IMPACT

GREEN METHANOL FOR A GREEN FUTURE

This project is funded by the European Union

SPIRE
Sustainable Process Industry through Resource and Energy Efficiency

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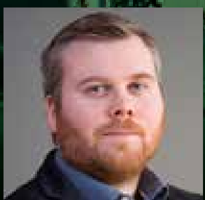
Impact Objective

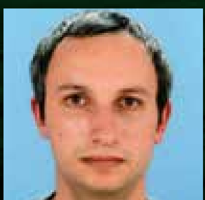
- Develop an innovative green chemical production technology which contributes to the EU's objectives of decreasing CO_2 emissions and increasing renewable energy usage

Curbing CO_2 with catalysis

***Ómar Freyr Sigurbjörnsson** and **Dr Loredana Magistri**, **Dr Blaž Likozar** and **Dr Angel Sánchez-Díaz** are testing the feasibility of a novel approach to carbon capture and utilisation as well as hydrogen storage. If successful, this could partially tackle the ongoing challenge of increasing CO_2 emissions*


Ómar Freyr Sigurbjörnsson


Dr Loredana Magistri


Dr Blaz Likozar


Dr Angel Sánchez-Díaz

Could you begin by briefly introducing yourselves?

ASD: For most of my career, I have worked in the ICT field and software engineering, always with a clear focus on technology exploitation. Currently, I am working on innovative approaches to create value from technology by realising the potential of research coming from high impact areas such as the low carbon economy, advanced and personalised food and gene editing.

LM: My fields of expertise are the analysis and simulation of high temperature fuel cells, innovative energy systems with carbon capture, energy storage by hydrogen, and platform chemicals production.

OFS: I joined Icelandic renewable methanol company Carbon Recycling International in 2009 and have been the Director of R&D there since 2010. My responsibilities include the management of research projects, pilot plant operations and application engineering, as well as intellectual property.

BL: I am an Acting Department Head, Senior Scientific Associate and Assistant Professor in the Department of Catalysis and Chemical Reaction Engineering at the National Institute of Chemistry, Ljubljana, Slovenia.

How did the MefCO2 (Synthesis of methanol from captured carbon dioxide using surplus electricity) project come about?

BL: The idea arose from the simple, well-known fact of increasing environmental CO2 emissions and by posing the questions of what could be done with this CO2 and how could it be converted in a manner that is close to existing chemical processes.

ASD: The need to reduce our economy's carbon footprint is indeed a challenge that can only be tackled by applying technology innovations. This is basically the goal of MefCO2, to demonstrate the economic feasibility of a novel CCU (carbon capture and utilisation) approach.

Could you give an insight into the collaborative nature of the project and why this is so important?

OFS: The technology being developed is integrating the power market with fast response electrolysis and carbon capture technology from existing point sources of CO2 into a flexible chemical production plant. This requires diverse skillsets and expertise from both the technical and commercial perspective, and collaboration is therefore very important to realising such a project in an effective manner.

It is still early on in the project, but has MefCO2 made any notable progress to date?

LM: Interesting results have been obtained in the catalysis study, system management and plant optimisation. In particular, considering the high capital cost of the plant, it has been highlighted that other revenue sources such as the oxygen selling are an important part of the potential benefits of the process.

How will the project be adapted to various plant sizes and gas composition?

ASD: Our business case foresees plants from 4,000 to 50,000 tonnes per year, and plants could be even bigger, increasing scale economies. As long as flue gas is required, we need a clean source. This implies having additional rigs for removing harming chemicals like sulphur, which may eventually poison our catalyst.

What hopes and aspirations do you have for MefCO2 and further research in the coming 5 to 10 years?

ASD: We need to learn more about continuous operation; a 5 to 10 year period will give us more information about the right 'configuration space' for operation. We also have to improve our knowledge on catalyst characterisation and synthesis; the underpinning chemistry is becoming mainstream, but we need cheaper and more reliable catalysts.

Green methanol for a green future

***MefCO$_2$* is a highly collaborative and multidisciplinary project that is developing an innovative technology that will use surplus electricity to synthesise 'green' methanol from captured CO_2. This could help mitigate global warming, abating one of the most pressing global challenges we face**

The EU has ambitious goals regarding the use of renewables, with the target set at a reduction of 20 per cent of CO_2 emissions by the year 2020, along with an increase of 20 per cent of renewables and an increase of 20 per cent in energy efficiency. One project has been designed to make a significant and sustainable contribution to these goals, while simultaneously enhancing Europe's competitiveness in the field. MefCO$_2$ (Synthesis of methanol from captured carbon dioxide using surplus electricity) is a four-year EU Horizon 2020 project aiming to develop an innovative green chemical production technology.

'With the increased deployment of renewable electricity generation from intermittent sources like wind and solar, the need to store or find alternative uses for surplus energy has become more apparent,' explains Ómar Freyr Sigurbjörnsson, who is Director of R&D at renewable methanol company Carbon Recycling International, Iceland, and a key collaborator in the project.

TRANSNATIONAL COLLABORATION

Alongside Sigurbjörnsson, other key collaborators include Loredana Magistri, Associate Professor at the University of Genoa, Italy, who is collaborating with national and international companies and is part of the steering committee of the Rolls-Royce LG Fuel Cell Systems UTC; Blaž Likozar of the National Institute of Chemistry, Ljubljana, Slovenia, a Fulbright Program alumnus; and Ángel Sánchez-Díaz, who has a doctorate in Applied Physics and is CEO of i-deals Innovation & Technology Venturing Services, Spain.

MefCO$_2$ has united like-minded individuals from private companies, institutions and universities across Europe to lay the foundations for a sustainable new business model. 'The MefCO$_2$ business model works by coupling together such diverse industries as power generation, transportation and manufacturing,' Sigurbjörnsson explains. In fact, it brings together eight partners from across Europe: i-deals (project coordinator); National Institute of Chemistry (NIC), Slovenia; Mitsubishi Hitachi Power Systems Europe (MHPSE), Germany; Cardiff Catalysis Institute (CCI), UK; Carbon Recycling International EHF (CRI), Iceland; the University of Genoa (UNIGE), Italy; Hydrogenics Europe NV (HYGS), Belgium; and the University of Duisburg-Essen (UDE), Germany.

The project involves industrial and institutional consortium partners on an international scale, with partners participating in various Work Packages (WPs) spanning heterogeneous catalyst development to commissioning and testing of the demonstrational pilot site. Likozar highlights the importance of the project's collaborative nature: 'Such a collaborative organisational nature is important as it demonstrates a good practice example along the way of commercialisation, with partners cooperating along the whole R&D chain, as well as transnationally, practically all over the EU territory.'

NEW USES FOR METHANOL

The project is making use of one of the most common and widespread platform chemicals and precursors for further syntheses: methanol. However, whereas methanol is traditionally produced from synthesis gas, which is obtained by reforming natural gas and demands very low CO_2 and stable hydrogen to carbon monoxide ratios, in MefCO$_2$ flexible methanol synthesis will occur with high CO_2 streams as an input, which will originate from thermal power stations that use fossil fuels. Hydrogen will be obtained from water electrolysis using surplus intermittent energy that otherwise would have low or negative value to the grid. MefCO$_2$ is seeking to demonstrate the economic feasibility of valorising captured CO_2 by turning it into a versatile platform chemical and renewable fuel such as methanol using hydrogen produced from renewable energy surplus. Essentially methanol becomes an energy carrier for renewable energy from non-biological sources, such as wind and solar.

The main benefits of the project are threefold: first, the mitigation of exhaust CO_2 and reduction of greenhouse gas emissions; second, the stabilisation of the electric grid by the consumption of the electric energy at its

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peaks; and third, the production of methanol as a versatile chemical for further conversion. The 'coupling technology' being further developed through MefCO$_2$ can be easily deployed where stranded or surplus energy needs to be stored and utilised. It also provides a way to simultaneously address economic and environmental objectives by making carbon capture and utilisation economically feasible. Furthermore, it facilitates the transition to greener economies and in a way that does not jeopardise the competitiveness of key European industries. 'Ultimately, we are talking about the need to create a business case for carbon capture and utilisation. Energy utilities and operators have not yet reached this point,' Sánchez-Díaz explains. 'If MefCO$_2$ can demonstrate that carbon capture and utilisation can be, under some circumstances, paid off we will have made a significant leap ahead in the adoption of these technologies.'

MOVING SWIFTLY AND EFFICIENTLY

Having commenced in late 2014, the project is still completing its first phase and is currently in the engineering and permitting phase. It is soon to move into the next phase, which is erection and integration, followed by commissioning and operation, which will continue until 2019. MefCO2 comprises five WPs with a combined duration of 48 months: catalyst synthesis, characterisation and performance screening (WP1); effect of process conditions during continuous operation (WP2); scale-up to industrial process and linking reactant and product sides (WP3); efficient grid integration of renewable energy via hydrogen production (WP4); and project coordination and the exploitation and dissemination of results (WP5).

In WP1, material for the catalytic conversion of pure CO_2 and hydrogen into methanol will be synthesised, with different synthesis variations. Catalyst characterisation will also take place, and will be followed by catalyst performance assessment. This work requires a strong cooperation between the NIC in Ljubljana and CCI in Cardiff. In WP2, the effect of process conditions during continuous operation will be tested and observed, with process conditions and process modelling being explored. In WP3, the work will be scaled up to industrial processes and reactant will be linked to product sides of the reaction. The different impacts that will be investigated are economic, social and environmental. MHPSE will coordinate all the engineering activities integrating the different rigs: electrolyser (HYGS), CCS plant (UDE) and methanol plant (CRI).

PROGRESS AND PATENTS

Despite it still being fairly young, MefCO$_2$ is progressing nicely and the collaborators are pleased with developments to date. 'The project has already resulted in a new reaction system design that is scalable, simple to construct, maintain and operate, and capable of more flexible operation than our existing system,' Sigurbjörnsson says. The team is also set to file a patent, Sánchez-Díaz reveals: 'We are to file a patent regarding our catalyst characterisation and preparation phase. We have also issued our first economic estimates that show situations under which this methanol synthesis process can be sustainable.'

Looking ahead, the team believes the future is bright for MefCO$_2$: 'Despite all the technical development work planned in MefCO2 project, the power to methanol technology is already at an advanced stage of deployment at methanol plant (CRI),' Sigurbjörnsson enthuses. 'In addition to the research efforts we anticipate several commercial facilities being brought online in the years to come, bringing us further along the learning curve.' Magistri believes the results obtained from this first analysis show an interesting potential for innovative low carbon footprint methanol production: 'A similar study could be applied to other industrial processes and chemical productions.'

Likozar is confident that the project is laying the foundations for a bright future: 'MefCO$_2$ is paving the way towards future commercial CO_2-to-methanol industrial cases, as well as other carbon capture and utilisation opportunities, in addition to cutting-edge domestic engineering and technology development.'

Project Insights

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PARTNERS

i-deals (Spain) • National Institute of Chemistry (Slovenia) • Mitsubishi Hitachi Power Systems Europe (Germany) • Cardiff Catalysis Institute (UK) • Carbon Recycling International (Iceland) • University of Genoa (Italy) • Hydrogenics Europe (Belgium) • University of Duisburg-Essen (Germany)

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PROJECT COORDINATOR BIO

Dr Ángel Sánchez-Díaz was born in Madrid in 1970, the city where he obtained his PhD in Applied Physics. After leaving academia Sánchez-Díaz joined IBM, where he led the development of software solutions for managing environmental and quality systems. Currently, Sánchez-Díaz is the CEO of i-deals and a board member of several of the portfolio companies of Fitalent (venture capital fund), all of which are Madrid-based everis spin-offs.

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