

# MISSION INNOVATION

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Accelerating the Clean Energy Revolution

## **Mission Innovation Challenges:**

### **Progress and Highlights**

**Prepared for the 2<sup>nd</sup> Mission Innovation Ministerial Meeting**

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## Mission Innovation Challenges: Progress and Highlights

### Introduction

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Innovation Challenges are global calls to action aimed at catalyzing global research efforts in areas that could provide significant benefits in reducing greenhouse gas emissions, increasing energy access and security, and creating new opportunities for clean economic growth. Seven Innovation Challenges were launched at COP22 in November 2016.

The Innovation Challenges cover the entire spectrum of research, development, and demonstration (RD&D); from early stage research needs assessments to technology demonstration projects. They were developed through a collaborative process between MI members. Engagement in an Innovation Challenge is entirely voluntary and is built around a coalition of interested MI members. With sufficient interest from MI members, new Innovation Challenges could be launched in the future.

The 7 Innovation Challenges are as follows:

1. **Smart Grids Innovation Challenge** – to enable future grids that are powered by affordable, reliable, decentralised renewable electricity systems;
2. **Off-Grid Access to Electricity Innovation Challenge** – to develop systems that enable off-grid households and communities to access affordable and reliable renewable electricity;
3. **Carbon Capture Innovation Challenge** – to enable near-zero carbon dioxide (CO<sub>2</sub>) emissions from power plants and carbon intensive industries;
4. **Sustainable Biofuels Innovation Challenge** – to develop ways to produce, at scale, widely affordable, advanced biofuels for transportation and industrial applications;
5. **Converting Sunlight Innovation Challenge** – to discover affordable ways to convert sunlight into storable solar fuels;
6. **Clean Energy Materials Innovation Challenge** – to accelerate the exploration, discovery, and use of new high-performance, low-cost clean energy materials; and
7. **Affordable Heating and Cooling of Buildings Innovation Challenge** – to make low-carbon heating and cooling affordable for everyone.

### Collective Objectives

Work under the Innovation Challenges is guided by 4 collective objectives:

- 1) Building an improved and shared understanding of what is needed to address the Challenge, and how to define measurable targets and track progress towards them;
- 2) Identifying key gaps and opportunities not sufficiently addressed by current activities;
- 3) Promoting opportunities for researchers, innovators and investors in order to build support and excitement around the Challenges and boost engagement; and
- 4) Strengthening and expanding collaboration between key partners, including governments, researchers, innovators, and private sector stakeholders.

## Progress

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### **Building a Shared Understanding**

The Innovation Challenge teams have made significant progress in building a shared understanding of the scope, objective, and priorities for their individual Challenges. The Challenges each encompass a large technology area with many potential avenues for research and development (R&D). As such, a number of the Challenge teams have focussed first on defining their Challenge's scope, or identifying key areas of focus. Others will be defining areas of focus as a priority activity over the coming months. Building a shared understanding of what is needed to address their Challenge has helped the Challenge teams prioritize their actions, and will support the development of measurable targets to track their success going forward. In all cases, further work is planned to deepen that understanding and broaden awareness.

### **Identifying Key Gaps and Opportunities**

Innovation Challenge teams have also been working to gather and share information to better understand the state-of-the-art in each Challenge area, and identify the gaps and opportunities on which to focus efforts, while ensuring the Challenge complements and adds to existing national and international research. Most Challenges have conducted, or intend to conduct, survey exercises to map out the current activities and methodologies being advanced around the world. All Challenges are planning one or more international workshops to bring together global experts and policy leads, as well as investors, to identify and explore the most critical gaps and opportunities for new activities.

### **Promoting Opportunities for Stakeholders**

The Innovation Challenge teams have highlighted the importance and value of engaging and leveraging stakeholders in the advancement of work under their Challenges. A wide range of workshops and events are in planning and will bring together key stakeholders to agree on priorities and explore opportunities for further collaboration. These and other events will be used to promote Mission Innovation's messages on the importance of innovation and the opportunities for innovators and investors.

### **Strengthening and Expanding Collaboration**

In launching the Innovation Challenges, one of Mission Innovation's main goals is to encourage and facilitate the leveraging of knowledge, capabilities, and resources among Mission Innovation members and other stakeholders, in order to accelerate progress and amplify outcomes in clean energy research and development. The Innovation Challenge teams have been coordinating internally, as well as with international organizations and initiatives, to identify existing efforts and expertise and avoid unproductive duplication. Informed by that work, individual countries and groups of countries are looking at opportunities for deeper collaboration with each other and with the private sector.

## Next Steps

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Following the 2<sup>nd</sup> Mission Innovation Ministerial, Innovation Challenge teams will focus on the implementation of their Work Programmes, delivering on the agreed actions and continuing to develop new collaborations. Particular focuses for further work are expected to include: the development and agreement of metrics to track improvements; deepening engagement with private sector companies and investors; and expanding bi-lateral and multi-lateral collaborations on key innovation needs. The Work Programmes will be reviewed and refreshed periodically, and in particular will be revisited in advance of the 2018 Mission Innovation Preparatory meeting.

## Innovation Challenge Work Programme Highlights

Innovation Challenge	Objective	Work Programme Highlights
Smart Grids	Enable future grids powered by affordable, reliable, decentralised renewable electricity systems	<ul style="list-style-type: none"> <li>• Four main sub-challenges in which to focus efforts have been identified.</li> <li>• In the short-term, aim to gain an improved understanding of the Innovation Challenge and identify gaps not addressed by others through engagement with Innovation Challenge members.</li> <li>• Plan to host a 3.5 day deep-dive workshop (1 day “Smart Grids Innovation Workshop” open to the public) in Beijing (June 4-7, 2017) alongside the 2nd Mission Innovation Ministerial to convene a diverse group of international experts, policy makers and innovators in the field of smart grids, focusing on the challenges behind smart grids R&amp;D and defining medium-long term activities for the Challenge. Main outcomes will be summarized in a workshop report.</li> <li>• During 2017, develop a set of Key Performance Indicators to monitor the progress and the rate of success of activities.</li> <li>• By the end of 2017, develop a service platform to enable information sharing, data repository, working space for experts, etc.</li> <li>• Intend to hold twice-yearly deep-dive workshops (the first of which is organized for June 2017 in Beijing) on different key aspects of Challenge, to discuss ongoing strategy and share achievements.</li> <li>• Aim to produce yearly country reports in order to share information relevant to the Innovation Challenge.</li> <li>• Plan to publish Annual General Reports to provide an overview of the innovation landscape worldwide and recommendations for stakeholders, and provide an increased and shared understand of actions required to address the Challenge.</li> <li>• Plan to work with the Business and Investor Engagement Sub-Group and targeted international organizations, for example World Economic Forum, in order to draw in potential private sector participation in collaborations.</li> <li>• Will explore other mechanisms of collaboration (e.g. innovation prizes) to accelerate innovation in priority areas.</li> </ul>
Off-Grid Access to Electricity	Develop systems that enable off-grid households and communities to access affordable, reliable renewable electricity.	<ul style="list-style-type: none"> <li>• By surveying MI members and through international workshops (Delhi, May 2017; Paris, July 2017), gather information about ongoing national and international initiatives and bottlenecks, and develop measurable targets for the Challenge. This work will develop a common understanding of the state of the art solutions, gaps and opportunities and inform further national and multi-national efforts.</li> <li>• In June 2017, publish a document that describes the current ‘state-of-play’ of innovation for this Challenge</li> <li>• In the medium term, explore ways to mobilize stakeholders and boost engagement from the R&amp;D community, companies, foundations and non-governmental organizations, who can identify critical needs on the ground and work with local communities to accompany innovation.</li> <li>• Plan to launch prize(s) and/or call(s) for demonstration projects, to support the experimentation of innovative solutions between now and 2020.</li> <li>• Aim to publish a new state of the art report in 2020 to summarize Innovation Challenge progress, lessons learned and the remaining innovation needs and barriers to uptake.</li> </ul>

Innovation Challenge	Objective	Work Programme Highlights
Carbon Capture	Enable zero CO <sub>2</sub> emissions from power plants and carbon-intensive industries.	<ul style="list-style-type: none"> <li>• Plan to convene international CCUS experts from a variety of academic and industry perspectives at an Experts Workshop in Houston from September 25 to 29, 2017 to share information and best practices, and discuss R&amp;D programmes in carbon capture, geologic storage, CO<sub>2</sub> utilization, and cross-cutting topics.</li> <li>• In January 2018, intend to develop a workshop report to outline the suggestions from all members and aid in the identification of future areas of international collaboration and recommendations for research expansion.</li> <li>• Intend to conduct stakeholder briefings with industry, NGOs, academia and other organizations that may be interested in contributing to activities under the challenge in collaboration with the Business and Investor Engagement sub-group and engage private-sector interests. In particular, work to engage the World Economic Forum as well as the Oil and Gas Climate Initiative to leverage ongoing activities and private sector investments related to CCUS.</li> <li>• In the longer-term, intend to establish a more formal mechanism for communications, information sharing, and building collaborations on R&amp;D on breakthrough and innovative CCUS technologies that can continue beyond the Experts Workshop.</li> </ul>
Sustainable Biofuels	Develop ways to produce at-scale widely affordable, advanced biofuels for transportation and industrial applications.	<ul style="list-style-type: none"> <li>• Facilitate cooperation and avoid duplication of efforts by identifying defined areas of interest between the Challenge and international organizations and initiatives such as the International Energy Agency (IEA), Biofuture Platform, and others.</li> <li>• Currently in the process of developing a joint survey with the Biofuture Platform to better understand the landscape of biofuels technology and identify gaps and opportunities. With support of IEA and others.</li> <li>• Intend to prepare a Biofuels Roadmap document to identify research priorities and collaboration opportunities.</li> <li>• Intend to publish a Scale-up Lessons Learned Report this fall to better understand and overcome the challenges of scale-up initiatives.</li> <li>• Plan to host joint workshops with the Biofuture Platform in India and Brazil in 2018, to foster dialogue and collaboration between academia, government and the private sector, and identify and prioritise innovation needs and collaboration opportunities where research and development can result in significant advances in biofuel technologies.</li> </ul>
Converting Sunlight	Discover affordable ways to convert sunlight into storable solar fuels.	<ul style="list-style-type: none"> <li>• Work within the Innovation Challenge team, with the help of an established international experts group, to define quantifiable targets for selected fields of cooperation, the organization of joint actions between participating countries, and the implementation of the Challenge.</li> <li>• Plan to engage in the presentation of the Converting Sunlight Innovation Challenge at international scientific conferences in order to make it well-known in the scientific community and motivate scientists to participate in envisioned activities.</li> <li>• Plan to explore the feasibility of initiatives that aim to strengthen and expand collaboration among participating countries, including: <ul style="list-style-type: none"> <li>◦ Setting up a scholarship exchange programme for Post-Docs to enhance international collaboration and exchange best practices;</li> <li>◦ Designing and launching inducement prizes to stimulate development in this Challenge area;</li> <li>◦ Developing joint tasks between IEA TCPs or setting up a separate dedicated TCP;</li> <li>◦ Establishing an online platform to facilitate the sharing of data, materials or research infrastructure;</li> <li>◦ Creating bi-/multi-lateral research programmes.</li> </ul> </li> </ul>

Innovation Challenge	Objective	Work Programme Highlights
Clean Energy Materials	Accelerate the exploration, discovery and use of new high-performance, low-cost clean energy materials.	<ul style="list-style-type: none"> <li>• Plan to host a 3-day Energy Materials Innovation (EMI) Expert Workshop that will take place in Mexico City on September 11-14, 2017 to convene more than 50 preeminent scientists and experts in advanced theoretical and applied physical chemistry/materials sciences, advanced computing, machine learning, and robotics. These experts will identify critical R&amp;D priorities and gaps in clean energy materials innovation processes and explore opportunities for deeper collaboration. Representatives from business interests are also invited to attend the workshop as observers and to provide insights from the private sector perspective regarding materials discovery innovation opportunities.</li> <li>• Plan to publish a workshop report describing the state-of-the-art of technologies and methods relevant for materials discovery and identifying the gaps, opportunities and recommendations to accelerate materials discovery. This report will intend to serve as a resource for academia, private sector, government and any stakeholders interested in R&amp;D efforts to accelerate materials discovery and technologies in this field.</li> <li>• MI members and other stakeholders may consider launching Requests for Proposals, grants, research programmes, and collaboration projects to address the gaps and opportunities identified by the leading scientists participating in this Challenge and the EMI Expert Workshop.</li> <li>• In the longer term, plan to develop a fully integrated platform in the form of laboratories that incorporate automated synthesis and characterization facilities, together with the modeling and theoretical work, which will lead to more and faster materials' discoveries.</li> </ul>
Affordable Heating and Cooling of Buildings	Make low-carbon heating and cooling affordable for everyone.	<ul style="list-style-type: none"> <li>• Six priority areas have already been identified on which to focus research efforts, which together satisfy the diverse nature of Members' heating and cooling needs.</li> <li>• Work is underway to identify Members' existing national and international research, and key research gaps and opportunities.</li> <li>• Planning for technical expert workshops on these priority areas to be held in 2017 which aim to :1) identify gaps and opportunities for future collaboration; 2) develop specific measurable targets to fill the research gaps in each area; 3) promote opportunities to researchers, innovators and investors in order to increase support and engagement and facilitate collaboration between key partners, and; 4) spawn a number of opportunities for new collaborative research to meet the defined targets.</li> <li>• Beyond 2017, aim to monitor progress against defined targets, and share new opportunities for research widely with the research community, while results of research will be promoted in government, industry and with potential investors, to encourage pull-through.</li> <li>• Plan to work with the Business and Investor Engagement Sub-Group to draw in potential private sector participation in collaborations.</li> <li>• Will explore other mechanisms of collaboration (e.g. prizes) to accelerate innovation in priority areas.</li> </ul>

## Innovation Challenges: Leads and Participants

		Australia	Brazil	Canada	Chile	China	Denmark	EC	Finland	France	Germany	India	Indonesia	Italy	Japan	Mexico	Norway	Republic of Korea	Saudi Arabia	Sweden	The Netherlands	UAE	UK	USA
1	Smart Grids Innovation Challenge																							
2	Off Grid Access to Electricity Innovation Challenge																							
3	Carbon Capture Innovation Challenge																							
4	Sustainable Biofuels Innovation Challenge																							
5	Converting Sunlight Innovation Challenge																							
6	Clean Energy Materials Innovation Challenge																							
7	Affordable Heating and Cooling of Buildings Innovation Challenge																							

Lead

Participant



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## Accelerating the Clean Energy Revolution

### Smart Grids Innovation Challenge – Progress Summary

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#### **Issue**

Research and Development (R&D) in the field of Smart Grids is needed to address the challenges related to the development, integration, operation, management, and optimization of accessible, reliable and resilient power systems with steadily increasing penetration of Renewable Energy Sources (RES) worldwide. This implies the development, demonstration, and application of innovative technologies and solutions. Smart grids offer the promise of increasing the efficiency and utilisation across the whole energy system, deferring or avoiding investments in costly physical infrastructure, and increasing access to electricity at a lower cost than traditional solutions.

#### **Objective**

The Smart Grids Innovation Challenge will support the transition from today's power grid - strongly based on fossil fuelled power plants - to tomorrow's grid powered by affordable, reliable, decentralised renewable electricity systems able to balance supply and demand at any time, even when primary energy sources are not available. In particular, the Challenge aims at developing an improved and shared understanding of main R&D needs and gaps; fostering national research towards jointly identified R&D priorities; promoting opportunities to researchers, innovators and investors from around the world; and strengthening and expanding collaboration between key partners, leveraging their complementarity and synergies.

#### **Organization**

The Smart Grids Innovation Challenge is co-led by: China, India, and Italy.

Other participating members include: Australia, Brazil, Canada, Denmark, the European Commission, Finland, France, Germany, Indonesia, Mexico, Norway, Saudi Arabia, Republic of Korea, Sweden, the Netherlands, the United Kingdom, and the United States.

#### **Approach**

The Smart Grids Innovation Challenge aims at highlighting and demonstrating the considerable benefits arising from the widespread use of smart grids technologies in different grid applications at regional and distribution grids as well as micro-grids in different geographical areas. In order to accommodate up to 100% of RES based power plants, this Challenge will identify specific technological solutions to be further developed, and push forward their implementation into reliable clean energy systems.

The cornerstone of success for the Challenge will be the ability to leverage the knowledge already available from participating members on technology and power system management, and the endorsement and widespread implementation of the identified solutions. In this frame, the Challenge will extend a collaborative network to involve institutes, businesses and investors and expand its influence worldwide.

This Challenge recognizes the importance of interacting with and leveraging on the outcomes available from ongoing initiatives. Therefore, interaction with international agencies, such as International Energy Agency (IEA), IRENA and other frameworks (e.g. WEF, ETIP SNET, EERA, CRES, etc.) will be pursued.

## **Progress**

Four main sub-challenges have been identified: Regional grid innovation, distribution grid innovation, micro grid innovation, and cross innovation.

Research on smart grids is ongoing in many countries, and the identification and selection of the most relevant research, development and demonstration (RD&D) topics for each participating member has been the first action and constitutes the basis for the future work. In order to achieve this, the Smart Grids Innovation Challenge asked the participating members to identify their smart grids innovation priorities, and provide information on their ongoing national and international activities, engaged stakeholders and their initial ideas for precise measurable targets for the Challenge. This information will help build a shared understanding of R&D gaps and opportunities in the smart grids field.

The template for an annual R&D Smart Grids Country Report has been developed and approved. Preparatory work under the Challenge has been undertaken both remotely and by means of dedicated Challenge workshops, namely on April 4 in Ispra (IT) and on May 22 in New Delhi (IN). Fruitful interactions have been already established with IEA and in particular with the IEA ISGAN TCP with whom a close collaboration is deemed highly strategic.

## **Next Steps**

A 3.5 day technical workshop will be held in Beijing (4<sup>th</sup>-7<sup>th</sup> June) which looks to bring together a diverse group of international experts, policy makers and innovators in the field of smart grids. The workshop aims to achieve a shared view on the agreed top R&D priorities and related actions towards smart grids innovation. The main outcomes will include a consolidated version of the Challenge work plan and a draft country report including members' contribution that will be finalized by the end of 2017. Building on the first Challenge workshop, the co-leads propose to organize a series of deep-dive workshops (likely two a year) on different key aspects of the Innovation Challenge to discuss its ongoing strategy and shared achievements.

During 2017, the Smart Grid Innovation Challenge will develop a set of Key Performance Indicators (KPIs) to monitor the progress and the rate of success of the Challenge activities. Before the end of 2017 a service platform supporting this Challenge's activity with respect to information sharing, data repository, working space for experts, etc. will be developed. In the meantime, relevant information and documents are stored at [www.electrairp.eu](http://www.electrairp.eu).

Annual country reports will be produced by each member in order to continuously update information about smart grid related activities. In addition, an annual General Report will be released to provide an overview of the smart grids innovation landscape worldwide, recommendations for stakeholders, and provide an increased and shared understanding of actions required to address the Innovation Challenge. The first one of these will be published by June 2018 based on 2017 information.

Further collaboration on Smart Grids innovation beyond 2020 will likely be needed to realise the foreseen objectives. The role of Smart Grids Innovation Challenge will be reviewed in 2019.

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## Accelerating the Clean Energy Revolution

### **Off-grid Access to Electricity Innovation Challenge – Progress Summary**

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#### **Issue**

Access to affordable fossil-free electricity for rural and urban households is a major challenge at the global level and is identified as one of the UN sustainable development goals. According to the World Bank's Global Tracking Framework, an estimated 1.06 billion people – 15% of the global population – did not have access to electricity in 2014.

For isolated household or communities, research and development (R&D) is needed to bring down the cost of reliable low carbon off-grid solutions, either to equip people with no access or to modernize existing systems by switching to renewable energy. In the short term, innovation on components, efficient appliances and systems optimization may reduce the cost of delivered electricity for essential needs, such as lighting and communication. In the longer term, breakthrough technologies could be incorporated to provide greater services. Beyond greenhouse gas emissions reductions, the outcome is an energy system in which uninterrupted supply becomes the expectation rather than the exception. This will translate into increased productivity and a major boost to economic activity.

#### **Objective**

The objective for the Off-grid Access to Electricity Innovation Challenge is to develop renewable systems that are cheaper than fossil fuel alternatives for affordable access to electricity by off grid households and communities.

For individual homes, the objective is to support the significant reduction in price and increase performance of renewable power systems by 2020.

For remote communities, the objective is, by 2020, to demonstrate in diverse geographic and climate conditions, the robust, reliable, autonomous operation of renewable power systems up to around 100 kW at a significant lower cost than today.

#### **Organization**

The Off-Grid Access to Electricity Innovation Challenge is co-led by France and India.

Other participating members include: Australia, Brazil, Canada, China, European Commission, Finland, Indonesia, Italy, Mexico, Norway, Saudi Arabia, Republic of Korea, Sweden, the Netherlands, the United Kingdom, and the United States.

#### **Approach**

To address this Challenge, innovation needed on technologies includes renewable sources integration, storage and smart mini-grids management technologies (systems safety, reliability, interoperability and scalability, etc.) but also efficient appliances design. Beyond technology, local implementation conditions should also be able to cope with limited access to skilled labour and infrastructure financing,

and include innovation on installation, operation and maintenance, standardization issues and business models allowing a sustainable deployment.

The Off-grid Access to Electricity Innovation Challenge will focus on R&D at the mid- to high- Technology Readiness Levels, and advance three areas of work:

1. Develop in 2017 a common understanding of the state of the art solutions, gaps and opportunities, to define precise and measurable targets and inform further national and multi-national efforts.
2. Mobilize stakeholders for the challenge and boost engagement from the R&D community but also from companies, foundations and nongovernmental organizations, who can identify critical needs on the ground and work with local communities to accompany innovation.
3. Launch prize(s) and/or call(s) for demonstration projects, to support the experimentation of innovative solutions between now and 2020.

### **Progress**

As a first action, the Innovation Challenge co-leads have gathered information from members about ongoing national activities linked to the challenge (to get a consolidated view and to enable potential match making for new collaborations), existing international initiatives linked to the challenge (to build a list of potential partners, maximise leverage and focus on critical gaps) and ideas about real bottlenecks and precise measurable targets for the challenge within the MI timeframe (to share a common understanding of what success looks like).

Based on the results of the survey and of a stakeholders' workshop organized in Delhi in May 2017, a synthesis state-of-play document has been drafted and is being shared at the Mission Innovation Ministerial meeting in Beijing in June 2017.

### **Next Steps**

An international workshop will be held in Paris on July 12, 2017 in collaboration with the International Energy Agency. More than 100 participants (researchers, companies, development banks, international organizations, and NGOs) will be invited. The expected outcome is the identification of gaps for innovation and definition of more precise targets and milestones for the challenge. A report will be published in the following months on the basis of the workshop discussions and on members' inputs.

In the second half of 2017 and in 2018, interested members will launch, individually or together, a series of calls for projects and prizes to attract innovators. The supported demonstration projects should include local experiments and cover various conditions (size, climate, renewable resources, services provided, etc.).

A new state of the art report summarising the progress made, lessons learned, breakthroughs, and the remaining innovation needs and barriers to uptake will be published in 2020.

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## Accelerating the Clean Energy Revolution

### **Carbon Capture Innovation Challenge – Progress Summary**

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#### **Issue**

The science and technologies supporting carbon capture, utilization, and storage (CCUS) have greatly advanced over the last two decades. CCUS research and development (R&D) portfolios have grown, international collaboration has expanded, and CCUS projects in the power and industrial sectors continue to come online, with 17 large scale projects currently operating and additional projects nearing completion. Yet, opportunities remain for reducing costs, improving performance, assessing global storage capacity, creating better business and regulatory models, and discovering new uses for carbon dioxide (CO<sub>2</sub>).

#### **Objective**

The objective of the Carbon Capture Innovation Challenge is to advance CCUS technology development with the goal of reduced costs and improved performance.

This Challenge will seek to identify and prioritize breakthrough technologies, and recommend R&D pathways and collaboration mechanisms. It aims to build an improved, shared understanding of knowledge gaps, opportunities and technological progress. Further, it aims to promote opportunities to researchers, innovators, and potential investors, as well as strengthen and expand collaboration between key partners (government to government, researcher to researcher, public-private collaboration, etc.).

#### **Organization**

The Carbon Capture Innovation Challenge is co-led by the United States and Saudi Arabia.

Other participating countries include: Australia, Canada, China, the European Commission, Denmark, Finland, France, Germany, India, Indonesia, Italy, Japan, Republic of Korea, Mexico, the Netherlands, Norway, Sweden, the United Arab Emirates, and the United Kingdom.

#### **Approach**

Mission Innovation membership comprises countries that also support the Carbon Sequestration Leadership Forum (CSLF) and are members of, or participants in, International Energy Agency (IEA) implementing programmes. Policy and deployment activities are coordinated through the CSLF, and analytical activities are advanced through the IEA and other organizations. This presents a unique and meaningful space where Mission Innovation can coordinate breakthrough CCUS technologies. As such, to maximize efforts, work conducted under this Challenge will be directed towards early stage breakthrough CCUS technologies.

## **Progress**

The Carbon Capture Innovation Challenge is currently planning to host an experts' workshop, focused on early stage breakthrough CCUS technologies, on September 25-29, 2017 in Houston, Texas. The workshop will convene international CCUS experts from a variety of academic and industry perspectives to discuss breakthrough opportunities and international R&D synergies in carbon capture, carbon storage, and CO<sub>2</sub> utilization. Further work to coordinate R&D programmes, share information and best practices, and engage with international policy and technical groups will add to the body of knowledge on CCUS technology development and bolster all international platforms.

Upon completion of the workshop, a report will be published outlining the suggestions from all members and aiding in the identification of future areas of international collaboration on CCUS technology R&D.

## **Next Steps**

Beyond the workshop, the Carbon Capture Innovation Challenge aims to coordinate and align international R&D programmes to best utilize and direct funding for CCUS. This role will be heavily coordinated with other international efforts, including the policy and technical deployment efforts of the CSLF, potential work under the Clean Energy Ministerial, and the analysis and modeling capabilities within the International Energy Agency and other relevant bodies.

In the medium-term, the Carbon Capture Innovation Challenge will explore ways to engage private sector interests, in collaboration with the Mission Innovation Business and Investor Engagement subgroup.

In the longer term, this Challenge intends to establish a standing platform for communications, information sharing, and building collaborations on R&D on breakthrough and innovative CCUS technologies.

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## Accelerating the Clean Energy Revolution

### **Sustainable Biofuels Innovation Challenge – Progress Summary**

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#### **Issue**

The use of fossil fuels in transportation and industrial production contributes up to 35% of global greenhouse gas (GHG) emissions. Increased use of biofuels in transportation and industrial applications can contribute to mitigating climate change in key areas of the global economy. With global action, the International Energy Agency (IEA) projects that biofuels could provide around 30% of all transportation fuels by 2050, thereby avoiding around 2.1 giga-tonnes of CO<sub>2</sub> emissions per year compared to continued use of petroleum-derived fuels. In addition to environmental benefits, biofuels can contribute to energy security by diversifying the energy mix and by providing a renewable energy resource. However, many of the most exciting biofuels remain at the pre-commercial stage of development.

#### **Objective**

The objective of the Sustainable Biofuels Innovation Challenge is to develop ways to produce, at scale, widely affordable, sustainable, advanced biofuels for transportation and industrial applications.

#### **Organization**

The Sustainable Biofuels Innovation Challenge is co-led by Brazil, Canada, China, and India.

Other participating countries include: Australia, the European Commission, Finland, France, Indonesia, Italy, Mexico, Norway, Sweden, the Netherlands, the United Kingdom, and the United States.

#### **Approach**

Mission Innovation members participating in the Sustainable Biofuels Innovation Challenge have developed a Work Programme based on three parallel work streams to allow each Challenge member to focus on areas in which they have the greatest interest and expertise:

- A. Improve the large-scale production and supply of biological feedstocks including cultivation, harvesting, collection, handling, transport and pre-treatment practices;
- B. Overcome barriers to demonstrating technologies for at-scale production of biofuels meeting end-use specifications; and
- C. Research and improve upon new technologies for the high efficiency utilization of biofuels in transport and industry, including biogas applications, high-efficiency combustion engine applications, and applications combining electric, fuel cell and biofuels (e.g. vehicle fuel cell concepts for on-board generation of power from biofuels), as well as applications for heavy duty road freights, aviation and shipping.

This Challenge aims to accelerate biofuels-related research, development, and demonstration in order to achieve performance breakthroughs and cost reductions with the potential to substantially lower GHG emissions.

It also aims to drive research and innovation not only in the refining and production stages, but also upstream and downstream at the feedstock and utilization stages including, for example, the development of high-efficiency energy crops and the leveraging of biofuels in new, more efficient vehicle engines.

## **Progress**

The Sustainable Biofuels Innovation Challenge continues to build on the existing work of individual countries and international institutions, such as the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), and the United Nations Conference on Trade and Development (UNCTAD) to identify and prioritise innovation needs and collaboration opportunities where research and development can result in significant advances in biofuel technologies. Further, this Challenge will define joint work and collaboration to pursue with the Biofuture Platform, as it has demonstrable linkages with the goals of that initiative<sup>1</sup>. In order to facilitate cooperation and avoid duplication of efforts, the Sustainable Biofuels Innovation Challenge has established a defined set of “areas of interest” between these organizations, initiatives and mechanisms.

Building on existing work, SBIC is preparing “maps” of the work being done in the participating countries, and developing a roadmap for future collaborative work. The mapping and roadmap exercises are crucial in identifying gaps and opportunities. In order to facilitate this mapping exercise, SBIC developed a template to be used for collecting data. In order to facilitate data collection, the development of the template was coordinated with other international initiatives. The online survey template was completed in advance of the Mission Innovation Ministerial in June 2017 and individual countries are currently populating the database survey towards production of a mapping document by late 2017.

Following the mapping exercise, the development of a roadmap including consideration of appropriate TRL levels will commence in order to identify research priorities and collaboration opportunities. This will be done through a series of meetings culminating in a workshop to formalize these arrangements, to be held in late 2017/early 2018. The lead and degree of collaboration for research areas and type of biofuel will arise out of the initial mapping exercise.

## **Next Steps**

Subsequent workshops will provide an overview of scientific, technological and market challenges and discuss opportunities for research collaboration. Key industry players and innovators will be invited to discuss best practices, lessons learned and identify potential industry demands. This approach is intended to foster dialogue and collaboration between academia, government and the private sector in order to guide and accelerate R&D and innovation activities.

If emissions reduction targets are to be achieved, especially in the short and medium terms, biofuels have an important contribution to make. Moving forward, the Sustainable Biofuels Innovation Challenge will aim to provide opportunities to: accelerate the adoption of sustainable practices in agriculture, forestry, and land management; take advantage of synergistic mitigation and adaptation practices; and multiply opportunities for economic development by growing the market share of advanced biofuels.

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<sup>1</sup> The Biofuture Platform is an international mechanism for policy dialogue and collaboration among countries, organizations, academia and private sector actors conscious of the need to accelerate deployment of sustainable low carbon alternatives to fossil based products in transport, chemicals, plastics and other sectors.



# MISSION INNOVATION

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## Accelerating the Clean Energy Revolution

### Converting Sunlight Innovation Challenge – Progress Summary

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#### **Issue**

Enough energy strikes the earth in the form of sunlight to fulfill all of mankind's energy needs. However, the transition from fossil fuels to cleaner solar fuels has been hindered by low maturity and the high cost of conversion technologies. Research and innovation is needed to bring solar fuel technologies from infancy to maturity. Producing carbon-neutral clean fuels and developing breakthrough energy storage chemicals will not only contribute to mitigating climate change, they will also serve to enhance energy security and will provide opportunities for economic development across the globe.

#### **Objective**

The objective of the Converting Sunlight Innovation Challenge is to stimulate international cooperation and exchange in this area, with the ultimate goal of discovering affordable ways to convert sunlight into storable solar fuels.

#### **Organization**

The Converting Sunlight Innovation Challenge is co-led by the European Commission and Germany.

Other participating countries include: Australia, Brazil, Canada, Chile, China, Denmark, Finland, France, India, Italy, Japan, Mexico, Norway, Saudi Arabia, Sweden, the Netherlands, the United Arab Emirates, the United Kingdom, and the United States.

#### **Approach**

Presently, there are few international organizations and initiatives concerned with research in the area of the Converting Sunlight Innovation Challenge. Therefore, there is a significant opportunity to enhance international collaboration and help this topic get the attention it deserves and the resources it needs.

The Converting Sunlight Innovation Challenge intends focus efforts on:

1. Coordinating and working with existing relevant organizations and international initiatives;
2. Identifying and developing measures to promote collaboration;
3. Implementing research and exchange collaborations; and
4. Evaluating the success of these measures, developing new measures based on lessons learned.

Much of the scientific work addressed within the Converting Sunlight Innovation Challenge is still basic science and technology development, which makes enhancing scientific collaboration the top priority. However, in certain areas, work has already progressed towards technology prototype experiments.

## **Progress**

The Challenge has established an international experts group (up to two experts per country), in order to help with the definition of the scope of the Challenge. The group is composed of 18 experts from 12 countries. Based on the input from these experts we have identified areas of particular interest and some guiding principles. These are: catalysts for water splitting and CO<sub>2</sub> reduction, light harvesting, micro-algae, photo-electrochemical cells, concentrated solar light to energy rich chemicals and engineering of production devices.

Within these areas, key knowledge and technology gaps and break-through opportunities have been identified and will be further refined. To cover a current key gap, work within the Converting Sunlight Innovation Challenge will consider the guiding principle of a plausible pathway to scale the technology to the terawatt scale until 2050. This includes scalable, non-toxic materials and processes, full recyclability and potential for a high-energy return on investment.

We have already identified and contacted organizations working with international collaboration between researchers, industry and policy makers in the area and will coordinate our work to obtain maximum leverage. These include International Energy Agency Technology Collaboration programmes (TCP), such as SolarPACES and Bio Energy, the Joint Center for Artificial Photosynthesis (JCAP), the Solar Fuels Institute (SOFI) and the Solar Fuels Network and International Partnership for Hydrogen Economy (IPHE). The jointly funded collaborative projects will also increase collaboration between governments and governmental agencies.

## **Next Steps**

The Converting Sunlight Innovation Challenge will continue consultations with international experts through presentations at international scientific conferences. This Challenge also intends to conduct a country survey on past/present/future activities and organize a dedicated webinar to further develop the steps in each of the presently identified areas and possible technology targets.

Moving forward, the Converting Sunlight Innovation Challenge intends to explore and discuss the feasibility of a number of activities to strengthen and expand collaboration within the countries participating in the Challenge.

Some possible activities include: setting up a scholarship exchange programme for Post-Docs to enhance international collaboration and exchange of best practices; designing and launching inducement prizes to stimulate development in this Challenge area; the development of joint tasks between the Challenge and international organizations; establishing an online platform to facilitate the sharing of data, materials or research infrastructure; creating bi-/multi-lateral research programmes; and publishing outcomes like roadmaps, benchmarking, and TRL guidance.

# MISSION INNOVATION

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## Accelerating the Clean Energy Revolution

### **Clean Energy Materials Innovation Challenge – Progress Summary**

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#### **Issue**

Materials discovery is a key element of the innovation cycle of energy conversion, transmission, and storage technologies, as well as energy use. Development of next-generation energy technologies faces the challenge of finding and integrating new materials at a faster rate. However, even with current state-of-the-art technologies, the innovation process to discover new materials and bring these to market can take 10 to 20 years and is very expensive. Accelerating and improving this process through international collaborative research and development (R&D) could result in major breakthroughs for the energy sector and beyond.

#### **Organization**

The Clean Energy Materials Innovation Challenge is led by Mexico, and co-led by the United States.

Other participating countries include: Australia, Canada, Denmark, the European Commission, France, Germany, India, Italy, the United Arab Emirates, Finland, Norway, Republic of Korea, Saudi Arabia, Sweden, the Netherlands, and the United Kingdom.

#### **Objective**

The Clean Energy Materials Innovation Challenge aims to accelerate by 10x the innovation process for new, high-performance, low-cost clean energy materials.

This Challenge has the following goals:

1. Build an improved, shared understanding of the state of technologies for the automation of materials discovery, as well as identify the knowledge gaps, opportunities and the recommendations from the leading scientists around the world;
2. Promote collaboration opportunities to researchers, innovators, and potential investors;
3. Develop new collaboration projects between key partners (government-to-government, researcher-to-researcher, public-private, etc.) in order to integrating and automating the components of materials discovery; and
4. Inspire the decision makers and leaders around the world and showcase the possibilities and benefits that can be generated from bringing together the top minds in science and industry and from working together on finding solutions to the biggest global materials challenges.

#### **Approach**

Work conducted under this Challenge will be directed towards developing a fully integrated, end-to-end platform that will accelerate materials discovery along the whole process from low to high technology readiness levels (TRLs). The focus will be on R&D breakthrough technologies with a long-term approach towards 2030 and beyond that will lead to a single breakthrough as a platform, as opposed to deployment and/or policy issues with a shorter time horizon than MI.

This Innovation Challenge will combine advanced theoretical and applied physical chemistry/materials science with next-generation computing, artificial intelligence (machine learning), and robotics tools, with the aim of creating a comprehensive and fully integrated, end-to-end materials innovation platform. Experts and partners in this initiative will automate and/or improve each step of the innovation chain of new materials, such as the discovery, synthesis, data and performance assessment, and process design and scale-up. The proposed unified platform will benefit all stages of the materials innovation process (model, simulate, predict, synthesize, characterize, and test the properties and performance) of new clean energy materials and will leverage international advances from individual activities.

This initiative will benefit a wide range of energy sectors and applications. Specific application areas for new materials include, for example, advanced batteries, high efficiency solar cells and fuel cells, low energy semiconductors and solid state lighting, thermal storage, coatings for various applications, and catalysts for the conversion and capture of CO<sub>2</sub>.

### **Progress**

The Clean Energy Materials Innovation Challenge is currently planning to hold a 3-day Energy Materials Innovation Workshop (“EMI Workshop”) that will take place in Mexico City on September 11-14, 2017. This invitation-only workshop will convene more than 50 preeminent scientists and experts in advanced theoretical and applied physical chemistry/materials sciences, advanced computing, machine learning, and robotics. These experts will identify critical R&D priorities and gaps in clean energy materials innovation processes and propose opportunities for deeper collaboration.

The planning and organization of the EMI Workshop is fully under way. The event website ([IC6.mission-innovation.net](http://IC6.mission-innovation.net)) includes all details and agenda. To date, more than 100 experts, observers and keynote speakers have been invited; a number of them have been confirmed.

### **Next Steps**

This Challenge aims for short term pre-emptive funding to hit the ground running this fiscal, or early next fiscal.

The results and recommendations of the EMI Expert Workshop to be published in a detailed report by the end of 2017 will define the substantive next steps. The expectation is that the EMI Workshop and corresponding report will prove valuable to guide and align international R&D programmes, as well as to mobilize funding to meet this Challenge.

Following the EMI Workshop, the Clean Energy Materials Innovation Challenge may consider launching Requests for Proposals, grants, and collaboration projects to address the gaps and opportunities identified by the leading experts and perhaps follow some of their recommendations to meet this challenge. These collaborations could also include public private partnerships and R&D initiatives to discover advanced materials.

# MISSION INNOVATION

## Accelerating the Clean Energy Revolution

### **Affordable Heating and Cooling of Buildings Innovation Challenge – Progress Summary**

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#### **Issue**

Globally, buildings account for almost a third of final energy consumption, with space heating and cooling (H/C), and the provision of hot water, accounting for approximately half of this consumption. Space cooling is a fast growing sector. The H/C sector is extremely fragmented along: 1) local climatic conditions; 2) technologies; 3) age of installed stock; and 4) energy sources exploited. Most of the energy demand for H/C is currently satisfied with fossil fuels (natural gas, fuel oil and coal) with far less use of renewable energy sources. This is due to various obstacles, ranging from technical, financial, legal, social, and cultural.

#### **Objective**

The objective of the Affordable Heating and Cooling of Buildings Innovation Challenge is to make low-carbon heating and cooling affordable for everyone. This will be achieved by developing systems and measures to provide affordable solutions for the decarbonisation of the H/C sector through encouraging increased and better-targeted investment by public and private sector investors, and through the promotion of increased collaboration among the Innovation Challenge Members and between public and private sector investors.

#### **Organization**

The Affordable Heating and Cooling of Buildings Innovation Challenge is led by the United Kingdom, the United Arab Emirates, and the European Commission.

Other participating members include: Australia, Brazil, Canada, China, Denmark, Finland, France, Germany, India, Italy, Mexico, Norway, Saudi Arabia, Sweden, the Netherlands and the United States.

#### **Approach**

The exploitation of low-carbon energy sources for H/C offers safe, reliable and increasingly cost-competitive solutions. In order to realise this potential, and considering the MI global context, we have agreed to focus on a number of relevant "*cross-cutting*" technologies. In this way, the identified priority areas are specific enough to focus efforts but broad enough to engage all participating members, and be consistent with their diverse heating and cooling demands. These areas are: 1) thermal energy storage; 2) heat pumps; 3) non-atmospheric heat sinks and sources; 4) predictive maintenance and optimization; 5) building-level integration; and 6) physiological studies.

Under these headings, existing research activities will be reviewed and workshops of international experts convened to identify gaps, develop targets to measure success and scope further research needs. The workshops will promote collaboration between members on existing research and develop new research challenges, which will provide targets to track progress and set a framework with investors and industry to transition research and development into deployment in future years.

## **Progress**

The Affordable Heating and Cooling of Buildings Innovation Challenge has focused on building a shared understanding of key issues to address. The Innovation Challenge has undertaken a thorough analysis of technical aspects of the H/C sector, taking into consideration climatic conditions and H/C needs in each geographical area. A number of cross-cutting themes insufficiently addressed by current activities were identified and selected as the focus of the Innovation Challenge:

N°	Priority Area	Relevant for heating	Relevant for cooling
1	Thermal energy storage	***	*
2	Heat pumps	***	**
3	Non-atmospheric heat sinks and sources	*	***
4	Predictive maintenance and optimization	***	***
5	Building-level integration	***	***
6	Physiological studies	**	***

## **Next Steps**

- Establish a register of members' interest in specific priority areas to help identify potential partners for collaboration. (May 2017)
- Collate a record of relevant research being undertaken by members in their priority areas of interest, which can inform MI members' decisions on national activities and inform more detailed discussions on key gaps and opportunities. (End of June 2017)
- Hold workshops for priority areas, bringing together technical experts, private sector actors and policy makers worldwide to further define innovation needs, develop specific success criteria, review existing activities, identify critical gaps, and outline innovation and investment opportunities to innovators. (By the end of 2017)
- Technical workshops will be held to define technical focus areas and relevant targets for each priority area. Through collaboration between member countries, opportunities for new research to meet defined targets will be identified by mid-2018 and further explored. (2018 onwards)
- Members will look to facilitate research activities in their priority areas and report on technical findings and possible improvements. Progress will be tracked against technical targets and the Innovation Challenge will take a strategic approach to raising opportunities presented by developments with government and industry, to transition research and development into deployment. (2019-2020)