



**MISSION
INNOVATION**

accelerating the clean energy revolution

CARBON CAPTURE AND STORAGE CHALLENGE (MIC3) ACTION PLAN

Produced by all members of this Challenge

Led by the UK and KSA Co-Leads

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MISSION INNOVATION ASA WHOLE

Mission Innovation is a global initiative working to accelerate clean energy innovation. The power of innovation – driven by sustained public investment coupled with business leadership – [we believe] can make clean energy widely affordable and bring fledgling ideas into the mainstream. Mission Innovation (MI) is a global initiative of 24 countries and the European Commission (on behalf of the European Union).

By the end of 2020, MI will have helped deliver the following outcomes:

1. A substantial boost in public-sector investment in clean energy RD&D at the national level of MI members.
2. Increased private sector engagement and investment in energy innovation, particularly in key Innovation Challenges.
3. Many new or strengthened voluntary cross-border networks and partnerships on energy innovation, greater engagement from innovators, and accelerated progress in addressing specific Innovation Challenges.
4. Greater awareness amongst MI members and the wider clean energy community of the transformational potential of energy innovation, the progress being made, and the remaining critical clean energy innovation gaps and opportunities.

THE MISSION INNOVATION CARBON CAPTURE CHALLENGE (MIC3)

The Mission Innovation Carbon Capture Challenge (MIC3) is one of 8 challenges (the third challenge of the eight challenges).

There are two co-leads:



Eighteen Countries and the EU are members:



THE MIC3 CHALLENGE; WHAT THE MI WEBSITE STATES

Globally, power and industry account for about 50% of all greenhouse gas (GHG) emissions. Carbon Capture, Utilisation and Storage (CCUS) can achieve significant CO₂ reductions from power plants (fuelled by coal, natural gas, and biomass) and industrial applications. Industrial applications of CCUS include upstream oil and gas production, cement production, iron and steel production, and fertilizer manufacturing. These large (>100,000 t CO₂/yr) point sources of CO₂ emissions have few alternative options for significant reductions. Efforts to integrate bioenergy with CCUS also represent a pathway to negative emission technologies, which models suggest will become increasingly important in achieving deep decarbonisation. Technology could capture CO₂ from, for example, the waste stream of bioenergy facilities for storage. Coordinated decarbonisation efforts must include the development of additional technologies that (1) prevent and curtail emissions of CO₂, (2) result in carbon negative solutions, and (3) lead to safe and secure carbon storage.

The issue

Achieving Paris Agreement targets will require a significant acceleration of the development and deployment of technologies that dramatically reduce the output of CO₂. CCUS developments to date are noteworthy, but additional extensive and far-reaching efforts are required to combat climate change. Globally, the total CO₂ capture capacity of the 22 current projects (in operation or construction) is about 40 million tonnes per annum. The IEA's Energy Technology Perspectives report released in 2016 estimates that CCUS could provide 12% of the GHG emission reductions in the power sector needed to meet a 2°C scenario by 2050, or about 3.5 gigatonnes of abatement per year. In this scenario, 6.4 gigatonnes of CO₂ are captured in 2050 in the power and industrial sectors combined. Projects in power and industrial sectors have continued to demonstrate the technical feasibility of CCUS. However, overall costs need to be reduced for the technology to be adopted at a sufficient scale to meet the challenges of climate change. The science and technologies supporting CCUS have experienced great advances over the last decade, yet opportunities remain for reducing costs, improving performance, creating better business and regulatory models, and discovering new uses for CO₂.

The opportunity

CCUS is one of the only technologies able to achieve significant decarbonisation of our fossil fuel-based economies, particularly in carbon-intensive industries such as cement, iron and steel production. Operating CCUS projects offer important insight into the technical capabilities, policy and financing mechanisms, and permitting frameworks that could enable the successful deployment of CCUS. The goal of the Carbon Capture Innovation Challenge is twofold: first, to identify and prioritize breakthrough technologies; and second, to recommend research, development, and demonstration (RD&D) pathways and collaboration mechanisms.

The implementation

CCUS RD&D portfolios have grown, international collaboration has expanded, industrial CCUS projects continue to become operational, and the world's first large-scale project in the power sector has commenced operation, with additional projects nearing completion. Further efforts must be focused on research and development to enable new and novel carbon capture technologies, aimed at driving down costs and facilitating broader deployment. Fundamental research should be directed in areas that could result in revolutionary, not just incremental, advances in gas separation and geologic storage of CO₂. Parallel efforts to utilize CO₂ must also be pursued, exploring the use of captured CO₂ to create plastics

or algal biofuels, carbonate materials, or other uses yet-to-be-discovered. These efforts must also be diverse, addressing CO2 emissions from all fuels, including coal, natural gas, and biofuels, and developing new technologies to enable CCUS integration with industrial processes. Initial efforts through Mission Innovation will need to identify what can be done differently to accelerate CCUS. Technologies will need to be developed, tested, and vetted in collaborative forums, building on past experiences and improving on current efforts to further reduce costs. New approaches to collaboration along the entire RD&D chain must also be envisioned to rapidly evaluate prototype technologies.

THE MIC3 ACTION PLAN

The Action Plan was developed by members of the challenge and details of the seven actions follow.

Action #	MI Analysis & Joint Research Group Recommendation	MIC3 Response	Action Plan	Milestones	Target Completion Date	Support or Resources Required	Lead
Action #1	MIC3 should continue exploring collaborations with non-governmental organisations and the private sector	MIC3 will continue to develop and implement a clear and appropriate engagement strategy with a list of target organisations and points of contact with whom to start building relationships.	MIC3 has started to develop a stakeholder list of organisations that are conducting R&D in the Carbon Capture, Use and Storage field to harmonise efforts and identify the role that MIC3 can play in the global innovation	<ul style="list-style-type: none"> • Outreach strategy to be developed • Initial contacts to be compiled • Key industry partners to be brought on board for specific focus areas 	March 2020	All MIC3 members to provide contact information and implement outreach activities	All MIC3 Countries

Action #	MI Analysis & Joint Research Group Recommendation	MIC3 Response	Action Plan	Milestones	Target Completion Date	Support or Resources Required	Lead
Action #2	MIC3 should continue exploring collaborations with non-governmental organisations and the private sector	MIC3 to use an existing grant aid program ACT (Accelerating CCUS Technologies) to focus on addressing Workshop PRDs http://mission-innovation.net/wp-content/uploads/2018/09/Accelerating-Breakthrough-Innovation-in-Carbon-Capture-Utilization-and-Storage-0.pdf	<p>Continuing from the MIC3 Workshop Report the resultant PRDs were added to the ACT2 Call Text.</p> <p>MIC3 to map existing projects under ACT and in support of the MIC3 PRDs</p> <p>MIC3 PRDs used to develop full ACT2 proposals</p> <p>MIC3 countries consider being part of the potential ACT3 (September 2020) call</p>	<p>MIC3 to raise ACT profile through webinars, joint meetings, highlighting success stories, and sharing documents with an aim to secure participation from non-participating countries in the next ACT call for proposal</p> <p>MIC3 Workshop Report Priority Research Directions (PRDs) to be included in the ACT 2 Call</p> <p>ACT2 Project Proposals identified as addressing MIC3 PRDs</p>	<p>Ongoing</p> <p>ACT2 concludes 2022</p> <p>ACT3 potentially to conclude 2024</p>	UK together with all MIC3 countries already involved with ACT (USA, Norway, France, Germany, The Netherlands)	UK working with other ACT2 MIC3 countries

Action #	MI Analysis & Joint Research Group Recommendation	MIC3 Response	Action Plan	Milestones	Target Completion Date	Support or Resources Required	Lead
Action #3	MIC3 should continue exploring collaborations with non-governmental organisations and the private sector	EU Horizon 2020 Research and Innovation framework programme to publish specific call on a PRD relative to CCU targeting participation of MI countries active under MIC3	Continuing from MIC3 Workshop Report the PRD on CCU was added to EU Horizon 2020 2018 call on Energy on "Conversion of captured CO2" under which "international cooperation was encouraged, in particular with relevant Mission Innovation countries such as China "	<p>Evaluation of proposals was completed in November 2018</p> <p>3 successful proposals include cooperation with MI countries as below:</p> <p>These projects are:</p> <p>eCOCO2: Japan, China</p> <p>COZMOS: Saudi Arabia, China</p> <p>CO2Fokus: China</p> <p>Projects started in 2019</p> <p>EC Budget foreseen around €12M</p>	The projects are expected to end in 2022	<p>Funding of EU partners is from the European Commission.</p> <p>MI countries provide funding for their respective Partners in the projects.</p>	European Commission

Action #	MI Analysis & Joint Research Group Recommendation	MIC3 Response	Action Plan	Milestones	Target Completion Date	Support or Resources Required	Lead
Action #4	MIC3 should carve out an identity complimentary to and distinct from other international CCUS activities, such as e.g. CSLF, CEM, IEGHG, IEAWPFF	MIC3 to define its role within the global CCUS activity network, including identifying the added values of the IC within the frames of the MI mandate, and to define a vision for the IC	Define role of MIC3 Define added values of MIC3 in relation to other existing CCUS initiatives Define vision for MIC3	Roles, vision and added values defined and accepted by members	June 2020	All MIC3 members to contribute	Co-leads with support of MIC3 members.
Action #5	MIC3 should leverage cross-border networks and partnerships in order to increase involvement of private sector and other stakeholders	See Action 2 + develop an overview of existing and upcoming cooperation opportunities such as calls, projects, initiatives, etc., in addition to using existing channels such as EERA CCS in the EU to initiate/suggest new call openings based for instance on gaps identified in the MIC3 workshop report	Establish overview of existing and upcoming activities and possibilities Suggest new initiatives for calls or other cross-border network activities based on gaps in knowledge	Final overview List of suggestions for new activities/partnerships	June 2020 June 2020	All MIC3 members to provide information and contribute to engaging private companies	Co-leads with support of MIC3 members

Action #	MI Analysis & Joint Research Group Recommendation	MIC3 Response	Action Plan	Milestones	Target Completion Date	Support or Resources Required	Lead
Action #6	MIC3 should leverage cross-border networks and partnerships in order to increase involvement of private sector and other stakeholders	<p>Follow up (to Houston Workshop) MIC3 Workshop.</p> <p>The workshop will build on and continue the work from the Houston workshop towards implementation and commercialization of CCUS technologies.</p> <p><i>The objective of the workshop is to contribute in transferring early (low TRL) research activities to development and innovation activities (higher TRL) by developing guidance and development paths for emerging CCUS technologies, and suggestions for new and joint development activities, with the aim of</i></p>	<p>Locate with TCCS-10 in Trondheim to ensure wide as possible audience.</p> <p>Set up series of MIV#3 planning meetings</p> <p>Face to face planning meeting</p> <p>Development of programme with focus on industry</p>	Work to agreed plan	June 2019	All MIC3 members to contribute	Co-leads with support of MIC3 members working with SINTEF (Norway)

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		<p><i>accelerating the commercialisation and implementation process.</i></p> <p>The outcome will be a brief report consisting of:</p> <ul style="list-style-type: none"> • the guidance and development path documents produced during the workshop • proposals for new and joint development and innovation activities • a summary of the workshop discussions 					

Action #	MI Analysis & Joint Research Group Recommendation	MIC3 Response	Action Plan	Milestones	Target Completion Date	Support or Resources Required	Lead
Action #7	MIC3 should continue exploring collaborations with non-governmental organisations and the private sector	MIC3 will continue to seek and promote funding opportunities among MI governments that can provide engagement opportunities to non-governmental and private sector stakeholders.	Gather information from MIC3 countries on current and upcoming funding opportunities to collaborate internationally with other MI countries as well as with non-governmental and private sector stakeholders.	Gather in one table funding opportunities in CCUS.	Mar 2020		Co-leads with support of MIC3 members
		MIC3 to disseminate funding calls where both non-governmental and private sector stakeholders from MI countries can participate.	Seek information and explore with OGCI and other initiatives opportunities to disseminate information for MI countries to collaborate.	Present information on previous, current and upcoming CCUS MIC3 funding opportunities.	Mar 2020	Information from Secretariat on availability to highlight this information at MI4.	