European
Innovation
Council

Sustainability meets Scalability: Roadmap for Renewable Hydrogen, Fuels and Chemicals

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2. Event Summary

The event "Sustainability Meets Scalability," held on March 26-27, 2025, at the European Commission in Brussels, gathered over 200 participants from across academia, industry, startups, and policy circles. Spearheaded by the European Innovation Council[1] in partnership with imec,[2] the SOLDAC[3] and S2B[4] research projects, and the European large-scale initiative SUNERGY,[5] this pivotal gathering aimed to critically assess and propel the development of sustainable fuels, chemicals, and materials derived from renewable resources.

As climate change mitigation calls for urgent action, the event focused on transcending mere technological buzzwords to ensure that proposed solutions are both scalable and truly sustainable. Designed to tackle the challenges and leverage the opportunities within renewable hydrogen, fuels, and chemicals, the event encouraged candid discussions on current strategies and future directions.

Over two dynamic days, participants delved into diverse topics, ranging from hydrogen production to the carbon economy, with the objective of defining concrete outcomes and setting attainable milestones. Through a blend of plenary sessions, interactive formats, and a comprehensive road mapping exercise, stakeholders aligned on the societal needs, technological breakthroughs, and political frameworks essential for driving a truly sustainable future.

Key highlights included gaining a comprehensive overview of the current state-of-play in renewable technologies, exchanging insights with leading academics, entrepreneurs, industrial leaders, policymakers, and investors, and contributing to the development of an EU Technological Roadmap on Renewable Fuels and Chemicals. Ample networking opportunities facilitated future collaborations.

The event aimed to achieve a reality check by matching research and innovation realities with industrial needs and policy ambitions. Participants left with a clear understanding of forthcoming technological milestones, guided innovation towards sustainable configurations, and strengthened the collaborative ecosystem around renewable energy solutions.

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[1] The **European Innovation Council** (EIC) serves as a pivotal force in advancing pioneering innovations across Europe, bridging the gap from research to market. By offering comprehensive support through funding, expert guidance, and business acceleration services, the EIC facilitates the transformation of high-potential ideas into impactful technologies and commercially viable solutions. Website: https://eic.ec.europa.eu

[2] **imec** is a leading research and innovation hub in nanoelectronics and digital technologies, headquartered in Belgium. It combines world-class expertise and cutting-edge infrastructure to drive advancements in microchip technology, energy, healthcare, and other sectors, fostering collaboration between academia, industry, and governments worldwide. Website: https://www.imec-int.com/

[3] The **SOLDAC project** focuses on developing advanced photoelectrochemical cells. These cells aim to convert carbon dioxide (CO_2) into ethylene using sunlight as the primary energy source. Website: https://soldac-project.eu

[4] The **S2B project,** titled "Solar to Butanol – Solar Butanol Production by Solid-state Photosynthetic Cell Factories," aims to harness the potential of photosynthetic microbes to directly convert solar energy and CO_2 into butanol. S2B's innovative solid-state biocatalytic platform utilizes engineered thin-layer assemblies of cyanobacteria and bio-based matrix materials to optimize energy and carbon flow towards butanol formation. By improving light management, increasing CO_2 capture efficiency, and enabling effective butanol separation, the project seeks to establish a sustainable and continuous solar-driven butanol production process. Website: https://www.s2b-project.eu

[5] **SUNERGY** is a pan-European initiative working to enable a circular economy through the sustainable production of fossil-free fuels and base chemicals from renewable energy (sunlight, wind) and abundant molecules (CO2, water, nitrogen). It is supported via the European Coordination and Support Action SUNER-C. Website: https://sunergy-initiative.eu/

Topics addressed encompassed transitioning societal needs to technological innovation, evaluating current technical performances of solar-to-X devices, envisioning the devices of tomorrow and discussing the importance of techno-sustainability assessments early in the innovation journey. Key enablers like standards, common metrics, and fair benchmarking for upscaling technology were also explored.

Participants showcased European innovation through project pitches, offering tangible insights into the technological advancements propelling the renewable energy sector forward.

The European Innovation Council

The European Innovation Council (EIC) is a key initiative of the European Union designed to support the entire innovation journey, from initial research in the lab to the commercialization of breakthrough technologies by start-ups. The EIC employs a comprehensive suite of tools and services to foster innovation.

Core Tools:

Pathfinder: Supports visionary research aimed at developing transformative technologies. (Technology Readiness level – TRL 1-4)

Transition: Focuses on transforming promising research results into innovations that can be commercialized. (TRL 4-6)

Accelerator: Provides funding and support for start-ups and small to medium-sized enterprises (SMEs) to scale their innovative solutions. (TRL 6+)

Unique Features:

Proactive Portfolio Management: EIC program managers, who are experts in their respective sectors, provide active management and guidance of thematic portfolios, ensuring focused progress and impactful outcomes.

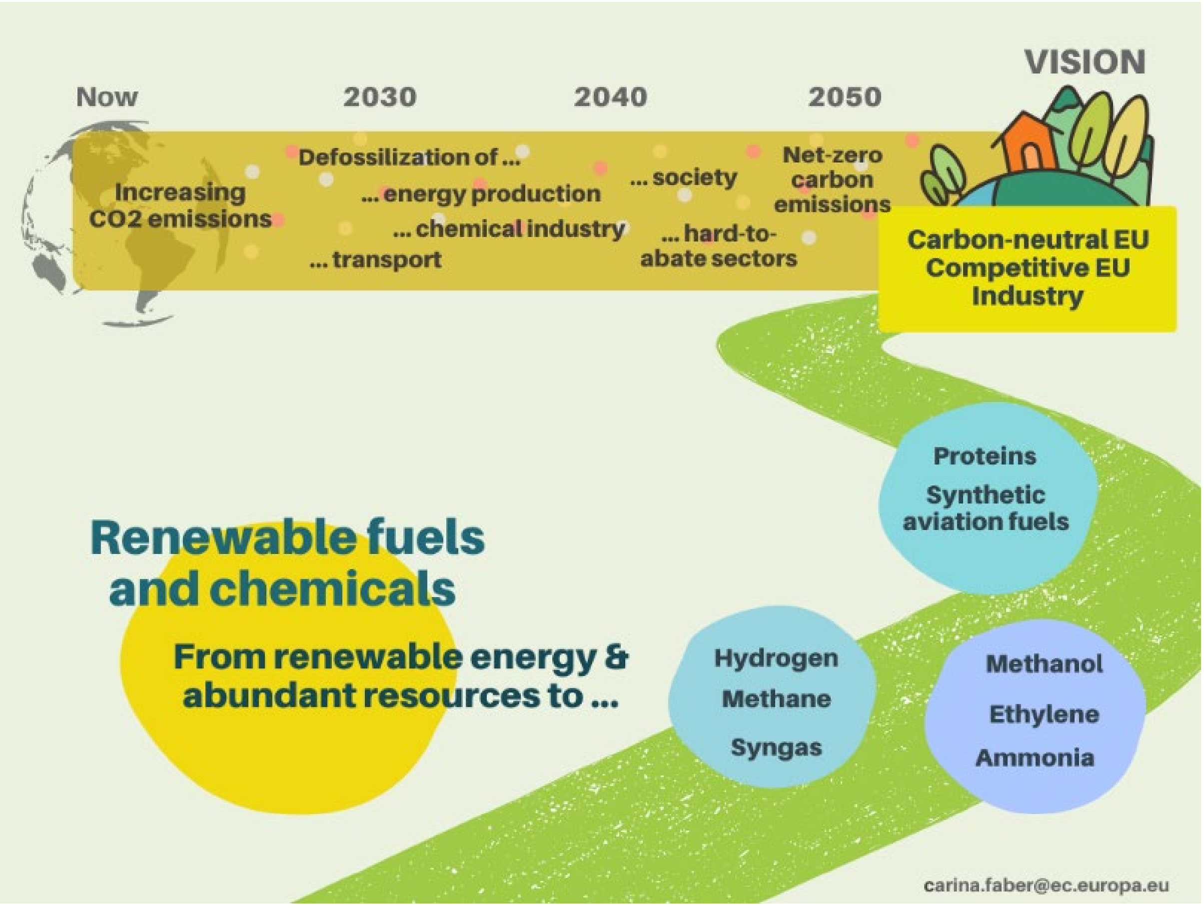
Comprehensive Support: The EIC offers not only grant funding and equity investment to drive innovation but also emphasizes ecosystem building to connect innovators with industry stakeholders and partners.

Business Acceleration Services: Beyond funding, the EIC delivers additional services to enhance business growth and accelerate market-readiness.

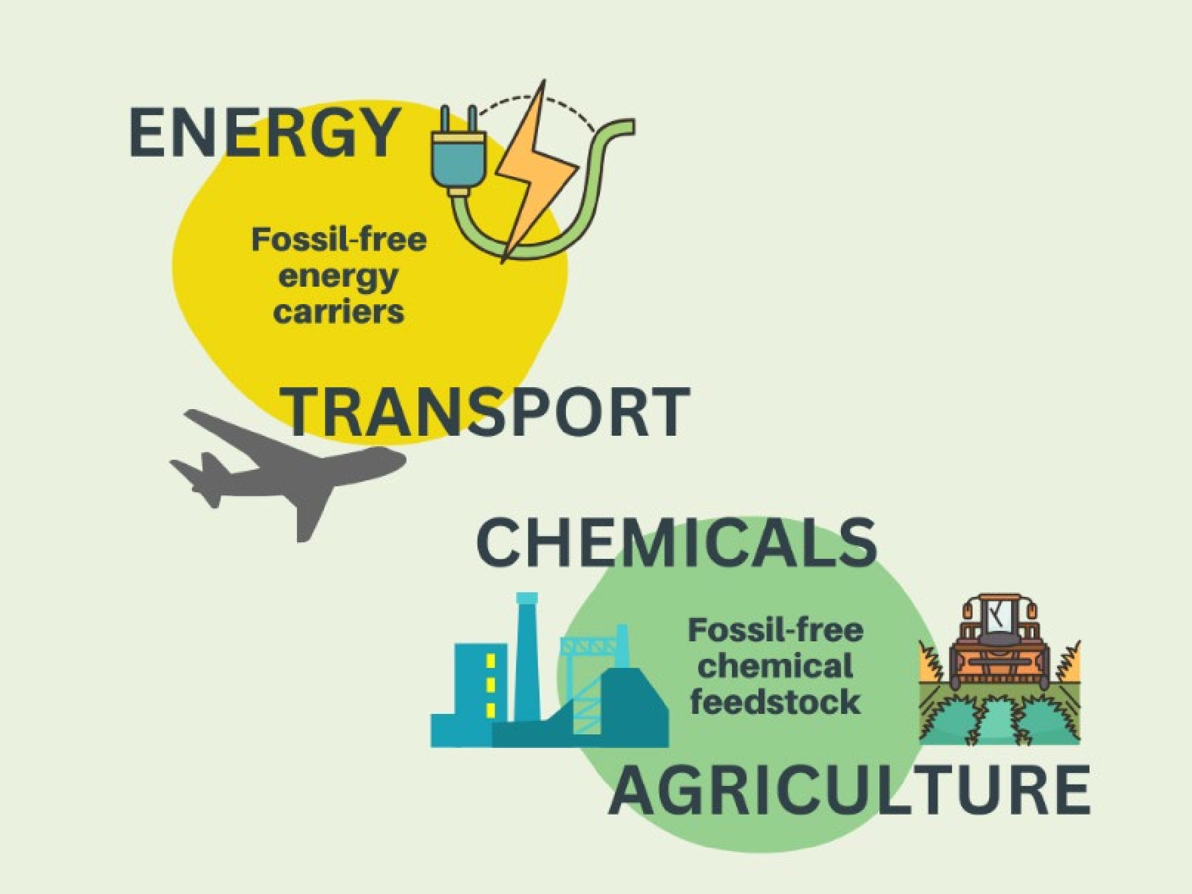
3. Foreword

Welcome to the report on "Sustainability Meets Scalability: Roadmap on Renewable Hydrogen, Fuels, and Chemicals." This gathering brought together a diverse group of experts and stakeholders, all united by a shared mission: transforming carbon dioxide (CO_2), a major contributor to climate change, from a challenge into an opportunity. Our collective goal is to harness renewable resources to produce sustainable fuels and chemicals, crucial for Europe's ambition to achieve carbon neutrality by 2050 while maintaining industrial competitiveness.

The event was a platform for exploring innovative technological advancements that convert CO_2 and other abundant molecules, such as N_2, into valuable products like hydrogen, methane, and long-chain hydrocarbons. This transformation is about more than providing new fuels – it's about creating **energy resilience and long-term energy storage** solutions, decoupling industrial production from fossil fuels, and fostering local production capabilities.



We delved into a wide spectrum of technologies, from emerging to advanced, including Power-to-X, Carbon Capture and Utilization, and Solar-to-X. These approaches showcase the potential to transform not just energy systems, but also our entire approach to production and consumption, empowering local communities by reducing reliance on complex global supply chains.



Yet, significant challenges need to be addressed, including regulatory uncertainties, investment needs, and concerns over scalability and sustainability. It is crucial that the technologies we develop today are capable of overcoming these barriers, positioning them as strategic enablers for Europe’s future.

As we work towards overcoming the barriers of sustainability and scalability, these technologies hold the potential to become strategic enablers for key European sectors. The innovation landscape is vast and dynamic, with no clear frontrunner, highlighting the continued need for innovation and development. On the market side, the current regulatory framework presents uncertainties that impede product competitiveness, and while there are significant future market opportunities, today's business models face challenges due to a lack of price competitiveness. Substantial capital investments are required to mitigate risks and spur development. Moreover, the scalability of these technologies is affected by the use of critical and scarce resources such as drinking water, green electricity, and CRM/SRM. We must ensure that the technologies developed today can surpass these challenges, positioning them to drive strategic growth and sustainability across Europe.

In recent years, numerous European initiatives, such as SUNERGY and various Joint Undertakings under the Horizon Europe framework (e.g., the Clean Hydrogen Joint Undertaking), have made remarkable strides in advancing these technologies. Their efforts align with international initiatives like Mission Innovation, demonstrating a global commitment to sustainable innovation.

At the heart of our event was technological roadmapping – a tool to visualize the journey from current state-of-the-art technologies to a visionary future. This process builds on previous work by SUNERGY, providing us with a foundation to define milestones and focus our efforts on the most promising directions.

The discussions over the two days centred on timelines, goals, and methods, emphasizing the enablers and barriers that must be navigated to achieve full sustainability and scalability. By bringing together innovators, researchers, investors, policymakers, and a broad array of stakeholders, we conducted a reality check to align research and innovation with industrial needs and policy ambitions.

Together, we are shaping the roadmap to a sustainable and resilient future, leveraging the momentum of this dynamic field!

Carina Faber

EIC Programme Manager for Renewable Energy and Alternative Resource Exploitation

4. First day

4.1 Summary

Day 1 of the "Sustainability Meets Scalability" event offered a rich program designed to set the stage for understanding the pivotal role of molecules in the energy industry, and to facilitate meaningful exchanges among participants. The agenda was a blend of insightful industry and policy presentations combined with research and innovation showcases, ensuring coverage of all maturity levels from fundamental research to startup innovations. The day began with the keynote "Reality Check: Pivotal Role of Molecules in Energy Industry" delivered by Jan Mertens, Chief Science Officer at ENGIE Research and Visiting Professor at the University of Ghent, which highlighted the importance of molecules in shaping the future energy landscape.

This was followed by the session "Societal Needs: Frame Setting and Policy Support," featuring presentations from several European Commission representatives, emphasizing the policy frameworks supporting renewable innovation. The morning continued with "Showcasing European R&I on Renewable Hydrogen," where project pitches from the EIC Green H2 Challenge Portfolio exemplified foundational research and innovation at work for emerging hydrogen technologies.

In the session "Innovation in Practice," we heard keynotes from Michiel Scheffer, President of the Board of the European Innovation Council, and Tim van den Bergh, Lead of Climate Tech Innovation at the World Economic Forum. This session delved into key enablers of innovation, highlighting areas such as benchmarking or capacity building in education. Notably, several EU start-ups shared their insights and experiences, enriching the dialogue with practical perspectives on innovation and challenges for commercialization.

The afternoon was dedicated to interactive learning and cross-sector collaboration through the Technological Roadmapping Session. Organized by SUNERGY and the EIC, this session focused on state-of-the-art technologies and future milestones, featuring four working groups concentrating on Advanced Electrochemical Conversion, Photosynthetic Devices, Biological Conversion, and Carbon Capture. Running parallel, a Young Researcher Working Group engaged the next generation of innovators, fostering fresh perspectives and ideas.

Day 1 set a collaborative and insightful tone for the event, bringing together multiple perspectives to advance the discussions on sustainable and scalable innovations in renewable hydrogen, fuels, and chemicals.

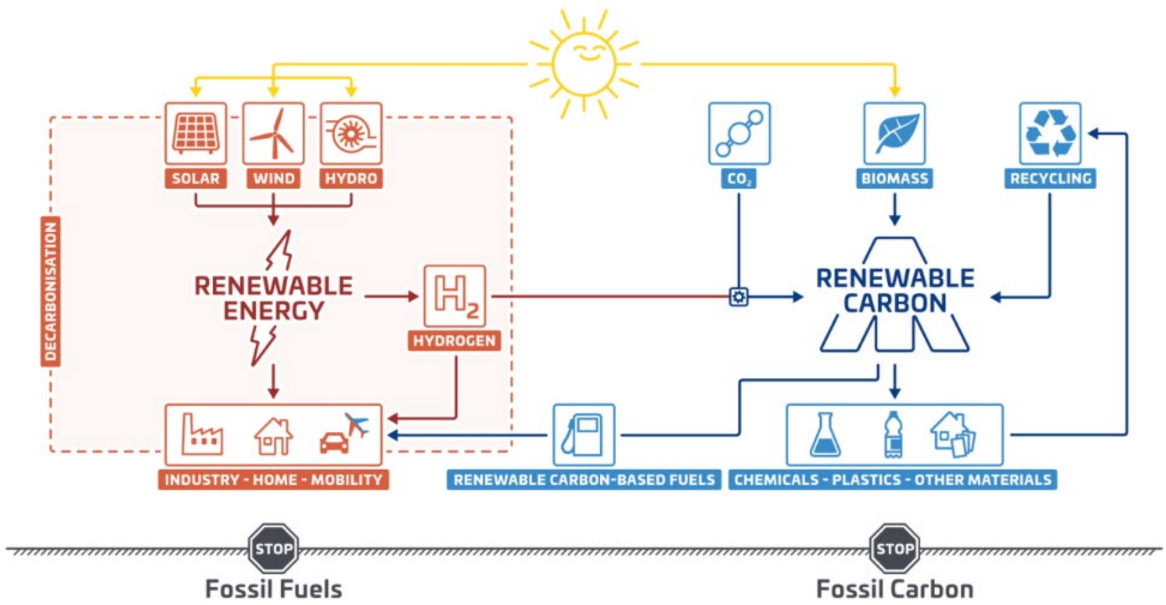
4.2 Reality check: The pivotal role of molecules in energy industry

Keynote address by Prof. Jan Mertens, ENGIE, University of Ghent

Jan Mertens challenged conventional narratives around the energy transition by placing chemicals and molecules at the centre of future energy systems. While electrification will remain the dominant path, accounting for approximately two-thirds of final energy use in ENGIE's models, Mertens emphasized the irreplaceable role that molecules play in addressing hard-to-electrify sectors such as shipping, aviation and long-duration energy storage. Beyond their role as fuels, molecules are also essential feedstocks to produce chemicals and materials, a basic backbone for industrial value chains.

Mertens laid out a three-pathway strategy for reaching climate neutrality: first, increase energy efficiency; second, electrify wherever feasible; and finally, make molecules more important in the transition, especially in spaces where electrification is unfeasible. Here, different types of molecules come into play, both bio-based solutions and synthetic fuels from non-biomass-based feedstock such as atmospheric CO_2. In this vision, e-molecules, produced from renewable electricity and abundant resources, such e-methanol, e-kerosene, and e-ammonia, will complement electrification, especially as vectors for transporting energy between renewable-rich and renewable-poor regions.

Despite the availability of mature technologies to convert carbon into fuels and chemicals, Mertens pointed to the key challenge of adaptability. The chemical industry must be reconfigured to support these new inputs. For example, biogas, often seen purely as an energy source, could be revalorized as a chemical feedstock. Emerging processes such as the oxidative coupling of methane (OCM) and biomass hydrogenation are improving carbon efficiency and offering viable alternatives to fossil-based olefins.



Transport and storage costs of renewable fuels and chemicals, however, remain a significant barrier. "Moving hydrogen around can nearly double its cost," Mertens warned, referencing one of his recent papers, published in Joule. He also suggested that synthetic hydrocarbons (as well as other substances like ammonia) could become more economically attractive for trade and energy import strategies. These products could preserve more value in the European economy by supporting local jobs and sustaining the continent's industrial base.

Shifting to a hydrocarbon economy would also mean the need for significant amounts of carbon, sourced in a fully sustainable manner, at scale. Mertens was clear: Direct Air Capture (DAC) will be indispensable. According to ENGIE calculations, DAC shows great promises in terms of energy and feedstock optimisation when directly combined with e-molecule production could exploit waste heat from exothermic reactions, such as those in e-fuel production, to reduce its energy footprint—creating a more circular system. Cost projections for DAC are promising, with estimates dropping to around $100/tonne CO_2 (approx. 85€/tonne) by 2050.

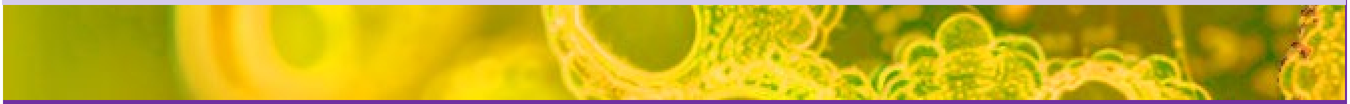
Despite technological readiness, several systemic challenges persist such as high energy prices in Europe, elevated labour costs, and a regulatory framework that can discourage innovation. Mertens argued that these structural factors, rather than technical limitations, are the primary barriers to implementation. Nevertheless, he remained optimistic about the technologies ahead. Thanks to the recent strategies in research and innovation of the European Commission, emerging and low-TRL technologies are progressing rapidly. In this context, the strategic focus must pursue industrial scale-up, market integration, and regulatory adaptation to ensure that Europe remains at the forefront in the global transition to sustainable molecules.

Sustainable molecules

Sustainable molecules represent a shift towards cleaner, renewable alternatives to traditional fossil fuels. They refer to a diverse range of fuels, chemicals and materials produced exclusively from renewable resources. This includes so-called ***e-fuels*** or ***e-molecules***, produced using renewable electricity. and ***solar fuels and chemicals*** produced directly from sunlight. The focus is on synthesizing these molecules from abundant and readily available feedstocks like water (H_2O), carbon dioxide (CO_2), and nitrogen (N_2). ***Hydrogen*** – often produced via water electrolysis using renewable electricity – is a fundamental component of sustainable molecules and serves as both a fuel and a building block for more complex molecules.

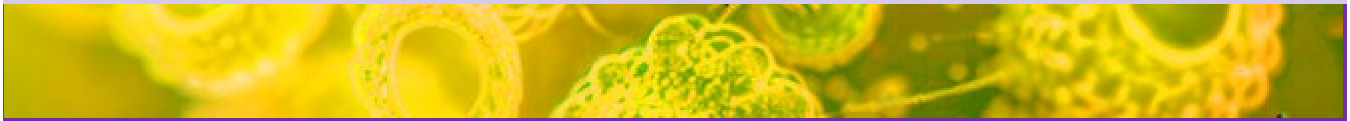
CCU technologies in a nutshell

Carbon capture and utilization (CCU) technologies aim to reduce carbon dioxide (CO_2) emissions by capturing CO_2 from sources like industrial plants or directly from the air and using it to create useful products. Instead of letting CO_2 contribute to climate change, these technologies transform it into fuels, building materials or chemicals that are valuable for different industries. This process promotes a circular economy. Unlike carbon capture and storage (CCS), which involves capturing and storing CO_2 underground to prevent it from entering the atmosphere, CCU focuses on harnessing the captured CO_2 as a resource for new products.



Power-to-X technologies in a nutshell

Power-to-X (PtX) technologies use surplus renewable electricity to produce a wide range of products. The "X" stands for various outputs, such as gases, fuels or chemicals. For example, excess electricity can be used to produce hydrogen through water electrolysis, which can then be stored or converted into other fuels like methane, methanol or ammonia. These technologies provide a flexible way to store renewable electricity, integrate it into existing energy systems, and create sustainable alternatives to fossil fuels. By transforming renewable electricity into different forms, PtX helps to enhance energy security, balance supply and provide long-term energy renewable energy storage.



Solar-to-X technologies in a nutshell

Solar-to-X technologies mimic the natural process of photosynthesis to convert sunlight directly into fuels or other valuable products. By using sunlight to drive chemical reactions, these technologies transform simple inputs like water and carbon dioxide into energy-rich compounds such as hydrogen, methane or liquid fuels. This process effectively allows solar energy to be stored in chemical bonds, providing a clean and sustainable energy source that can be used when the sun is not shining.

4.3 Societal needs: Policy Perspectives on Sustainable Molecules

This session built on Jan Merten's keynote address, who had presented an industrial perspective on the importance of sustainable molecule production, the potential of emerging technologies and the regulatory barriers to large-scale deployment. This view was then complemented by policy representatives, who outlined current policy ambitions and research & innovation priorities. Four panellists representing key European Commission Directorates-General, namely GROW, CLIMA, REGIO, and MOVE, provided an integrated view of EU strategies supporting the transition to renewable fuels and chemicals. The discussion highlighted the importance of aligning industrial, regional and climate policies with technology deployment and global competitiveness, while also reinforcing Europe's strategic autonomy.

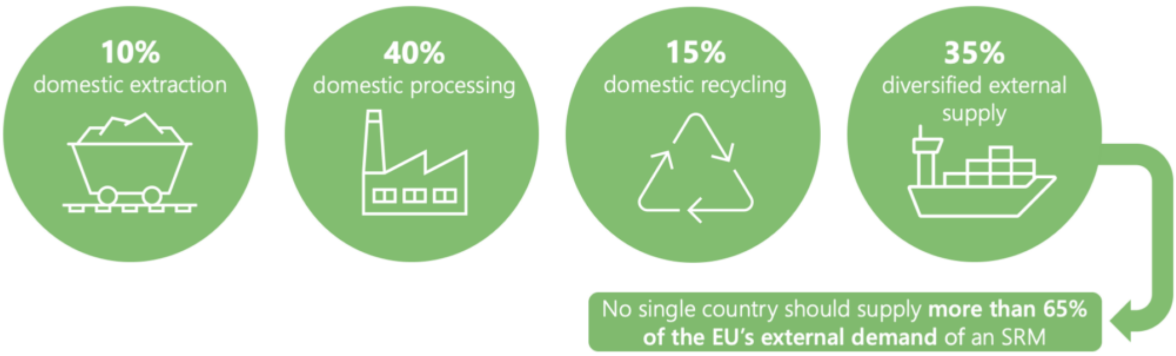
4.3.1 Strategic Autonomy through Critical and Strategic Raw Materials

Martin Lange, Policy Officer in Raw Materials, European Commission DG-GROW

Martin Lange (DG GROW) presented the European Critical Raw Materials Act as a cornerstone of EU's industrial resilience strategy. Against a backdrop of disrupted global supply chains, exacerbated by the COVID-19 pandemic, geopolitical instability, and trade tensions, he underlined the urgent need to secure critical and strategic raw materials (CRMs and SRMs) essential for the green and digital transitions.

The CRM Act defines 34 raw materials as critical and further identifies a subset of substances as "strategic", because of their relevance in high-growth sectors such as renewable energies, aerospace and digital technologies. These materials are crucial in solar-to-X solutions, namely technologies like electrolysers, which rely on elements such as platinum group metals (PGMs), cobalt, titanium and rare earths. The European Union currently holds very limited shares of global production and processing for most of these materials, highlighting its vulnerability along key segments of the value chain.

To reduce these dependencies, the Act establishes ambitious targets to be met by 2030: at least 10% of extraction, 40% of processing and 25% of recycling of strategic materials should be carried out within the EU. Moreover, no more than 65% of any material should be sourced from a single third country. To address these issues, in 2024, the European Commission opened a call for applications on strategic projects under the Critical Raw Materials Act. Over 170 strategic project applications were received, with 47 selected for EU funding—targeting a diversified and resilient supply chain by 2030.



4.3.2 Carbon Capture and Utilisation as an Industrial Enabler

Fabien Ramos, Carbon Removal Lead, European Commission, Directorate General CLIMA

Fabien Ramos (DGl CLIMA) emphasised the central role of Carbon Capture and Utilisation (CCU) in the EU's path towards climate neutrality. CCU technologies offer a dual benefit: enabling emissions reductions in hard-to-abate sectors and serving as a carbon source for renewable fuels and chemicals. Although recognised as a net-zero technology under the Net Zero Industry Act, CCU support remains fragmented across EU instruments and policymakers.

Currently, the Commission is pursuing a more coherent framework to align CCU deployment with broader industrial decarbonisation goals. Existing policy initiatives such as the Renewable Energy Directive, ReFuelEU Aviation, and FuelEU Maritime already support CCU for fuel production. Additional mechanisms under development aim to expand CCU across industrial sectors, particularly in the context of carbon reuse and synthetic feedstock production.

Similarly to the current situation with renewable hydrogen provision, Ramos highlighted the importance of creating a transport infrastructure for CO_2, ready to upscale and underpin a functioning carbon market in Europe. Without a reliable network for moving captured carbon to storage or utilisation sites, CCU and CCS projects remain geographically constrained and commercially limited. Future policy measures will aim to address this gap by supporting shared infrastructure and regional hubs.

4.3.3 Regional Cohesion and Energy Equity

Eva Nussmüller, acting Head of Unit, European Commission, Directorate General REGIO

Renewable fuels and chemicals bare the potential of decentralized, site-specific energy and production systems. In context of this future deployment vision, Eva Nussmüller (DG REGIO) gave insights into the regional EU policy perspective, arguing that cohesion policy can play a crucial role in scaling up renewable fuels and chemical solutions. The focus of DG REGIO is to mobilise energy investment across all regions of the EU, with special attention to rural and less-developed areas that hold significant untapped renewable potential.

Under the 2021–2027 Cohesion Policy, around €14.5 billion were assigned for renewable energy deployment, targeting both mature and emerging technologies across solar, wind, biomass, and marine sectors. In this model, regional authorities lead the design and implementation of projects, promoting tailored solutions such as energy communities and building-integrated systems. An additional €6.5 billion was directed toward smart energy systems, storage, and green hydrogen projects.

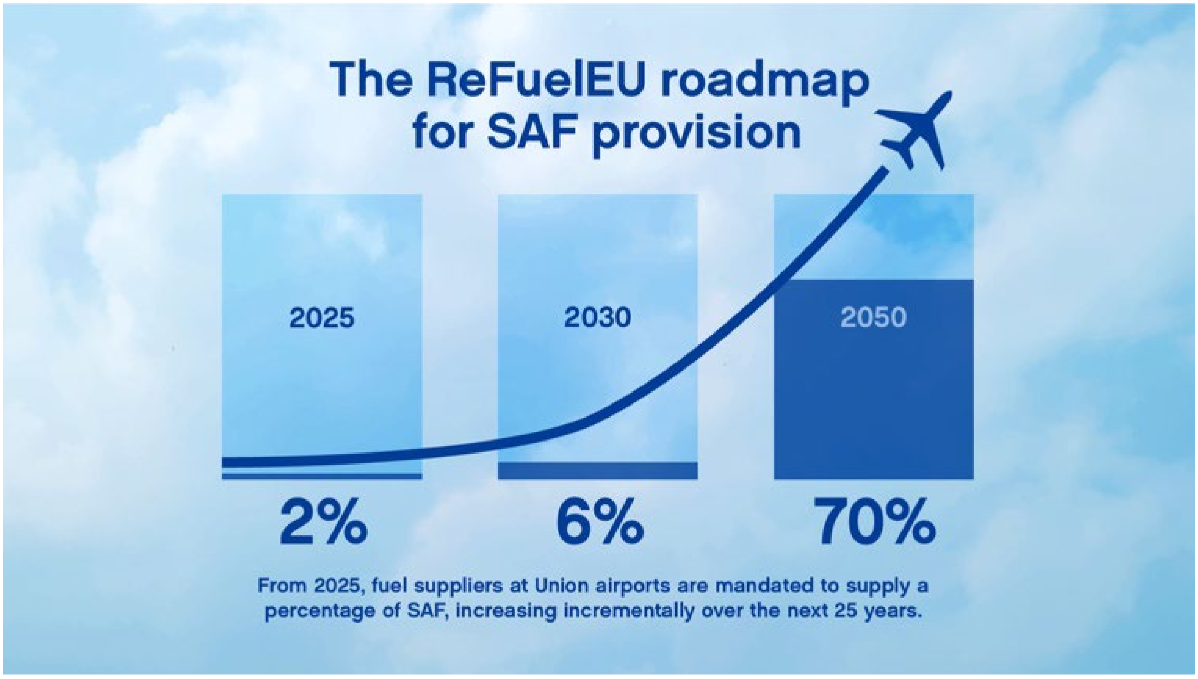
However, implementation challenges persist. Many regions struggle with administrative bottlenecks, limited institutional capacity, and overlapping funding mechanisms. These structural barriers can delay permitting, procurement, and regulatory compliance, especially for complex infrastructure and high-TRL projects. DG REGIO is addressing these gaps through technical assistance and closer coordination with Horizon Europe and other innovation instruments.

4.3.4 Transport Emissions and Sustainable Aviation Fuels

Pedro Francisco, Policy Officer, European Commission, Directorate General MOVE

Pedro Francisco (DG MOVE) outlined the critical role of the transport sector in achieving the EU's decarbonisation targets, particularly under the Fit for 55 Package and the 2040 climate framework. Transport remains the third-largest source of greenhouse gas emissions in the EU, with aviation accounting for nearly 14% of that share.

The Commission's flagship initiative in this space, ReFuelEU Aviation, is designed to support the market deployment of Sustainable Aviation Fuels (SAFs) – some of which will derive directly from Solar-to-X and Power-to-X solutions. The recent regulation establishes binding obligations for fuel suppliers, airport operators, and airlines to ensure the gradual integration of SAFs across all Union airports, starting in 2025. SAFs,[6] an acronym that encompasses synthetic fuels, advanced biofuels, and recycled carbon fuels—must meet the sustainability criteria set under the Renewable Energy Directive.



[6] SAF stands for Sustainable Aviation Fuels and the definition is set out in the ReFuelEU Aviation Regulation. It covers different drop-in aviation fuels compliant with the sustainability criteria of the Renewable Energy Directive (RED):

- Synthetic aviation fuels from renewable hydrogen and captured carbon, often abbreviated e-SAF;
- Advanced biofuels from waste and residues;
- Biofuels produced from oils and fats;
- Recycled carbon aviation fuels.

For more information, please refer to the ReFuelEU regulation.

4.4 Showcasing European R&I on Hydrogen – How does it work in practice?

With the industrial keynote and the policy session setting the overall frame and context of the event, the focus then shifted to practice. The next session showcased concrete innovations in the field of hydrogen, highlighting how technological advances are already taking shape and contributing to the transition toward sustainable energy systems.

Six running EIC projects on hydrogen presented their innovation goals. In line with the technological roadmapping character of the workshop, all projects—for one of the first times—followed a strict template to present the state-of-the-art of technical key performance indicators and their future milestones. This approach ensured a structured and comparable overview, serving as a direct outcome and valorisation of EU project results for the roadmapping exercise. The goal of this session was to present the overall innovation idea and the contribution of each technology to a fully sustainable and scalable hydrogen production, to give the state-of-the-art and future technical milestones in a transparent manner, and to highlight current hurdles at all levels, including technical and regulatory. The individual project pitches can be found in the appendix.

The European Innovation Council (EIC) stands at the forefront of Europe's research and innovation landscape, supporting disruptive ideas and fostering their commercialisation and technology transfer. Among its initiatives, the EIC has introduced "project portfolios," collaborative efforts that bring together projects across related topics to accelerate innovation. One of the first such initiatives, launched in 2021, is the EIC Green Hydrogen Portfolio, created under the Pathfinder Challenge call *"Novel Routes to Green Hydrogen Production."* The portfolio brings together nine projects with nearly €29 million in combined funding, running through September 2027. Its aim is to advance disruptive, early-stage research into sustainable hydrogen production based on renewable energy and non-critical raw materials, covering biological, electrochemical, and solar-driven pathways. Reflecting the EIC's high-risk, high-gain approach to funding, the portfolio seeks to bridge the gap between exploratory research and scalable solutions. During the session, six of the nine projects presented their innovative approaches, illustrating both the scientific creativity and systemic integration potential driving Europe's hydrogen future.

ANEMEL

Pau Farras presented the ANEMEL project which addresses a key challenge in scalable hydrogen production: working with impure water.

Utilizing a membrane-based system, ANEMEL can directly split saline and wastewater using renewable electricity, bypassing pre-treatment processes. This innovation reduces energy and material inputs while achieving high industrial current densities. With selective membranes and non-precious metal catalysts, ANEMEL ensures corrosion resistance and stable performance in saline conditions, ideal for off-grid or offshore applications where fresh water is scarce. Early tests demonstrate minimal degradation, indicating strong potential for scalability and durability in diverse water chemistries, aligning with sustainability goals.

Kathryn Toghill presented DualFlow.eu which reimagines hydrogen production as part of an integrated energy and chemical manufacturing system.

Rather than traditional electrolysis, the project uses flow batteries with redox mediators that can be selectively charged and discharged to generate hydrogen or high-value chemicals. This decoupled design allows flexible operation under intermittent renewable inputs. The system produces hydrogen at a targeted rate of 1 kg/h while simultaneously synthesizing compounds like luciferin and nanocellulose precursors, fine chemicals with a market value exceeding €100 per gram. The current focus lies in improving redox mediator stability and catalytic cycling efficiency. Challenges include managing product separation, system water balance, and developing flow battery standards suitable for certification and integration. DualFlow's novel co-production model positions it at the crossroads of energy storage, green chemistry, and decentralised manufacturing.

Wei Zhao presented MacGhyver explores the convergence of wastewater treatment and green hydrogen generation through microfluidic membrane-less electrolyzers (MMEs).

Designed for pharmaceutical and municipal wastewater streams, the device uses renewable energy to split water while concurrently removing contaminants. This dual-purpose system offers a compelling value proposition: treating difficult effluents while generating clean hydrogen. The technology's key advantage is its ability to maintain high current densities and efficient bubble management within a compact, modular architecture. The project demonstrates strong alignment with EU goals around water reuse, circular economy, and decentralised hydrogen deployment.

Alfonso Jaramillo presented PhotosSynH2 which builds on a fully biological, light-driven hydrogen production approach using genetically engineered cyanobacteria.

By reconfiguring natural photosynthesis, the team has developed strains capable of channelling electrons from water splitting toward oxygen-resistant hydrogenases. The process operates in a custom-built, multiplate photobioreactor using solar energy and seawater, generating biohydrogen in a closed-loop system. The project reports solar-to-hydrogen efficiencies of 5%, with ambitions to reach 10% through advanced gene regulation and reactor design. Innovations include enhanced cyanobacteria strains with improved tolerance and modified electron pathways to maintain stable hydrogenase activity. This method not only promises sustainable biohydrogen production but also offers potential co-products like astaxanthin. Addressing technical challenges like enzyme oxygen sensitivity and the scalability of photobioreactors, PhotoSynH2 represents a forward-thinking alternative to conventional hydrogen technologies, contributing to the future of solar fuels.

Fredrik Granberg presented EPOCH's novel concept for green hydrogen: co-producing hydrogen and platform chemicals through electrocatalytic oxidation of lignin derivatives.

Using a metal-free, carbon-based catalyst in a flow cell, the system converts water and biomass waste into liquid organic hydrogen carriers and oxygenated lignin compounds. This dual-output configuration aims to lower the overall cost of hydrogen by valorising side streams. The process avoids oxygen gas production at the anode, improving energy efficiency and reactor safety. Although still at prototype level, EPOCH has demonstrated functional oxidation of phenolic substrates and is working toward identifying optimal lignin feedstocks. Scalability, feedstock cost, and hydrogen throughput remain key constraints. Nonetheless, the technology's potential to decouple hydrogen production from water electrolysis, reduce critical raw materials (CRM) dependency, and unlock biorefinery synergies positions it as a highly promising pathway.

Sixto Giménez presented OHPERA which focuses on the direct solar-driven hydrogen production from waste glycerol using eco-designed photoelectrochemical cells.

The process uses lead-free halide perovskites and non-CRM electrocatalysts to convert biomass-derived glycerol into hydrogen and dihydroxyacetone (DHA), a high-value chemical used in pharmaceuticals and cosmetics. A key strength of OHPERA is its integration of eco-design principles and sustainability assessments from the outset. The team has built 10 cm^2 lab-scale reactors and is now addressing scale-up challenges, such as the deposition of perovskite layers and mass transfer optimization. Feedstock availability and market demand for DHA are also being evaluated. OHPERA bridges the renewable energy, waste valorisation, and specialty chemicals sectors, demonstrating how clean energy transitions can benefit from cross-sectoral circularity.

Philippe Vernoux presented ELOBIO which targets the large-scale production of hydrogen and bio-based platform chemicals from lignocellulosic biomass.

Unlike conventional electrolysis, the project leverages the co-electrolysis of sugars and hydroxymethylfurfural to simultaneously yield green hydrogen and high added-value chemicals, such as FDCA (furandicarboxylic acid, a sustainable substituent for terephthalate in the production of plastics) and glucaric acid (also an interesting starting material in the synthesis bio-based plastics, detergents, and food products). ELOBIO's design avoids the use of per- and polyfluoroalkyl substances (i.e. PFAS) and precious metals, relying instead on flow reactors and selective electrocatalysts. Despite their varied approaches to hydrogen production, the projects in this EIC-funded portfolio share several common hurdles. Chief among them is the challenge of scale-up – from lab-scale devices and prototypes to commercially viable systems. Whether operating in microfluidic, photobiological, or flow reactor configurations, each project must contend with material durability, system integration, and long-term operational stability. Additionally, feedstock availability (glycerol, lignin, wastewater) and the need to avoid or substitute CRMs are recurring themes. Regulatory ambiguity – particularly around environmental standards, product classification, and genetically modified organisms – further complicates the path to market. Finally, economic competitiveness hinges on the successful co-production of value-added chemicals or integration into broader energy systems, underscoring the importance of cross-sector collaboration.

4.5 Innovation in practice

Building on the morning sessions, several key insights had emerged: sustainable molecules such as hydrogen are central to defossilising energy, chemicals, agriculture, and other hard-to-abate sectors; novel technologies are indispensable in this transition; the future scale of demand for these molecules will be enormous, making full sustainability and scalability essential; and Europe's policy ambitions underline carbon neutrality, strategic autonomy, and secure energy supply. The innovation session had already highlighted promising low-TRL hydrogen technologies, but the critical question remained: how can these solutions move from the lab to the fab?

To address this, the next session opened with broad perspectives on innovation from Michiel Scheffer, President of the Board of the European Innovation Council, and Tim van den Bergh of the World Economic Forum. Their contributions set the stage for two thematic discussions. The first explored system-level enablers of innovation, such as standardized benchmarking for solar-to-X technologies, the role of incubators, large-scale public–private initiatives, and the importance of early capacity building in education. The second gave voice to start-ups and SMEs, with four promising companies presenting their innovations while candidly sharing the regulatory and market hurdles they face in bringing renewable molecules to cost-competitive deployment. Michiel Scheffer, President of the EIC Board,[7] opened this session with a candid reflection on the role of the EIC in transforming breakthrough science into large-scale industrial change. Representing the "innovation arm" of the European Union, the EIC operates not simply as a funding agency but as a dynamic instrument of policy implementation, designed to accelerate the EU's green and digital transitions.

4.5.1 Towards a European Innovation Ecosystem

Michiel Scheffer, President of the Board, European Innovation

Scheffer began by highlighting the ecosystem-building mission of the EIC. While innovation networks have long existed across Europe, the EIC's role is to consolidate and enhance these networks by actively supporting promising technologies and covering the infamous innovation "valley of death" through a structured pathway of instruments: Pathfinder, Transition, and Accelerator. With this structure, the EIC aims to help deep tech innovators climb the ladder from early experimentation to industrial deployment, not just with grants but with advisory services, training, and ecosystem connection.

Scheffer described the EIC as a political instrument, implementing the policy goals of the European Commission. Green innovation is a central priority, with a target for at least one-third of the EIC's portfolio to address environmental challenges. At present, this figure stands closer to 17–18%, underscoring the need for stronger uptake in energy, materials, and climate-related sectors. Scheffer noted that while Europe has made significant progress in achieving autonomy in renewable energy, materials innovation is lagging behind. Advancing Europe's independence in critical materials and green manufacturing is a strategic priority, and EIC-funded projects in this domain are essential contributors.

[7] The EIC Board, composed of independent experts, provides strategic leadership and guidance for the European Innovation Council, ensuring its programs effectively support breakthrough innovations and entrepreneurial growth across Europe. Its functions include advising on strategic priorities, overseeing program implementation, and engaging with key stakeholders to foster a robust innovation ecosystem.

The importance of scalability was another focal point. Projects operating at the lab scale, Scheffer argued, will not be sufficient to meet the urgency of climate objectives. Industrial relevance will only be achieved when Europe builds plants capable of processing tens or hundreds of thousands of tonnes per year. The current funding structure now includes larger-scale instruments, and upcoming opportunities will support more mature demonstrations. For the green hydrogen and sustainable materials clusters in particular, Scheffer encouraged consortia to think beyond pilot stages and to develop robust business cases that support real industrial deployment.

Scheffer also highlighted the importance of identifying regulatory barriers. While technical progress is often emphasised, policy and regulation can enable or obstruct innovation. The EIC is tasked with collecting structured feedback on these issues and liaising with the European Commission and Member States to improve the enabling environment. Innovators were encouraged to channel such insights via their programme officers or directly through the EIC Board's consultation mechanisms.

4.5.2 CCU towards a circular carbon economy

Tim van den Bergh, Climate Lead, World Economic Forum

As a second keynote, Tim van den Bergh of the World Economic Forum (WEF)[8] addressed the transformative role of innovation in building a sustainable, circular carbon economy. Whitin the urgency of the climate crisis, van den Bergh argued that greenhouse gas emissions should not be viewed merely as a compliance challenge, but as a catalytic opportunity for industrial modernisation, job creation, and long-term economic growth. The CCU sector alone, he noted, has the potential to evolve into a $4.4 trillion global market.

Yet, the commercial maturity of CCU technologies remains limited. Currently, only around 20–30 industrial-scale CCU facilities operate globally, underscoring the difficulties associated with scaling high-impact

[8] The World Economic Forum (WEF) is an international organization that convenes leaders from business, government, academia, and civil society to discuss and address major global challenges. Best known for its annual meeting in Davos, the WEF aims to foster public-private cooperation to improve global economic and social conditions.

technologies in this space. Barriers include unfavourable regulatory frameworks, the dominance of carbon capture and storage (CCS) over CCU in climate policy, and prohibitive financing requirements. Van den Bergh noted that financial and policy environments are still largely structured around sequestration rather than circular utilisation, limiting innovation in synthetic fuels, chemicals, and other carbon-based products.

In this context, van den Bergh introduced UpLink, a World Economic Forum platform developed in collaboration with Salesforce and Deloitte. UpLink is designed to support high-potential startups tackling sustainability challenges through targeted ecosystem development, visibility, and funding pathways. Since its launch in 2020, the platform has facilitated 66 innovation challenges, supported over 500 top innovators from 75 countries, and established 11 thematic innovation ecosystems across domains such as clean energy, sustainable mining, and water management. Startups can leverage WEF's convening power to connect with industrial players, policymakers, investors, and public institutions. The platform also supports public–private collaboration models and blended finance initiatives that are essential to derisk large-scale deployment of emerging climate technologies. Van den Bergh highlighted successful EIC-funded startups that have entered the UpLink ecosystem, such as eChemicles and D-CRBN, UpCatalyst, as examples of how European innovation can achieve global relevance through strategic partnerships.

Concerning the financial realities of scaling CCU, Van den Bergh pointed out that capital intensity remains a significant barrier, particularly for process infrastructure and demonstration plants. This makes the role of innovative finance, including venture funding, concessionary loans, and government-backed guarantees, especially crucial. He stressed the need for financing models that can accommodate long development cycles and the systemic nature of climate innovation.

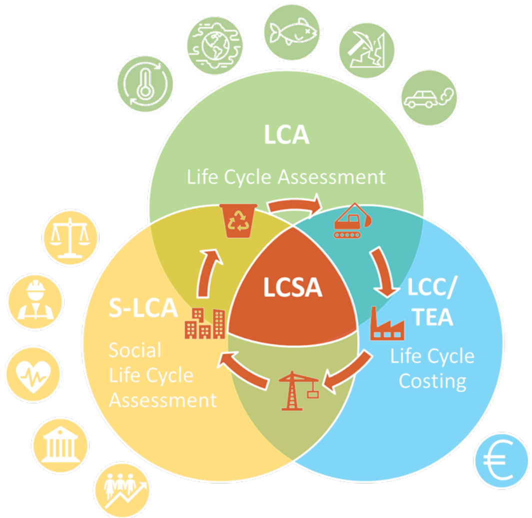
4.5.3 Key enablers: from benchmark to capacity building

Next to appropriate financing mechanisms, multiple other factors are key to enable the upscaling of deep tech innovation. This sub-session explored some enablers that shape the trajectory of sustainable innovation, ranging from early-stage sustainability assessments to the infrastructure and policy tools that accelerate market deployment.

Together, the speakers demonstrated that sustainable innovation requires more than breakthrough ideas; it needs the right frameworks, funding instruments, and collaboration models to scale. Whether through early sustainability benchmarking, mission-driven public policy, start-up incubation, or coordinated EU investment in hydrogen, each intervention reinforced the message that enabling structures are just as critical as the technologies themselves.

Miet van Dael, VITO: From benchmarking to capacity building row

Miet Van Dael (VITO) emphasized the importance of embedding sustainability analysis into the earliest stages of technological development. According to Van Dael, more than 80% of a technology's future environmental and social impact is locked in at low TRLs. Therefore, sustainability cannot be a downstream validation exercise, guiding research, design, and funding priorities from the outset. She introduced a framework called "techno-sustainability analysis," designed to align emerging technologies with environmental, economic, and social performance indicators right from the beginning. Rather than simply performing lifecycle assessments (LCA) at the end of development, this approach incorporates questions around scalability, feedstock availability, location-specific factors, and market positioning into the R&D process. It helps innovators identify potential bottlenecks, select promising alternatives, and set tangible research targets that support sustainability by design.



Van Dael also argued that this kind of harmonised and transparent sustainability benchmarking provides a critical decision-making tool, not only for researchers but also for industrial partners and policymakers. It enables early-stage projects to engage in structured dialogue with regulators and funding bodies, ensuring that promising innovations are aligned with long-term climate goals and European strategic interests. Her intervention provided a strong reminder that techno-economic feasibility must be matched with sustainability feasibility if the EU is to achieve industrial decarbonisation at scale.

Vera Grimm, German Federal Ministry of Education and Research: Empowering the innovators of tomorrow

Representing the German Federal Ministry of Education and Research, **Vera Grimm** underlined that the transition to sustainable energy and chemicals will depend as much on people and research culture as on technology itself. While breakthrough fields such as artificial photosynthesis and sunlight-to-X hold enormous promise, Grimm stressed that true innovation is rarely linear: disruptive advances emerge from long-term, curiosity-driven science rather than short project cycles. She emphasised the essential role of young researchers, whose creativity, risk-taking and interdisciplinary skills are indispensable for developing the scientific foundations of future climate solutions. Yet early-career scientists face significant barriers. Drawing on the European Commission's studies, Grimm highlighted persistent obstacles including lack of long-term career prospects, difficulties in securing funding, limited autonomy, and the need for mentoring and access to cutting-edge facilities. These challenges are amplified in interdisciplinary areas like artificial photosynthesis, which require expertise across chemistry, materials science, engineering, and policy. To address these gaps, Grimm presented targeted capacity-building initiatives such as Germany's SINATRA programme, which establishes junior research groups in solar energy conversion and provides up to six years of secure support. Beyond funding, SINATRA fosters international collaboration, mobility, mentoring by senior experts, and links to industry and start-ups—creating what she described as an environment where young scientists can truly excel. Similar models are being extended to other strategic fields, including nuclear fusion. Grimm closed by calling for a bold, independent budget for research and innovation in the post-2027 EU financial framework. Empowering the next generation, she argued, is essential to Europe's competitiveness and to building the scientific breakthroughs needed for a sustainable, circular carbon economy.

Liesbet Boogaerts, Bluechem: **An incubator for sustainable chemistry**

Liesbet Boogaerts introduced BlueChem as a pioneering incubator for sustainable chemistry, located in the heart of Europe's largest chemical cluster in Antwerp (Belgium). As the first of its kind in Belgium, BlueChem provides start-ups and scale-ups with ready-to-use lab space, tailored services, and a fully integrated industrial ecosystem designed to fast-track innovation into market-ready solutions. The incubator supports circular chemistry, advanced bio-based materials, process intensification, and green product design, with a strong emphasis on industrial symbiosis. It offers more than just physical infrastructure: BlueChem's "Kickstart Fund" enables lab installation subsidies of up to 80%, while its strategic partnerships connect start-ups to legal, regulatory, HR, IP, and funding expertise. The initiative also works closely with BlueApp and the University of Antwerp to bridge research and commercialisation. Boogaerts highlighted the unique positioning of Antwerp as a global hub for chemical innovation, offering access to logistics, talent, and international markets. BlueChem leverages this to offer an "innovation journey" for sustainable chemistry companies, supporting them from idea to industrial scale, across different levels of technological maturity. This holistic model has already attracted multiple residents and partnerships and is now being expanded as part of the region's broader mission to become a leader in the circular economy.

Claudiu Pavel, Clean Hydrogen Joint Undertaking: **Advancing hydrogen research and innovation through public-private funding**

Claudiu Pavel representing the Clean Hydrogen Joint Undertaking (JU) addressed the EU's coordinated investment strategy to build a comprehensive hydrogen value chain. With over €1 billion allocated through Horizon Europe and an additional €200 million for Hydrogen Valleys under REPowerEU, the JU supports over 380 projects across production, storage, distribution, and end-use applications. Pavel outlined the evolution of the JU as a unique public–private partnership, bringing together over 770 members from research, industry, and regions. Its mission is to improve the efficiency, reliability, and cost-effectiveness of clean hydrogen technologies while strengthening EU competitiveness and accelerating market adoption. The JU not only funds research but plays an active role in standardisation, regulatory development, and knowledge dissemination across Member States. The Clean Hydrogen JU is increasingly focused on large-scale demonstrations and market pull activities. Its latest strategic research agenda (SRIA 2021–2027) includes topics like next-generation electrolysers, hydrogen transport, and industrial decarbonisation. Pavel emphasized the growing collaboration with the EIC, particularly in aligning calls and amplifying the results of high-risk, early-stage projects through the JU's infrastructure. Finally, Pavel invited stakeholders to contribute to shaping upcoming calls and deepen synergies between funding instruments, calling for broader engagement to ensure clean hydrogen becomes not just a research priority but a mainstream energy solution.

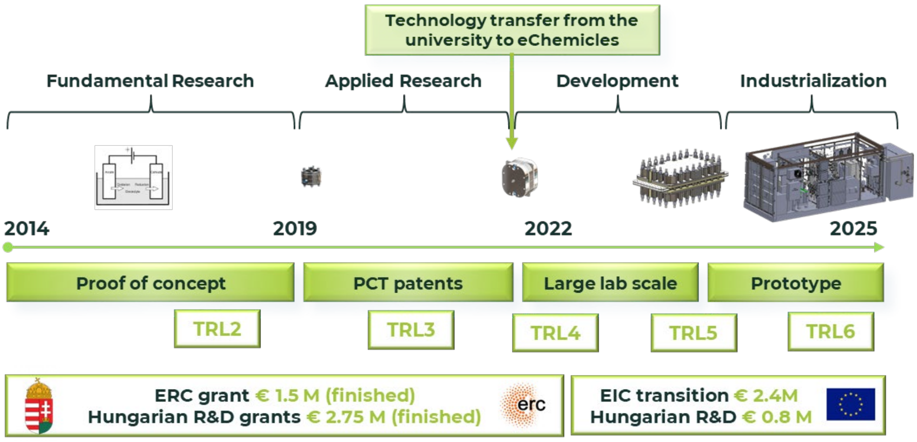
4.5.4 A start-up perspective on innovation

This sub-session brought together four pioneering entrepreneurs to reflect on the journey from lab-scale innovation to market-driven impact. Featuring case studies from eChemicles, Matteco, Ionysis, and TripleHelix, the panel showcased the diversity of pathways to industrialisation in climate tech from electrochemical CO_2 conversion to next-generation fuel cells and circular chemistry. Each presentation highlighted the critical role of public support in deeptech in bridging the "valley of death," and underscored the importance of integrating technical excellence with business acumen, strategic partnerships, and flexible financing models. Together, the speakers offered a grounded view of the challenges and opportunities facing Europe's emerging deep-tech champions.

Across the interventions, a set of common threads emerged: the urgency of scaling under capital constraints, the complexity of system integration, and the need for long-term policy alignment to unlock industrial uptake. While the technologies presented differed in focus and application, each speaker emphasised that successful climate innovation requires not only breakthrough science, but the creation of ecosystems to link start-ups with infrastructure, talent, and demand. The EIC's Transition instrument was consistently cited as a crucial enabler, but speakers also pointed to gaps in permitting, procurement, and finance that still hinder industrial deployment. The session ultimately served as a call to action: to complement frontier innovation with the right conditions for commercialisation, and to empower the next wave of European industrial leaders.

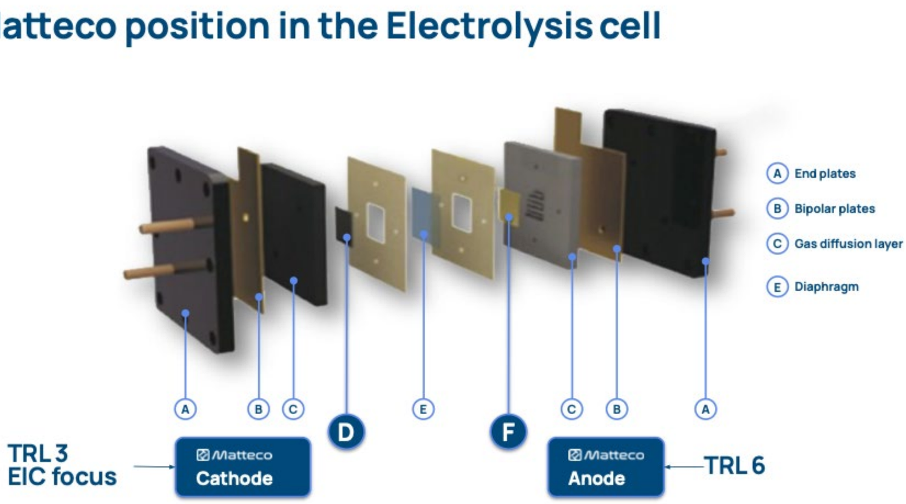
Csaba Janáky, eChemicles: **World's first containerised low temperature CO_2 electrolyser**

Csaba Janáky presented eChemicles, a spin-off built to commercialise low-temperature electrochemical CO_2 conversion technologies. The company's mission is to transform captured CO_2 into valuable industrial feedstocks, first to carbon monoxide (CO), and then to ethylene, all using renewable electricity. This technology offers a pathway to sustainable chemical production while helping decouple industrial emissions from fossil-based processes. A successfully completed EIC Transition grant, the SolarCO2Value project, has contributed to bring this CO_2 electrolysis technology from TRL 4 to TRL 6. Janáky highlighted eChemicles' containerised electrolyser system, a first-of-its-kind solution achieving class-leading metrics such as 400 mA cm^{-2} current density, over 90% Faradaic efficiency, and 50% energy efficiency. These results have positioned the company at the frontier of electrochemical CO_2 reduction. The firm is currently focused on four scaling axes: technology (pilot plant development), operations (MEA manufacturing), HR (doubling its team), and commercial (market entry with containerised units). Now, a €15M Series A round is underway to support this expansion. Janáky stressed that commercialisation hinges not just on technological performance but on system integration and investment partnerships. The EIC's support through the Transition programme was critical in bridging early scientific breakthroughs into an investable business proposition. The company is now actively engaging with industrial clients and exploring strategic co-development routes to accelerate adoption. The presentation served as a compelling example of deep-tech valorisation from lab-scale to industrial relevance.



Carlos Sanz, Matteco: Catalysts and electrodes to decarbonise the economy

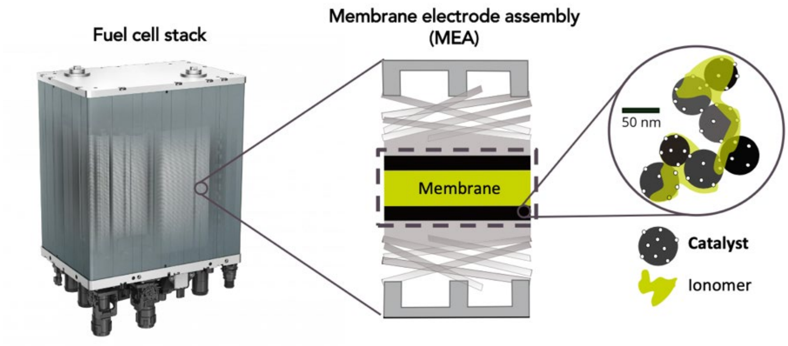
Carlos Sanz introduced Matteco, a cleantech start-up based in Valencia, spun out from over a decade of R&D in advanced materials. The company develops high-performance, cost-effective electrodes and catalysts designed to optimise green hydrogen production, targeting substantial improvements in energy efficiency, durability, and economic viability. Their innovations are central to electrolysis, one of the key technologies behind the transition to a hydrogen economy. Matteco's flagship materials contribute to up to 20% reductions in the levelized cost of hydrogen, while also removing the need for platinum group metals (PGMs) and reducing surface area and maintenance costs. The company has already launched its first catalysts to market and is rapidly scaling up manufacturing capabilities in a new 10,000 m^2 facility. Their roadmap includes extending product offerings across hydrogen and e-fuels applications, with ambitions to enter the battery and water purification sectors.



The [MATCATH2.0 project](), recently started under the EIC Transition programme, targets the transition from TRL 3 to TRL 6, facilitating first market deployments and setting the stage for larger-scale industrial adoption. Matteco has already closed a €15M Series A funding round and is growing its team and infrastructure. Sanz framed the company as a bridge between scientific excellence and industrial need, all while emphasising the strategic role of materials in energy transition and the catalytic impact of EIC support in accelerating commercialization.

Andreas Büchler, ionysis: PSFA-free membrane-electrode assemblies and electrodes

Andreas Büchler presented the EIC Transition project ENABLER, carried out jointly by the Slovenian start-up ReCatalyst and the German start-up ionysis. The project aims at commercialising next-generation fuel cell technology. At the heart of their work is the development of PFAS-free membrane electrode assemblies (MEAs) that reduce environmental harm, cost, and critical material dependency, particularly on platinum and fluoropolymers, which are problematic in current systems.



The innovation lies in the design and scale-up of high-performance, roll-to-roll fabricated MEAs using intermetallic platinum-alloy catalysts and fluorine-free ionomers. These MEAs aim to achieve <€75/kW cost, 20,000-hour durability, and compatibility with operating temperatures above 100°C, all benchmarks needed for automotive and heavy-duty transport. ENABLER is advancing the technology from TRL 3–4 to TRL 6, targeting a validated short-stack for commercial demonstration within three years.

The EIC Transition funding allowed ENABLER to accelerate development cycles through coordinated milestones: catalyst tuning, membrane and ionomer development, stack validation, and early commercial partnerships. Büchler emphasized that this integrated and iterative model has created a unique dual-track innovation pipeline, enabling both ionysis and ReCatalyst to grow in parallel. The project's broader goal is to catalyse a clean, PFAS-free hydrogen economy, starting in transport and with potential spillovers to electrolyser applications. As such, ENABLER exemplifies how collaborative deep-tech development can resolve systemic barriers in Europe's energy transition.

Steven Peleman, TripleHelix: Materials reincarnation – molecules as a service

Steven Peleman delivered a dynamic, reality-grounded talk from the perspective of a serial entrepreneur navigating deep-tech scale-up. As co-founder of TripleHelix, Peleman focuses on circular ventures that transform waste into valuable chemicals, particularly in polyurethane recycling. His model hinges on "molecules-as-a-service", which would deliver value by preserving and repurposing chemical building blocks instead of discarding or incinerating them. TripleHelix's current pilot, G-PUR/SurePUre, recycles post-consumer PET and PU waste into circular polyols, addressing both environmental imperatives and supply chain resilience. The startup operates from BlueChem in Antwerp and is designed for replication within industrial clusters, supporting scalable, low-carbon, and economically viable circular chemistry. Peleman, however, cautioned against idealism. He described the "CAPEX cliff" that many hard-tech startups face when transitioning from pilot to commercial scale. Without robust industrial demand signals and adaptive financing tools, many viable technologies risk stalling. He also pointed to geopolitical instability, permitting delays, and procurement inertia as systemic hurdles that Europe must address to realise its climate ambitions. Nevertheless, TripleHelix is advancing toward industrial replication with strong regional support. Peleman concluded by calling for greater agility in funding instruments and public-private cooperation, stressing that circular startups represent not just innovation potential, but the new industrial reality Europe must embrace.

4.6 Co-creation workshops

The afternoon session facilitated direct exchanges among stakeholders, capitalizing on the diverse representation within the innovation ecosystem present at the event. Two main objectives guided these discussions. First, participants aimed to attain a comprehensive understanding of the current technological state-of-the-art and identify the essential next steps towards developing fully sustainable and scalable technologies. Insights from the morning presentations, structured around key performance indicators, provided valuable input for this endeavour, facilitated by technological roadmapping working groups. Second, the session addressed the critical issue of capacity building in education by convening a working group specifically for young researchers, further expanding upon discussions in the morning.

4.6.1 State-of-play: EIC-SUNERGY Technological Roadmapping Workshop

The European Innovation Council (EIC) is at the forefront of driving technological innovation, particularly in the realm of renewable fuels and chemicals. Recognizing the critical role of sustainable innovation in addressing global energy challenges, the EIC has been a pivotal force in advancing technological roadmapping as an essential tool for uniting the innovation ecosystem. With this mission in focus, the EIC organized, in tight collaboration with the European SUNERGY initiative, an afternoon working group session dedicated to technological roadmapping.[9]

Renewable fuels and chemicals, derived from renewable energy, water and abundantly available molecules, represent a promising pathway towards the circular utilization of natural resources. The exploration of various conversion technologies paves the way for a sustainable transition. A multitude of innovative approaches is explored, ranging from electricity-based devices to those capable of directly storing sunlight within chemical bonds. However, the foresight required to navigate this complex innovation landscape is no small feat, given the extensive array of technologies and stakeholders involved.

In addition to the variety of technological solutions being explored, there is an expansive choice of possible products. From fundamental molecules like water, CO_2, and N_2, a multitude of products can be constructed, similar to assembling with Lego blocks. The simplest product is molecular hydrogen, obtained by splitting water. However, more complex hydrocarbons can also be synthesized; these either serve as direct energy carriers, such as methane, or as valuable feedstocks for the chemical industry, like ethylene. Generally, the more carbon atoms involved, the more challenging it becomes to drive these reactions using renewable energy. For instance, the production of C1 molecules via CO_2 electrolysis is relatively mature, but producing longer carbon chains, such as C2 (ethylene) or C4+ (like those in aviation fuel), remains a significant research focus, particularly when the objective is to synthesize them within a single device directly from water and CO_2.

The Technological Roadmapping session held at the event facilitated this process through four distinct technical working groups: 1) Sustainable Carbon Capture, 2) Advanced electrochemical conversion, 3) Photosynthetic devices, and 4) Biological conversion. By fostering collaboration and dialogue among experts from various academic disciplines, industry leaders, and policy influencers, the roadmapping effort established a cohesive vision for the scalability and sustainability of these emerging technologies.

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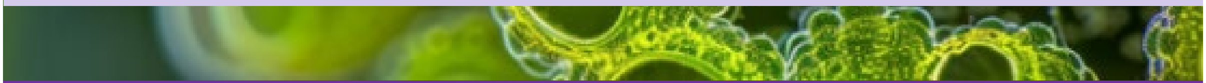
[9] For detailed information about the SUNERGY Technological Roadmapping, its methodology, process and ambition, please see: Faber C., Kargul J. et al (2025) *Solar fuels and chemicals technologies: A roadmap for innovation*. In: Studies in Surface Science and Catalysis: Unlocking the renewable energy and chemistry future through catalysis. vol. 180, Eds: V.I. Parvulescu, B.M. Weckhuysen, G. Centi and S. Perathoner, Elsevier: Solar fuels and chemicals technologies: A roadmap for innovation - ScienceDirect.

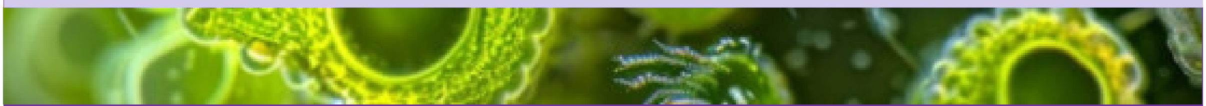
Advanced electrochemical conversion

This technology stores renewable electricity in the form of chemical bonds at the long-term. The focus is on highly integrated approaches where simple feedstock molecules, like CO_2, N_2 or water are converted into energy-rich molecules in a single system. This method promises energy efficiency and economic benefits by minimizing the additional equipment and downstream treatment. For example, instead of producing hydrogen from water and CO from CO_2 separately and combining them in a third reactor to create hydrocarbons, a single electrolyzer produces directly complex molecules from CO_2 and water.



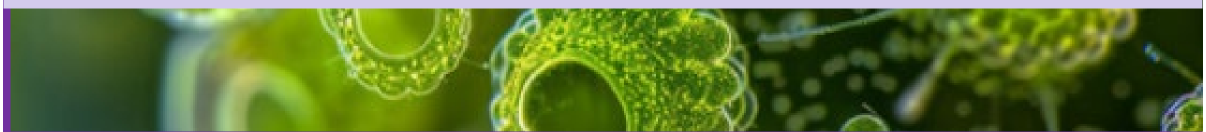
Sustainable carbon capture

Carbon capture represents the initial step in the production of fuels and chemicals from non-fossil resources. In the chemical industry, completely eliminating carbon is not possible, as carbon atoms are fundamental components in most chemical products. Given the vast scale of the chemical and transportation sectors, it is crucial to source carbon not only from fossil-free resources – achieving defossilization – but also to do so sustainably, with energy efficient and economically viable technologies.



Photosynthetic devices

Inspired by nature's process of photosynthesis, these technologies harness sunlight to convert simple, abundant feedstock molecules into complex molecules. A significant advantage of photosynthetic devices is their potential for fully decentralized use, which means they do not require connection to traditional grid infrastructure. This capability supports the vision of independent, self-sufficient energy and material communities. Additionally, they enable the long-term storage of solar energy in the form of chemical bonds.



Biological conversion

Biological conversion leverages the natural capabilities of microorganisms to construct complex molecules from basic feedstock. Through synthetic biology, the metabolic pathways of these organisms can be engineered to produce a wide array of desired products. For example, protein-rich powders, which are valuable for aquafeed applications as a sustainable alternative to fishmeal, can be produced. These powders, composed of long chains of carbon and hydrogen, can be synthesized from hydrogen and CO_2 using hydrogen-oxidizing bacteria. This approach showcases the versatility and potential of biological systems in creating sustainable solutions for various industries.

Through this event and the subsequent development of the technological roadmap, the EIC reinforces its commitment to fostering groundbreaking innovation and ensuring a sustainable and scalable future for renewable fuels and chemicals.

The afternoon working group sessions yielded crucial insights and strategic outcomes across different technological fronts, highlighting both the current state and future trajectories for carbon capture technologies, renewable hydrogen, fuels, and chemicals.

1. For sustainable carbon dioxide capture technologies, the discussions revealed that while absorption, adsorption, membrane, and cryogenic systems have attained a notable level of technological readiness, they still need advancements in market readiness. Emerging technologies like oxy-combustion, direct air capture (DAC), and direct ocean capture (DOC), although at the initial stages of development, are poised to become competitive by 2050 as R&D efforts accelerate.

2. In electrochemical technologies, it is anticipated that the first industrial implementations for C1 carbon molecules (e.g., CO and formates) may occur by 2035, with industrial demonstrators for C2 carbon molecules (e.g., ethylene and ethanol) expected to be ready by 2050. However, bio-electrolysis and low-temperature ammonia conversion still require extensive R&D before entering the piloting phase post-2035.

3. The working group on photosynthetic devices used the outcomes of the EIC Horizon Prize "Fuel from the Sun" competition as a launchpad for discussions.[10] The prize provided valuable insights into the state-of-the-art of diverse device architectures but emphasized the need for further device development and standardized testing. The vision for future applications highlighted the importance of developing devices akin to PV panels – compact, maintainable, and sustainable – suitable for decentralized, off-grid use without relying on toxic or critical raw materials. This also implies the crucial choice of which products to produce. At this early stage, a range of products is feasible, including hydrogen, methane, and jet fuel. It is important to support directions that align with envisaged application scenarios, focusing on products that are easy to store and directly usable in decentralized or remote applications.

4. Biological conversion technologies, particularly gas fermentation and third-generation algae biorefineries, have made substantial technical progress. By 2035, gas fermentation is anticipated to be on the brink of commercialization, with potential maturity by 2050. Similarly, algae-based biorefineries are progressing towards industrialization. In contrast, engineered microorganisms will require continued R&D to reach piloting stages after 2035.

The overarching conclusion from the SUNERGY roadmap indicates the potential for technological evolution across the CO_2 capture and utilization value chain. Early-stage technologies like biohybrid and direct photosynthetic conversion require ongoing efforts, while mature approaches like electrochemical synthesis of C1 molecules and gas fermentation are industrially feasible. Emphasizing industrial implementation can generate feedback loops to accelerate less mature technologies. By 2035, targeted efforts in integration, scaling, and sustainable system optimization could lessen the transition burden by 2050, paving the way

[10] For a detailed analysis of the competition outcome, please see: Faber C., Matteucci F., *Renewable fuels and chemicals from the sun: innovation in artificial photosynthesis research,* In: Studies in Surface Science and Catalysis: Unlocking the renewable energy and chemistry future through catalysis. vol. 180, Eds: V.I. Parvulescu, B.M. Weckhuysen, G. Centi and S. Perathoner, Elsevier: Renewable fuels and chemicals from the sun: Innovation in artificial photosynthesis research - ScienceDirect.

for industrial readiness of renewable fuels, chemicals, and plastics. Looking forward, cohesive technological packages integrating CO_2 capture, conversion, and product separation aligned with sustainability are essential. The SUNERGY network's collaboration among academia, industry, and policy is crucial, alongside a supportive policy framework to establish a de-fossilized industry in the EU. Regular updates to the SUNERGY roadmapping exercise will ensure adaptability to geopolitical, technological, and regulatory shifts.

4.6.2 Capacity building in practice: Young Researcher Workshop

The objective of this workshop was to raise awareness among young scientists on the types of skills required to take innovations to market. In the first session, attendees chose a low-maturity emerging technology and to list a series of actions and skills required to bring this technology to the market.

In the second session, a template previously prepared by the hosts was presented to the Young Researchers, including a list of six skills and knowledge categories, namely: (i) IPR and Publication; (ii) Business and Entrepreneurship; (iii) Communication and Networking; (iv) Regulation and Policy; (v) Scientific, Technologic and Upscaling; and (vi) Transversal skills. The Young Researchers were then asked to give their inputs on how they felt about each category/topic: "confident and knowledgeable", "unsure", or "no idea". Following this activity, the attendees were given space to comment on their response, and to think about which of these skills should be prioritized throughout their education and why and which ones instead can be potentially complemented by a team member or subcontracted as external services. To conclude the workshop, an open discussion encompassed different sources of information, education and training programs available for Young Scientists to complement their scientific profile with non-scientific skills.

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5. Second day

5.1 Summary

Day 2 of the "Sustainability Meets Scalability" event continued to facilitate dynamic exchanges among all stakeholders by offering a comprehensive overview of the innovation landscape for renewable fuels and chemicals – beyond hydrogen technologies. The agenda featured a mix of industry insights, policy framing, and practical demonstrations, showcasing the entire innovation journey from lab research to startup ventures, aligning with the EIC's commitment to supporting innovations at all stages.

The day began with a keynote address titled "Reality Check: The Scales We Need for Defossilization" by Prof. Maximilian Fleischer, Chief Technical Expert of Siemens-Energy and Honorary Professor at TU-Budapest. His talk highlighted the critical scales required for successful defossilization across industries.

This was followed by the "Renewable Fuels & Chemicals: Frame Setting" session, featuring a moderated round table discussion with leaders from European associations and initiatives, including Frédéric Chandezon from the EU SUNERGY Initiative, Alexis Dunand from Carbon Gap, Ludo Diels from P4P, Tudy Bernier from CO2ValueEurope, and Sophie Wilmet from Cefic. These discussions aimed to establish a comprehensive framework for advancing renewable solutions across Europe.

In the "Showcasing European R&I on Renewable Fuels & Chemicals" session, Claire Gauthier from the Programme Economie Circulaire du Carbone at CEA delivered a keynote address, followed by project pitches from EU-funded initiatives and startups. This segment highlighted the practical application of research and innovation, reflecting the full spectrum of technological maturity from lab development to commercialization.

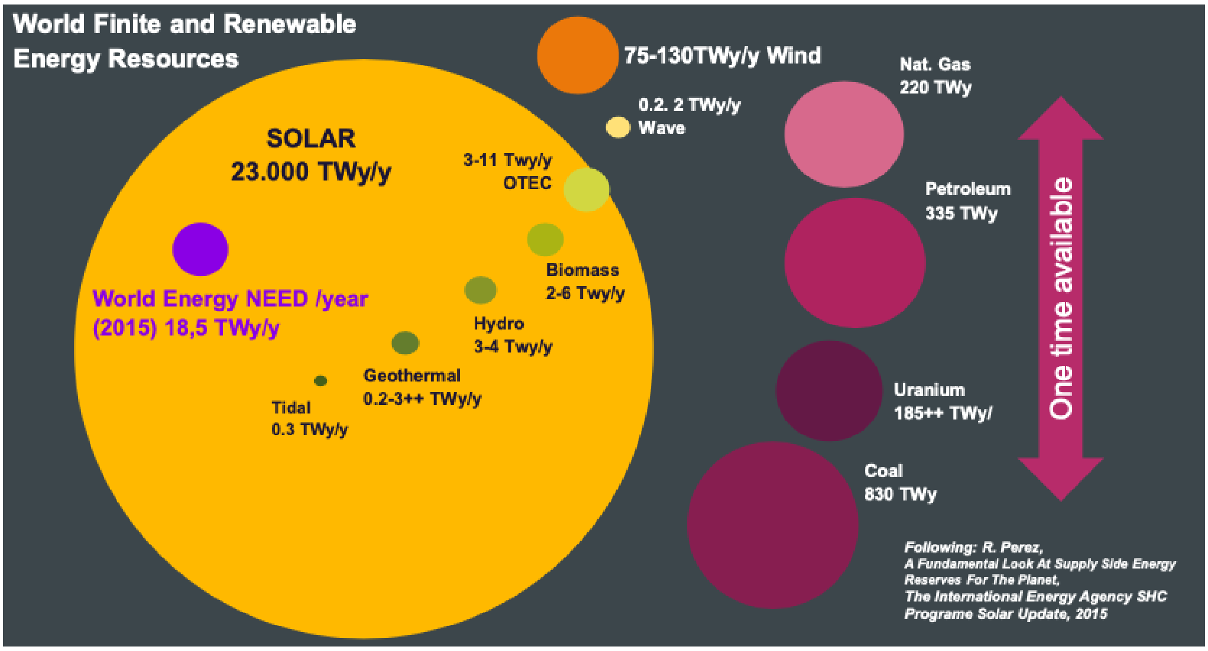
The afternoon featured a Co-Creation Session focused on the industrial uptake of Carbon Capture and Utilization (CCU) technologies. Participants had the option to join two breakout workshops: the SOLDAC Workshop on Sustainability & Integrated Industrial Process, or the Workshop on CCU Finance, Policy, and Cross-sector Collaboration. The latter was hosted by Tim van den Bergh from the World Economic Forum and Carina Faber from the European Innovation Council, with contributions from industry leaders such as Guus Keder from Fenix Ventures, Prachi Singh from LyondellBasell, and Csaba Janáky from eChemicles.

Day 2 reinforced the collaborative spirit of the event, bridging the gap between research, industry, and policy to drive forward innovations in renewable fuels and chemicals. Through diverse perspectives and an inclusive approach, the event underscored the vital steps needed to achieve a sustainable, fossil-free future.

5.2 Reality check: the scales needed for defossilisation

Prof. Dr. Maximilian Fleischer, Chief Technological Expert & CTO Siemens Energy Ventures

Maximilian Fleischer opened the second day with a powerful reality check on the scales and systems required to deliver a truly defossilised global energy economy. Speaking from Siemens Energy's unique position as a leading industrial actor and technology developer, Fleischer outlined the enormous yet technically feasible effort required to replace fossil energy with renewable sources, storage, and synthetic fuels. Fleischer began by framing the energy challenge not in terms of scarcity, but abundance of renewable energy, especially solar and wind. The sun provides more than 23,000 TWy/y, far more than the world's annual energy need (~18.5 TWy/y in 2015), but the key bottleneck lies in harvesting, storing, and transporting that energy at industrial scales.



With illustrative calculations, he showed that global primary energy demand could theoretically be met by photovoltaics alone, requiring an area the size of a third of Saudi Arabia and an investment between $60–100 trillion. While this may seem overwhelming, he pointed out that this investment is of similar magnitude to what the world already spends on fossil fuels over two decades. Additionally, the presentation stressed that the transition is no longer about whether it is technically possible, but whether we can scale the technologies fast enough. Siemens Energy is actively contributing to this scale-up with industrial-scale electrolyser production, as well as advanced hydrogen-capable turbines, sector coupling strategies, and large-scale deployment of renewable technologies.

Fleischer advocated for sector coupling as an essential principle of the energy transition. While power generation has seen the fastest decarbonization gains, other sectors - transport, industry, and buildings, still account for around 60% of global emissions but have seen much slower adoption of renewables. Electrification alone will not suffice: in line with the first presentation of the workshop by ENGIE's Chief Scientific Officer Jan Mertens, Fleischer stressed the importance of molecules to store, carry, and deliver power where and when it's needed, especially for hard-to-electrify industrial processes, such as long-haul transport, and aviation. In this sense, chemical storage in the shape of synthetic hydrocarbons offers the highest energy density and best option for long-duration and inter-seasonal storage, critical for system balancing. Such a system will need robust global infrastructure for energy transport, whether through hydrogen, ammonia, or synthetic fuels, all of which will contribute to the delocalisation and democratisation of energy.

The talk concluded with remarks on the importance of continued research and innovation to close technological gaps in areas like direct CO_2 electrolysis, DAC, and synthetic SAF pathways. Fleischer pointed to ongoing efforts, such as the large-scale demonstrator in Kassø, Denmark, and Siemens Energy's engagement in SAF production for the shipping and aviation sectors. Ultimately, the keynote served an optimistic assessment: the world has enough energy to cover its future needs, but requires coordinated industrial deployment, massive investment, and sustained innovation to convert that potential into climate-neutral infrastructure at the scale and speed that defossilisation demands.

5.3 Roundtable on Renewable Fuels & Chemicals: Frame setting

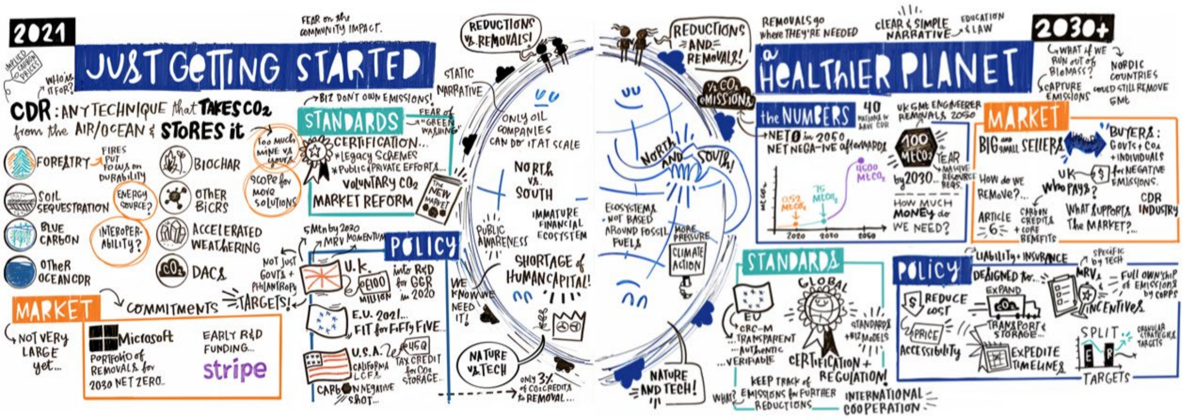
This roundtable brought together leading voices from European associations and initiatives to reflect on the state of renewable fuels and chemicals across policy, industry, and innovation. The multidisciplinary discussion tackled the key points and steps towards fully defossilising the energy and chemical value chains in Europe.

Ludo Diels, from the Processes4Planet partnership opened with a clear framing of the renewable carbon challenge. According to Diels, the future of the chemical industry must rely on carbon sourced from recycling, biomass, or CCU. However, even the best recycling systems incur losses of around 20%, which must still be replaced with virgin carbon, ideally from non-fossil sources. And while CCU is advancing in sectors like cement and inorganics, organic molecules (such as fuels, alcohols, and methane) still lag behind, largely due to technical and economic challenges in synthesis and hydrogen integration. Diels stressed that building up this new carbon economy will require integrated value chains, robust grid infrastructure, and technology pipelines capable of scaling to higher molecular complexity.

Tudy Bernier, from CO2ValueEurope reinforced this view, highlighting the current regulatory disconnect that penalises circular carbon pathways. In today's EU framework, CO_2 reused from industrial capture costs more than fossil fuel feedstocks, making CCU less competitive. Bernier urged for updated accounting frameworks and incentive mechanisms that reflect the true climate benefit of carbon circularity. Despite this, he kept optimistic tone, noting how renewable carbon technologies are increasingly present in EU strategies, from the Clean Industrial Deal to RePowerEU. Europe now has an opportunity to lead by example, avoiding the complacency seen in other jurisdictions reacting to recent US policy shifts like the Inflation Reduction Act.

Representing the industrial perspective, **Sophie Wilmet** from CEFIC underscored the foundational role of carbon in the chemical sector. "We cannot decarbonise carbon," she noted. Instead, the focus must shift to circular carbon management through closed-loop recycling, biomass, and CCU. She pointed to the structural investments needed to realise this shift: Europe currently lacks the infrastructure for important routes in refining, like methanol-to-olefins, which improve to meaningfully replace fossil carbon in chemical products. Access to renewable electricity and hydrogen, combined with long-term policy certainty, are essential enablers. A successful circular carbon strategy, she concluded, must treat chemicals on par with energy and climate in the EU cleantech agenda.

Alexis Dunand from Carbon Gap brought the discussion into the carbon removal space. He reminded the audience that many forms of CCS, such as concrete, plastics, biomass, and DAC-derived products, are long-lived and should be recognised within climate frameworks. According to EU targets, carbon removals must grow from 5 Mt/year today to potentially 100 Mt/year in the coming decades. This growth is not optional; it is necessary to achieve net-negative emissions and address legacy CO_2 from the industrial era. Dunand called for urgent progress in certification frameworks, deployment targets, and national integration strategies to enable carbon removal to contribute fully to climate goals.



Finally, **Frédéric Chandezon,** representing SUNERGY, a large-scale European Initiative on solar fuels and chemicals, offered closing reflections focused on system-level design. The future carbon economy cannot be circular in the strictest sense, some losses and needs for virgin carbon will persist. Therefore, we must create an industrial approach with built-in flexibility, adaptability, and resilience from the start. He also emphasised the human factor: engineers, technicians, and communities must be embedded into circular models, not just as beneficiaries but as active participants. Circularity, he concluded, must be implemented in parallel with large-scale capture and conversion technologies, supported by enabling infrastructure and policy.

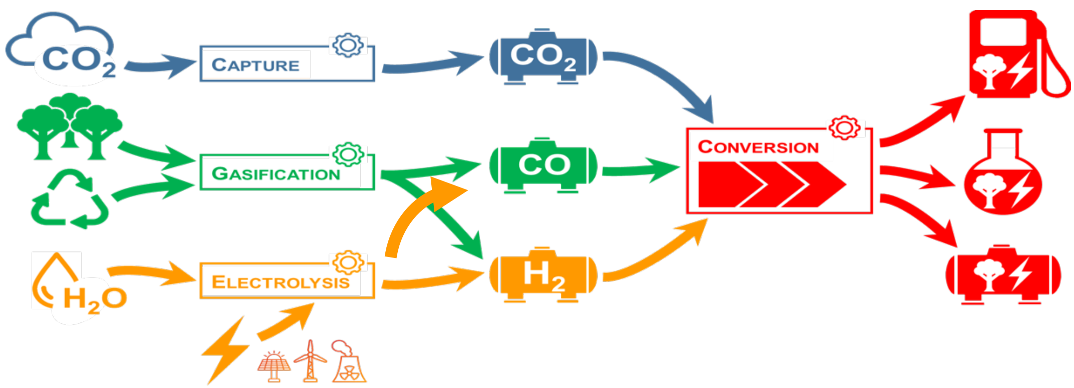
5.4 Showcasing European R&I on Renewable Fuels & Chemicals – How Does It Work in Practice?

This session provided a detailed and diverse look at how cutting-edge European research and innovation are driving real-world progress in renewable fuels and chemicals. With a particular emphasis on the transition from fossil feedstocks to sustainable, circular carbon solutions, the session gathered contributions from several forward-looking projects, all supported by the EU. The goal of the session was not just to show scientific potential, but to underline the diversity of ideas in the Solar-to-X and Power-to-X technological landscape. Additionally, the speakers commented on the concrete technological readiness, scalability pathways, and cross-sector integration required to defossilise complex sectors such as chemicals, aviation, and food production.

5.4.1 Research and innovation for a circular carbon economy

Claire Gauthier, Head of Circular Carbon Economy, CEA France

To start, **Claire Gauthier** from the French programme on circular carbon economy, delivered a keynote to set the stage. This session framed the urgency and systemic nature of the technological transformation underway. She reinforced the message that electrification, while essential, cannot fully substitute carbon-based materials in all sectors. For long-range transport, industrial heat, and chemical production, carbon remains indispensable. Thus, a circular carbon economy is not an optional vision, but a necessity.



Drawing on the IPCC's 2022 report and the Draghi's 2024 strategy on EU competitiveness, Gauthier described a future in which carbon is continuously reused through technologies such as CCU, DAC, and bioconversion pathways. This vision rests on four key technological approaches, including biological, photocatalytic, thermocatalytic, and electrocatalytic, all supported by low-carbon energy. The aim is to shift from a linear to a regenerative model, with optimised and integrated "technological bricks" that balance yield, energy efficiency, and life-cycle impact.

Importantly, the keynote stressed the dual need for more mature bricks (i.e. technologies ready for scalability), as well as disruptive bricks (i.e. innovative approaches to radically reshape future value chains). In this sense, the EIC and other European research and innovation programmes were highlighted as crucial actors in enabling both tracks to co-exist and accelerate. After this, the project presentations started, showcasing success stories across different EU funding frameworks, all focused on solutions towards synthetic fuels.

The subsequent project pitches demonstrated the extraordinary diversity and maturity of EU-funded research in renewable fuels and chemicals. Whether through biological, chemical, or electrochemical means, the projects all pursue the same goal: to defossilise key sectors while maintaining competitiveness and resource efficiency. From food to fuel, from DAC to methanation, these projects exemplify how the European research ecosystem is not only inventing the technologies of tomorrow but testing them in practice.

5.4.2 EU-funded projects and start-ups

SolDAC
FULL SPECTRUM SOLAR DIRECT AIR CAPTURE & CONVERSION

Isaac Herráiz from the SolDAC project explained a pioneering fully solar-driven process to capture CO_2 from ambient air and convert it into synthetic fuels through DAC and photo-electrocatalysis.

The system relies on modular photoelectrochemical cells capable of handling real-world solar flux and weather variability. This makes the technology especially suitable for off-grid or remote production hubs where green hydrogen infrastructure is lacking. With funding from Horizon Europe and support from the EIC ecosystem, SolDAC aims to provide a competitive, decentralised alternative to fossil-based fuels for sectors such as shipping and aviation. One of the project's strengths is its holistic approach: it integrates capture, conversion, and synthesis in a compact device, potentially lowering CAPEX and OPEX compared to segmented systems. The project also emphasises circular material use and lifecycle impact, developing sustainable membranes and catalysts with minimal reliance on critical raw materials. The EU support has been pivotal not only for the R&D itself, but for forging transnational collaboration across universities, SMEs, and industrial actors. SolDAC positions itself as a bridge between basic science and market readiness, with several key performance indicators already demonstrating feasibility at lab scale.

S2B

Yagut Allahverdiyeva-Rinne, from the Sunlight to Butanol (or S2B) project presented biological solutions to renewable fuel production, specifically leveraging photosynthetic microorganisms to convert solar energy and CO_2 directly into useful chemicals and feedstocks.

The goal is to unlock a highly scalable biotechnological platform for carbon-neutral production without the need for arable land or biomass feedstock. The S2B consortium combines expertise in microbiology, bioprocessing, and systems integration, supported by European funding mechanisms that make such multidisciplinary collaboration viable. Core innovations include synthetic biology for strain engineering and optimised photobioreactor design. The project also contributes to knowledge-sharing on energy efficiency and the productivity of phototrophic platforms, an area where plant-based routes have historically underperformed. The EIC's funding allows the project to tackle long-term challenges, such as scale-up and metabolic efficiency, while also investing in communication and policy engagement to support future regulatory frameworks for microbial biomanufacturing. S2B aligns strongly with the circular carbon economy vision by offering a biological pathway to fuels and chemicals that is circular, land-sparing, and modular.

Ezgi Oegun Ramalhete, from Mi-Hy, presented a Project with a highly innovative proposal: combining microbiological processes with hydrogen and CO_2 to produce renewable methane.

The process exploits the unique metabolic pathways of methanogenic microorganisms in a bio-electrochemical setup. By coupling hydrogen production from renewable electricity with biological conversion, the project offers a promising avenue for green methane production, particularly relevant for grid injection and industrial feedstocks. Backed by EU support, Mi-Hy focuses on simplifying the value chain by removing intermediate chemical steps. The concept demonstrates impressive energy efficiency and offers real-time flexibility, ideal for intermittent renewable energy supply. Moreover, the system could support local, decentralised production units, contributing to grid resilience and rural development. Mi-Hy is a classic example of an EIC-funded project, following a high risk, high reward. It stands at the intersection of bioengineering, energy systems, and circular chemistry. So far, the funding has helped the team accelerate development from lab scale to pilot validation, with tangible KPIs in conversion yield and process stability. The project also contributes to wider goals around EU energy autonomy and defossilisation of the gas grid.

Juha-Pekka Pitkänen introduced the Finish start-up Solar Foods, one of the most compelling and innovative examples of CO_2 valorisation, which works towards transforming carbon emissions into protein-rich food.

Their proprietary "Solein" process uses hydrogen-oxidising bacteria to transform CO_2, water, and renewable electricity into a high-protein powder. Compared to traditional agriculture, this process is 10x more energy efficient per calorie and completely decoupled from land use, seasonality, or climate. Solar Foods has already reached TRL8–9, with a commercial demonstration plant producing 100 tonnes of Solein annually. The company is part of two major EU projects: the IPCEI Hydrogen programme and the EIC Pathfinder-funded HydroCow initiative. This dual support has been crucial in scaling production and navigating regulatory hurdles, particularly with novel food approvals within the EFSA. This approach not only helps decarbonise food production but also intersects with climate goals by permanently sequestering CO_2 in consumable products. Solar Foods exemplifies how biotechnological innovation, backed by the EU, can create entirely new industries that are both sustainable and economically viable.

Alessio Fuoco, from DAM4CO2, presented a project to merge CO_2 capture and conversion in a single membrane-based device. Using renewable energy and advanced catalytic membranes, the system produces C4+ hydrocarbons such as RFNBOs (renewable fuels of non-biological origin) for hard-to-abate sectors like aviation.

The innovation lies in combining separation and synthesis in a compact, integrated platform, reducing energy losses and improving system efficiency. The project's unique selling points include avoiding critical raw materials and achieving scalability for both small and large emitters. It uses photocatalysis and Fischer–Tropsch chemistry to convert CO into longer-chain hydrocarbons, while addressing key bottlenecks like membrane durability and light-exposure optimisation. With EIC Pathfinder funding, DAM4CO2 is currently at single-function device level, with upcoming milestones focused on integration and stack development. The EU contribution is central to progressing past lab bottlenecks and accessing test facilities for real-world conditions. DAM4CO2 reflects a broader trend in EU-funded innovation: compressing complexity to increase feasibility.

TURN2X

Davide Testa introduced the project TURN2X, which targets the production of renewable natural gas using a novel reactor design that combines green hydrogen and biogenic CO_2.

With modular, metallic honeycomb structures and catalyst coatings, the reactor is designed for high methane yield, stability under fluctuating load, and thermal robustness – an attractive solution for hard-to-abate sectors like steel, glass, and ceramics. Recently, the project achieved a major milestone by injecting its first natural gas molecules into the grid. Backed by EIC Accelerator funding (€2.4M grant plus €17.4M in equity), TURN2X is moving fast toward commercial readiness. A 1MW pilot in Spain will soon be followed by a 9MW demo, showcasing scalability and cost-competitiveness. TURN2X underlines the importance of combining technical performance with market timing. The EU grant was instrumental in de-risking early development and attracting additional private capital. Its business model demonstrates how technological maturity can catalyse investment and regulatory alignment, accelerating deployment.

5.5 Co-creation workshops for CCU Industrial Uptake

The afternoon of Day 2 was dedicated to an engaging series of co-creation sessions focused on the industrial uptake of Carbon Capture and Utilization (CCU) technologies. These sessions provided participants with the opportunity to delve deeply into key aspects of integrating innovative CCU solutions within existing industrial frameworks. Two breakout workshops offered distinct yet complementary perspectives on advancing CCU technologies. These co-creation sessions underscored the event's commitment to facilitating holistic dialogues and collaborative efforts, essential for transforming innovative CCU ideas into scalable industrial solutions.

1. SOLDAC Workshop on Sustainability & Integrated Industrial Process

The SOLDAC Workshop on Sustainability & Integrated Industrial Process examined the viability and market readiness of CO_2-based products, discussing which products possess the greatest scaling potential and what factors contribute to their competitiveness. It also explored strategies for integrating CCU technologies into existing infrastructure, identifying quick wins that could facilitate broader adoption. Additionally, the workshop emphasized the importance of sustainability metrics to evaluate and enhance the long-term success of these technologies.

Rationale of the Workshop:

The co-creation workshop was designed to ensure that SolDAC's technological development in Carbon Capture and Utilisation (CCU) aligns with societal needs, market realities, and regulatory frameworks. By bringing together diverse stakeholders from academia, industry, policy, and civil society, the session aimed to anticipate bottlenecks, gather grounded insights, and co-design practical pathways for industrial uptake of CCU technologies. Participatory methodologies were used to generate forward-looking, inclusive strategies that consider not only technical feasibility but also economic, regulatory, environmental, and social dimensions.

Key outcomes:

- Central priority: Scaling CCU technologies from pilot to industrial demonstration emerged as the most urgent need, with emphasis on proving feasibility in real-world conditions.
- Financial mechanisms: Stakeholders stressed the lack of funding for mid-stage scale-up ("valley of death"), calling for subsidised proof-of-concept plants, first-of-a-kind deployments, and risk-sharing instruments.
- Regulatory clarity: Standardised carbon accounting, certification of CO_2-derived products, and long-term incentives were seen as essential to create viable business cases and attract investment.
- Industrial leadership: Major industrial actors must drive adoption, validating technologies and creating market pull for new value chains.
- Integration & interoperability: Modular, flexible systems that can co-locate with CO_2 sources and operate on variable renewable energy were identified as key enablers, supported by regional clustering and public–private partnerships.
- Technological needs: Priorities include efficient, scalable, low-energy systems; alternatives to critical raw materials; and sustainability-oriented design validated by LCA/TEA.

- **Market outlook:** Chemicals and fertilisers hold the greatest scaling potential, followed by synthetic fuels, polymers, and building materials. Competitiveness depends on cost, performance, regulation, and demand.
- **Societal dimension:** While economic and technological factors dominated, participants emphasised that public trust, transparency, and inclusive governance are crucial for long-term legitimacy.

Conclusion:

The workshop confirmed that CCU deployment hinges on scaling, financial and regulatory enablers, and industrial leadership – supported by technological innovation, systemic integration, and sustained societal trust.

2. Workshop on CCU Finance, Policy and Cross-sector Collaboration

Rationale:

Concurrently, the *Workshop on CCU Finance, Policy, and Cross-sector Collaboration*, hosted by the World Economic Forum and the European Innovation Council, featured contributions from industry leaders such as Guus Keder of Fenix Ventures, Prachi Singh from LyondellBasell, and Csaba Janaky of eChemicles. This session focused on unlocking financial mechanisms and risk management strategies essential for overcoming economic barriers. Policy discussions centred on developing supportive regulatory frameworks and market conditions, while cross-sector collaboration aimed to highlight essential alliances across the value chain necessary for scaling up CCU technologies.

Key Outcomes:

- **Policy:** Current regulation favors CCS over CCU. A technology-agnostic, market-incentivizing framework aligned with innovation cycles is needed.
- **Finance:** Funding mechanisms are fragmented, with a mismatch between early-stage instruments and industrial-scale needs. Priorities include patient capital, standardized performance indicators, and financing linked to long-term CCU markets.
- **Cross-Sector Collaboration:** Start-ups drive innovation, but deployment depends on integration into industrial value chains. Industry incumbents can accelerate scale-up through pilots, industrial symbiosis, and long-term off-take agreements.

Background on WEF's efforts in CCU:

Through the CCU Innovation Ecosystem, the Forum aims to accelerate the commercialization of CCU technologies by convening start-ups, corporates, investors, governments, and academia. Building on the global UpLink CCU Challenge, the initiative focuses on overcoming systemic barriers in finance, policy, and market creation, while supporting deployment opportunities and producing evidence-based insights, such as the [CCU Community Paper with Wood Mackenzie.]

6. Event highlights

Held over two enriching days in Brussels, the "Sustainability Meets Scalability" event brought together a diverse group of over 200 participants, including industry leaders, academics, policymakers, and start-ups, to explore the future of renewable hydrogen, fuels, and chemicals. Organized by the European Innovation Council in collaboration with partners such as imec, SOLDAC, S2B, and the SUNERGY initiative, this event served as a crucial platform for aligning technological innovations with Europe's ambitious climate goals.

The event commenced with a keynote by Jan Mertens, Chief Science Officer at ENGIE Research, who emphasized the pivotal role of molecules in the energy industry. This set the stage for subsequent sessions on societal needs and policy support, with insights from European Commission representatives. The showcase of cutting-edge European Research and Innovation (R&I) on renewable hydrogen featured pitches that spanned from fundamental research to startup innovations, reflecting the EIC's dedication to supporting the entire innovation journey. The afternoon focused on interactive working groups, including the Technological Roadmapping Session organized by SUNERGY and EIC, which outlined future milestones in technologies such as Advanced Electrochemical Conversion, Photosynthetic Devices, Synthetic biology or Carbon Capture. Simultaneously, a Young Researcher Working Group engaged emerging scientists.

The second day started with Prof. Maximilian Fleischer's keynote on the scales necessary for defossilization. A round table discussion involving representatives from European associations set the framework for renewable fuels and chemicals. The subsequent project pitches session demonstrated the extraordinary diversity and maturity of EU-funded research in renewable fuels and chemicals. Whether through biological, chemical, or electrochemical means, the projects all pursue the same goal: to defossilise key sectors while maintaining competitiveness and resource efficiency. From food to fuel, from Direct Air Capture (DAC) to methanation, these projects exemplify how the European research ecosystem is not only inventing the technologies of tomorrow but also testing them in practice. The agenda continued with keynotes and project pitches, showcasing practical applications of CCU technologies. Co-Creation Sessions in the afternoon provided breakout options for deeper dives into specific challenges and opportunities, with workshops on sustainability, integration, finance, policy, and cross-sector collaboration.

Throughout the event, key themes underscored the need for technological advancements that convert CO_2 and other simple molecules into valuable resources, supporting a transition to a sustainable, fossil-free Europe. Discussions highlighted the essential role of innovation across all stages – lab research, startup development, and industrial application – backed by supportive policy and financial frameworks. The collaborative atmosphere fostered a shared commitment to creating viable markets and overcoming current challenges such as regulatory uncertainties and investment needs.

The event concluded with a shared vision of fostering an innovation ecosystem capable of driving the strategic and sustainable growth of Europe's energy and chemical sectors. Through meaningful exchanges and roadmapping exercises, participants were empowered to contribute actively to shaping a cleaner, sustainable future.

7. Appendix A: List and pitches of projects in the "Novel routes to green hydrogen production" EIC Pathfinder Challenge Portfolio

Project Acronym	In a nutshell	Coordinator
ANEMEL	Hydrogen from saline water electrolysis, without PGM nor PFAS.	University of Galway (IR)
DualFlow	Using the reducing and oxidizing power of charged flow battery electrolytes to selectively store electricity OR co-produce H_2 and high value compounds.	University of Turku (FI)
MACGHYVER	High-throughput Microfluidic Membraneless Electrolyzer to produce hydrogen.	Eden Tech (FR)
PhotoSynH_2	Genetically engineered cyanobacteria to produce hydrogen from water and sunlight.	CSIC (ES)
EPOCH	Electrocatalytic Production of a Liquid Organic Hydrogen Carrier (LOHC) and chemicals from lignin.	Luleå University of Technology (SE)
OHPERA	Hydrogen and added value chemicals (DHA) from solar energy and glycerol as biomass waste.	Jaume I University (ES)
e-lobio	Large-scale production of green H_2 and value-added decarbonized chemicals from lignocellulosic biomass.	CNRS (FR)
GH2	Hydrogen and chemicals from sunlight and bioethanol.	LEITAT (ES)
H2Steel	Catalytic methane pyrolysis for the production of hydrogen and upgraded bio-coal in steel industry.	Politecnico di Torino (IT)

ANEMEL

European Innovation Council

From dirty water and renewable energy, ANEMEL produces high purity H_2 and O_2

Material feedstock: Saline water

Products: Hydrogen & Oxygen

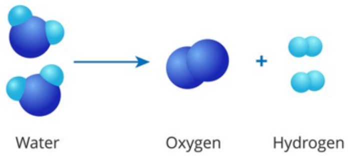
Energy input: Renewable Energy

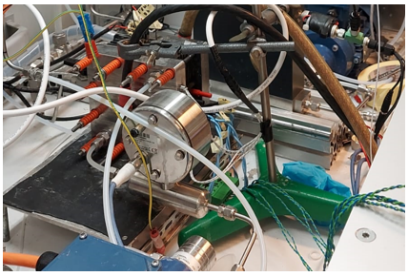
Materials for device fabrication: Stainless Steel, polymer membrane, metallic electrodes, electric cables

Targeted sector: off-shore renewable energy platforms; oil/gas refineries; wastewater treatment plants

© Prof. Pau Farras, University of Galway

Conversion technology:





How does it work? Our Technology in a Nutshell

DualFlow

European Innovation Council

Using the reducing and oxidising power of charged flow battery electrolytes to selectively store electricity OR co-produce H_2 and high value compounds (HVC)

Material feedstock: hydrocarbon redox mediators (RM) and ferrocyanide redox mediators (FC)

Products:
Fine chemicals – **Luciferin**, benzothiazole compounds
Polymer films; nanocellulose
Hydrogen

Energy input(s): Electricity to charge redox mediators (RM)

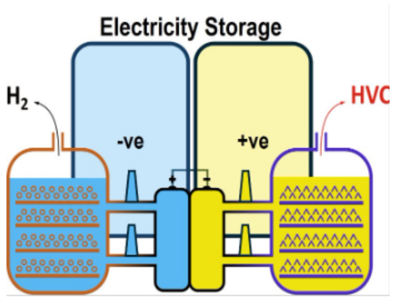
Materials for device fabrication: Standard flow battery/ secondary reactors/catalysts/gas capture.

Targeted sector: Chemical industry, Energy

BATTERY: $RM_{(discharged)} +/- e^- \rightarrow RM_{(charged)}$

RED: $RM_{(charged)} + H_2O \rightarrow RM_{(discharged)} + H_2(g)$ and $OH^-_{(aq)}$

OX: $RM_{(charged)}$ + PRECURSOR $\rightarrow RM_{(discharged)}$ + HVC



How does it work?
Our Technology in a Nutshell

MACGHYVER

European Innovation Council

High-throughput Microfluidic Membraneless Electrolyzer (MME) that uses wastewater as feed along with renewable energy to produce hydrogen.

Material feedstock: Pharmaceutical Wastewater

Products: Hydrogen & Clean disposable water

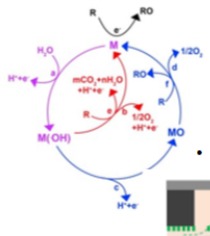
Energy input: Renewable energy

Materials for device fabrication: Thermoplastic polymer for MME, porous electrodes and Non-CRM catalysts, polymer membrane for Electrochemical Compressor, stainless steel bipolar plates;

Targeted sector: Chemical synthesis industry and pharmaceutical industry; Municipal energy industry;

Conversion technology:

- **Anodic Oxidation:**



- **Cathodic Reaction:**

$2H^+ + 2e^- \rightarrow H_2$

- **Figure of device:**

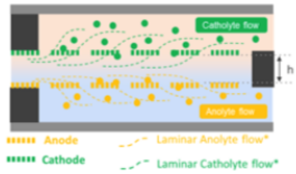


Figure 1. Microfluidic membraneless electrolysis cell

How does it work?
Our Technology in a Nutshell

PhotoSynH$_2$

European Innovation Council

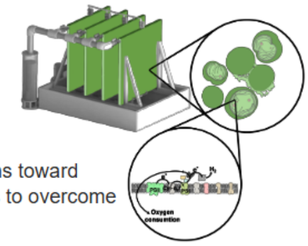
We harness solar energy in genetically engineered cyanobacteria to produce hydrogen.

Conversion technology: Integration of oxygen-resistant hydrogenases, accelerated RNA/protein evolution, and a 1,300L multiplate photobioreactor.

Formula of chemical reaction: Light-driven water splitting ($2H_2O$ + light → $2H_2 + O_2$) with in situ oxygen scavenging.

Products: Hydrogen, high-value biomass.

Energy input: Solar energy.



Materials for device fabrication: Engineered components for a multiplate photobioreactor.

Targeted sector: Renewable energy and sustainable hydrogen production.

Main principle: We re-engineer cyanobacterial photosynthesis to redirect water-splitting electrons toward hydrogen production, coupling oxygen-resistant hydrogenases with oxygen consumption devices to overcome oxygen inhibition and minimize electron loss.

Conversion technology: Integration of six key innovations – engineered strains, an accelerated evolution platform, advanced multiplate photobioreactors, photosynthetic electron focusing, salt-tolerant cultivation, and microanaerobic devices.

How does it work?
Our Technology in a Nutshell

EPOCH

European Innovation Council

Electrocatalytic Production of a Liquid Organic Hydrogen Carrier (LOHC) and chemicals from lignin.

Material feedstock: Water and lignin derivatives

Products: Loaded LOHC and high-value oxygenated lignin derivatives

Energy input(s): Renewable power

Materials for device fabrication: Viton, Steel, PTFE

Targeted sector: Biorefineries, hydrogen users, chemical producers

Conversion technology: Electrocatalytic flow cell

Formula of chemical reaction:

Cathode:

Anode:

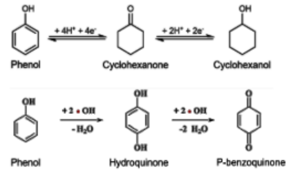
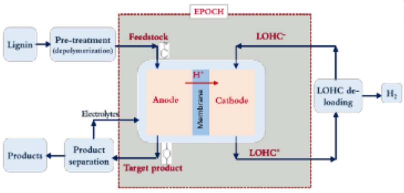


Figure of device



How does it work?
Our Technology in a Nutshell

OHPERA

European Innovation Council

From solar energy and glycerol as biomass waste, OHPERA produces H_2 and added value chemicals (DHA).

Material feedstock: Water, glycerol

Products: H_2, DHA,

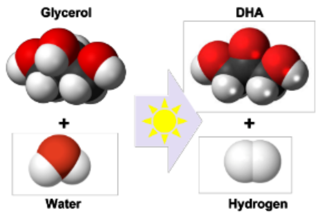
Energy input: Solar light

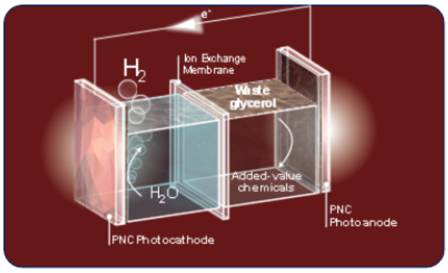
Materials for device fabrication: Lead-free halide perovskite photoabsorbers, GOR and HER catalysts (Ni, Fe, Zr, Bi)

Targeted sector: Chemical sector

GOR: glycerol oxidation reaction; **HER**: hydrogen evolution reaction; **PNC**: Perovskite nanocrystals

Conversion technology:





How does it work?
Our Technology in a Nutshell

e-lobio

European Innovation Council

Large-scale production of green H_2 and value-added decarbonized chemicals from lignocellulosic biomass.

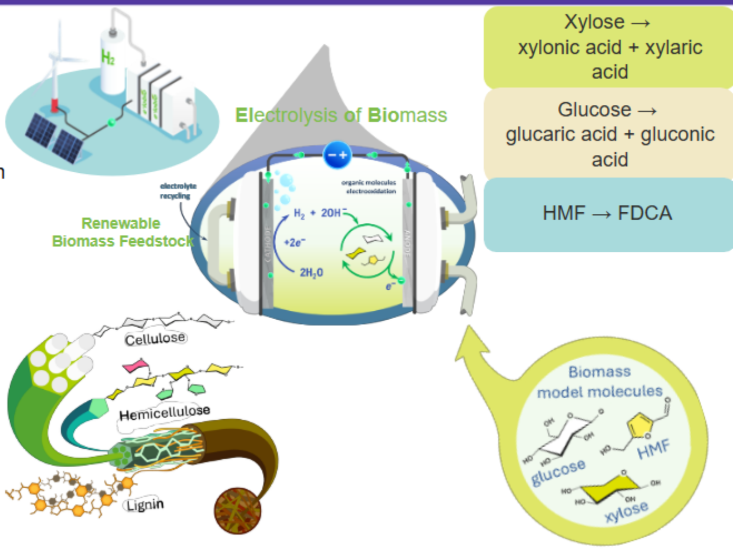
Material feedstock: lignocellulosic biomass from wood/forestry and agriculture residues

Products: green H_2 and value-added chemicals

Energy inputs: renewable electricity

Materials for device fabrication: non-precious metals, PFAS free components

Targeted sector: chemical and biorefineries, catalyst producers and material suppliers, electrolyzer manufacturers



Our Technology in a Nutshell

GH2

European Innovation Council

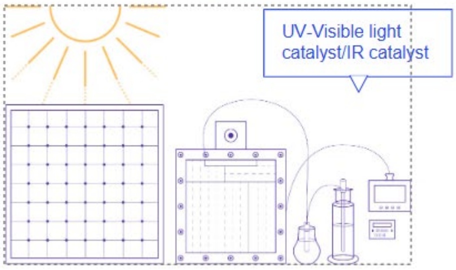
GH2 will produce H2 and valuable chemicals using solar energy and bioethanol

- **Material feedstock:** Bioethanol, water
- **Products:** Hydrogen & Acetaldehyde
- **Energy input:** Solar light
- **Materials for device fabrication:** Inexpensive Materials
- **Targeted sector:** Hydrogen, Catalyst industry and Chemical Sectors

Conversion Technology:

$$CH_3CH_2OH \xrightarrow{\text{Full solar spectrum}} CH_3CHO + H_2$$

UV-Visible/IR catalysts (non-CRM), H_2O



How does it work?

Our Technology in a Nutshell

European Innovation Council

Main principle in a nutshell

Material feedstock:
- Biowastes/Biomass for catalyst production (Industrial and civil sewage sludge, agricultural digestate)
- Biomethane/Methane/Natural gas

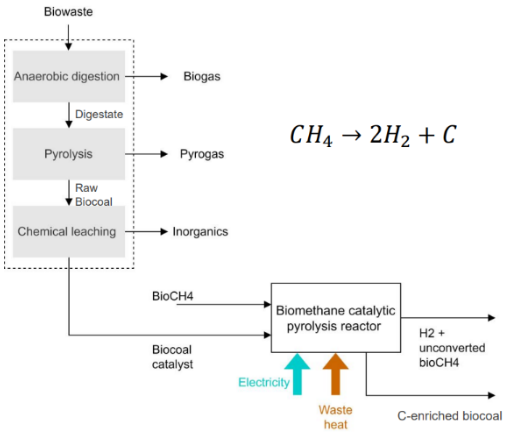
Products:
- Hydrogen
- Upgraded Bio-coal
- Carbon credits
- Fertilizers (as inorganics)

Energy inputs: Electricity, Biomethane or waste heat as thermal energy for methane cracker

Materials for device fabrication: AISI 310S, e 253 MA

Targeted sector: Steel sector

Conversion technology: catalytic methane pyrolysis process



8. Appendix B: List and pitches of projects in the "CO_2 and N-Compound Management and Valorisation" EIC Pathfinder Challenge Portfolio

Project Acronym	In a nutshell	Coordinator
HYDROWCOW	Protein powders from hydrogen and CO_2 via hydrogen-oxidizing bacteria.	Solar Foods (FI)
Mi-Hy	From wastewater and CO_2 to liquid fertilizer and electricity via microbial fuel cells (MFC), up to vegetables via a subsequent hydroponics step.	KU Leuven (BE)
DAM4CO_2	Novel membrane technology for integrated CO_2 separation and conversion to C4+ molecules.	CNR-ITM (IT)
CONFETI	From air, waste water and crop liches, CO_2 and nitrogenous compounds are captured and converted into green urea/ ammonia for on-site fertilization.	UAB (ES)
ECOMO	From CO_2 from flue gas and nitrogen from wastewater to C3+ diamine chemicals .	TUM (DE)
ICONIC	Direct co-electrolysis of carbonates and nitrates from seawater into urea.	ICFO (ES)
SuperVal	From solar energy and flue gas to formic acid and ammonia.	ICIQ (ES)
MINICOR	Carbon-negative syngas and biochar through integrated self-sustained thermal conversion of biomass residues.	Lund University (SE)

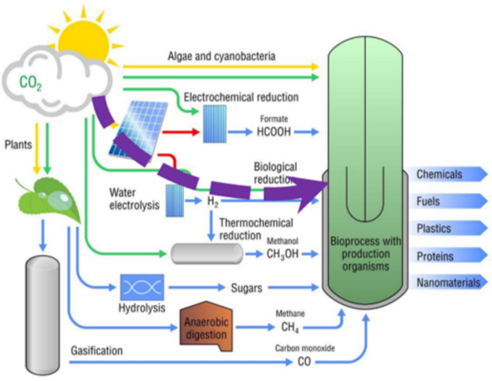
HYDROWCOW - Solarfoods

European Innovation Council

Why to explore our approach?

OVERVIEW OF ROUTES FROM SUNLIGHT AND CO_2 TO PRODUCTS THROUGH BIOTECHNOLOGY

- Energy efficiency of plant photosynthesis is c. 0.5-1 % from sunlight
- Thus, all routes based on plant biomass have poor energy efficiency, and global land area is limited
- **Combination of solar panels, electrolysers and Hydrogen Oxidizing Bacteria can have c. 5 % energy efficiency form sunlight to edible calories = 10x better**
- Algae and cyanobacteria with artificial light is not as good, and open pond cultivations have their limitations
- Electrochemical and thermochemical intermediates need their own additional unit operation; thus, lowering the energy efficiency and/or TRL
- **We aim to food products due to large market volume and higher price point than fuels and chemicals**
- **The price of products based on renewable electricity and CO_2 should be above 5 €/kg; possible in food.**



(Originates from work done c. 2016 at VTT Technical Research Centre of Finland)

© Juha-Pekka Pitkänen, Solarfoods

How does it work?

Our Technology in a Nutshell

DAM4CO2

European Innovation Council

DAM4CO$_2$ aims to develop a novel membrane technology for the simultaneous CO_2 separation and its conversion to C_{4+} molecules, as renewable fuels.

Material feedstock: CO_2 from flue gas

Products: C4+ molecules, RFNBOs

Energy input(s): Sunlight

Materials for device fabrication: Soluble and insoluble polymers, MOFs, Mono-bifunctional catalysts, stainless steel, glass/quartz

Targeted sector: Hard to abate industry, transport/aviation

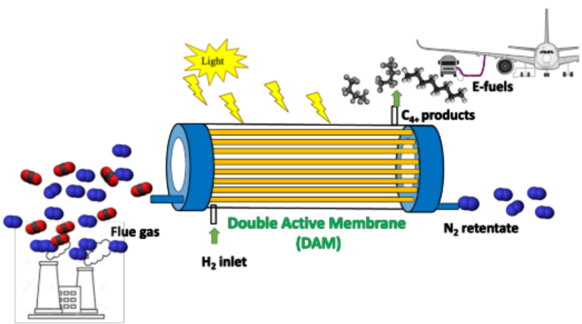
Conversion technology: Photocatalysis

Reverse water gas shift reaction

$$CO_2 + H_2 \longleftrightarrow CO + nH_2O$$

Fischer – Tropsch reaction

$$nCO + (2n+1)H_2 \longleftrightarrow C_nH_{(2n+2)} + nH_2O$$



How does it work? Our Technology in a Nutshell

MIHY

European Innovation Council

From wastewater and CO_2 to liquid fertilizer and electricity via microbial fuel cells (MFC), up to vegetables via a subsequent hydroponics step.

Material feedstock: Wastewater and CO_2

Products: Electricity, balanced fertilizer, plant growth

Energy input(s): Chemical energy in wastewater

Materials for device fabrication: Electrodes, membrane, nutrient delivery systems, plant support structures, lights

Targeted sector: Hydroponics, organic and urban farming, Wastewater treatment

Conversion technology:

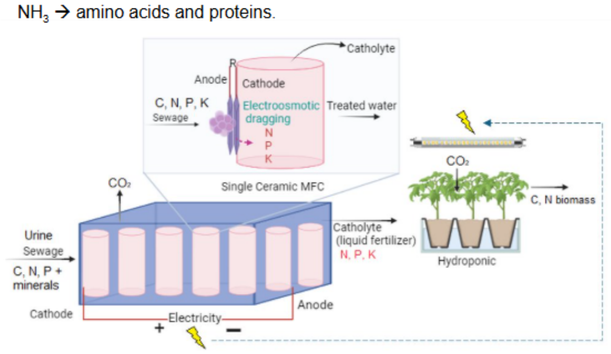
Anode reaction: $CH_4N_2O + 6H_2O \rightarrow 2HCO_3^- + 2NH_4^+ + 6H^+ + 6e^-$

Organic N (urea $CH_4N_2O + H_2O$ + inorganic salts) → inorganic N + H^+ + e^-

Cathode reaction: $O_2 + 4e^- + 4H^+ + NH_4^+ \rightarrow NO_3^- + 2H_2O$

Biomass synthesis: $6CO_2 + 12H_2O + 4NO_3^- + 4H^+$ + minerals $\rightarrow C_6H_{12}O_6 + 6O_2 + 4NH_3$

NH_3 → amino acids and proteins.



How does it work? Our Technology in a Nutshell

CO2NFETI

European Innovation Council

From air, waste water and crop liches, CONFETI aims to capture CO_2 and nitrogenous compounds and convert them into green urea and/or ammonia enabling on-site fertilization.

Material feedstock: CO2 from air and N-compounds from wastewater & soil

Products: Urea and Ammonia

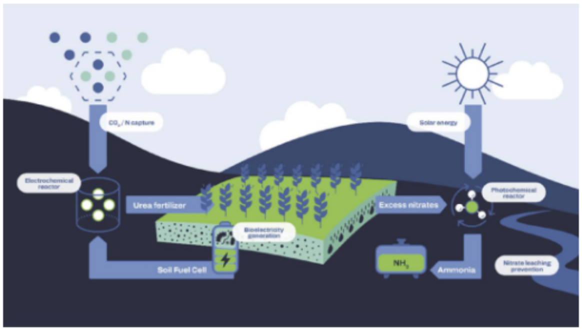
Energy input(s): Chemical energy from soil, Sunlight

Materials for device fabrication: Electrolyzer components, Photoreactor components & Soil Microbial Fuel Cell components

Targeted sector: Agricultural sector

$$CO_2 + N_2/NO_3^- \rightarrow CO(NH_2)_2$$

- An **electrochemical reactor** for capturing, storing and converting CO_2 and N_2 into urea, powered by a soil microbial fuel cell.
- A **photochemical reactor** for reducing nitrate (NO_3^-) to ammonia/urea using photocatalytic agents powered by sunlight.



How does it work?

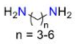
Our Technology in a Nutshell

ECOMO — European Innovation Council

Main principle in a nutshell: by harnessing CO_2 from flue gas and nitrogen from wastewater, project ECOMO produces C3+ diamine chemicals

Material feedstock: **CO_2 from flue gas**

$(NH_4)_2SO_4$ from sewage wastewater

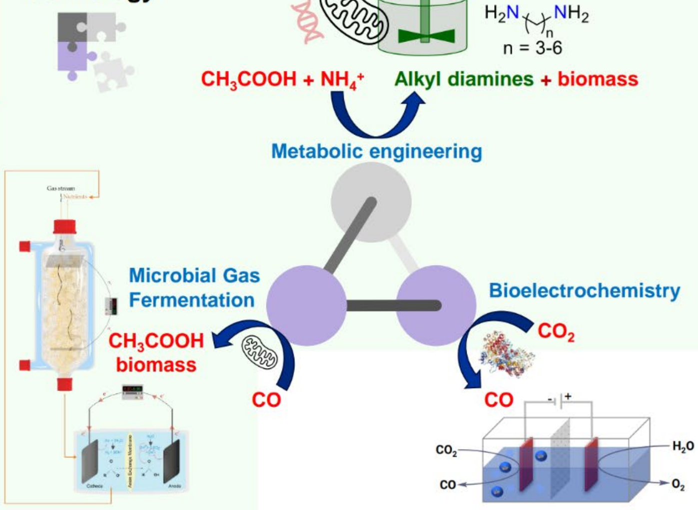
Products: **Alkyl diamines** 

Energy input(s): **Electricity**

Materials for device fabrication: **Enzymes (catalysts), Polymers (enzyme-compatible), carbon felt, stainless steel, glass, chemical-resistant polymers**

Targeted sector: **Polymer industry** 

Technology:



How does it work?

Our Technology in a Nutshell

ICONIC — European Innovation Council

ICONIC pursues the direct co-electrolysis of carbonates and nitrates from seawater into urea. This new technology could be used to remediate water ecosystems that have been polluted due to intense agriculture, farming, and CO_2 emissions, while producing a global commodity such as urea.

Material feedstock: Bicarbonates/nitrates in seawater

Products: Urea

Energy input(s): Electricity

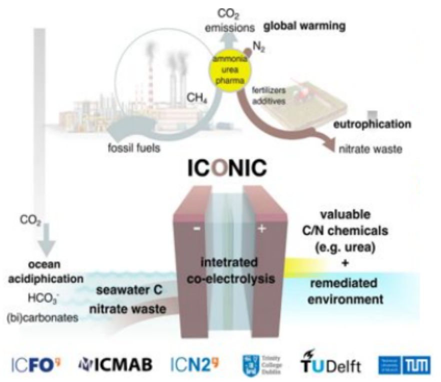
Materials for device fabrication: non-CRM catalysts, GDEs carbon support, membranes (bipolar)

Targeted sector: 1) Fertilizer; 2) Water remediation

Technology: Electrosynthesis

Formula of chemical reaction

$$2HCO_3^- + 2NO_3^- + 8H^+ \rightarrow CO(NH_2)_2 + 3H_2O + 2O_2$$



How does it work?
Our Technology in a Nutshell

superval | European Innovation Council

Main principle in a nutshell: from solar energy and flue gas to HCOOH and NH_3

Material feedstock: Flue gas and water

Products: Formic acid, ammonia

Energy input(s): Sunlight

Materials for device fabrication: Non-CRM materials (Fe, Cu, Pb, C)

Targeted sector: Chemical industry, waste management, agriculture

Technology:

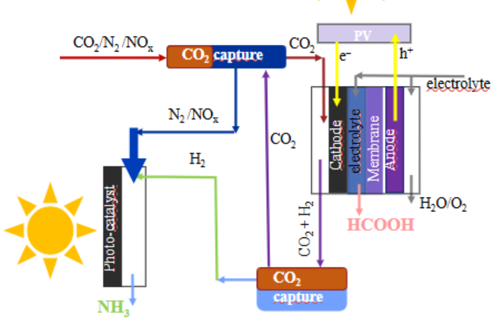
1) Flue gas =>> CO_2 + N_2 + NO_x capture and purification
2) CO_2 + N_2 + NO_x =>> Solar powered valorization to NH_3 and HCOOH

$$2CO_2 + 2H_2O \rightarrow 2HCOOH + O_2$$

$$2H_2O \rightarrow 2H_2 + O_2$$

$$N_2 + 3H_2 \rightarrow 2NH_3$$

$$NO_x + (x + 3/2)H_2 \rightarrow NH_3 + xH_2O$$



How does it work?
Our Technology in a Nutshell

MINICOR | European Innovation Council

MINICOR produces carbon-negative syngas and biochar through integrated self-sustained thermal conversion of biomass residues.

Material feedstock: Biomass

Products: Syngas, biochar, biooil, energy

Energy input(s): Heat for pyrolysis

Materials for device fabrication: Steel (primarily)

Targeted sector: Chemical production, fuel

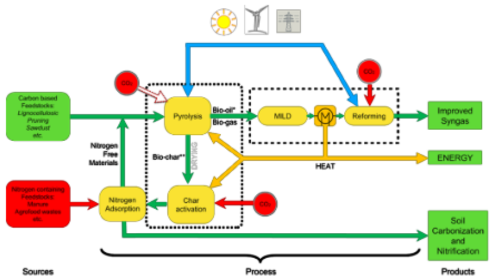
Technology: Thermochemical conversion

Pyrolysis + MILD combustion + reforming

Pyrolysis: biomass = biogas + bio-oil + biochar

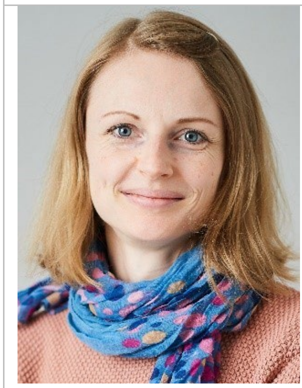
MILD combustion Biogas + air = CO_2 and H_2O

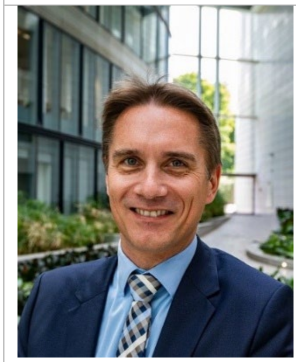
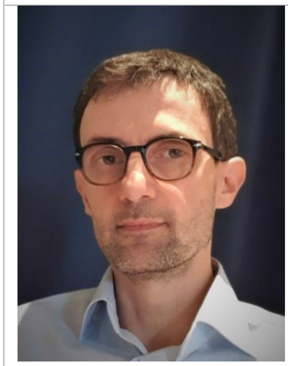
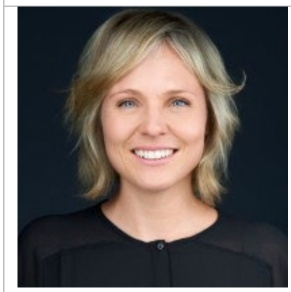
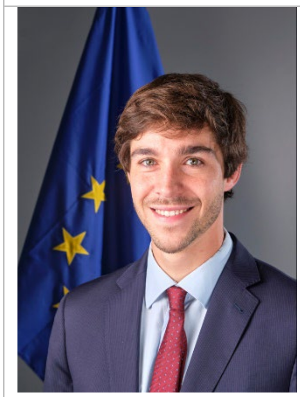
Dry reforming: Biooil + CO_2 = syngas (CO/H_2)



9. Appendix C: List of speakers and panelists

Wednesday 26 March 2025

10:00	Reality Check: Pivotal Role of Molecules in Energy Industry
	Opening remarks by the organizers
	Carina Faber (European Commission – European Innovation Council) Dr. Carina Faber's expertise is on alternative fuels and chemicals made from renewable energy. The considered technologies are diverse, ranging from mature electricity-based to emerging sunlight-driven approaches based on synthetic biology and artificial photosynthesis. To enable a fully circular and sustainable economy, her work also comprises the valorisation of alternative resources, such as wastewater, brines or plastic waste. Her background is on computational materials science, with a PhD in Theoretical Physics. From 2020-22, she co-leads a 2-years R&I program on e-fuels for ENGIE. In 2019, during a post-doctoral fellowship at UCLouvain, she leads the development of a technological roadmap on artificial photosynthesis within the EU large-scale initiative SUNRISE.
	Joachim John (imec) Dr. Joachim John studied physics at the Albert-Ludwigs-University in Freiburg and received his Ph.D. in physics at the Federal Institute of Technology in Zurich. Later he joined the Interuniversity Micro Electronic Centre (imec) in Belgium, where he currently is the Energy Department's Sr. Project Manager. Since 2021, he co-organizes the e-MRS Fall Symposium "Advanced catalytic materials for (photo)electrochemical energy conversion" in the Program "Materials for Energy". In 2014, he was awarded with the Otto-von-Guericke medal of the University of Magdeburg by minister-president of Saxony-Anhalt Dr. Reiner Haseloff. He has published more than 250 papers, gave more than 40 invited presentations, and holds 5 patents. His h-index is 25 with more than 2100 citations of his work.
	Jan Mertens (ENGIE Research & Professor at University of Ghent) Professor Jan Mertens is ENGIE's Chief Science Officer building ENGIE's long term vision on technologies, identifying key international research players on selected emerging technologies, and initiating research partnerships worldwide for the group. Since 2019, Jan is also part-time professor at the University of Ghent in the domain of sustainable energy. He holds a PhD in environmental engineering from the Katholieke Universiteit Leuven. He has over 60 scientific publications and his main research topics are related to emerging energy technologies, sustainability assessment including life cycle assessment, critical raw materials, emissions monitoring, carbon capture, carbon use, and water footprinting.

10:30	Societal needs: Frame setting and Policy Support
	**Martin Lange (European Commission – Directorate General GROW)** Dr. Martin Lange is Policy Officer – Raw Materials at the European Commission's Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW) since March 2024. During his 15-years of public service at the European Commission he has been involved in the design and implementation of various parts of the Research & Innovation Framework Programmes: the European Innovation Council's Pathfinder under Horizon Europe, Future and Emerging Technologies under Horizon 2020 as well as Marie Skłodowska-Curie Actions under FP6, FP7 and Horizon 2020. Before joining the Commission, Martin worked as researcher in both industrial and academic context. He holds a PhD in Physics from K.U. Leuven and a Master's in Physics from RWTH Aachen.
	**Fabien Ramos (European Commission - Directorate General CLIMA)** Dr. Fabien Ramos is a policy officer at the European Commission. With a decade of experience in climate policies, he plays a leading role in the European Commission's work on Sustainable Carbon Cycles, Industrial Carbon Management, and Carbon Removals policies. Fabien holds a PhD in Geosciences and enjoys gravel cycling in his free time.
	**Eva Nussmüller (European Commission - Directorate General REGIO)** Eva Nussmüller is acting Head of Unit at the European Commission's Directorate-General for Regional and Urban Policy in unit G1, dealing with Smart and Sustainable Growth. Core to her work is to support all regions in Europe to contribute to more competitiveness and to the transition to a decarbonised Europe. Eva is an expert in regional policy. She has worked for the Commission for more than 15 years, has done research and teaching on regional development and has also worked for the national administration. She holds a Master's degree in Economics from Vienna University of Economics and Business.
	**Pedro Francisco (European Commission - Directorate General MOVE)** Pedro Francisco is a policy officer at the European Commission's DG MOVE, specialising in aviation policy with a particular emphasis on aviation fuels. His work comprises assisting in the adoption of sustainable aviation fuels, including synthetic aviation fuels, to decarbonise the aviation sector (namely assisting in the implementation of ReFuelEU Aviation). Pedro has a background in EU affairs, with previous experience at the Portuguese Permanent Representation to the EU, where he worked on energy policy, and as an EU Researcher at Equinor. He holds a Master's degree in International Relations and Diplomacy from the College of Europe and a law degree from Universidade Católica Portuguesa.

11:30	Showcasing European R&I on Renewable Hydrogen
	**Pau Farras (University of Galway)** Prof. Pau Farras is an Associate Professor in Inorganic Chemistry at the University of Galway. He received his BSc in Chemical Engineering from the Autonomous University of Barcelona and obtained the PhD in Chemistry from the Materials Science Institute of Barcelona.
	**Kathryn Toghill (Lancaster University)** Kathryn Toghill is Professor of Sustainable Electrochemistry and Energy Materials at Lancaster University in the UK. She is particularly active in the fields of electrochemical long duration energy storage focussing primarily on flow batteries, green hydrogen and CO2 reduction to synthetic fuels. Kathryn leads the UK Flow Battery Network and is an advocate of holistic research programmes that consider technologies from cradle-to grave as well as their societal impact.
	**Wei Zhao (Eden Microfluidics)** Wei ZHAO, Chief Product Officer at Eden Tech and Coordinator for the EIC Pathfinder MACGHYVER project. Ph.D. in Catalysis, Molecular and Kinetic Modeling, and Photovoltaics with over 4 years of experience in product development, project management, and research in microfluidic electrolysis, catalysis, and material chemistry. Expertise in green hydrogen production technologies and photovoltaic characterization.
	**Alfonso Jaramillo (CSIC)** Prof. Alfonso Jaramillo has a Ph.D. in Theoretical Particle Physics from the University of Valencia and undertook postdoctoral research at the Université Libre de Bruxelles, Université Louis Pasteur, and then Harvard. Between 2003-2009, he was appointed as a tenured Lecturer at École Polytechnique, 2009-2015 as a tenured Chargé de Recherche at CNRS, and 2013-2021 as Full Professor of Synthetic Biology at the University of Warwick. Since 2015 he has been Directeur de Recherche at CNRS. In 2021, he assumed the roles of Investigador Científico at CSIC and Honorary Professor of Synthetic Biology at the University of Warwick. In 2017, he was elected as Fellow of the Royal Society of Biology. His research focuses on developing new phage-assisted accelerated evolution techniques for engineering proteins, targeting the re-engineering of gene regulation, and phages for innovative antimicrobial development. Also, he explores the creation of neuromorphic gene circuits in bacteria, aiming to develop new forms of living artificial intelligence.

Fredrik Granberg (Luleå University of Technology)

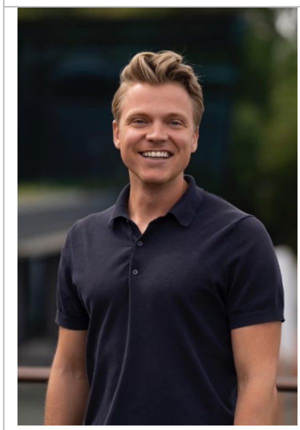
Fredrik Granberg has a master's degree in chemical engineering from Luleå University of Technology. He started his career in the pulp and paper industry followed by energy business. Between 2005-2012 he was employed by Chemrec as a part of the team finalizing construction and starting up a 3 MW black liquor gasifier pilot, and between 2008 – 2012 as the project manager for permitting, engineering, construction and start-up of a gas conditioning, synthesis plant and product storage integrated with the existing black liquor gasifier and host pulp mill. Later he became chief process and projects/maintenance at the plant. Fredrik holds now two positions as Project Manager at Luleå University of Technology and CEO of LTU Green Fuels. He has been involved in several sustainable aviation fuels projects. Since 2021 he's part of LTU Centre for Hydrogen Energy Systems Sweden management team. He wishes to bring his broad experience from the different areas in research and innovation towards commercialization.

Sixto Giménez (Universitat Jaume I de Castelló)

Sixto Giménez is a Professor at Universitat Jaume I de Castelló in Spain. His career is focused on the study of micro and nanostructured materials for different applications spanning from structural components to optoelectronic devices. During his PhD thesis, he studied the relationship between processing of metallic and ceramic powders. As a postdoctoral researcher, at Katholiek Universiteit Leuven, he focused on the development of non-destructive and in-situ characterization techniques of the sintering behavior of metallic porous materials. Since 2008, he works at the University Jaume I and is actively involved in the development of new concepts for photovoltaic and photoelectrochemical devices based on nanoscale materials. Presently, he coordinates the Pathfinder OPHERA project.

Philippe Vernoux (CNRS – IRCELYON)

Dr. Philippe Vernoux is a scientist and Research Director at CNRS, based in Lyon, France. With a PhD in Electrochemistry and a Habilitation in Catalysis, he has made contributions solid-state electrochemistry, emission control, low-temperature electrolysis, environmental catalysis, and electrochemical promotion of catalysis, among others. His career spans over two decades, during which he has authored more than 150 refereed papers, filed 21 patents, delivered numerous invited lectures and oral communications. Dr. Vernoux is coordinating the European Pathfinder project Elobio (Electrolysis of Biomass) and heading the CARE (Catalytic and Atmospheric Reactivity for the Environment) group at the Institute for Research on Catalysis and Environment of Lyon.

13:45	Innovation in practice
	**Michiel Scheffer (President of the Board of the European Innovation Council)** Michiel Scheffer has three decades of experience in the field of innovation, including on breakthrough technologies, disruptive innovations, start-ups impact investment. He worked with over 20 universities, and more than 200 partners across the EU in large R&D Projects and he is the author of more than 100 publications. He authored a PHD dissertation at the Utrecht University on 'Trading Places, fashion, retailers and the changing geography of clothing production, a study on Netherlands, Belgium, France and UK'. Since 2000, he is the Founder and CEO of Polisema BV, and until 2015 he was the Founder and CEO of Noéton Policy in Innovation BV, where he designed and managed several EU Funded Projects. Additionally, he was three times elected regional party leader.
	**Tim van den Bergh (World Economic Forum)** Tim van den Bergh, Lead, Climate Tech Innovation, at the World Economic Forum. In this role he works on identifying novel decarbonisaton technologies and advises public and private sector stakeholders on how to ingrate these solutions in their business models and value chains to accelerate the transition to a carbon-neutral future. Prior to this role he was the acting lead in Data & AI for Climate Action, managing multi-stakeholder partnerships between the public and private sector to ensure AI solutions are being developed and used for the benefit of people and planet.
	Key Enablers for Innovation: from benchmarking to capacity building
	**Miet Van Dael (VITO)** Dr. Miet Van Dael holds a doctoral degree in applied economic sciences and master's in business engineering with the option of technology, innovation and environmental management. Furthermore, she is a guest professor in the environmental economics group at the Hasselt University where she teaches sustainability assessments for emerging technologies. In her PhD she elaborated on the techno-economic assessment of energy conversion parks and now applies it in the field of biobased economy, CCU and plastics recycling. In her research she is further extending the techno-economic assessment to a full sustainability assessment including environmental and social impacts. Currently she works as a researcher at VITO in the Materials & Chemistry unit.

Vera Grimm (German Ministry of Education and Research)

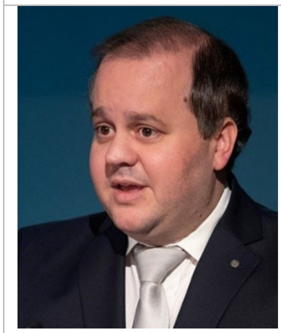
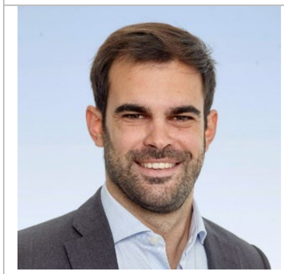
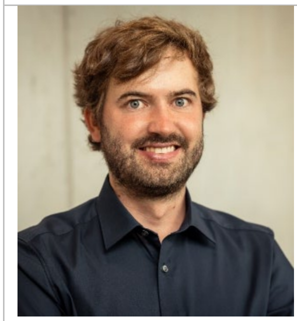
Dr. Vera Grimm studied chemistry at the Universities of Cologne and Heidelberg and received her PhD in bioinformatics from the University of Cologne in 2003. During her postdoc at the Center of Excellence in Bioinformatics, Buffalo, NY, she worked with Jeff Skolnick on the protein-protein docking problem. She then worked for six years as a Senior Technology Consultant in Foresight at VDI Technologiezentrum and for five years at Projekttraeger Juelich / Forschungszentrum, most recently as Deputy Head of Unit. Her work focused on identifying future technologies in the fields of biotechnology, bioeconomy, renewable energies as well as developing strategies. In 2017, she moved to the German Federal Ministry of Education and Research (BMBF), where she is responsible for the design and implementation of R&I funding programmes.

Liesbet Boogaerts (BlueChem)

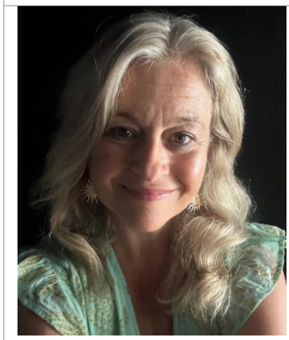
Liesbet Boogaerts is actively involved in fostering innovation and sustainability within the chemical industry. As general manager of BlueChem, the incubator for sustainable chemistry, she supports startups and scale-ups in developing groundbreaking technologies, introducing more efficient production processes, and commercializing sustainable products. Liesbet started her professional career at ExxonMobil, where over the years she held various strategic positions in Belgium and abroad. During her career, she built a strong expertise and broad knowledge of how innovations from the chemical sector can contribute to the circular economy and a more sustainable world.

Claudiu Pavel (Clean Hydrogen Partnership)

Dr. Claudiu Pavel is a Project Officer at the Clean Hydrogen Partnership, supporting the EU's research programme on the development of hydrogen technologies. Previously, he was a Scientific Project Officer at the European Commission's Joint Research Centre, focusing on critical materials for energy technologies and industrial innovation. With experience in private R&D sector and postdoctoral research across Europe, he has contributed to many scientific publications. He holds a Ph.D. in Environmental Technology and a B.Sc. in Chemistry and Physics.

	A Start-up perspective on Innovation
	**Csaba Janaky (eChemicles)** Csaba Janáky graduated as a chemist and economist at the University of Szeged and was a Marie Curie a fellow at the UT Arlington (USA). With his research group he has published over 100 papers (full IF>10 00), filed over 20 patent applications (many of them have already been granted) in the last 10 years. His team has achieved breakthrough results in the development of electrochemical hydrogen generators and in the development of carbon dioxide electrolyzers. He is co-founder of eChemicles, a company where they are scaling-up CO2 electrolysis.
	**Carlos Sanz (Matteco)** Carlos Sanz is the Corporate Development Director at Matteco, an advanced materials cleantech company with new solutions to decarbonize the economy and boost cost competitive green hydrogen. With a background in aeronautical engineering, Carlos has extensive experience in strategy, corporate development, and operations. As a consultant, he has worked with various companies—from high-growth startups to IBEX35 corporations—across multiple industries, including energy, retail, logistics, healthcare, and banking. Throughout his career, he has collaborated with local and multinational organizations such as KPMG, Santander, Paack, and BlueBull, driving strategic initiatives and business growth.
	**Andreas Büchler (ionysis GmbH)** Dr. Andreas Büchler is an entrepreneur and researcher with a proven track record in climate innovation, renewable energy, and electrochemical technologies. As co-founder and COO of "ionysis," he has successfully scaled the start-up to 25 employees, raised €11M in funding, and driven the development of cutting-edge catalyst-coated membranes (CCMs) for electrochemical applications. With a PhD in Microsystems Engineering, he has led high-impact projects ranging from climate stress-testing for European regulators to renewable energy diagnostics. His expertise spans strategic leadership, technology innovation, and business development, bridging the gap between sustainability and technological advancement.
	**Steven Peleman (TripleHelix)** Steven is an Antwerp based industrial entrepreneur who held executive positions at Deloitte, Caterpillar, Husky Injection Molding Systems and Huntsman. He is co-founder of the European Center for Open Innovation and TomorrowLab. In 2019, merging his studies, passion and professional background, he introduced the idea of a dedicated circular venture studio, called Triple Helix Molecules as a Service and created a platform focusing on material reincarnation. In addition to the soon to be built 90 million PU recycling plant in Antwerp, Triple Helix now has several recycling and GHG conversion initiatives in its portfolio.

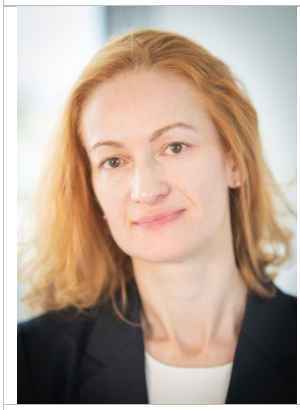
Thursday 27 March 2025

9:30	Reality Check: The Scales We Need for Defossilization Opening remarks by the organizers
	Elke Moors (European Innovation Marketplace) Elke Moors is the CEO of two European non-profit organisations both based in Belgium: the European Innovation Marketplace (EIM) and the Building Digital Twin Association (BDTA). The first one promotes the digitalization and standardization of the construction industry, and the second one is active in research for multisector decarbonisation. Between 2018 - 2022, she was the Economic and Commercial Representative for the Flemish Government in Spain. Before that she ran her own consultancy firm collaborating closely with Media and Advertising Agencies in EMEA and LATAM and at the beginning of her career she has been the Marketing & Communications Director of Carglass Spain for 13 years. Elke holds a Master in Strategical Marketing Management, a Master in Gestalt Therapy of Arts, a Master in NLP and has a Degree in Communication Science.
	Maximilian Fleischer (Chief Technical Expert of Siemens-Energy and Honorary Professor at TU-Budapest) Dr. Maximilian Fleischer received a PhD in physics from TU-Munich, his habilitation and honorary professorship from the TU-Budapest and is member of the Hungarian Academy of Science. He is serving as the Chief Technical Expert of Siemens-Energy in the Corporate Innovation department providing guidance on science and technology and driving innovation. He engages in various industrial boards of Max Plank, Fraunhofer and Helmholtz Institutes, CEC projects, and the US “Liquid Sunlight Alliance” as well as in the pan-European initiative for a cyclic economy “SUNERGY”. He has published almost 350 times, H-index of 42 and is co-inventor in 180 international patent families.

10:00	Renewable Fuels & Chemicals: Frame setting Moderated round table with European associations and initiatives
	**Frédéric Chandezon (EU SUNERGY Initiative)** Frédéric holds an engineer degree in physics from the Physics and Chemistry school of Paris and a Ph.D. from Grenoble University. After a postdoctoral stay at the Niels Bohr Institute, he joined CEA in Grenoble as research scientist. He is currently European policy officer for SUNERGY and renewable energy programmes at the Interdisciplinary Research Institute of Grenoble at CEA. Before that, he headed the SyMMES laboratory, a CEA-CNRS-Grenoble University joint laboratory that develops basic research related to low-carbon energy and health. Between 2013-2020, he was the coordinator of the EERA Joint Program AMPEA (Advanced Materials and Processes for Energy Applications). Since 2019, he is the deputy coordinator of the SUNERGY European initiative on fossil-free fuels and chemicals and of the SUNER-C European project.
	**Alexis Dunand (Carbon Gap)** Alexis is Associate Policy Lead at Carbon Gap. He currently focuses on expanding the EU CDR Policy Tracker's coverage. Prior to joining Carbon Gap, Alexis was acting as a civil servant at the Swiss Federal Institute of Technology in Lausanne (EPFL). He previously served as a research consultant at Carbonfuture, focusing on EU and US CDR policy. Before that, he was part of the leadership team of illuminem, heading the content creation section.
	**Ludo Diels (P4P)** Ludo Diels, Dr. in chemistry & biotechnology, is professor at Antwerp University, and senior advisor at VITO. He is Portfolio manager at Processes4Planet, chair of the Mutual Learning Exercise for decarbonization of the European Energy Intensive Industry, chair of the advisory board of Biorizon, member of the advisory board of the World Bio Economy Forum, member of the Scientific Council of the Nobel Peace Laureates secretariat. He is also involved in the sustainable development of the Energy Intensive Industry in Europe and contact person for the Circular Biobased Economy partnership. He is specialized in lignin valorisation for chemical applications.

Tudy Bernier (CO2ValueEurope)

Tudy is Policy Director at CO_2 Value Europe, the EU association representing the Carbon Capture and Utilisation (CCU) value chain, which he joined in July 2021. He leads the work of the organisation on advocacy and public affairs on EU policies for energy, climate and environment. His responsibilities involve analysing political and policy discussions at EU level, writing position papers on regulatory issues, establishing and implementing advocacy strategies, and representing the CCU value chain in regular meetings with EU and national policy makers, as well as national stakeholders, including industries, companies, NGOs, think tanks and other relevant partners at EU and national level. He also represents the CCU community in official platforms, forums and conferences.



Wilmet Sophie (Cefic)

Sophie Wilmet joined Cefic, the European Chemical Industry Council in 2007. She has covered various innovation priorities related to sustainable chemistry and is currently Senior Innovation Manager in charge of Safe and Sustainable by Design and low CO2 emissions technologies, including the utilisation of CO2 as feedstock. She is a member of the partnership board of the Processes4Planet public-private partnership. She graduated as a chemical engineer and holds a PhD in chemistry.

11:00

Showcasing European R&I on Renewable Fuels & Chemicals: *How Does It Work in Practice?*

Claire Gauthier (Programme Economie Circulaire du Carbone, CEA)

Engineer in mechanics and energy, PhD in mechanical engineering, I worked for a long time in the field of numerical simulation. Then I managed the dynamics studies laboratory at the CEA and worked as a senior expert in the field of fast transient dynamics, before turning to program management in the domain of new energy technologies. Particularly interested in the energy transition, I'm now in charge of the CEA Circular Carbon Economy program, which addresses R&D on technologies for producing advanced biofuels and synthetic fuels from low carbon energy and different carbon sources (CO2, biomass, waste, etc.), after being the deputy head since June 2023.

Project pitches by EU-funded projects and start-ups

Isaac Herraiz (SOLDAC)

Dr. Isaac Herraiz Cardona received his PhD from the Polytechnic University of Valencia in hydrogen production. He continued in academia as a postdoctoral researcher at Universitat Jaume I, focusing on photoelectrochemical water splitting, perovskite solar cells, and semiconductor-based catalysts for solar fuels. Later, he became R&D Manager at Kerionics S.L., where he led the scale-up of solid oxide oxygen separation technologies, managed EU-funded innovation projects, and co-authored patents on ceramic membranes for gas separation. Currently, he is a Technical Coordinator at LOMARTOV S.L., where he leads sustainability strategies, Life Cycle Assessment (LCA), eco-design, and environmental certifications for cutting-edge energy technologies. He is also an

Associate Lecturer at the Polytechnic University of Valencia.

Yagut Allahverdiyeva-Rinne (S2B)

Yagut Allahverdiyeva-Rinne is a full Professor of Basic and Applied Photosynthesis at the Department of Life Technologies, University of Turku. Her research focuses on the regulation of natural photosynthesis, with emphasis on alternative electron transport pathways and their role in the bioenergetics of photosynthesis. Her team applies this expertise to develop sustainable biotechnological applications through two strategic approaches; a short-term strategy aimed at producing sustainable algal biomass utilizing a circular bioeconomy concept, and a long-term strategy focused on engineering living cell factories and biohybrid systems for the production of solar-driven chemicals and fuels. She serves as the coordinator or principal investigator in several EU, Nordic, and national consortia, including the Solar to Butanol (S2B) EU RIA project.

Egzi Ogun Ramalhete (Mi-Hy)

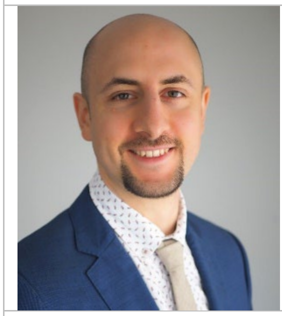
Dr. Ezgi Ogun Ramalhete is currently a Research Associate at KU Leuven, within the Department of Design and Engineering of Construction and Architecture. She is an active member of the Regenerative Architecture, Arts & Design research group, led by Prof. Rachel Armstrong, and serves as the Research Associate for the Mi-Hy project. Dr. Ogun Ramalhete holds a Ph.D. in Environmental Engineering and has over a decade of professional experience focusing on sustainable technologies, particularly in wastewater treatment and bioelectrochemical systems. Her expertise encompasses microbial electrochemical technologies, carbon sequestration strategies, and comprehensive environmental impact assessments.

Juha-Pekka Pitkänen (SolarFoods)

Dr. Juha-Pekka Pitkänen is Chief Scientific Officer and co-founder of Finnish start-up company Solar Foods Oyj, which brings to the market a radically new protein produced without agriculture or requirement for arable land. The process uses a microorganism grown in tanks as those in breweries, using carbon dioxide, renewable electricity, water, and minerals as raw materials. This closed process enables efficient food production regardless of environmental conditions, with no pesticides or irrigation needed, while avoiding environmental impacts, such as greenhouse gas emissions and water pollution. Prior to co-founding Solar Foods, Dr. Pitkänen was a principal scientist in bioprocess engineering at VTT Technical Research Centre of Finland.

Alessio Fuoco (DAM4CO2)

Alessio Fuoco is a Materials Scientist and earned his Erasmus Mundus Doctorate in Membrane Engineering (EUDIME) at the Universities of Toulouse (FR), Calabria (IT) and Twente (NL). His main research activities are focused on the preparation, characterization and modelling of polymeric and mixed matrix membranes for gas and vapour separation and valorisation. Currently, he is senior researcher at the Institute on Membrane Technology of the National Research Council of Italy and he is the coordinator of two national projects, and he is the coordinator of "DAM4CO2 - Double-Active Membranes for a sustainable CO2 cycle", and EIC-

	Pathfinder challenge project within the portfolio "Carbon Dioxide and Nitrogen management and valorisation".
	**Davide Testa (TURN2X)** Davide Testa is the Grants Manager at TURN2X, a Munich-based startup pioneering green hydrogen and renewable gas technologies. Currently completing a PhD in Public Health, he has extensive experience in securing funding for high-impact sustainability projects. At TURN2X, he strategically aligns TURN2X's innovations with key European initiatives to accelerate the energy transition.
13:00	Co-Creation Session for CCU Industrial Uptake
	**Guus Keder (Fenix Ventures)** Guus studied electrical engineering at Eindhoven Technical University, Management at Rotterdam University, and obtained an MBA from INSEAD. During his career, he has mostly dealt with technology-based high-growth entities, in the roles of corporate manager, venture capitalist, entrepreneur, business angel and board member. He is currently involved in research related to the better functioning of the innovation and startup ecosystem, is Chairman of two technology companies and occasionally serves as a jury member for the European Innovation Council.
	**Prachi Singh (LyondellBasell)** Dr. Prachi Singh is working in LyondellBasell as Sr Technology Manager for Carbon Capture & Hydrogen technologies in Innovation business unit for over two years. She has PhD in Carbon capture technology from Twente University, The Netherlands. Her over 20 years of combined experience focuses mainly on Carbon Capture, CO2 Utilization and Storage, Hydrogen, Gas Processing, Renewable Energy, Environment & Sustainability technologies in hard to abate sectors. Her international experience includes working at University of Twente, Shell, The Netherlands; IEA GHG UK; ADNOC, UAE; CEMEX.

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