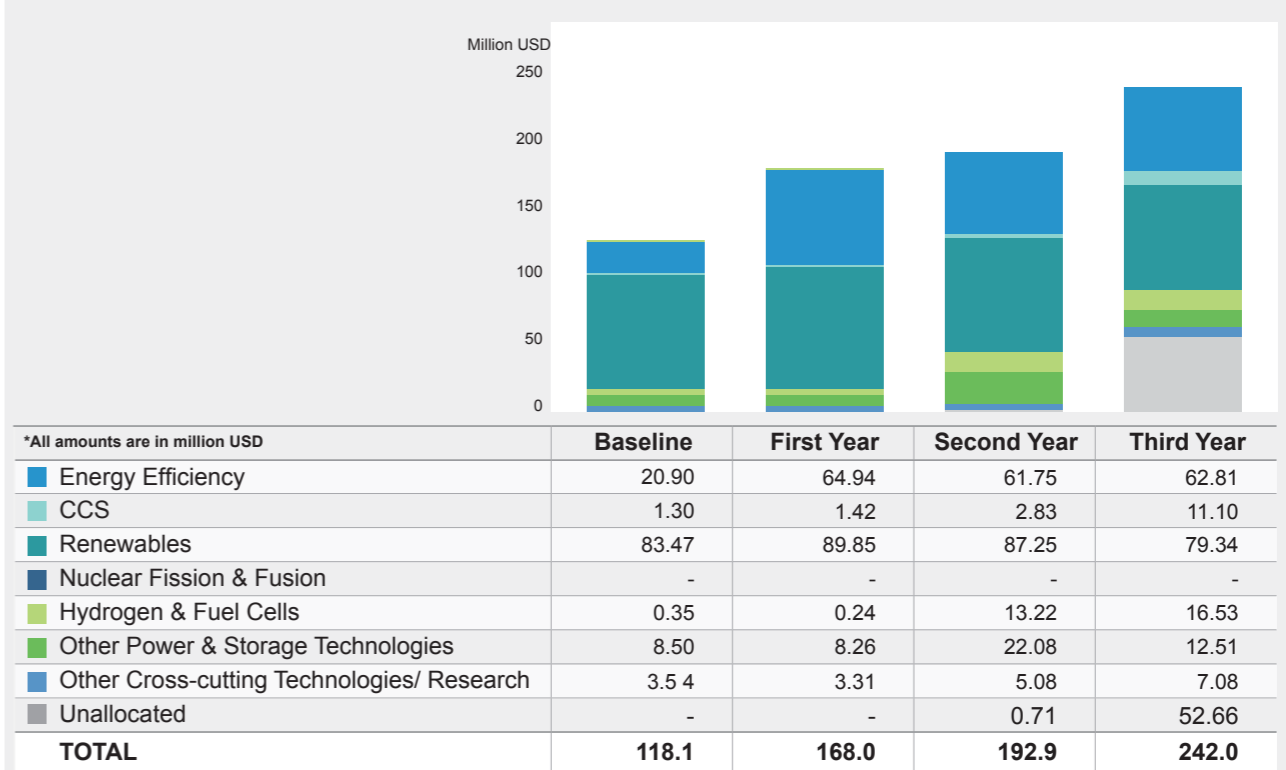
#### Additional climate budget for the national Climate Agreement:

nationally supports the objectives under IC3, IC4, IC7 and IC8.

### Other Mission Innovation related activity in 2018/19

- The Netherlands has participated in the MI-champions program.
- We are investigating with the Communication Department of the Dutch Ministry of Economic Affairs and Climate Policy, how we can improve the promotion of Mission Innovation.
- Within the framework of the 13 mission-oriented innovation programs we are aiming at further developing these programs according to the triple helix model. This implies that the Netherlands is actively looking at how to reinforce private engagement, but also how to strengthen and re-assess international means.

### Public sector RD&D investment



#### IMPORTANT DISCLAIMER:

The outsourced amounts for 2018 – MI Third year Research, Development and Demonstration - are not yet official and are to be considered provisional only. Further analysis is ongoing on the allocation of the spend against the categories provided, and also some budgets are still to be legally committed (funding agreement) and therefore not yet included. The latter concerns the renewable energy program that supports early technologies to achieve cost reduction.

In 2018, the Dutch government made a budget available for innovation projects in accordance with the extra budget that the cabinet has assigned for the upcoming National Climate Agreement (in total €300 million/year). As is shown in the table, with this additional budget the Netherlands has met her doubling objectives in the third year of being a member of MI.



# NORWAY

## Update on clean energy innovation policies and strategies

In June 2018, right after the third MI Ministerial (MI-3), Norway launched an updated national strategy for research, development, demonstration and commercialisation of new climate-friendly energy technology.

- Digitalised and integrated energy systems
- Climate-friendly energy technologies for maritime transport
- Solar power for an international market
- Offshore wind power for an international market
- Hydropower as the backbone of the Norwegian energy supply
- Climate-friendly and energy-efficient industry, including Carbon Capture and Storage (CCS)

The strategy<sup>41</sup> provides the authorities and the business sector with recommendations on how to target activities relating to new technologies for the energy sector.

## Major innovation initiatives in 2018/19

### PILOT-E: Fast-track from idea to market

PILOT-E is a collaboration between different Norwegian energy research, development and demonstration support schemes and it works as a "fast-track" through the stages of research; from idea to market. PILOT-E has been highlighted at earlier Ministerials and has been very successful so far. Three calls have been completed and a fourth is currently in progress. The maritime sector has been a priority in two of the calls so far. By 2022, around 70 new electric ferries will be operating on the Norwegian fjords. There are also projects for hydrogen ferries underway. This is being made possible by public funding to develop the required technology and the roll-out of necessary infrastructure. Today, as a rule, all new public tenders for car ferries require zero or low emission technology.

The fourth PILOT-E call was published in late March 2019 and will focus on two specific areas:

- Complete hydrogen supply chains
- Emission-free construction

### The Norwegian CCS demonstration project

Norway is currently developing a full-chain demonstration project. This includes capture, transport and storage solutions. Norcem and Fortum Oslo Varme is currently studying CO<sub>2</sub>-capture at their respective plants (a cement plant and a waste incineration facility) At the same time, Equinor, Shell and Total are working on a solution for transport and storage. The plan is to transport CO<sub>2</sub> from the industrial sites and store it offshore. The storage facilities will have excess capacity – much more than what is needed for domestic needs - and the transport solution will be flexible. Thus, Norway is preparing the ground for future European projects, making it more attractive for European industry to consider CO<sub>2</sub>-capture.

## Major activities in support of the Innovation Challenges in 2018/19

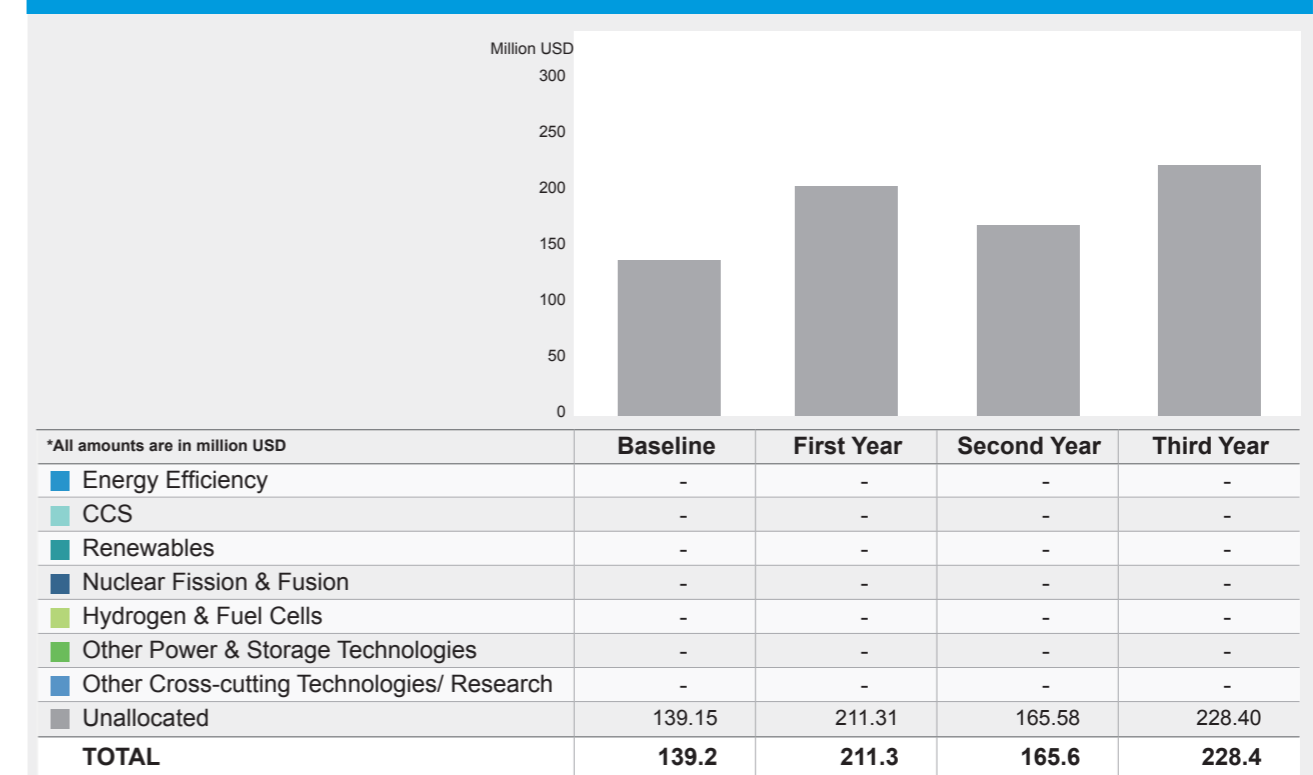
Norway participates actively in ACT<sup>42</sup>. ACT means Accelerating CCS Technologies, and the ambition of the 13 partners is to fund research and innovation projects that can lead to safe and cost-effective technology. This is a multilateral initiative involving different MI countries. ACT published the first call for project proposals in June 2016. Eight new projects were started in the autumn of 2017 with € 41.2 million in financial support from ACT. A second ACT call was published 4<sup>th</sup> June 2018. The budget for the call is up to € 30 million and full project proposals were submitted on 1st March 2019. Another call is planned for 2020.

<sup>41</sup> [https://www.energi21.no/prognnett-energi21/Home\\_page/1253955410599](https://www.energi21.no/prognnett-energi21/Home_page/1253955410599)

<sup>42</sup> <http://www.act-ccs.eu/>

Norway will also host a workshop for IC3, the MI Carbon Capture Challenge in Trondheim in June 2019. This will follow up the first workshop that was held in Houston in 2017 and the subsequent report completed in 2018. It is important to ensure continued progress in the direction of full-scale implementation and commercialization of CO<sub>2</sub> capture, utilisation and storage technologies. A workshop is, therefore, held back-to-back with the Trondheim CCS-10 Conference where 400-500 CCS experts are gathered. Representatives from all MI members are invited.

## Public sector RD&D investment



Year 1 - Funds allocated for studies on the Norwegian full-scale CCS project were significant this year.

Year 2 - Last year's reporting was incorrect as the funds allocated for technological development through state agency Enova was lower than originally reported. The correct figures are reported above.

Year 3 - This includes an allocation of NOK 345 million to be confirmed in May 2019 related to the Norwegian full-scale CCS project (which forms part of the baseline).

## New Collaborations

Collaborators	Name of Collaboration	Brief Description	Sectors	Type of Collaboration	Duration	Funding amount
China	The MoST - RCN Joint Funding Call on Consortium Collaboration on Energy	Call for bilateral R&D-projects on following subjects: <ul style="list-style-type: none"> <li>• Windpower</li> <li>• Electrical Vehicles</li> <li>• Energy efficiency</li> </ul>	Public-private	Research and Development	2020 to 2023	75 million kroner (NOK) from each country



# REPUBLIC OF KOREA

## Mission Innovation impact case study

### Saemangeum Renewable Energy Project

- The Republic of Korea will establish a 4GW renewable energy production complex on Saemangeum region, a vast tract of reclaimed land on the west coast. The central and provincial governments will build a 3GW solar power farm on land and a 1GW offshore wind farm near Gunsan. The power generation site represents 9.36 percent of the total reclaimed area.
- The government and Jeollabuk-do will establish 2.4GW of photovoltaic power and 0.6GW of offshore wind power (0.1GW of inside and 0.5GW of outside of Saemangeum) by 2022 and also decided to accelerate construction related to power transmission and substation and regulatory work so the rest of the power generation business will be in accordance with local acceptability and progress on the internal development of Saemangeum.
- The dissemination and expansion of renewable energy are recognized as an important policy tool, focusing on eco-friendly energy policies pursued by MI. In line with this global trend, Korea is also planning to reorganize its energy policies and projects into clean energy and expand the role of renewable energy nationwide. Renewable energy projects in Saemangeum are being carried out as part of this project.
- The Saemangeum Development Administration, Jeollabuk-do, Gunsan City, Saemangeum Corporation, and the Korea Institute of Energy Technology Evaluation and Planning have signed multiple business agreements for the establishment of the Saemangeum Renewable Energy National Demonstration Research Complex in March 2019. The project plans to involve 100 companies and create 0.1 million jobs over the next 10 years.

## Update on clean energy innovation policies and strategies

### Hydrogen Economy Roadmap

- The Republic of Korea government proposes a future national energy vision that is a hydrogen economy roadmap in January 2019. Along with the roadmap the government hopes to create new jobs through the transformation of the economic industry structure. Korea aims to build an industrial ecosystem that can lead the hydrogen economy based on hydrogen vehicles and fuel cells.
- The Roadmap includes several targets such as the number of hydrogen vehicles and hydrogen charging stations by the year 2040. According to the roadmap, 1,800 hydrogen vehicles have already been produced and the target numbers of hydrogen vehicles is 0.8M units in 2022 and 6.2M units in 2040. For the hydrogen bus, the target is 35 units in 2019, 2,000 units in 2022, and 40,000 units in 2040. The hydrogen taxi pilot project will launch in 2019 and will involve 80,000 taxis in 2040. 14 hydrogen charging stations are already built nationwide. The roadmap plans 310 charging stations in 2022 and 1,200 charging stations in 2040. The capacity of the fuel cells for power generation would reach 15GW including 2.1 GW for houses and buildings.

## Major innovation initiatives in 2018/19

### 4<sup>th</sup> Energy technology development plan Kick-off

- In November 2018 Korea held the kick-off meeting of the 4<sup>th</sup> energy technology development plan for successful energy transition and the establishment of strategies for technological innovation to enhance the competitiveness of the energy industry.
- The Energy Technology Development Plan is a top-level plan for energy technology development that is established every five years under the Energy Act. This includes mid and long-term investment technologies, research and development regulations, commercialization, human resources development, and international cooperation. In 2019 the Korean government formed a general committee and five working groups (policy, infrastructure, clean energy, smart energy, and safe energy) for the 4th energy technology development plan (2019 - 2028).

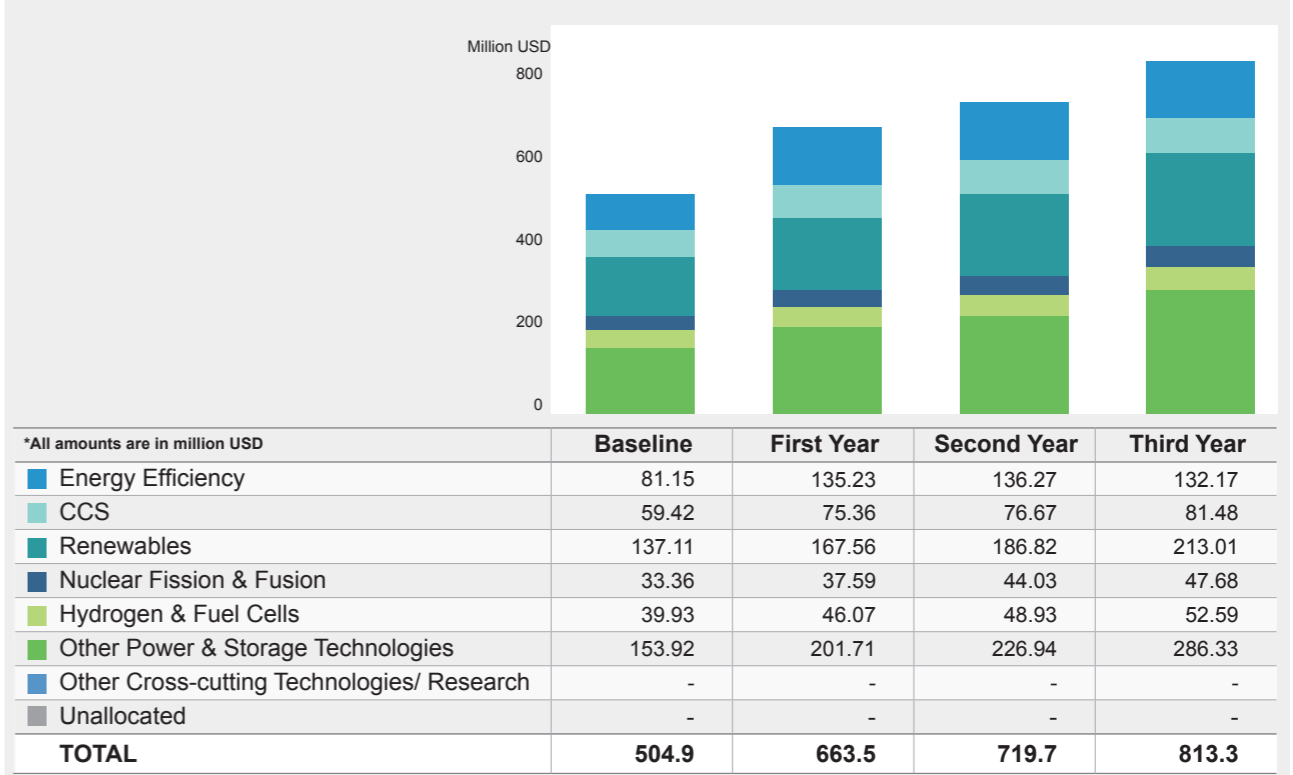
## Energy Transition Conference

- In November 2018 Korea held an energy transition conference to define the meaning of energy transition and facilitate sustainable energy transition discussion between international experts and companies. This was a useful opportunity to establish the meaning of energy transition and the direction of sustainable development with international experts. Danish Energy Director, Bloomberg Oceania branch office president, and GE Asia-Pacific CEO introduced the results and impacts of the first anniversary of the energy transition.

## Major activities in support of the Innovation Challenges in 2018/19

- The Republic of Korea has been working in IC1,2,3,6,7, and 8 since the launch of the MI. The government has designed a new joint research program for the MI Challenges which was approved for launch in December 2018. The funding budget for this program is 3 billion Korean Won (approximately 2.7 million USD) per IC for 3 years i.e. a total of 21.6 million USD. For this program all sectors related to the Innovation Challenges are eligible. Korean researchers cooperate with the experts from MI members. This is eligible for funding as long as their consortium is formed with Korean participants. Researchers from Canada, the US, India, and Germany are working together with Korean experts.
- The program supports a total of 8 projects in the area of the innovation challenge, one each), various activities such as joint workshop, manpower dispatch, recruitment, joint thesis announcement, research sample exchange, and visits to demonstration plants are underway.

## Public sector RD&D investment





# SAUDI ARABIA

## Update on clean energy innovation policies and strategies

The National Industrial Development and Logistics Program (NIDLP) was launched in January 2019 as a part of the 2030 Vision. The program is mandated to transform the Kingdom of Saudi Arabia into a leading industrial powerhouse and a global logistics hub in promising growth. The program has a research, development, and innovation (R&DI) section that includes oil and gas R&DI including carbon capture, utilization, and storage.

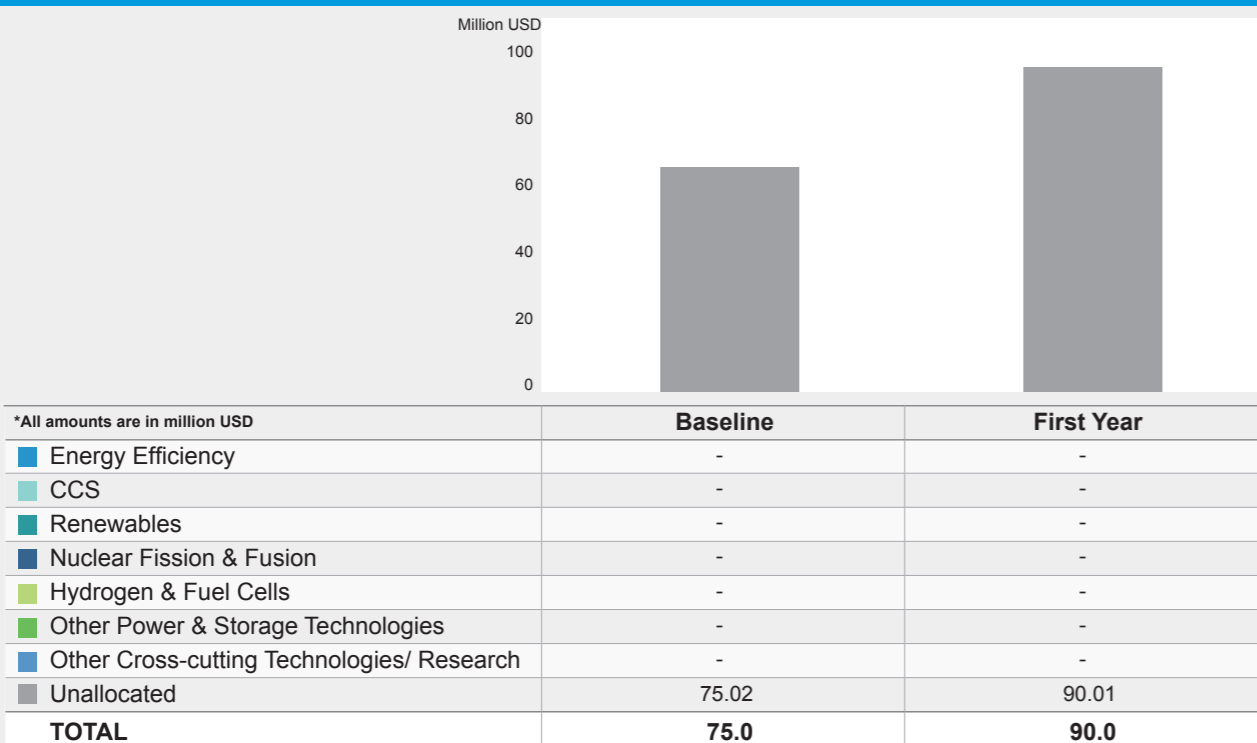
## Major innovation initiatives in 2018/19

- Saudi Arabia Basic Industries Corporation (SABIC) is currently developing a process to utilize CO<sub>2</sub> to produce acrylic acid by catalytic coupling of CO<sub>2</sub> and ethylene. The main advantages of this process are
  - (i) the CO<sub>2</sub> represents ~60% of the final product mass and
  - (ii) it will lead to the avoidance of the feedstock loss, by over-oxidation, in the current commercial technology to produce acrylic acid via propylene oxidation.
- SABIC is currently developing a technology to produce hydrogen from water splitting. Solar H<sub>2</sub> production from water could be the key to a sustainable energy economy with wide environmental, economic and social impacts. H<sub>2</sub> is commercially made mainly from natural gas or coal reforming, where 8kg of CO<sub>2</sub> is produced for every 1 kg of hydrogen made.

## Major activities in support of the Innovation Challenges in 2018/19

Saudi Arabia is working with the United Kingdom, Mexico, and Norway to identify innovation opportunities in higher technology readiness levels that are of particular interest to industry partners. A workshop is being planned for mid-2019 with CO<sub>2</sub> capture, utilisation and storage (CCUS) experts from academia and industry partners in the oil and gas, power, and energy intensives industries to build and complement the IC3 CCUS report with technological challenges that have the potential to accelerated CCUS deployment.

## Public sector RD&D investment



# SWEDEN

## Mission Innovation impact case study

The Avoided Emissions Framework is an initiative to support technologies, system solutions and companies that deliver solutions that help facilitate rapid reductions of greenhouse gases (GHG) in society.

The framework will support an accelerated uptake of disruptive solutions by supporting increased transparency regarding actual and potential GHG reductions making it easier to identify, support and invest in the next generation of solution providers. The framework will also support a psychological and structural shift from a problem and risk agenda with focus on only incremental improvements in existing systems, to a solution and opportunity agenda that also includes disruptive change.

MI was launched at the perfect time when the urgency to reduce global GHG emissions, the appetite for new innovative partnerships and realisation that we have entered a 4<sup>th</sup> industrial revolution converged. MI therefore became the perfect body for this kind of new global tool that requires agile thinking, a cooperative atmosphere and a strong focus on concrete results. Support from MI has laid the foundation for international collaboration and fostered sufficient momentum for the framework to establish itself in a relatively short time.

The activity is not itself a clean energy product or service, but an analytical tool intended to help with financing and development of solutions. Therefore, it has no direct results on emissions, technology cost, employment or access, but assists solution providers, investors and policy makers to achieve such results. For MI-4, solutions with more than 2 gigatons of potential reductions/year by 2030 have been identified and new collaborations established. Above all, the initiative has helped increase the visibility of a new generation of clean energy innovation and helped policy makers and investors see clean energy innovation as an opportunity and an investment.

## Update on clean energy innovation policies and strategies

The Riksdag (the Swedish Parliament) has set the following goals:

- The Swedish electricity supply should be 100% renewable by 2040.
- The energy use should be 50% more efficient by 2030 in relation to 2005, in terms relative to the Gross Domestic Product.
- There should be net zero Swedish emissions of GHG to the atmosphere in 2045; with negative net emissions after 2045.

The new government formed in January 2019 rests on an agreement between four political parties that includes a number of action items including:

- It should be made easier and more profitable to invest in renewable energy for your own use, e.g. in solar PV and solar heating, or in sea-based wind power.
- Taxes on work and commercial activities are to be lowered in exchange for increased environmental taxes.
- The infrastructure for charging and for filling vehicles with fossil free fuels are to be expanded.
- An investment support for pilot plants achieving negative climate emissions will be implemented.
- The sale of petrol- or diesel-powered cars should not be allowed after 2030.

Sweden was the main host of the MI-3 Ministerial meeting in Malmö in 2018.

Major innovation initiatives in 2018/19

The Swedish National Energy Research and Innovation Programme is administered by the Swedish Energy Agency (SEA) and is, as a whole, focused on clean and efficient, sustainable energy solutions, products and services. The budget for 2018 was about 1,5 billion SEK. Within the research and innovation (R&I) programme, small and medium sized companies are given support for product development and innovation through soft loans, grants with royalty agreements, and grants. Twenty of the companies supported have subsequently been introduced on the stock exchange, representing a total value of more than 12 billion SEK.

The Swedish doubling commitment relates to the efforts within the programme on long-term, bottom-up, clean energy research. The baseline was established as the average for the years 2013 – 2015, amounting to 134 million SEK. The estimate for 2019 is about 250 million SEK, and the prognosis for 2020 is well above a doubling.

In addition to the dedicated National Energy Research and Innovation Programme, there are many other public R&I efforts related to clean energy in Sweden. These data are collated and reported to the International Energy Agency energy research, development and demonstration database.

Furthermore, there are also resources made available for commercialisation and product development, e.g. through the Swedish Energy Agency and the GreenTech Venture Capital Fund.

The government initiative of five Innovation Partnership Programmes announced in last year’s country survey are still being implemented, as well as the two ten-year national research programmes on Climate research and on Spatial Planning/Smart Cities.

Several conferences and workshops to connect innovative companies with venture capital have been arranged.

Major activities in support of the Innovation Challenges in 2018/19

- Sweden and Austria are planning a pilot multilateral call for proposals in the field of Storage Systems and Storage integration in Autumn 2019; with relevance for the IC1, the IC7 and the IC8.
- Sweden is developing the Avoided Emissions Framework as a tool for assessing the impact of clean energy innovations.
- A multilateral European R&D call was launched and communicated during the MI-3 in Malmö 2018. 24 transnational projects supporting IC1 and IC7 with a total public funding of €32 million has been selected. The projects will start during 2019.
- Sweden is running the Challenge from Sweden programme which launches a series of competitions, events and other initiatives to implement innovation procurement, testing and implementation of clean energy solutions.

Other Mission Innovation related activity in 2018/19

The Swedish company Climeon has entered a partnership with the Breakthrough Energy Ventures. The SEA has supported Climeon in developing technology for low-temperature heat power production; e.g. from waste or geothermal heat.

The Swedish company Exeger has entered a partnership with, and received funding from, the SoftBank Group Corp. The SEA has supported Exeger in developing and manufactures solar cells that work efficiently in ambient light conditions with the potential to enable self-powered devices.

The winners of the earlier referenced A Challenge from Sweden competition on local energy systems (Innoenergy, Sweden; Ferroamp, Sweden; Amzur, USA; and Certh, Greece) have now had the opportunity to test their solutions in four different locations, demonstrating potential for providing system services to the grid.

The Sweden Sustaintech Venture Day was held in Stockholm on 14 February 2019. The event combined a focused outlook on sector growth opportunities and successful investment strategies with carefully selected Sustaintech company presentations. More than 200 investors participated.

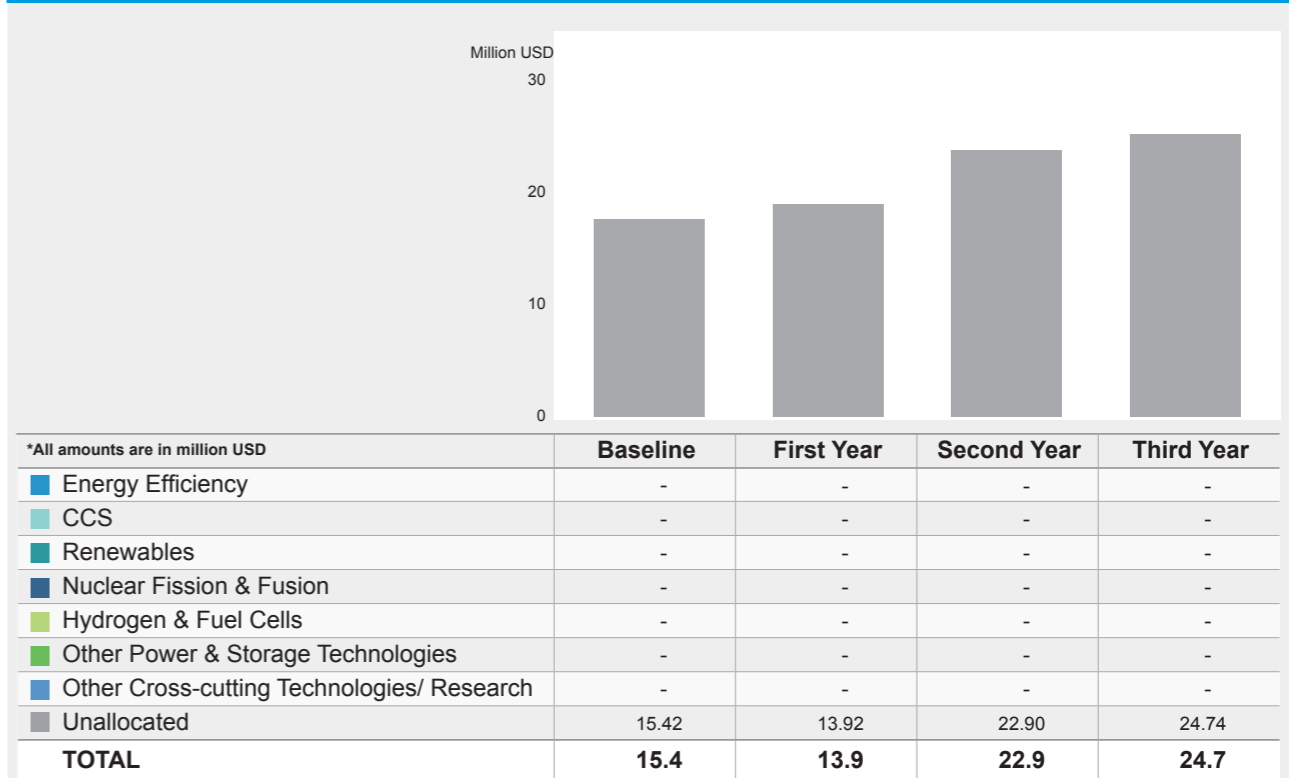
A Cleantech Forum conference will have been held in Stockholm on the 21 - 23 May 2019. This is the second time the Cleantech Forum has been held in Sweden, the first being in 2014.

Sweden, together with Canada and members of the World Energy Council, participates in the German Start-up Energy Transition (SET). The SET is a leading international platform supporting innovation in energy transition. SET is implemented with the conviction that sustainable energy solutions and mitigating climate change are directly linked to a bridge between inventive business models and political will. Powered by the German Energy Agency (dena) in cooperation with the World Energy Council (WEC), the initiative connects start-ups, international venture capitalists & investors, and partners in the public sector. As a global platform, it links like-minded people from various fields to promote innovation and make global energy transition a success.

Sweden increased its application from 3 start-ups to 24 and reached the top 4, after Germany (53 start-ups), USA (26 start-ups) and Canada (25 start-ups). Sweden had 3 finalists, all three supported by the Swedish Energy Agency (SEA).

Sweden and the SEA have launched a Cleantech Hub in New York, USA; for establishing an soft-landing program for our SEA portfolio companies from Sweden, close and nearby BEVs HQ in Boston. The Focus is start-ups with a proof of concept and a verified solution.

Public sector RD&D investment

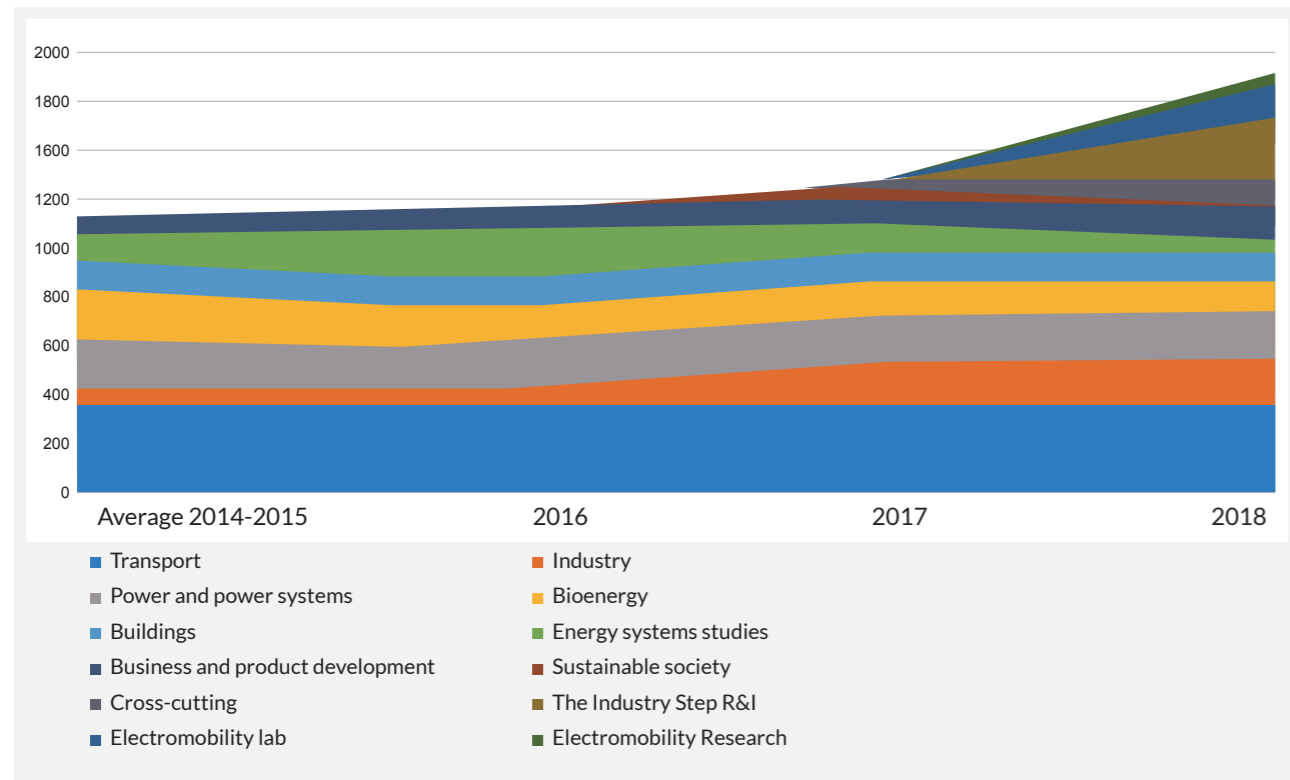


The doubling commitment is not as broad as the total energy RD&D effort reported to the IEA.

The national energy research and innovation (R&I) programme administered by the Swedish Energy Agency (SEA) is the main source of public energy R&I funding in Sweden. However, some activities in the programme may fall outside the scope of the IEA database; i.e. support to SME's for business and product development etc. Also, the activities of the programme are annually reported to the Government and to Parliament using another structure than the IEA database. In addition to this, the Energy Agency has recently received budget for a number of specific tasks; e.g. on establishing an electromobility lab, on funding R&I on biofuels and transport electrification, and on funding R&I for decreasing the GHG emissions of the process industry.

The development of this funding is shown in the following diagram (units of 1 000 SEK):

SEA Funding of Energy Related R&I



Please note that the figures shown are estimates, with some data from actual spending and some from budgets made available.

New Collaborations

Collaborators	Name of Collaboration	Brief Description	Sectors	Type of Collaboration	Duration	Funding amount	Additional information
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SE, EU Com, IT, UK, NL, FR, US, NO, KR, CH, JP, FI, AT, DE, DK, CA, BE, IEA HPT & ECES collaboration with IC7	Comfort & Climate Box	See next line below:	Public-private	Research and Development	Q4 2018 to Q2 2021	530 000 EUR (SE Budget)	<a href="https://heatpumpingtechnologies.org/annexes/ideas-and-proposals/">https://heatpumpingtechnologies.org/annexes/ideas-and-proposals/</a>
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- Integrated systems consisting of heat pumps and storage are an important technological option to accelerate the use of renewable energy for heating and cooling. By combining heat pumps and storage, several issues may be tackled, such as grid load balancing; increased self-usage of renewables; optimizing economics, CO<sub>2</sub>, fuel use and supply security.
- Commercial development of these packages is progressing slowly. This Combined Annex will help accelerate market development. The goal of this Combined Annex is to develop and disseminate knowledge, evaluate prototypes and coordinate field tests involving HP/storage-packages in existing buildings.

SE, AT, IT, NO, DK, DE, FR, NL, FI, ES, UK (total 30 funding partners counting non- MI partners as well) Ongoing discussion with China, India, Morocco, Chile, Mexico.	Joint Programming Platform Smart Energy Systems (JPP SES)	Public-public-private	Research, development, demonstration and innovation	Q2 2018 (at Malmö MI-3) to earliest 2025 (tentative)	32 MEUR granted in 2019 ~125 MEUR 2025 (~20 MEUR p.a.)	<a href="https://www.eranet-smartenergy systems.eu/">https://www.eranet-smartenergy systems.eu/</a>
EU countries	Battery 2030+	SE participates in EU Large-scale Research Initiative on battery research	Public-public; public-private	Large-Scale, Long-Term Research	Started in 2019	<a href="https://ec.europa.eu/digital-single-market/en/news/battery-2030-inventing-batteries-future">https://ec.europa.eu/digital-single-market/en/news/battery-2030-inventing-batteries-future</a>
EC; 8 MI members	SUNRISE	SE participates in EU Large-scale Research Initiative on the production of fuel and chemicals from sunlight	Public-public	Large-Scale, Long-Term Research	2019 to 2020 (first step)	1M€ from the EC <a href="https://docs.wixstatic.com/ugd/8993fb_d548a65940774debabf4645423c6f83a.pdf">https://docs.wixstatic.com/ugd/8993fb_d548a65940774debabf4645423c6f83a.pdf</a>
About 80 members from 30 countries.	Accelerate Energy Summit	See line following immediately below.	Public-Private	Strategic collaborations between incubators, accelerations regarding accelerate Energy innovations internationally	2019 to 2020	<a href="https://aes2019.splashthat.com/">https://aes2019.splashthat.com/</a>

- The Accelerate Energy Summit (AES) is the largest annual gathering of leading clean energy incubators and accelerators from around the world. New Energy Nexus has over 80 members in 30 countries, and AES is our flagship event.
- Our goal is to accelerate the global energy transition by increasing peer collaboration and knowledge sharing between energy startup supporters around the world.
- In 2016, New Energy Nexus together with Asian Development Bank (ADB) hosted a group of 25 existing and up and coming clean energy incubators and accelerators in Manila. In 2017, the Accelerate Energy Summit was hosted in Shanghai with partners including IncubatEnergy, World Wildlife Fund (WWF), ADB and World Bank, and last year AES was in Los Angeles, California and co-hosted with IncubatEnergy as part of the EPRI Electrification 2018 conference.
- This year, AES is coming to Stockholm, Sweden, with the support of The Swedish Energy Agency, World Wildlife Fund for Nature, EIT Climate-KIC and The Cleantech Group. The conference will be held the days before the start of Cleantech Forum Europe.



# UNITED ARAB EMIRATES

## Update on clean energy innovation policies and strategies

**Energy Strategy 2050:** In 2017, the UAE launched 'Energy Strategy 2050', which is considered the first unified energy strategy in the country that is based on supply and demand. The strategy aims to increase the contribution of clean energy in the total energy mix 50% by 2050 and reduce the carbon footprint of power generation by 70%. It also seeks to increase the consumption efficiency of individuals and corporates by 40%.

**National Climate Change Plan 2050:** The National Climate Change Plan of the UAE 2017–2050 is the UAE's comprehensive framework to address the causes and impacts of climate change, plan the transition into a climate resilient green economy and achieve a better quality of life. The primary objectives of the Climate Plan are to: manage greenhouse gas (GHG) emissions while sustaining economic growth, minimise risks and improve capacity of adaptation to climate change, and enhance the UAE's economic diversification agenda through innovative solutions.

**National Strategy for Advanced Innovation:** In February 2018, the UAE government approved the National Strategy for Advanced Innovation. The new strategy is the updated version of the National Innovation Strategy and marks a new phase that is based on enabling people to shift from focusing on vital sectors to the goals and outcomes in seven areas: exploration, future skills, quality of health, living and life, green power, transport, harnessing technology to serve humankind.

The innovation strategy aims to position the UAE among the world's top leaders of innovation and to develop a type of thinking that encourages experimentation and taking well-thought-out risks to achieve the goals of UAE Centennial 2071.

**National Advanced Sciences Agenda 2031:** In April 2018, the UAE government launched the National Advanced Sciences Agenda 2031 and the 2021 Advanced Science Strategy, which falls under the Agenda 2031. The 2031 Agenda aims to utilize advanced sciences in the development and creation of solutions to future challenges and support the government's efforts to achieve the objectives of Vision 2021 and Centennial Plan 2071 through three consecutive strategies starting with 2021 Advanced Science Strategy. The 2031 Agenda sets out eight scientific priorities up to 2031 and 30 scientific targets up to 2021. The eight scientific priorities aim to make the most of all strategic natural resources in the country through: national capacity-building, promoting the sustainable energy sector, enhancing water security using advanced and clean technology, developing advanced scientific food security system, addressing health challenges in the UAE through a national scientific system, developing advanced industries sector, building a system of logistical support based on scientific studies and data, creating a strategic industries complex.

## Major innovation initiatives in 2018/19

The UAE government and XPRIZE will invest \$81 million towards research and development (R&D) of new technologies as part of the Ghadan 21 programme. The programme will direct \$13.6 billion to accelerate the Abu Dhabi economy through digital technologies, new business models and partnerships with local, regional and international players in various industries. The \$81 million Ghadan investment will be directed towards R&D of solutions to address water scarcity, energy efficiency, food security, artificial intelligence, human ageing, and environmental conservation.

In 2017, Abu Dhabi fund Mubadala announced plans for its Aerospace, Renewables & ICT platform to invest a further AED 82.5 million (\$22.4 million) in R&D over the next five years.

Solar Decathlon Middle East is a collegiate competition of 10 contests that challenge students to design and build solar-powered houses. On June 17, 2015, the Dubai Supreme Council of Energy, Dubai Electricity and Water Authority, and the U.S. Department of Energy signed an agreement to collaborate on the development of Solar Decathlon Middle East (SDME 2018-2020), a competition that will integrate unique local and regional characteristics. In 2018, 18 university teams from 16 countries competing at Solar Decathlon.

In 2014, DEWA launched the R&D Centre in Mohammed bin Rashid Al Maktoum Solar Park, which focuses on four key operations: producing electricity using solar energy, integration of smart grids, energy efficiency, and water. AED 500 million is being dedicated towards the R&D and the Centre will be ready in 2020.

From its inception in 1971 up to December 2018, Abu Dhabi Fund for Development (ADFD), the leading national entity for international development aid, has financed hundreds of development projects in the renewable energy sector around the world worth AED 4.4 billion (US\$1.187 billion). Driving the objectives of the United Nations' Sustainable Development Goals (SDGs), these projects have contributed to the production of about 2,584 MW of renewable energy in different countries. Since 1974, ADFD has contributed to financing about AED 2.7 billion (US\$737 million) in renewable energy projects through joint financing agreements with the governments of many developing countries. The remaining funds were allocated through innovative and strategic partnerships including the seven-cycle AED 1.285 billion (US\$350 million) International Renewable Energy Agency (IRENA)/ADFD Project Facility, the AED 183.4 million (US\$50 million) UAE-Caribbean Renewable Energy Fund (UAE-CREF), as well as the UAE-Pacific Partnership Fund (UAE-PPF) valued at AED 183.4 million (US\$50 million). In addition to supporting sustainable development in key socio-economic sectors, ADFD has funded important renewable energy projects. Notable projects include:

### • Sheikh Zayed Solar Power Complex in Jordan

In line with the Jordanian government's objective of generating 20 per cent of energy from renewables by early-2020, ADFD contributed AED 550 million (US\$150 million) to funding the Sheikh Zayed Solar Power Complex. The project involved the installation of 328,320 photovoltaic panels that will produce 227 GWh of solar power annually over a period of 20 years, enough to illuminate about 50,000 homes

Project works included the provision of electrical switches, a medium voltage and signal cable system, transformers and all required equipment to connect the plant to the national power grid. The support also covered civil construction works, roads and safety systems as well as overall project operation and management.

The plant contributed to the creation of about 1,000 jobs during the construction phase and is set to provide 30 permanent jobs for its sustained operation and maintenance.

### • Upper Atbara and Setit Dam Complex in Sudan

ADFD allocated an US \$90 million concessionary loan and contributed to the construction of the Upper Atbara and Setit Dam Complex in Eastern Sudan. With a storage capacity of 2.7 billion cubic metres of water, the twin dams provide the hydroelectric power plant with enough power to generate 320 megawatts of electricity.

### • Merowe Dam in Sudan

ADFD provided AED 735 million for the construction of the Merowe Dam in north Sudan. One of the largest hydropower projects in Africa and the second major hydropower project in Sudan, this strategic project helps the country fill its power deficit by producing electricity totalling 1,250 megawatts – benefitting more than 30 million people.

Located nearly 350 km north of the capital Khartoum, the dam is about 1.1 km across the river and is 9 km long and 60 metres tall. The project included all the necessary civil works including the power plant to accommodate 10 generators, each with a capacity of 125 megawatts, and the electromechanical works. The works also comprised the transmission lines and connectivity to the national grid.

### • Waste-to-energy facility in the emirate of Sharjah

ADFD allocated an AED 121 million (US\$33 million) concessionary loan for the development of a waste-to-energy facility in the emirate of Sharjah.

Expected to treat more than 300,000 tonnes of municipal solid waste (MSW) each year, or 37.5 tonnes per hour, the plant will have the capacity to generate around 30 megawatts of energy. Due for completion by early 2021, the facility aims to help attain Sharjah's zero-waste-to-landfill target and the UAE's objective of diverting 75 per cent of its municipal solid waste from landfills by 2021.

### • Producing electricity using wind power in Seychelles

In the Republic of Seychelles, ADFD allocated AED 103 million (US\$28 million) to produce clean electricity using wind turbine technology.

Known for being costly to operate and maintain as well as harmful to the environment, diesel-powered electrical power plants were replaced with wind power. This project included the supply, installation and activation of wind turbine farms for electric power generation in several different areas of the island of Mahé.

Eight farms were built to generate between 4 to 6 MW of electrical power. The project also included maintenance and the development of the transmission network, as well as technical services for the studies of wind power and project management.



**• IRENA/ADFD Project Facility**

In 2013, ADFD committed US\$ 350 million over seven funding cycles for the IRENA/ADFD Project Facility. After the announcement of the sixth funding cycle in January 2019, the cumulative funding to date is US\$ 245 million. The Facility helps developing countries access low-cost capital for renewable energy projects to increase energy access, improve livelihoods and advance sustainable development.

Since the selection of projects for the first cycle in 2014, ADFD’s funding has benefitted 24 renewable energy projects in 23 countries, covering up to 50 per cent of the total project costs. They will bring more than 157 megawatts of renewable energy capacity online and create electricity access for over seven million people, significantly improving their livelihoods. Spanning Asia, Africa, Latin America and Small Island Developing States, the projects encompass a broad spectrum of renewable energy sources – wind, solar, hydro, geothermal and biomass – and technologies.

In 2019, the sixth cycle of this Project Facility has approved projects worth \$31 Million USD with the following projects:

- In **Guyana**, a project will receive a loan of US\$ 8 million to install 5.2 megawatt (MW) grid-connected solar PV systems in the hinterland regions to reduce fossil fuel consumption and increase the reliability of electricity supply. An estimated 34,700 people in the target areas will benefit and around 120 direct and indirect jobs are set to be created throughout the project lifecycle.
- In **Liberia**, the loan of US\$8 million will contribute to the construction of a 2.1 MW run-of-river hydropower plant on the Gee River. The project will benefit over 30,000 people through providing a clean, reliable and affordable source of energy to households, schools, health facilities and small businesses, enhancing living conditions and helping to reduce poverty.
- In **Togo**, a 30 MW grid-connected solar PV plant will be constructed with the investment of a US\$15 million loan. The project aims to bring clean, reliable power to around 700,000 households and small businesses and reduce greenhouse gas emissions by 9,242 tonnes/year. Local communities will benefit from greater access to drinking water, education and healthcare as well as job creation that prioritises women.

**• UAE-Caribbean Renewable Energy Fund (UAE-CREF)**

Launched at Abu Dhabi Sustainability Week 2017, UAE-CREF aims to deploy renewable energy projects with a capacity of 11 MW in 16 Caribbean countries to help reduce reliance on fossil fuel imports, stimulate economic activity and enhance climate change resilience. The fund is also a testament to the UAE’s efforts to advance the UN Sustainable Development Goals.

At Abu Dhabi Sustainability Week 2019, the third cycle of the US\$ 50 million UAE-Caribbean Renewable Energy Fund (CREF), was allocated to projects delivered in Jamaica, Cuba, Suriname, Trinidad & Tobago.

**• UAE-Pacific Partnership Fund (UAE-PPF)**

ADFD earmarked US\$ 50 million in funding to the UAE-Pacific Partnership Fund (UAE-PPF), a pillar of the UAE’s wider strategy to support sustainable development projects around the globe through the deployment of renewable energy, with the supervision of the UAE’s Ministry of Foreign Affairs and International Cooperation. Abu Dhabi Future Energy Company, Masdar was appointed to develop and implement renewable energy projects in 11 countries under UAE-PPF.

The first cycle of UAE-PPF funding enabled the completion of small-scale solar and wind power projects in Kiribati, Fiji, Samoa, Tonga, Tuvalu and Vanuatu. The project deliverables included cyclone-proof wind turbines and space-optimising solar power solutions. In some cases, the installed projects met as much as 50% of local power requirements.

In May 2016, phase 2 of UAE-PPF supported the delivery of renewable energy projects in the Solomon Islands, Nauru, the Marshall Islands, Palau and the Federated States of Micronesia – with a combined power generating capacity of 3.25 megawatts, displacing more than 4,000 tonnes of carbon dioxide annually, and reducing diesel imports by as much as 1.5 million litres per year.

In 2019, the Abu Dhabi Sustainable Finance Declaration (the Declaration) was signed by 25 public and private sector entities at the inaugural Abu Dhabi Sustainable Finance Forum (ADSFF) on 16 January as a united front to foster positive economic, social and environmental impacts and advocate sustainable finance and investments for the long-term well-being and growth of the country’s economy.

UAE is host to the world’s largest battery bank in Abu Dhabi, with a capacity of 108 megawatts distributed over 10 sites across the emirate. We believe storage has tremendous potential in the long term.

In 2019, DEWA launched its first Smart Grid Station (SGS) which comprises a 200-kilowatt (kW) photovoltaic solar power production system; a 9-kilowatt (kW) wind turbine; and a 500-kilowatt hour (kWh) lithium-ion battery energy storage system, which stores energy for later use. The station also includes over 2,000 sensors based on the Internet of Things (IoT) technology, and smart meters distributed throughout the facility to monitor power and water demand data in real-time for the purpose of improved energy and water management, with the potential to reduce demand when required by eliminating non-critical loads through smart lighting, smart power outlets, and smart air conditioning system.

Masdar and Beeah launched the Bee’ah Waste Management Center in Sharjah, the new plant will process more than 37.5 tonnes of municipal solid waste (MSW) per hour to generate electricity sustainably. Once operational, it will contribute significantly to reaching the UAE’s target of diverting 75 per cent of its solid waste from landfills by 2021, as well as Sharjah’s zero-waste-to-landfill goal.

**Major activities in support of the Innovation Challenges in 2018/19**

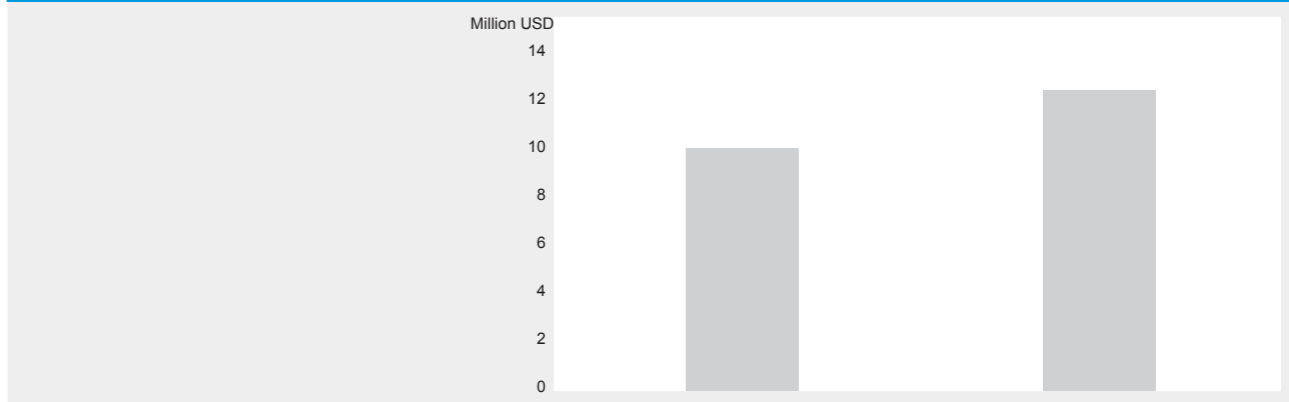
As co-leads of the Affordable Heating and Cooling in Buildings Innovation Challenge along with the United Kingdom and the European Commission, the UAE is proud of the progress of this challenge which comes as a result of the efforts of the co-leading countries as well as India, Sweden and Australia, who have provided substantial support along with the member countries that have actively participated.

The UAE is pleased to have hosted the first workshop for IC7 which was held in November last year in its capital, Abu Dhabi. This IC7 workshop brought together 70 international experts from 13 countries to discuss the priority areas in Heating and Cooling and develop ideas and actions moving forward. The workshop provided the necessary platform for experts to discuss ideas for technological advancements and resulted in innovative ideas and research actions that aim for the development of commercially viable solutions.

The UAE is championing one of the main priority areas under IC7: Alternative Heat Sinks and Sources.

A conference call was hosted by the UAE in April 2019 to discuss progress and actions moving forward with different member countries.

**Public sector RD&D investment**



\*All amounts are in million USD

	Baseline	First Year
Energy Efficiency	-	-
CCS	-	-
Renewables	-	-
Nuclear Fission & Fusion	-	-
Hydrogen & Fuel Cells	-	-
Other Power & Storage Technologies	-	-
Other Cross-cutting Technologies/ Research	-	-
Unallocated	10.00	12.20
<b>TOTAL</b>	<b>10.0</b>	<b>12.2</b>



# UNITED KINGDOM

## Mission Innovation impact case study

### Power Forward Challenge: UK-Canada joint challenge on smart energy systems innovation

As electric vehicles, smart devices, storage systems and remote connectivity become more commonplace, the demands placed on our electricity grids are becoming highly complex and very different from when they were built. Through the Power Forward Challenge, the UK and Canada are jointly offering over £11 million to develop the best smart energy systems for the 21st Century with the aim of having pilot-scale demonstrations by December 2020. The Challenge is looking for innovators who can bring disruptive technologies or new thinking to develop clean, robust and flexible power grids and energy systems that anticipate and meet the needs of networks around the world, looking ahead to 2030 and beyond.

This funding competition is a result of the relationships and understanding of mutual priorities that have been developed between the UK and Canada through MI. As a result of this relationship, in September 2017, the Prime Ministers of the UK and Canada agreed a Clean Growth and Climate Change Partnership. The joint challenge was announced at the 3<sup>rd</sup> MI Ministerial in May 2018 by Minister Claire Perry, Department for Business, Energy & Industrial Strategy, and Parliamentary Secretary Kim Rudd, Natural Resources Canada, with the challenge launched at Green Great Britain Week in October 2018.

The challenge has generated significant interest on both sides of the Atlantic with 21 UK and Canadian companies funded<sup>43</sup> for the Phase 1 feasibility studies. New collaborations between UK and Canadian companies are being supported, for instance, the Maple project is exploring the feasibility of exporting smart demand balancing controls systems domestic hybrid heat pumps to Canada whilst the OpenFlex project bring proven smart grid and smart home technology from Canada to the UK and take advantage of the new UK smart metering infrastructure to deliver an open standards-based, low cost, and interoperable system for flexibility services. In phase 2, project teams can apply for up to £1.8 million (C\$3m) per project for demonstration projects in the UK or Canada.

### Accelerating CCUS Technologies

Accelerating CCUS Technologies (ACT) is an international initiative to facilitate research, development and demonstration (RD&D) and innovation within CO<sub>2</sub> capture, utilisation and storage (CCUS). The second phase of ACT from 2018-2022 is facilitating eleven countries to work together with the ambition to fund world class RD&D innovation that can lead to safe and cost effective CCUS technology. The ACT programme originated out of the EU's ERANET programme.

Due to the Carbon Capture Innovation Challenge and MI, the CCUS ACT consortium opened its second call to MI countries. This resulted in two additional MI members, the US and France, joining the Call. The current Call for project proposals (closed in March 2019) included call text that actively encouraged projects to address the Priority Research Directions (PRDs) developed during the 2017 Houston Mission Innovation Workshop<sup>44</sup>. The initiative now involves seven MI members (Norway, Germany, France, The Netherlands, UK, USA as well as the EU). Other countries involved are also exposed to the MI Innovation Challenge (Spain, Switzerland, Romania, Turkey, Greece).

An ACT Call was published 4 June 2018 with the total budget for the Call in the range €22.05 million to €30.05 million.

<sup>43</sup> [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/783351/power\\_forward\\_challenge\\_SME\\_support.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/783351/power_forward_challenge_SME_support.pdf)

<sup>44</sup> <https://www.energy.gov/fe/articles/doe-releases-report-mission-innovation-ccus-experts-workshop>

## Update on clean energy innovation policies and strategies

The UK has continued to make good progress<sup>45</sup> on implementing our Clean Growth Strategy and have announced new initiatives to deliver this Strategy.

- **Green GB Week:** We hosted the inaugural Green GB Week<sup>46</sup> in October 2018 – an incredible example of Government, academia, business and civil society coming together to raise awareness of clean growth. More than 100 events were held across the UK and over 50 commitments were made from Government and business. This included holding the European launch of the Intergovernmental Panel on Climate Change (IPCC)'s 1.5 degrees special report to an audience of European senior government officials, climate scientists, non-governmental organisations and think tanks at Imperial College.
- **Buildings Mission:** In May 2018 the Prime Minister announced the first mission under the Clean Growth Grand Challenge, which is to at least halve the energy use of new buildings by 2030. In Green GB Week, Minister Perry announced the Home of 2030 design competition, aiming to galvanise collaboration across the public and private sector to generate housing design fit for the future.
- **Clusters Mission:** In December 2018, the UK's Climate Change Minister, Minister Claire Perry, announced the UK's second Clean Growth mission, which is to establish the world's first net-zero carbon industrial cluster by 2040 and at least one low carbon cluster by 2030. The UK Government will be investing up to £170m in innovation support to kick-start this mission.

Alongside the launch of the Special Report on Global Warming of 1.5 °C, in October 2018 we requested the Committee on Climate Change (CCC)'s advice on the implications of the Paris Agreement for the UK's long-term emissions reduction targets, which advised on the 2<sup>nd</sup> **May for the UK government to set a net zero greenhouse gas target by 2050.**

## Major innovation initiatives in 2018/19

### Basic and Applied Research

- The Engineering and Physical Sciences Research Council invested around £140m in basic and applied energy research in 2018/19, covering most energy technologies.

### Built Environment

- the Transforming Construction Challenge<sup>47</sup> was launched to help companies to adopt digital and manufacturing technologies that will help them construct buildings faster and cheaper and with half the lifetime carbon emissions. The UK government will invest up to £170 million, matched by £250 million from industry, to create new construction processes and techniques.
- launched the **£5.6m Boosting Access for SMEs to Energy Efficiency (BASSE) Competition** to scale-up business energy efficiency
- awarded **£4.1m to 8 suppliers in the Smart Meter Enabled Thermal Efficiency Ratings (SMETER) project** to develop more reliable methods to determine the energy efficiency rating of homes
- awarded **£6.2m of projects to develop boilers, fires and cookers certified to operate with 100% hydrogen** as part of the Hy4Heat project to de-risk the use of hydrogen for heating buildings

### Smart Grids

- as part of the UK's £102.5m Prospering from the Energy Revolution Challenge<sup>48</sup>, we are funding the growth of **smart local energy systems**, with four demonstration projects across the UK announced<sup>49</sup> in April 2019.

<sup>45</sup> [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/748296/delivering-clean-growth.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/748296/delivering-clean-growth.pdf)

<sup>46</sup> <https://greengb.campaign.gov.uk/>

<sup>47</sup> <https://www.ukri.org/innovation/industrial-strategy-challenge-fund/transforming-construction/>

<sup>48</sup> <https://www.ukri.org/innovation/industrial-strategy-challenge-fund/prospering-from-the-energy-revolution/>

<sup>49</sup> <https://innovateuk.blog.gov.uk/2019/04/03/the-local-energy-revolution-4-energy-demonstrators-announced/>

- through the Faraday Battery Challenge<sup>50</sup> we are creating an £80 million automotive battery industrialisation centre to enable companies to quickly develop their capabilities to manufacture batteries and creating the £78 million Faraday Institution<sup>51</sup> at the Harwell Science and Innovation campus to speed up research into battery technologies.
- **launched the £4 million FleX Competition** to test innovative approaches to valuing and trading flexibility and **launched the £20 million Storage at Scale programme** to support the delivery of large-scale, pre-commercial energy storage facilities using innovative (non-battery) technologies.

### CCUS & Industry

- launched phase 2 of the **£20 million Industrial Fuel Switching competition** to stimulate early investment in fuel switching processes and technologies
- allocated up to £20 million to design and construct **CCU demonstration** projects in the UK.
- launched a **£15m Call for CCUS Innovation** to offer grant funding for innovation projects that lead to a reduction in the cost of capturing and sequestering carbon dioxide

### Innovation for development

The UK will invest at least £100 million in 2020-21 on projects that will help to address the clean energy needs of developing countries.

- held a Transforming Energy Access: Innovations towards SDG7 conference in London announcing<sup>52</sup> £51m of new relevant clean energy RD&D funding via the Transforming Energy Access programme<sup>53</sup> (£30m) and Africa Clean Energy (ACE) programme on Mini-Grids (£21m)
- supported the second round of the Global LEAP Awards<sup>54</sup> to identify highly energy-efficient, durable, off- and weak-grid appropriate refrigerators
- announced 10 finalists for the off-grid cold chain prize via the **Ideas to Impact** innovation prizes programme.

These investments are resulting in new solutions that support the economy and jobs such as Chimney Sheep<sup>55</sup>, supported by the Energy Entrepreneurs Fund, which has produced a chimney draught excluder that is breathable and sustainable, while also blocking 93% of airflow up a chimney and Switchee<sup>56</sup> which was supported by Innovate UK to develop a smart, internet connected thermostat – one integrated solution that helps residents consume less energy and provide landlords with insights to make homes more energy efficient.

### Major activities in support of the Innovation Challenges in 2018/19

The UK has actively participated in all of the Innovation Challenges in 2018-19 and co-leads the Carbon Capture (IC3) and Heating & Cooling (IC7) Innovation Challenges. A few highlights are illustrated below:

#### IC3 – Carbon Capture

The UK joined Saudi Arabia and Mexico as co-leads of the Carbon Capture Innovation Challenge at the 3<sup>rd</sup> MI Ministerial. Over the past year, the UK has facilitated the international expansion of the CCUS ACT Consortium<sup>57</sup> that provides research and demonstration and innovation grants to collaborating countries. The second Call launched in June 2018 with a total budget of €30.05 million including £6.5 million from the UK and involving 6 other MI members and five other countries. The UK ensured that the Call text actively encouraged projects to address the Priority Research Directions (PRDs) developed during the 2017 Houston Mission Innovation Workshop<sup>58</sup>. The UK is planning the next IC3 workshop in Norway in June 2019.

<sup>50</sup> <https://www.ukri.org/innovation/industrial-strategy-challenge-fund/faraday-battery-challenge/>

<sup>51</sup> <http://www.faraday.ac.uk/the-faraday-institution-announces-42-million-for-energy-storage-research/>

<sup>52</sup> <https://www.gov.uk/government/news/uk-aid-to-give-clean-energy-boost-to-africa>

<sup>53</sup> <https://www.carbontrust.com/tea/>

<sup>54</sup> <https://globalleapawards.org/refrigerators>

<sup>55</sup> <https://www.futurebuild.co.uk/blogs--insights/innovation-stories-chimney-sheep#/>

<sup>56</sup> <https://www.futurebuild.co.uk/blogs--insights/innovation-stories-switchee#/>

<sup>57</sup> <http://www.act-ccs.eu/>

<sup>58</sup> <https://www.energy.gov/fe/articles/doe-releases-report-mission-innovation-ccus-experts-workshop>

#### IC5 – Artificial Photosynthesis

The UK hosted an international meeting at Cambridge University on 25<sup>th</sup> March 2019 to agree the IC5 Global Actions for Sunlight Conversion and a plan for taking it forwards. The document was drafted by the UK IC lead Prof. James Durrant from Imperial College with Prof Leif Hammarstrom from Uppsala University, Sweden.

#### IC7 – Heating & Cooling of Buildings

Effort this year has focused on the development of 24 research foci in 6 priority areas and increasing communication activities. The UK represented MI and the Heating & Cooling Innovation Challenge at the launch of the Global Cooling Prize by Indian Minister Harsh Vardhan. The \$3M #GlobalCoolingPrize aims to spur the development of technologies with 5x less climate impact than air conditioners being sold today by 2020. The UK has also supported workshops to develop a Technology Assessment Document on Sorption Heat Pumps, Predictive Maintenance and Operation, and the “Comfort and Climate Box”.

### Other Mission Innovation related activity in 2018/19

The UK has continued to provide the Head of Secretariat for MI over the past year raising ambition through member-led initiatives. The UK also provided senior resource via a Strategic Adviser to the Head of Secretariat from August 2018 from the Department of Business, Energy and Industrial Strategy (BEIS). We are delighted that the UK nomination of the Chief Scientific Advisor for BEIS, Prof. John Loughhead, as Chair of the Steering Committee from June 2019 – June 2020 was approved by MI members.

#### COP24 Events

Three clean energy innovation events were held in the UK Pavilion at COP24 on 12<sup>th</sup> December:

- To mark the third anniversary of MI, the UK hosted a side event<sup>59</sup> at COP24 entitled **Mission Innovation and the role of clean energy innovation in pursuing efforts towards 1.5°C**, involving both Prof John Loughhead, Vice Chair of the Steering Committee as keynote and panellist and Dr Julia Knights, Strategic Adviser to Head of Secretariat in BEIS as the Chair of the side event.
- The **Accelerating CCUS deployment** event focused on the role of innovation and international collaboration in accelerating CCUS deployment globally.
- The **Low carbon cooling** event launched the Global Clean Cooling Landscape Assessment discussed the key policy, innovation and financing gaps.

#### UK-Canada Power Forward Challenge

The winning teams from the first stage of the joint £11m UK-Canada Power Forward Challenge<sup>60</sup> were announced which has brought together innovators from the UK and Canada to demonstrate our shared ability to aggregate and manage distributed generation, energy storage and flexible loads in future energy systems.

#### UK-South Korea Competition on Smart Energy Innovation

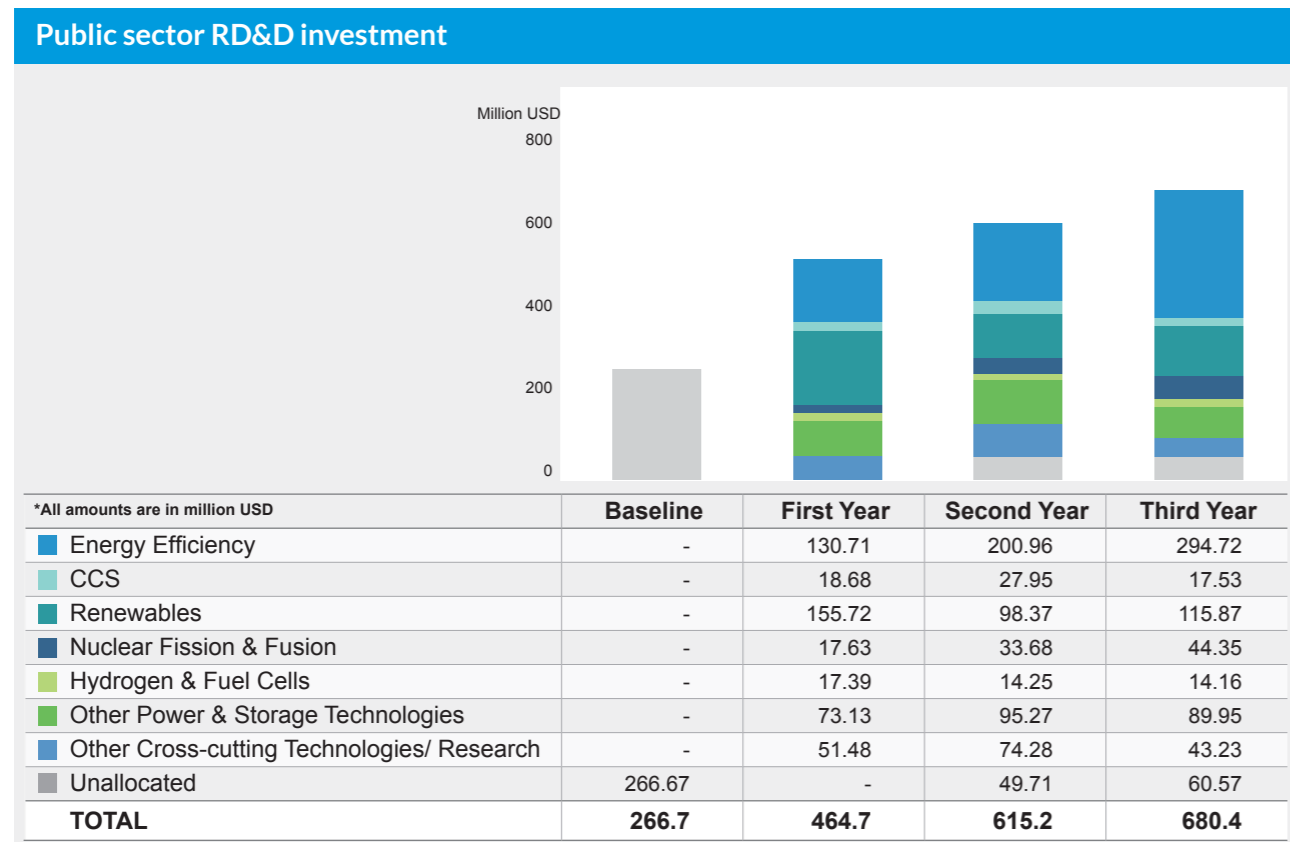
The winners of the £6 million UK / South Korea bilateral programme<sup>61</sup> to collaboratively develop innovative smart energy solutions were announced.

UK is one of five MI governments working with the Breakthrough Energy Coalition (BEC), an initiative led by Bill Gates that includes over 30 influential investors from around the world. We are continuing to explore opportunities to boost private sector investment to support UK researchers and companies.

<sup>59</sup> <http://www.mission-innovation.net/2018/12/19/cop24-a-clear-road-ahead-towards-the-paris-agreement-goals/>

<sup>60</sup> <https://www.gov.uk/guidance/funding-for-innovative-smart-energy-systems#power-forward-challenge-funding-for-uk--canada-joint-challenge-on-smart-energy-systems-innovation>

<sup>61</sup> <https://www.gov.uk/guidance/funding-for-innovative-smart-energy-systems#funding-for-uksouth-korea-bilateral-collaboration-on-smart-energy-innovation>



**Please note:** This data is based on the UK's full IEA return and previous reporting to MI<sup>62</sup>. The MI Third year RD&D numbers are provisional only. Further analysis is ongoing on the allocation of the spend against the categories provided. The UK MI baseline and doubling goal does not include all UK energy innovation spend. It does not include basic research and only includes those programmes specifically targeted at clean energy innovation challenges that are consistent with the UK's priorities to deliver through MI. The UK's RD&D spend is calculated over the normal accounting period from beginning April to end March for each year.

<sup>62</sup> <http://www.mission-innovation.net/our-members/united-kingdom/>

### New Collaborations

Collaborators	Name of Collaboration	Brief Description	Sectors	Type of Collaboration	Duration	Funding amount	Additional information
EU, Germany, France, The Netherlands, Norway, United States, UK (and Spain, Switzerland, Romania, Turkey, Greece).	2 <sup>nd</sup> Call - Accelerating CCS Technologies (ACT)	An international initiative to fund research and innovation projects that can lead to safe and cost-effective technology.	Public-public	Research, development, and/or demonstration	2018 to 2022	€30.05 million	<a href="http://www.act-ccs.eu">http://www.act-ccs.eu</a>
IC5 project through H2020 with 8 MI countries.	SUNRISE	EU Large-scale Research Initiative on the production of fuel and chemicals from sunlight.	Public-public	Large-Scale, Long-Term Research	2019 to 2020 (first step)	1M€ from the EC	<a href="https://docs.wixstatic.com/ugd/8993fb_d548a65940774debabf4645423c6f83a.pdf">https://docs.wixstatic.com/ugd/8993fb_d548a65940774debabf4645423c6f83a.pdf</a>
Belgium (IWT), Denmark (EUDP), The Netherlands (RVO), Portugal (FCT), Spain (CDTI)	Demowind 1-2	Principal objective is to fund public-private projects that develop and demonstrate offshore wind energy technologies	Public-public	research, development, and/or demonstration	2015 to 2020	25M€ from the EC (UK contribution £3M)	<a href="http://www.demowind.eu">www.demowind.eu</a>
United States	Civil Nuclear Energy Research and Development (R&D) Action Plan	The action plan calls for working groups to address various aspects of nuclear energy research, and aims to ensure nuclear energy's contribution to both countries' strategic energy resources, low carbon emissions targets, nonproliferation goals, and nuclear energy safety objectives.	Public-public	Research	2018 to 2022 with automatic extension		<a href="https://www.energy.gov/ne/articles/doe-s-office-nuclear-energy-agrees-nuclear-action-plan-united-kingdom">https://www.energy.gov/ne/articles/doe-s-office-nuclear-energy-agrees-nuclear-action-plan-united-kingdom</a>
Japan	Civil Nuclear Fission phase 5 and 6 calls	Collaborative research in nuclear decommissioning technologies	Public-public	Research	2018 to 2021	£1m	
United States	Civil Nuclear Energy University Programme (NEUP)	Collaborative research in nuclear technologies	Public-public	Research	2019 to 2022	£1.5m	
Republic of Korea	Civil Nuclear Fission phase 2	Collaborative research in nuclear decommissioning technologies	Public-public	Research	2019 to 2022	£2.5m	
India	Civil Nuclear Fission phase 5 Call	Collaborative research in nuclear technologies including plant safety, nuclear engineering, thermal hydraulics and waste immobilisation	Public-public	Research	2020 to 2023	£3.0m	



# UNITED STATES

## Update on clean energy innovation policies and strategies

The United States is moving forward swiftly with a true “all of the above” energy strategy founded on a new energy realism to drive clean energy progress through innovation. This includes a definition of clean energy that recognizes the role of nuclear energy and high-efficiency fossil fuels in the energy mix for the foreseeable future, as well as the strong progress of cost competitive renewable energy technologies in the marketplace. Cutting edge research and development (R&D) in highly efficient fossil fuels, next generation nuclear reactors and fuels, renewable energy technologies, energy storage and grid technologies, and energy efficiency remains a critical element of the overall energy and economic strategy of the United States.

### Recognition of R&D Success

The U.S. Department of Energy (DOE) engages in a wide range of R&D activities in energy and basic science. Research at DOE’s National Laboratories is widely recognized in the scientific community as cutting edge. In 2018, DOE researchers won or shared 32 of the 100 awards given out by R&D Magazine and received “Special Recognitions” for “Green Tech,” “Market Disruptor—Products,” and “Corporate Social Responsibility.” The annual R&D 100 Awards<sup>63</sup> are given in recognition of exceptional new products or processes that were developed and introduced into the marketplace during the previous year. DOE’s national laboratories have received more than 800 R&D 100 awards since the annual competition began in 1962. The awards are selected by an independent panel of judges based on the technical significance, uniqueness, and usefulness of projects and technologies from across industry, government, and academia. Many of these projects were developed in collaboration with private companies or academic institutions.

### Advanced Nuclear

Through a multiyear, multipart funding opportunity announcement (FOA), U.S. Industry Opportunities for Advanced Nuclear Energy Technology Development, DOE established cost-shared private-public partnerships with U.S. companies for multiple domestic advanced nuclear technology projects, totaling approximately \$98 million<sup>64</sup>.

At the same time, a partnership with NuScale continues, assuring advanced Small Modular Reactor design can be completed and made available for deployment in the mid-2020s.

### Grid Integration of Renewables

In October 2018, the U.S. DOE announced up to \$46 million in new funding for new technologies that increase the resiliency of solar generated electricity. With more and more solar generation coming online every day, grid operators need the tools and technologies to ensure that the electric grid is resilient and energy services are delivered to critical infrastructure. These projects will develop and validate control strategies, real-time system monitoring, robust communications and other technologies to make solar power at the bulk power and distribution levels more resilient.

In March 2019, the DOE selected up to \$36 million in research projects that will advance solar energy’s role in strengthening the resilience of the Nation’s electricity grid. While fires, natural disasters, and cyberattacks can cause wide-spread power losses, even temporary disruptions in power quality can result in major economic losses. With more and more solar being added to the U.S. electricity generation portfolio, these projects will enable grid operators to rapidly detect physical and cyber-based abnormalities in the power system and utilize solar generation to recover quickly from power outages, in many cases without human control.

<sup>63</sup> <https://www.rd100conference.com/awards/winners-finalists/year/2018/>

<sup>64</sup> <https://www.energy.gov/ne/articles/us-advanced-nuclear-technology-projects-receive-18-million-us-department-energy>

## Expanding the Renewables Workforce

In October 2018, the DOE announced up to \$53 million in new projects to advance early-stage solar technologies; aims include lowered electricity costs and workforce expansion, including training programs for veterans and transitioning military personnel.

In March 2019, the DOE announced up to \$130 million for new research to advance early-stage solar technologies. These projects will help to achieve affordable and reliable energy to enhance America’s economic growth and energy security. This funding program targets five research areas: photovoltaics (PV), concentrating solar-thermal power (CSP), soft costs reduction, innovations in manufacturing, and solar systems integration. These projects will make solar energy more affordable, reliable, and secure, while working to boost domestic solar manufacturing, reduce red tape, and make PV more resilient to cyberattack.

In March 2019, the DOE announced up to \$28.1 million in funding aimed at advancing wind energy nationwide across the land-based, offshore, and distributed wind sectors. While utility-scale wind energy in the United States has grown to 90 gigawatts, significant opportunities for cost reductions remain, especially in the areas of offshore wind, distributed wind, and tall wind.

## Enhancing Oil Recovery and Natural Gas Midstream Infrastructure, and Mitigating Methane Emissions

On April 16, 2019, the DOE announced up to \$39 million in federal funding for cost-shared research and development projects that aim to improve oil and natural gas technologies. One of the research areas aims to improve efficiency and capabilities for enhanced oil recovery in offshore wells. The other research area is to enhance the safety, mitigate methane emissions and efficiency of the nation’s natural gas production, gathering, transmission, and storage infrastructure<sup>65</sup>.

## Supercomputing

In 2018, DOE reaffirmed U.S. superiority in high performance computing (HPC). The Summit supercomputer at Oak Ridge National Laboratory (ORNL) topped the TOP500 list of the world’s fastest, with Sierra at Lawrence Livermore National Laboratory ranked as number two. Two teams of DOE-supported researchers shared the prestigious Gordon Bell Prize for the world’s most outstanding HPC application, cementing the U.S. lead in supercomputing hardware, software, and applications.

## Major innovation initiatives in 2018/19

### Water Security Grand Challenge (WSGC)

In October 2018, Secretary Perry announced the launch of the WSGC, a White House-initiated, DOE-led framework to advance transformational technologies to meet the global need for clean, abundant and affordable water.

Using a coordinated suite of prizes, competitions, early-stage research and development funding opportunities, critical partnerships, and other programs, the Water Security Grand Challenge sets the following goals for the United States to reach by 2030:

- Launch desalination technologies that deliver cost-competitive clean water
- Transform the energy sector’s produced water from a waste to a resource
- Achieve near-zero water impact for new thermoelectric power plants, and significantly lower freshwater use intensity within the existing fleet
- Double resource recovery from municipal wastewater
- Develop small, modular energy-water systems for urban, rural, tribal, national security, and disaster response settings.

<sup>65</sup> <https://www.energy.gov/articles/department-energy-announces-39-million-oil-and-natural-gas-rd-projects>

### Carbon Capture

In February 2019, U.S. Secretary of Energy Rick Perry announced the selection of eight projects to receive nearly \$24 million in federal funds for cost-shared R&D for Novel and Enabling Carbon Capture Transformational Technologies. The selected projects will focus on the development of solvent, sorbent, and membrane technologies to address scientific challenges and knowledge gaps associated with reducing the cost of carbon capture. These projects will allow the United States, along with the rest of the world, to use both coal and natural gas with near-zero emissions.

### Advance Hydropower and Marine Energy

On April 1, 2019, DOE Assistant Secretary for Energy Efficiency and Renewable Energy Daniel Simmons announced up to \$26.1 million in funding to drive innovative industry-led technology solutions to advance the marine and hydrokinetics (MHK) industry and increase hydropower's ability to serve as a flexible grid resource. The Water Power Technologies Office (WPTO) will select projects that aim to increase affordability of hydropower and marine energy, strengthen U.S. manufacturing competitiveness, and build on Department-wide energy storage initiatives to improve the capability of technologies to deliver value to the grid.

Hydropower has significant capabilities for flexible operation, making it well-positioned to contribute to system reliability and resilience in an evolving electricity system. Today, the complexity of multi-use constraints affects many hydropower plants, and together with the wide variability in plant configurations across the fleet, understanding the fleet's potential for flexibility is a formidable challenge. This area seeks to quantify the flexible capabilities of hydropower and advance operational strategies to increase such flexibility to better serve an evolving grid<sup>66</sup>.

<sup>66</sup> <https://www.energy.gov/articles/doe-announces-261-million-advance-hydropower-and-marine-energy>

## ANNEX A

### Full data set

The full datasets submitted by members according to IEA research, development and demonstration (RD&D) categorisations are provided overleaf. Please note that this data only refers to Mission Innovation baselines and Mission Innovation relevant spend for the first, second and third years of Mission Innovation. Each country – according to its own priorities, policies, processes, and laws – has independently determined its baseline and the best use of its RD&D funding and defines its own RD&D priorities and path to reach the doubling goal. This data may not therefore be the same as other RD&D public sector data sets. Numbers denoted by “zero” in the following tables may indicate that no information has been provided for spend in that category.

Category	Australia			Austria	
	Million AUD			Million euros	
	Baseline	First Year	Second Year	Baseline	First Year (2018)
<b>1. Energy Efficiency</b>					
1.1 Industry	2.43	1.18	1.71	0.00	11.88
1.2 Residential and commercial buildings, appliances and equipment	2.55	4.55	4.78	0.00	0.00
1.3 Transport	1.95	1.46	1.56	0.00	0.00
1.4 Other energy efficiency	6.95	5.17	5.24	0.00	0.00
1.5 Unallocated energy efficiency	14.96	9.12	18.99	0.00	0.00
<b>2. Cleaner Fossil Fuels</b>					
2.1 Oil and gas	0.00	0.00	0.00	0.00	0.00
2.2 Coal	0.00	0.00	0.00	0.00	0.00
2.3 CO2 capture and storage	10.9	20.45	14.56	0.00	0.00
2.4 Unallocated fossil fuels	0.00	0.00	0.00	0.00	0.00
<b>3. Renewable Energy Sources</b>					
3.1 Solar energy	32.5	43.1	48.69	0.00	0.00
3.2 Wind energy	0.42	0.5	0.29	0.00	0.00
3.3 Ocean energy	0.8	1.24	1.53	0.00	0.00
3.4 Biofuels (including liquid & solid biofuels and biogases)	3.9	5.23	3.77	0.00	0.00
3.5 Geothermal energy	0.24	0.57	0.7	0.00	0.00
3.6 Hydroelectricity	0.00	0.00	0.19	0.00	0.00
3.7 Other renewable energy sources	0.00	0.00	0.24	0.00	0.00
3.8 Unallocated renewable energy sources	10.45	1.73	11.83	0.00	0.00
<b>4. Nuclear Fission and Fusion</b>					
4.1 Nuclear fission	7.4	15.3	11.45	0.00	0.00
4.2 Nuclear fusion	1.72	2.14	1.26	0.00	0.00
4.3 Unallocated nuclear fission and fusion	0	0.11	0.18	0.00	0.00
<b>5. Hydrogen and Fuel Cells</b>					
5.1 Hydrogen	2.41	2.32	3.75	0.00	4.29
5.2 Fuel cells	1.74	1.57	1.72	0.00	4.52
5.3 Unallocated hydrogen and fuel cells	0.00	0.00	0.00	0.00	0.00
<b>6. Other Power and Storage Technologies</b>					
6.1 Grid communication, control systems and integration	1.37	8.28	6.41	0.00	0.00
6.2 Electricity transmission and distribution	4.59	5.36	6.55	0.00	2.06
6.3 Energy storage (non-transport applications)	0.00	0.00	0.00	0.00	3.73
6.4 Unallocated other power and storage technologies	0.00	0.00	0.00	0.00	0.00
<b>7. Other Cross-cutting Technologies or Research</b>					
7.1 Energy system analysis	0.00	0.00	0.00	0.00	1.45
7.2 Basic energy research that cannot be allocated to a specific category	0.00	0.00	0.00	0.00	0.00
7.3 Other	0.00	0.00	0.00	0.00	2.48
<b>8. Unallocated</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>16.00</b>	<b>0.00</b>
<b>TOTAL BUDGET</b>	<b>107.28</b>	<b>129.38</b>	<b>145.40</b>	<b>16.00</b>	<b>30.41</b>

Category	Canada				Chile			
	Million CAD				Million CLP			
	Baseline	First Year	Second Year	Third Year	Baseline	First Year	Second Year	Third Year
<b>1. Energy Efficiency</b>								
1.1 Industry	11.92	30.46	30.68	31.51	412.00	384.30	590.03	114.00
1.2 Residential and commercial buildings, appliances and equipment	17.09	20.64	19.41	31.98	0.00	0.00	0.00	0.00
1.3 Transport	45.74	30.56	21.78	53.99	0.00	0.00	0.00	0.00
1.4 Other energy efficiency	10.26	13.20	13.83	10.22	0.00	0.00	0.00	0.00
1.5 Unallocated energy efficiency	0.02	1.23	1.22	2.00	0.00	0.00	0.00	0.00
<b>2. Cleaner Fossil Fuels</b>								
2.1 Oil and gas	64.17	69.80	65.57	114.06	0.00	0.00	0.00	0.00
2.2 Coal	6.91	5.18	4.93	5.05	0.00	0.00	0.00	0.00
2.3 CO2 capture and storage	26.70	15.15	17.17	21.92	0.00	0.00	0.00	0.00
2.4 Unallocated fossil fuels	0.44	1.36	2.08	1.23	0.00	0.00	0.00	0.00
<b>3. Renewable Energy Sources</b>								
3.1 Solar energy	19.34	13.95	12.47	21.45	815.00	2,593.51	3,790.00	2,993.00
3.2 Wind energy	3.89	2.80	2.93	3.92	0.00	0.00	0.00	0.00
3.3 Ocean energy	10.97	4.22	1.59	2.65	0.00	449.90	469.00	469.00
3.4 Biofuels (including liquid & solid biofuels and biogases)	25.34	73.66	70.58	31.54	1,229.00	0.00	0.00	0.00
3.5 Geothermal energy	1.81	0.77	0.89	2.81	0.00	0.00	0.00	0.00
3.6 Hydroelectricity	1.87	3.73	3.47	3.52	0.00	0.00	0.00	0.00
3.7 Other renewable energy sources	0.31	0.94	0.51	0.52	0.00	0.00	0.00	0.00
3.8 Unallocated renewable energy sources	0.34	0.38	0.76	1.47	0.00	0.00	0.00	0.00
<b>4. Nuclear Fission and Fusion</b>								
4.1 Nuclear fission	88.11	138.90	106.79	116.22	0.00	0.00	0.00	0.00
4.2 Nuclear fusion	6.51	8.41	12.49	2.39	0.00	0.00	0.00	0.00
4.3 Unallocated nuclear fission and fusion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>5. Hydrogen and Fuel Cells</b>								
5.1 Hydrogen	3.18	3.03	2.25	6.46	0.00	0.00	0.00	1,242.00
5.2 Fuel cells	8.91	8.17	10.65	6.38	0.00	0.00	0.00	325.00
5.3 Unallocated hydrogen and fuel cells	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>6. Other Power and Storage Technologies</b>								
6.1 Grid communication, control systems and integration	1.56	2.31	1.89	2.10	0.00	0.00	0.00	0.00
6.2 Electricity transmission and distribution	17.97	15.04	15.41	17.41	0.00	0.00	0.00	0.00
6.3 Energy storage (non-transport applications)	9.37	10.18	14.71	15.41	0.00	0.00	0.00	0.00
6.4 Unallocated other power and storage technologies	0.06	0.62	0.06	2.35	0.00	0.00	0.00	0.00
<b>7. Other Cross-cutting Technologies or Research</b>								
7.1 Energy system analysis	2.58	1.59	1.20	5.86	0.00	0.00	0.00	0.00
7.2 Basic energy research that cannot be allocated to a specific category	0.56	1.48	1.14	0.13	0.00	0.00	0.00	0.00
7.3 Other	0.76	1.31	1.47	4.05	270.00	250.00	50.00	0.00
<b>8. Unallocated</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>20.52</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>
<b>TOTAL BUDGET</b>	<b>386.69</b>	<b>479.06</b>	<b>437.92</b>	<b>539.11</b>	<b>2726.00</b>	<b>3677.71</b>	<b>4899.03</b>	<b>5143.00</b>

Category	China			
	RMB Billion Yuan			
	Baseline	First Year	Second Year	Third Year
<b>1. Energy Efficiency</b>				
1.1 Industry	0.00	0.00	0.00	0.00
1.2 Residential and commercial buildings, appliances and equipment	0.00	0.00	0.00	0.00
1.3 Transport	0.00	0.00	0.00	0.00
1.4 Other energy efficiency	0.00	0.00	0.00	0.00
1.5 Unallocated energy efficiency	0.52	0.61	0.81	0.97
<b>2. Cleaner Fossil Fuels</b>				
2.1 Oil and gas	0.00	0.00	0.00	0.00
2.2 Coal	9.14	10.10	14.00	16.80
2.3 CO2 capture and storage	0.00	0.00	0.00	0.00
2.4 Unallocated fossil fuels	0.00	0.00	0.00	0.00
<b>3. Renewable Energy Sources</b>				
3.1 Solar energy	0.00	0.00	0.00	0.00
3.2 Wind energy	0.00	0.00	0.00	0.00
3.3 Ocean energy	0.00	0.00	0.00	0.00
3.4 Biofuels (including liquid & solid biofuels and biogases)	0.00	0.00	0.00	0.00
3.5 Geothermal energy	0.00	0.00	0.00	0.00
3.6 Hydroelectricity	0.00	0.00	0.00	0.00
3.7 Other renewable energy sources	0.00	0.00	0.00	0.00
3.8 Unallocated renewable energy sources	5.28	4.60	8.10	9.72
<b>4. Nuclear Fission and Fusion</b>				
4.1 Nuclear fission	0.00	0.00	0.00	0.00
4.2 Nuclear fusion	0.00	0.00	0.00	0.00
4.3 Unallocated nuclear fission and fusion	3.64	3.50	4.00	4.80
<b>5. Hydrogen and Fuel Cells</b>				
5.1 Hydrogen	0.00	0.00	0.00	0.00
5.2 Fuel cells	0.00	0.00	0.00	0.00
5.3 Unallocated hydrogen and fuel cells	0.12	0.30	0.70	0.84
<b>6. Other Power and Storage Technologies</b>				
6.1 Grid communication, control systems and integration	0.00	0.00	0.00	0.00
6.2 Electricity transmission and distribution	0.00	0.00	0.00	0.00
6.3 Energy storage (non-transport applications)	0.00	0.00	0.00	0.00
6.4 Unallocated other power and storage technologies	3.18	3.00	3.20	3.84
<b>7. Other Cross-cutting Technologies or Research</b>				
7.1 Energy system analysis	0.00	0.00	0.00	0.00
7.2 Basic energy research that cannot be allocated to a specific category	0.00	0.00	0.00	0.00
7.3 Other	3.12	3.39	4.19	5.03
<b>8. Unallocated</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>
<b>TOTAL BUDGET</b>	<b>25.00</b>	<b>25.50</b>	<b>35.00</b>	<b>42.00</b>

Category	Denmark				EC			
	Million DKK				Million euros			
	Baseline	First Year	Second Year	Third Year	Baseline	First Year	Second Year	Third Year
<b>1. Energy Efficiency</b>								
	2.20	9.30	33.30	14.40	0.00	151.30	130.80	102.50
	26.40	5.60	34.70	43.50	0.00	96.90	96.10	63.80
	0.00	6.30	7.50	6.60	0.00	41.60	101.50	25.30
	14.70	39.40	33.20	3.00	0.00	74.90	101.70	108.20
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>2. Cleaner Fossil Fuels</b>								
	0.00	0.00	0.00	0.00	0.00	4.90	0.00	1.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	17.10	66.70	46.90
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10
<b>3. Renewable Energy Sources</b>								
	28.50	13.70	9.50	12.90	0.00	112.80	104.80	85.00
	66.70	56.30	17.30	207.70	0.00	33.10	55.70	50.60
	11.00	0.10	1.70	1.10	0.00	47.00	47.10	27.90
	68.60	35.80	5.80	14.00	0.00	90.00	84.30	57.40
	7.20	0.00	0.00	8.00	0.00	25.20	31.90	27.40
	0.00	0.00	0.00	0.00	0.00	22.90	8.30	6.00
	0.00	5.00	0.00	0.00	0.00	41.30	4.90	4.10
	0.00	0.00	0.00	0.00	0.00	8.70	21.60	72.70
<b>4. Nuclear Fission and Fusion</b>								
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>5. Hydrogen and Fuel Cells</b>								
	0.60	16.50	15.30	14.10	0.00	67.70	40.60	44.70
	12.60	8.60	0.00	37.60	0.00	38.90	74.40	49.80
	0.00	0.00	0.00	32.00	0.00	7.20	9.80	4.50
<b>6. Other Power and Storage Technologies</b>								
	4.20	0.00	0.00	0.00	0.00	3.60	7.20	0.00
	28.80	0.00	0.00	0.00	0.00	134.00	175.00	145.80
	8.60	19.40	0.00	38.30	0.00	34.90	39.50	62.80
	0.00	0.00	142.90	5.90	0.00	0.10	3.80	0.00
<b>7. Other Cross-cutting Technologies or Research</b>								
	0.00	0.00	0.90	32.50	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	17.40	27.50	6.30
	11.80	37.80	119.90	14.40	0.00	47.00	101.40	139.80
	0.00	0.00	0.00	0.00	989.00	0.00	0.00	0.00
	<b>291.90</b>	<b>253.80</b>	<b>422.00</b>	<b>486.00</b>	<b>989.00</b>	<b>1118.50</b>	<b>1334.60</b>	<b>1133.60</b>



Category	Finland			
	Million euros			
	Baseline	First Year	Second Year	Third Year
<b>1. Energy Efficiency</b>				
1.1 Industry	0.00	0.00	0.00	0.00
1.2 Residential and commercial buildings, appliances and equipment	0.00	0.00	0.00	0.00
1.3 Transport	0.00	0.00	0.00	0.00
1.4 Other energy efficiency	0.00	0.00	0.00	0.00
1.5 Unallocated energy efficiency	0.00	0.00	0.00	0.00
<b>2. Cleaner Fossil Fuels</b>				
2.1 Oil and gas	0.00	0.00	0.00	0.00
2.2 Coal	0.00	0.00	0.00	0.00
2.3 CO2 capture and storage	0.00	0.00	0.00	0.00
2.4 Unallocated fossil fuels	0.00	0.00	0.00	0.00
<b>3. Renewable Energy Sources</b>				
3.1 Solar energy	0.00	0.00	0.00	0.00
3.2 Wind energy	0.00	0.00	0.00	0.00
3.3 Ocean energy	0.00	0.00	0.00	0.00
3.4 Biofuels (including liquid & solid biofuels and biogases)	0.00	0.00	0.00	0.00
3.5 Geothermal energy	0.00	0.00	0.00	0.00
3.6 Hydroelectricity	0.00	0.00	0.00	0.00
3.7 Other renewable energy sources	0.00	0.00	0.00	0.00
3.8 Unallocated renewable energy sources	0.00	27.00	32.00	28.60
<b>4. Nuclear Fission and Fusion</b>				
4.1 Nuclear fission	0.00	0.00	0.00	0.00
4.2 Nuclear fusion	0.00	0.00	0.00	0.00
4.3 Unallocated nuclear fission and fusion	0.00	0.00	0.00	0.00
<b>5. Hydrogen and Fuel Cells</b>				
5.1 Hydrogen	0.00	0.00	0.00	0.00
5.2 Fuel cells	0.00	0.00	0.00	0.00
5.3 Unallocated hydrogen and fuel cells	0.00	0.00	0.00	0.00
<b>6. Other Power and Storage Technologies</b>				
6.1 Grid communication, control systems and integration	0.00	0.00	0.00	0.00
6.2 Electricity transmission and distribution	0.00	3.90	3.50	2.30
6.3 Energy storage (non-transport applications)	0.00	4.30	1.80	3.60
6.4 Unallocated other power and storage technologies	0.00	0.00	0.00	0.00
<b>7. Other Cross-cutting Technologies or Research</b>				
7.1 Energy system analysis	0.00	4.50	6.30	15.80
7.2 Basic energy research that cannot be allocated to a specific category	0.00	0.00	0.00	0.00
7.3 Other	0.00	0.00	0.00	0.00
<b>8. Unallocated</b>	<b>54.90</b>	<b>31.20</b>	<b>31.60</b>	<b>42.60</b>
<b>TOTAL BUDGET</b>	<b>54.90</b>	<b>70.90</b>	<b>75.20</b>	<b>92.90</b>

Category	France				Germany			
	Million euros				Million euros			
	Baseline	First Year	First Year	Second Year	Baseline	First Year	Second Year	Third Year
<b>1. Energy Efficiency</b>								
1.1 Industry	0.00	14.60	13.88	12.04	0.00	33.40	47.10	52.41
1.2 Residential and commercial buildings, appliances and equipment	0.00	31.67	32.95	25.05	0.00	26.30	28.44	29.17
1.3 Transport	0.00	97.03	87.75	91.72	0.00	12.90	14.35	14.11
1.4 Other energy efficiency	0.00	23.16	17.39	22.42	0.00	0.00	0.00	0.00
1.5 Unallocated energy efficiency	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>2. Cleaner Fossil Fuels</b>								
2.1 Oil and gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.2 Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.3 CO2 capture and storage	0.00	20.49	14.67	12.28	0.00	17.40	18.70	42.41
2.4 Unallocated fossil fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>3. Renewable Energy Sources</b>								
3.1 Solar energy	0.00	71.17	62.77	56.22	0.00	78.60	99.35	92.68
3.2 Wind energy	0.00	9.62	6.94	6.23	0.00	49.70	75.11	59.70
3.3 Ocean energy	0.00	7.58	4.37	6.90	0.00	0.00	0.00	0.00
3.4 Biofuels (including liquid & solid biofuels and biogases)	0.00	84.81	73.45	52.80	0.00	37.30	32.74	28.54
3.5 Geothermal energy	0.00	6.59	4.67	3.22	0.00	12.50	16.50	15.38
3.6 Hydroelectricity	0.00	2.71	1.93	1.88	0.00	2.00	2.15	1.40
3.7 Other renewable energy sources	0.00	1.59	2.23	3.78	0.00	0.00	0.00	0.00
3.8 Unallocated renewable energy sources	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.00
<b>4. Nuclear Fission and Fusion</b>								
4.1 Nuclear fission	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.2 Nuclear fusion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.3 Unallocated nuclear fission and fusion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>5. Hydrogen and Fuel Cells</b>								
5.1 Hydrogen	0.00	19.51	14.67	15.65	0.00	0.00	0.00	0.00
5.2 Fuel cells	0.00	10.42	12.64	11.36	0.00	0.00	0.00	0.00
5.3 Unallocated hydrogen and fuel cells	0.00	1.24	1.15	1.02	0.00	15.40	21.92	27.58
<b>6. Other Power and Storage Technologies</b>								
6.1 Grid communication, control systems and integration	0.00	1.92	1.25	0.79	0.00	0.00	0.00	0.00
6.2 Electricity transmission and distribution	0.00	16.53	10.37	15.54	0.00	66.90	89.24	71.45
6.3 Energy storage (non-transport applications)	0.00	22.55	20.97	24.80	0.00	42.00	35.35	27.33
6.4 Unallocated other power and storage technologies	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
<b>7. Other Cross-cutting Technologies or Research</b>								
7.1 Energy system analysis	0.00	15.46	15.83	18.80	0.00	15.00	18.17	27.67
7.2 Basic energy research that cannot be allocated to a specific category	0.00	12.91	55.45	58.76	0.00	0.00	0.00	0.00
7.3 Other	0.00	30.03	32.41	29.74	0.00	0.00	0.00	0.00
<b>8. Unallocated</b>	<b>440.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>450.30</b>	<b>116.10</b>	<b>178.17</b>	<b>171.31</b>
<b>TOTAL BUDGET</b>	<b>440.00</b>	<b>501.61</b>	<b>488.35</b>	<b>470.99</b>	<b>450.30</b>	<b>525.50</b>	<b>677.29</b>	<b>661.15</b>

Category	Italy			
	Million euros			
	Baseline	First Year	Second Year	Third Year
<b>1. Energy Efficiency</b>				
1.1 Industry	0.00	0.00	0.00	0.00
1.2 Residential and commercial buildings, appliances and equipment	0.00	0.00	0.00	0.00
1.3 Transport	0.00	0.00	0.00	0.00
1.4 Other energy efficiency	0.00	0.00	0.00	0.00
1.5 Unallocated energy efficiency	58.55	46.24	44.01	51.91
<b>2. Cleaner Fossil Fuels</b>				
2.1 Oil and gas	0.00	0.00	0.00	0.00
2.2 Coal	0.00	0.00	0.00	0.00
2.3 CO2 capture and storage	0.00	0.00	0.00	0.00
2.4 Unallocated fossil fuels	0.00	0.00	0.00	0.00
<b>3. Renewable Energy Sources</b>				
3.1 Solar energy	0.00	0.00	0.00	0.00
3.2 Wind energy	0.00	0.00	0.00	0.00
3.3 Ocean energy	0.00	0.00	0.00	0.00
3.4 Biofuels (including liquid & solid biofuels and biogases)	0.00	0.00	0.00	0.00
3.5 Geothermal energy	0.00	0.00	0.00	0.00
3.6 Hydroelectricity	0.00	0.00	0.00	0.00
3.7 Other renewable energy sources	0.00	0.00	0.00	0.00
3.8 Unallocated renewable energy sources	71.08	54.25	62.55	63.53
<b>4. Nuclear Fission and Fusion</b>				
4.1 Nuclear fission	0.00	0.00	0.00	0.00
4.2 Nuclear fusion	0.00	0.00	0.00	0.00
4.3 Unallocated nuclear fission and fusion	0.00	0.00	0.00	0.00
<b>5. Hydrogen and Fuel Cells</b>				
5.1 Hydrogen	0.00	0.00	0.00	0.00
5.2 Fuel cells	0.00	0.00	0.00	0.00
5.3 Unallocated hydrogen and fuel cells	11.79	8.96	11.59	15.33
<b>6. Other Power and Storage Technologies</b>				
6.1 Grid communication, control systems and integration	0.00	0.00	0.00	0.00
6.2 Electricity transmission and distribution	0.00	0.00	0.00	0.00
6.3 Energy storage (non-transport applications)	0.00	0.00	0.00	0.00
6.4 Unallocated other power and storage technologies	44.76	16.71	45.27	45.49
<b>7. Other Cross-cutting Technologies or Research</b>				
7.1 Energy system analysis	0.00	0.00	0.00	0.00
7.2 Basic energy research that cannot be allocated to a specific category	0.00	0.00	0.00	0.00
7.3 Other	36.48	34.62	29.87	34.47
<b>8. Unallocated</b>	<b>0.00</b>	<b>30.00</b>	<b>0.00</b>	<b>0.00</b>
<b>TOTAL BUDGET</b>	<b>222.66</b>	<b>190.78</b>	<b>193.30</b>	<b>210.74</b>

Category	Mexico			Netherlands			
	Million pesos			Million euros			
	Baseline (avg 2013-15)	First Year	Second Year	Baseline	First Year	Second year	Third Year
<b>1. Energy Efficiency</b>							
1.33	41.10	40.20	7.40	34.00	27.00	21.90	
			5.70	6.00	11.00	14.30	
3.73	23.00	8.00	0.00	2.20	6.70	6.30	
	28.20	17.40	4.60	12.80	7.60	10.70	
0.00	0.00	0.00	0.00	0.00	0.00	0.00	
<b>2. Cleaner Fossil Fuels</b>							
0.00	0.00	0.00	0.00	0.00	0.00	0.00	
0.00	0.00	0.00	0.00	0.00	0.00	0.00	
2.53	29.40	2.20	1.10	1.20	2.40	9.40	
0.00	0.00	0.00	0.00	0.00	0.00	0.00	
<b>3. Renewable Energy Sources</b>							
89.43	181.40	105.30	33.90	19.30	17.90	10.70	
37.47	48.20	37.80	12.90	17.70	20.10	32.00	
0.43	0.80	132.60	2.20	0.00	0.70	1.20	
19.13	272.20	141.00	20.30	26.70	24.00	4.10	
183.83	211.60	150.40	1.40	8.70	11.20	18.80	
0.00	0.00	0.00	0.00	3.70	0.00	0.00	
0.00	0.00	54.60	0.00	0.00	0.00	0.40	
0.00	0.00	0.00	0.00	0.00	0.00	0.00	
<b>4. Nuclear Fission and Fusion</b>							
0.00	0.00	0.00	0.00	0.00	0.00	0.00	
0.00	0.00	0.00	0.00	0.00	0.00	0.00	
17.30	7.50	1.30	0.00	0.00	0.00	0.00	
<b>5. Hydrogen and Fuel Cells</b>							
0.00	0.00	0.00	0.30	0.10	8.90	11.90	
0.00	0.00	0.00	0.00	0.10	2.30	2.10	
2.50	14.10	14.60	0.00	0.00	0.00	0.00	
<b>6. Other Power and Storage Technologies</b>							
0.00	0.00	0.00	0.00	0.00	0.00	0.00	
0.00	0.00	0.00	3.10	0.70	3.50	5.60	
0.00	0.00	0.00	4.10	6.30	15.20	5.00	
0.00	0.00	0.00	0.00	0.00	0.00	0.00	
<b>7. Other Cross-cutting Technologies or Research</b>							
3.57	5.70	11.00	0.00	0.00	0.30	1.90	
0.00	0.00	0.00	3.00	2.80	4.00	4.10	
0.00	11.80	4.40	0.00	0.00	0.00	0.00	
<b>0.00</b>	<b>229.00</b>	<b>225.10</b>	<b>0.00</b>	<b>0.00</b>	<b>0.60</b>	<b>44.60</b>	
<b>361.27</b>	<b>1104.00</b>	<b>946.00</b>	<b>100.00</b>	<b>142.30</b>	<b>163.40</b>	<b>205.00</b>	

Republic of Korea				
Category	Million Won			
	Baseline	First Year	Second Year	Third Year
<b>1. Energy Efficiency</b>				
1.1 Industry	35,910	52,771	60,131	51,348
1.2 Residential and commercial buildings, appliances and equipment	21,420	34,338	34,300	39,078
1.3 Transport	32,767	63,027	56,858	56,307
1.4 Other energy efficiency	0	0	0	0
1.5 Unallocated energy efficiency	0	0	0	0
<b>2. Cleaner Fossil Fuels</b>				
2.1 Oil and gas	0	0	0	0
2.2 Coal	0	0	0	0
2.3 CO2 capture and storage	65,966	83,669	85,122	90,458
2.4 Unallocated fossil fuels	0	0	0	
<b>3. Renewable Energy Sources</b>				
3.1 Solar energy	60,842	72,198	78,601	94,360
3.2 Wind energy	40,844	40,679	50,636	64,063
3.3 Ocean energy	0	0	0	0
3.4 Biofuels (including liquid & solid biofuels and biogases)	34,267	40,510	45,442	40,294
3.5 Geothermal energy	0	0	0	0
3.6 Hydroelectricity	0	0	0	0
3.7 Other renewable energy sources	16,266	32,638	32,731	37,767
3.8 Unallocated renewable energy sources	0	0	0	0
<b>4. Nuclear Fission and Fusion</b>				
4.1 Nuclear fission	0	0	0	0
4.2 Nuclear fusion	0	0	0	0
4.3 Unallocated nuclear fission and fusion	37,038	41,733	48,882	52,935
<b>5. Hydrogen and Fuel Cells</b>				
5.1 Hydrogen	4,892	12,370	12,750	19,270
5.2 Fuel cells	39,441	38,773	41,569	33,707
5.3 Unallocated hydrogen and fuel cells	0	0	0	5,410
<b>6. Other Power and Storage Technologies</b>				
6.1 Grid communication, control systems and integration	46,769	60,693	60,843	95,110
6.2 Electricity transmission and distribution	85,156	109,016	135,006	167,757
6.3 Energy storage (non-transport applications)	38,957	54,231	56,095	44,741
6.4 Unallocated other power and storage technologies	0	0	0	10,275
<b>7. Other Cross-cutting Technologies or Research</b>				
7.1 Energy system analysis	0	0	0	0
7.2 Basic energy research that cannot be allocated to a specific category	0	0	0	0
7.3 Other	0	0	0	0
<b>8. Unallocated</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>TOTAL BUDGET</b>	<b>560,535</b>	<b>736,646</b>	<b>798,966</b>	<b>902,880</b>

UK				
Category	Million GBP			
	Baseline	First Year	Second Year	Third Year
<b>1. Energy Efficiency</b>				
	0.00	2.32	3.31	2.86
	0.00	11.55	22.10	23.92
	0.00	79.46	94.37	154.91
	0.00	2.86	2.50	5.43
	0.00	1.84	28.44	33.92
<b>2. Cleaner Fossil Fuels</b>				
	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00
	0.00	14.01	20.96	13.15
	0.00	0.00	0.00	0.00
<b>3. Renewable Energy Sources</b>				
	0.00	24.52	20.90	17.27
	0.00	36.10	26.54	31.61
	0.00	5.47	15.10	14.57
	0.00	15.82	19.45	18.43
	0.00	4.95	0.63	0.36
	0.00	8.84	3.31	3.25
	0.00	14.78	0.28	1.23
	0.00	6.31	3.17	0.18
<b>4. Nuclear Fission and Fusion</b>				
	0.00	8.84	24.35	33.10
	0.00	0.00	0.00	0.00
	0.00	4.38	0.91	0.16
<b>5. Hydrogen and Fuel Cells</b>				
	0.00	7.17	4.21	2.91
	0.00	5.22	6.46	7.71
	0.00	0.65	0.02	0.00
<b>6. Other Power and Storage Technologies</b>				
	0.00	0.31	0.08	0.45
	0.00	18.62	37.50	33.94
	0.00	12.67	17.03	20.85
	0.00	23.25	16.82	12.22
<b>7. Other Cross-cutting Technologies or Research</b>				
	0.00	7.87	0.95	2.99
	0.00	0.00	0.00	0.00
	0.00	30.74	54.76	29.43
	<b>200.00</b>	<b>0.00</b>	<b>37.28</b>	<b>45.43</b>
	<b>200.00</b>	<b>348.55</b>	<b>461.43</b>	<b>510.28</b>



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