



# PYRCO<sub>2</sub>

Strategic Intelligence Bulletin



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## FOREWORD

Climate change is one of the biggest challenges of our century. A simple Google search on the subject shows more than 754,000,000 results showing the interest of today's society in the topic. Companies are not only exposed to water scarcity, supply shortage or impacts of extreme weather events but also to transitional risks such as changes in technology and markets and new regulations that can increase business costs, affecting asset values and even the viability of products.

**Through the development of new technologies, businesses have the possibility to change the way they address climate change as an opportunity for innovation.** The industrial CO<sub>2</sub> emissions that were previously considered as waste are now being used to make new products, many of them with high added value and these new technologies are gaining momentum. The EU carbon prices of over 80 euros have also spurred commercial interest in some CCUS projects.

PYROCO<sub>2</sub> is one of these innovative projects. The project is receiving funding from the European Union's Horizon 2020 research and innovation program to demonstrate the scalability and economic viability of carbon capture and utilization (CCU) using an innovative hybrid catalytic and bioprocess to produce climate-positive acetone out of industrial CO<sub>2</sub> and green hydrogen.

AXELERA is a member of the PYROCO<sub>2</sub> consortium with the objective to facilitate the emergence of CCU projects at industrial scale in 4 European regions. The strategy will thereby explicitly expand well beyond the PYROCO<sub>2</sub> technology to provide CO<sub>2</sub> emitters with helpful information to facilitate investment decision on CCU projects (regulations, technologies, funding).

The strategic intelligence bulletins will be published every 3 months. It aims to help the partners of the PYROCO<sub>2</sub> consortium to make strategic decisions and to support the emergence of the CCU market also via broader dissemination, namely with the members of AXELERA cluster in order to engage them on the emergence of new CCU projects.

The content of this document refers to information from the previous three months, however, some older data with added value can be considered.

As CCU and CCS are strongly related for some projects, some publications about CCS which are relevant to the target audience are being included.

Do not hesitate to send us any comments to improve this document by writing or sharing information that could be relevant for the next bulletin to [marcos.versiani@axelera.org](mailto:marcos.versiani@axelera.org)

Have a good read!



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## MARKET INFORMATION

### MARKET NEWS

#### **ArcelorMittal expands partnership with carbon capture and re-use specialist LanzaTech through US\$30 million investment.**

Lanzatech, Dec 2021

ArcelorMittal announces it has made a US\$30 million investment in carbon recycling company, LanzaTech through its XCarb™ innovation fund, the fourth investment the Company has made through the fund since its launch in March 2021. [For more information](#)

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#### **Air Liquide, Borealis, Esso, Total Energies and Yara collaborate to help decarbonize the industrial basin of Normandy in France.**

Total Energies, Dec 2021

Air Liquide, Borealis, Esso S.A.F., Total Energies and Yara International ASA have signed a Memorandum of Understanding (MoU) to explore the development of a CO<sub>2</sub> infrastructure including capture and storage, to help decarbonize the industrial basin located in the Normandy region, France. With the objective to reduce CO<sub>2</sub> emissions by up to 3 million tons per year by 2030, which is equivalent to the emissions of more than 1 million passenger cars, the first phase will consist in studying the technical and economical feasibility of this project. This partnership, which will seek funding from European, French and Regional schemes, is open to other industrial parties. [For more information](#)

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#### **CCUS is gaining traction**

Ernst & Yang (EY), December 2021

[News](#)

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#### **From pollutant to product: the companies making stuff from CO<sub>2</sub>**

The Guardian December 2021

Vodka, jet fuel, protein... according to a new clutch of carbon-to-value startups, these are just some of the things that can be manufactured from thin air [For more information](#)

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#### **CCUS in Asia - Value and opportunities for deployment**

Carbon Capture Journal, December 2021

This news from Carbon capture journal brings information of the CCUS in China and Vietnam

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[For more information](#)

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**From dream to reality: Global airlines are turning to sustainable fuel to reduce CO2 emissions**  
General Electric, November 2021

[News](#)

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**NOIA sees Gulf Coast's potential for global CCUS hub**  
Off Shore Energy platform, January 14, 2022

The National Ocean Industries Association (NOIA) has considered the benefits of carbon capture, use, and storage (CCUS) projects in the U.S. offshore region, concluding that such deployment presents an opportunity to speed up the energy transition, reduce emissions, reach net-zero goals and turn the Gulf Coast into a global CCUS hub, which would further bolster and position the emerging U.S. CCUS sector as a top-tier player within the market. [For more information](#)

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### **CCUS in Industry and Transformation**

International Energy agency (IEA), Nov 2021

The industry and fuel transformation sectors currently have just under 30 commercial CCUS facilities in operation, with a growing pipeline of projects in development. Many planned projects target industrial hubs and low-carbon hydrogen production, and if all were to proceed, CO2 capture capacity from industry and fuel transformation would almost quadruple. Although a more inviting investment environment and net zero goals are raising interest in CCUS, its deployment remains woefully below the level required in the Net Zero Emissions by 2050 Scenario. Targeted support for lower-cost and less complex industrial CCUS applications, along with greater investment in CO2 transport and storage infrastructure, could unlock significant near-term emissions reductions. [For more information](#)

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## **MARKET ARTICLES**

**Potential CO2 utilization in Germany: An analysis of theoretical CO2 demand by 2030**  
Christopher Schmid, Alena Hahn, August 2021

**Abstract:** This study assesses a theoretical carbon dioxide capture and utilisation (CCU) potential for a broad spectrum of 55 CCU pathways for Germany in 2030, encompassing direct utilisation of CO2 for biomass cultivation or in techno-physical processes and its conversion to energy carriers, chemicals and inorganic carbonates. For each good or production process that could technically substitute fossil carbon sources by renewable ones, Germany-specific production data is collected

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and combined with its corresponding CO<sub>2</sub> conversion factors. By doing so, theoretical potentials for CO<sub>2</sub> consumption are determined per pathway, aggregated to a total theoretical CO<sub>2</sub> demand, which is then compared to German CO<sub>2</sub> emissions, as a proxy for potential CO<sub>2</sub> supply. The results show that the theoretical CO<sub>2</sub> demand of all considered CCU pathways amounts to about 234–423 Mt CO<sub>2</sub> p.a. in 2030 including energy carriers representing the largest share of more than 75 %. This theoretical demand exceeds the potential CO<sub>2</sub> provision from possible biogenic and industrial point sources. Considering exclusively CCU pathways, being technologically mature at present state, only 9–13 Mt CO<sub>2</sub> p.a. could be consumed in 2030, but a large variety of CCU pathways showing high consumption potentials are close to market maturity. [For more information](#)

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## MARKET – REPORTS

### Scaling up CCUS – Market insights

A report by Decarb Connect in association with Carbon Clean 2021

This Decarb Connect Report combines both qualitative and quantitative techniques to give a thorough insight into the current state of play for CCUS strategies and projects across hard-to-abate sectors. The report statistics and figures are taken from an anonymized survey of 70 hand-picked senior executives, chosen to represent prevailing thoughts and experiences across the industry, with just under 60% of respondents representing hard-to-abate asset owners, and 40% chosen from industry thought leaders such as policymakers, financial executives, academics in the subject area and industry experts. [For more information](#)

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### Global status of CCS 2021

Global CCS institute, October 2021

Global Status of CCS Report reveals that just as the acceleration in climate action commitment is unprecedented, so too is the growth in the CCS facility and project catalogue. In all the years that the Institute has been recording and publishing the data on CCS facilities and projects, never before has such a big single year increase in the project pipeline been recorded. This is the natural outworking of the commitments being made to address emissions and achieve net zero emissions. It confirms the findings of modelling undertaken by a variety of different, independent agencies: CCS is a necessary element of the technology suite that must be deployed if the world is to achieve the Paris Objectives. [For more information](#)

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### CCUS ROADMAP TO 2030

CCUS SET plan external reports, October 2021

The CCUS Roadmap to 2030 aims to identify and stress the actions that will be necessary for the large-scale development and deployment of CCS and CCU in the 2020s, build on the work done

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within the CCUS SET-Plan, and provide an overview of the status of the technologies today. The roadmap also includes a list of actions to be taken by European and national policymakers to underpin the European development of CCS and CCU. After a brief introduction, the Roadmap looks at the contribution of CCS and CCU to climate change mitigation, as examined by scientific modelling scenarios, and discusses the status of the technology and the progress made so far. Within the Roadmap, the new targets of the CCUS SET-Plan are also reported as a basis to take quick action and support the upscale of these technologies. Chapter five focuses on the way forward and the actions to be taken in the 2020s from a technological, policy, legal, and funding perspective and across the entire CCS/CCU value chain. Recommendations and actions for policymakers are summarised in the final chapter of the Roadmap. Complementing the Roadmap is an extensive, free-standing document containing the annexes. [For more information](#)

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### **CCUS around the globe**

International Organization of Oil & Gas producers (IOGP) April, 2021

This Infographic contains a map of existing and planned CCUS facilities around the globe, and contains tables with further detail on each facility, including the status of the project, the amount of CO<sub>2</sub> captured annually, and IOGP Member participation. [For more information](#)

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### **'Plan de Transition Sectoriel de l'Industrie Cimentière en France' (Sector transition plan for the cement industry in France)**

ADEME October 2021

This is a strategic document which presents the challenges of decarbonization for the cement industry in France for the next years taking into consideration different scenarios of climate change. [For more information](#)

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### **Energy Technology Perspective - Special Report on Carbon Capture Utilisation and Storage CCUS in clean energy transitions**

2020, International Energy agency (IEA)

The International Energy Agency (IEA) has released this report that gives an overview of the CCUS going through the main technologies, innovations, regional opportunities, deployment of CCUS and other relevant topics. Even being this is a September 2020 report, it is still interesting to have a look at the whole aspects of CCUS. [For more information](#)

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### **Map of CCUS projects in Europe**

Zero Emissions Platform, map updated yearly

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The projects included on this map are market-ready projects – projects that are on track to become operational before 2030, provided that supportive policy and financial frameworks are in place. [Link for the map](#)

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## TECHNOLOGY WATCH

### Technology Brief - CARBON CAPTURE, USE AND STORAGE (CCUS)

United Nations Economic Commission for Europe 2020/2021

This brief builds on the recommendations from the Pathways to Sustainable Energy project and is the first in a series of technology briefs that directly support implementation of the Carbon Neutrality project. The underlying objectives of this brief are: 1- Introduce member states to a portfolio of CCUS technologies 2 - Help policy makers to evaluate the benefits of the CCUS technologies 3 - Build capacity in economies in transition with regard to CCUS. [For more information](#)

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### Technological advances in the transformative utilization of CO<sub>2</sub> to value-added products

Aayush Alok, Rakesh Shrestha, Sagar Ban, Sijan Devkota, Bibek Uprety, Rajendra Joshi, January 2022

Abstract: Climate change is among the most urgent and serious problems that humanity must address. Climate change is driven by the atmospheric accumulation of several greenhouse gases (GHGs). Among these gases, CO<sub>2</sub> has been showing the most alarming global accumulation rate and as predicted by IPCC, its global concentration may reach up to 570 ppm raising the global temperature by around 1.5 °C near the year 2100. With a need for mitigation of the adverse effects accredited to it, carbon capture and utilization (CCU) technologies based on thermal, chemical, biochemical, photochemical and electrochemical pathways have had major appeal among the scientific community and the industries. These technologies, while reducing the rate of global CO<sub>2</sub> emission, also valorize the CO<sub>2</sub> for producing several products that complement the chemical industries. Despite low temperature application favor noble metals for thermal utilization of CO<sub>2</sub>, their high cost has led researchers to focus towards the development of catalysts based on earth abundant metals and their adaptability to a suitable support. Electrochemical transformation systems have yielded for example, formic acid whose production can lead to 95.01% reduction in global warming alongside formation of oxalic acid, CO, ethylene, ethanol etc. through electrical reduction within ambient conditions. Furthermore, the technology is based on utilizing renewable perpetual sources of electricity with development works focusing on increasing catalytic life. CO<sub>2</sub> has also been photochemically reduced with absorbed radiation generating an excited state followed by transferring the charge to a functional ligand. Developments related to for example photosensitizer, catalysts, and obtained yield are presented, describing various factors affecting the photochemical transformation. In the biochemical pathway; by selecting desired route and manipulating strains, CO<sub>2</sub> can be enzymatically transformed to other products with optimization in yields. In this review,



an overview on advancements achieved so far in the aforementioned technologies and future course of action are presented. [For more information](#)

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### **Bioprocesses for resource recovery from waste gases: Current trends and industrial applications**

Ramita Khanongnuch, Haris Nalakath Abubackar, Tugba Keskin, Mine Gungormusler, Gozde Duman, Ayushi Aggarwal, Shishir Kumar Behera, Lu Li, Büşra Bayar, Eldon R. Rene, 2022

Air pollution is a topic of important global concern because it has contributed significantly to an increase in the earth's global warming potential and contributed to severe health and environmental impacts. In this review, the different bioreactor configurations commonly used for waste gas treatment, namely the biofilters, the bio trickling filters and the bio scrubbers, and their industrial applications were compared in terms of the type of inoculum, the packing material/media, removal efficiency and elimination capacity. Typically, biofilters are operated under the following range of operating conditions: gas residence time = 15–60 s; gas flow rate = 50–300,000 m<sup>3</sup> h<sup>-1</sup>; temperature = 15–30 °C; pH = 6.0–7.5; filter area = 100–3000 m<sup>2</sup>; relative humidity >95.0%; and removal efficiencies >75.0% depending on the waste gas composition and concentration. The biotechnological approaches for resource recovery, i.e., the conversion of C1 gaseous compounds (CO, CO<sub>2</sub> and CH<sub>4</sub>) to liquified value-added products or biofuels have been discussed. From this review, it was evident that the performances of different aerobic, anoxic and/or anaerobic lab, pilot and full-scale bioreactors for waste gas treatment and resource recovery depend on the composition, the individual concentration of pollutants present in the waste gas and the gas flow rate. Although most of the research on product recovery from waste gas is rather limited to lab/pilot-scale studies, there are some key commercialized technologies that have proven to be economical at the full-scale. Thus, this review, comprehensively presents a complete overview of the current trends and limitations of conventional waste gas treatment systems, the benefits of novel bioreactor configurations and their potential to be applied for resource recovery from waste gases. [For more information](#)

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### **New electrocatalyst converts CO<sub>2</sub> into ethanol, acetone, and n-butanol with high efficiency 'An overview of CO<sub>2</sub> capture and utilization in energy models'**

Lucas Desport, Sandrine Seloisse, January 2022

**Abstract:** The recycling and utilization of CO<sub>2</sub> is gaining interest in the fight against global warming. Considering CO<sub>2</sub> not as a waste or a pollutant but as an opportunity is a concept that could prove promising for producing clean fuels in the future, as well as for producing chemicals, plastics and building materials. The extent of the benefits of Carbon Capture and Utilization (CCU) is still uncertain due to its many interactions with the rest of the energy system, and several energy models are trying to explore this area. As the global climate issue becomes an urgent policy priority, the scientific community is helping decision-makers choose the optimal technologies to successfully meet climate targets and decarbonize society. This paper reviews energy models that represent CCU as a decarbonization solution in an effort to understand and identify knowledge and modeling gaps. The results first show that CO<sub>2</sub> utilization is still poorly represented, and that when it is, it is rarely fully integrated. The conversion of CO<sub>2</sub> into fuels or chemicals is by far the most modeled of

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all the options CCU encompasses, while other key technologies for the decarbonization of the industry sector are barely considered. We discuss current CCU modeling methods and provide recommendations for future modelers who want to implement this set of technologies in their models. Additionally, we discuss the socioeconomic drivers and barriers that could support or discourage the deployment of CCU in the future energy mix. [For more information](#)

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### **Are Sustainable Aviation Fuels a Viable Option for Decarbonizing Air Transport in Europe? An Environmental and Economic Sustainability Assessment**

Alexander Barke, Timo Bley, Christian Thies, Christian Weckenborg, Thomas S. Spengler, January 2022

**Abstract:** The use of drop-in capable alternative fuels in aircraft can support the European aviation sector to achieve its goals for sustainable development. They can be a transitional solution in the short and medium term, as their use does not require any structural changes to the aircraft powertrain. However, the production of alternative fuels is often energy-intensive, and some feedstocks are associated with harmful effects on the environment. In addition, alternative fuels are often more expensive to produce than fossil kerosene, which can make their use unattractive. Therefore, this paper analyzes the environmental and economic impacts of four types of alternative fuels compared to fossil kerosene in a well-to-wake perspective. The fuels investigated are sustainable aviation fuels produced by power-to-liquid and biomass-to-liquid pathways. Life cycle assessment and life cycle costing are used as environmental and economic assessment methods. The results of this well-to-wake analysis reveal that the use of sustainable aviation fuels can reduce the environmental impacts of aircraft operations. However, an electricity mix based on renewable energies is needed to achieve significant reductions. In addition, from an economic perspective, the use of fossil kerosene ranks best among the alternatives. A scenario analysis confirms this result and shows that the production of sustainable aviation fuels using an electricity mix based solely on renewable energy can lead to significant reductions in environmental impact, but economic competitiveness remains problematic. [For more information](#)

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### **A review of technologies for carbon capture, sequestration, and utilization: Cost, capacity, and technology readiness**

Farzan Kazemifar, November 2021

**Abstract:** The continued rise in anthropogenic carbon dioxide (CO<sub>2</sub>) emissions and increase in atmospheric CO<sub>2</sub> concentration has led to calls from experts, including the Intergovernmental Panel on Climate Change that has estimated that global warming needs to be limited to 1.5 °C above preindustrial levels to avoid the worst effects of climate change, and that carbon neutrality would need to be achieved globally by 2050 to meet this target. Achieving carbon neutrality by mid-century will rely on successful implementation and widespread adoption of technologies for reducing emissions from large point sources of CO<sub>2</sub>, direct CO<sub>2</sub> capture from the air, as well as storage and utilization technologies that would convert CO<sub>2</sub> to a form that would ensure safety and permanency of storage. In this paper, engineering solutions for CO<sub>2</sub> capture, utilization, and storage are reviewed

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with a focus on technology readiness level, and cost. © 2021 Society of Chemical Industry and John Wiley & Sons, Ltd. [For more information](#)

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### Modelling the effect of bioreactor height on stripping fermentation products from the engineered bacterium *Geobacillus thermoglucosidasius*

Clare R. Rees-Zimmerman, Stephen T. Chaffin, December 2021

Mass transfer into microbubbles is important for stripping fermentation products from bioreactors. The effect of bioreactor height on stripping the ethanol produced by the thermophilic bacterium *Geobacillus thermoglucosidasius* is explored. Being thermophilic, this bacterium allows operation near the boiling point of ethanol. First, a model is developed for a tall bioreactor with a well-mixed liquid phase. An expression relating off-gas concentration, dissolved gas measurements and the mass transfer coefficient is derived. This gives a novel method for estimating the mass transfer coefficient. Second, this approach is adapted to formulate and numerically solve a model for fermentation with *Geobacillus thermoglucosidasius* in a tall bubble column. For validation, the model is shown to be consistent with an experimentally-validated model of fermentation in a tall bubble column in the literature. The model predicts that under typical operation with 100 µm diameter microbubbles, mass transfer is not limiting: the gas-phase product concentrations are metabolically driven. The model is run with different bubble sizes, obtaining a universal curve for the gas product concentrations. This curve indicates a previously unexplored mass transfer limited regime in which, for a 20 m column, the outlet ethanol gas-phase concentration could be increased by 45% compared to its equilibrium value. [For more information](#)

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### Liquid fuels from carbon dioxide Electrocatalyst converts CO<sub>2</sub> into multicarbon products

Prof. Fei Hu, Dr. Li Yang, Yawen Jiang, Dr. Chongxiong Duan, Dr. Xiaonong Wang, Longjiao Zeng, Xuefeng Lv, Delong Duan, Qi Liu, Prof. Tingting Kong, Prof. Jun Jiang, Ran Long, Prof. Yujie Xiong, October 2021

A team from Foshan University (Foshan, Guangdong), the University of Science and Technology of China (Hefei, Anhui), and Xi'an Shiyu University (Xi'an, Shaanxi), led by Fei Hu, Tingting Kong, Jun Jiang, and Yujie Xiong has now developed a novel electrocatalyst that efficiently converts CO<sub>2</sub> to liquid fuels with multiple carbon atoms (C<sub>2-4</sub>). The primary products are ethanol, acetone, and *n*-butanol. To make the electrocatalyst, thin ribbons of a copper/titanium alloy are etched with hydrofluoric acid to remove the titanium from the surface. This results in a material named a-CuTi@Cu, with a porous copper surface on an amorphous CuTi alloy. It has catalytically active copper centers with remarkably high activity, selectivity, and stability for the reduction of CO<sub>2</sub> to C<sub>2+</sub> products (total faradaic efficiency of about 49 % at 0.8 V vs. reversible hydrogen electrode for C<sub>2-4</sub>, and it is stable for at least three months). In contrast, pure copper foil produces C<sub>1</sub> products but hardly any C<sub>2+</sub> products. The reaction involves a multistep electron-transfer process via various intermediates. In the new electrocatalyst, the inactive titanium atoms below the surface actually play an important role; they increase the electron density of the Cu atoms on the surface. This stabilizes the adsorption of \*CO, the key intermediate in the formation of multicarbon products, allows for high

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coverage of the surface with \*CO, and lowers the energy barrier for di- and trimerization of the \*CO as new carbon-carbon bonds are formed. [For more information](#)

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### **Sustainable aviation fuels and imminent technologies - CO2 emissions evolution towards 2050**

Ivo Abrantes, Ana F. Ferreira, André Silva, Mário Costa, September 2021

Abstract: Nowadays, concerns about rising emissions and climate change have raised the issue of decarbonization. Several approaches have been promoted in the aeronautical sector to reduce CO<sub>2</sub> emissions. The present work provides quantitative data to support decision-making for the first pillar of International Air Transport Association (IATA) strategy to mitigate aviation climate impact. This strategy comprises improving aircraft technology and deploying sustainable low-carbon fuels. The most promising technologies for an imminent application are new engine architecture and natural laminar flow. On the other hand, efforts have been put to produce Sustainable Aviation Fuel (SAF) reaching the point where some methods for the production of alternative jet fuel are already approved by ASTM. Therefore, the present work quantifies the future reduction of CO<sub>2</sub> emissions by 2050 in the aeronautical sector with these strategies. For this purpose, two methodologies are used, a numerical model to calculate fuel consumption and CO<sub>2</sub> emissions from the global air transport fleet. For the SAF analysis, it is developed an approach that considers, besides the SAF production, the feedstocks, and the production pathway. Two cases and three scenarios represent the technological improvements and quantify the effects of new aircraft concepts and technologies on future CO<sub>2</sub> emissions. For the SAF analysis, four scenarios and two conditions assess the different production capacities and feedstocks. The combined effect of technologies with SAF is considered verifying if the goals proposed by IATA, carbon-neutral growth from 2020, and a reduction of 50% in net emissions by 2050 compared to 2005 levels are achieved. The assessment results reveal that the goals cannot be met only with the combined action of imminent aircraft technologies and the use of alternative fuels. Carbon-neutral growth is only reached when it is considered the combined effect of technologies with the scenario where the amount of SAF introduced is higher (an increase of 15% annually between 2030 and 2050). However, this carbon-neutral growth is only possible to start in 2040. Imminent aircraft technologies can reduce up to 15% in CO<sub>2</sub> emissions when compared to the Business as Usual scenario. The different feedstocks used in each process to produce SAF do not have a considerable impact on reducing CO<sub>2</sub> emissions, the maximum difference registered between each condition was 1.47%. [For more information](#)

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## EU POLICIES & LEGISLATION

### CO<sub>2</sub> valorization, under what conditions ? what are the benefits?

Point of view of ADEME specialist, France. September 2021 ( French only)

The capture and recovery -or utilization- of CO<sub>2</sub> (CCU) brings together different technologies that use the CO<sub>2</sub> captured from industrial sources (combustion fumes in particular) or sources using biomass (biogenic CO<sub>2</sub>) or even in the air as a feedstock for a wide spectrum of applications and products. CCU can be considered as a lever for decarbonization. However, the overall contribution of CO<sub>2</sub> recovery overall in terms of CO<sub>2</sub> emissions reduction remains difficult to quantify. In fact, analyses of actual CO<sub>2</sub> emission reductions depend on many parameters and the potential volumes vary greatly from one recovery pathway to another. Thus, this opinion aims to provide analytical keys to identify the relevant conditions for CO<sub>2</sub> recovery by analyzing the different recovery routes (direct use, chemical recovery, biological recovery) according to the biological) according to the maturity of the technologies, their market, their costs and the regulations. This paper shows that CO<sub>2</sub> recovery will be able to contribute to the objectives of carbon neutrality provided that the use of biogenic CO<sub>2</sub> is favored while massively using renewable energy, and by favoring the manufacture of products with a long temporal storage of CO<sub>2</sub> (at least several decades years). [For more information](#)

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### Implementing the EU Climate Law via the 'Fit for 55' package

Sabine Schlacke, Helen Wentzien, Eva-Maria Thierjung, Miriam Köster, January 2022

To implement the European Union (EU) Climate Law's newly established 55% greenhouse gas reduction objective for 2030, the EU Commission suggests a wave of reforms to the European energy and climate legislation. The contribution aims to describe the EU Commission's 16 initial legislative and strategic proposals regarding the major pillars of the European energy and climate legislation and intends to give an overview on the suggested reforms. By comparing the legal status quo with the legal framework de lege ferenda as presented by the Commission's proposals, the planned major changes to the legal structures are identified. To achieve the 55% greenhouse gas reduction objective for 2030, all existing legal climate and energy acts are planned to be tightened by amending their targets as well as scopes and revising their structures. The suggested reforms concern the existing EU emissions trading system, effort sharing system between the Member States, energy taxation, energy efficiency and renewable energies. Additionally, the implementation of new instruments, such as the second EU emissions trading system for the sectors buildings and transport, the Carbon Border Adjustment Mechanism and the Social Climate Fund, is proposed. The design of the package shows that the Commission still generally pursues a climate legislation characterized by a mix of instruments and policies being both price based and regulatory. So, even though the major proposed change—the introduction of a second separate emissions trading system—would strengthen the role of carbon pricing, the Commission still relies on a mix of instruments without defining a leading instrument. [For more information](#)

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### **Policy critical to unlock Carbon Capture and Utilization in Europe**

Power Engineering International, December 2021

Célia Sapart, Director Communications and Climate Science – CO2 Value Europe, at an Enlit Europe session that provided practical insights into how CCU technology can make a positive, decarbonising impact across various sectors, from aviation to chemicals. [For more information](#)

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### **Regulations for carbon capture, utilization and storage: Comparative analysis of development in Europe, China and the Middle East**

Hao Zhang, June 2021

**Abstract:** The development of the carbon capture, utilization and storage (CCUS) supply chain will require the establishment of a regulatory and legal regime, both at the international and domestic level, to manage risks at various parts of the supply chain and to support technology investment. Within this regulatory and legal framework, the regional and domestic regime has been identified as a crucial factor that could facilitate or inhibit the creation of a CCUS supply chain at a larger scale. According to the relevant literature, policy backing for CCUS has been supported in several countries and jurisdictions which represent both the source and sink of carbon dioxide. To evaluate the legal and regulatory developments which underpin the global matching of CO2 sources and sinks, this article reviews and critically analyzes the legal and regulatory systems to address various challenges facing the CCUS development in Europe, China and the Middle East, because these jurisdictions have good representations, as sinks and sources of CO2, in developing the CCUS supply chain. These challenges include ensuring regulatory clarity to support CCUS development, integration of CCUS in the portfolio of climate change mitigation to create an enabling environment to improve the financial viability of CCUS, and ensuring consistency with international law. The findings of this article suggest that the regulatory systems in the three regions face various challenges and this article proposes some regulatory changes that are necessary for facilitating the CCUS supply chain at the domestic and regional level. [For more information](#)

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### **EU drafts plan to remove more carbon emissions from the air**

Reuters, December 2021

BRUSSELS, Dec 1 (Reuters) - The European Union plans to capture five million tons of carbon dioxide from the atmosphere each year by 2030 through technologies, and create an EU system to certify carbon removals, according to a draft document seen by Reuters. [For more information](#)

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### **A legal exploration of the European Union's Carbon Border Adjustment Mechanism**

Indian Journal of International Economic Law, Vol. XIV, 2022 - Queen Mary University of London, School of Law

**Abstract:** In December 2019, the European Commission released a mechanism to fight climate change, namely the European Green Deal. This policy was put in place to materialize the goals of

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the Paris Agreement on Climate Change of 2015, that is, to combat the issue of climate change along the lines of sustainable development and fight poverty. In the context of the European Green Deal, one of the key instruments envisaged to achieve the ambitious plans of the European Union (EU) is the so-called Carbon Border Adjustment Mechanism (CBAM), which is the focus of this article and has been described as an 'extraterritorial outreach' for attempting to regulate matters outside the EU borders. This article seeks to answer is whether the CBAM is justified in line with the need to protect the environment and address climate change as well as increasing global economic welfare and reducing poverty. This article provides an overview of CBAM, analyzes the rationale behind CBAM as well as the various misgivings from third parties. It contextualizes CBAM in the context of free trade and examines whether CBAM is consistent with multilateral trade rules. It then provides the design of a CBAM based on the principles of international trade and sustainable development. The article concludes that, overall, the analysis of CBAMs, particularly regarding the fervency of the EU to make its CBAM compatible with both trade rules and climate change objectives, demonstrates states' growing interest in protecting the planet, while preserving economic values; it also indicates the importance of trade in managing those interests. [For more information](#)

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## FUNDING & TENDER OPPORTUNITIES

### FRANCE

#### Appel à projets i-Démo

BPI France

Deadline date :03/05/2022

The "i-Demo" action of the Future Investment Program (PIA) aims to develop industrial and service companies in promising markets, creating value and competitiveness for the economy and contributing to energy, ecological and digital transitions. [For more information](#)

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#### Investments for the decarbonization of production process

ASP (Agence de services et de paiement)

Deadline date: 31/12/2022

This topic is addressed to industrial companies of all sizes that wish to equip themselves to reduce their CO2 emissions or improve their energy efficiency. [For more information](#)

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## FUNDING & TENDER OPPORTUNITIES

### EUROPE

#### EU Innovation Fund - Launch of the second call for large-scale project proposals

Deadline date: 03 March, 2022

With a budget of EUR 1.5 billion, which is increased by 50% compared to the previous call, it will finance breakthrough technologies for renewable energy, energy-intensive industries, energy storage, and carbon capture, use and storage. [For more information](#)

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#### HORIZON-CL4-2022-TWIN-TRANSITION-01-11: Valorization of CO/CO<sub>2</sub> streams into added-value products of market interest

Deadline date: 30/03/2022

The proposals submitted under this topic are expected to provide concepts for utilisation of CO/CO<sub>2</sub> streams from point sources (e.g. large industrial installations such as steel, cement and chemical plants) converting them into added value products and/or intermediates and chemicals of wide interest (plastics, resins, composites, chemicals). The topic excludes explicitly fuels and renewable energy storage concepts. The technologies proposed should support cross-sectorial concepts and sector integration paradigms. They should also be able to work efficiently in a renewable based energy system, coping with potential fluctuations in the energy supply or be fully self-sustained from an energy standpoint. [For more information](#)

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#### HORIZON-CL5-2022-D3-01-15 Decarbonising industry with CCUS

Deadline date :26/04/2022

The focus of this topic lies in demonstrating the integrated chain of mature CO<sub>2</sub> capture technologies in industrial facilities with the perspective of geological storage and/or use. Based on a high TRL (7 – 8) CO<sub>2</sub> capture project a detailed plan on how to use the results, i.e. the subsequent transport, utilisation and/or underground storage of the captured CO<sub>2</sub> should be developed. Important aspects to address are of technical (e.g. the optimised integration of capture plant with industrial processes; flexibility, scalability; CO<sub>2</sub> purity), safety (e.g. during transportation and storage), financial (e.g. cost of capture; cost of integration) and strategic nature (e.g. business models; operation and logistics of industrial clusters and networks). The project should identify a detailed set of operational, environmental, technical and economic Key Performance Indicators (KPIs) to allow monitoring and assessing the progress achieved by the project. [For more information](#)

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#### Breakthrough Energy Catalyst

Deadline date :13/05/2022 - Submissions received after 15 June 2022 will be evaluated on a rolling basis, but no less frequently than semi-annually

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Commission President Ursula von der Leyen and Bill Gates have announced a pioneering partnership between the European Commission and Breakthrough Energy Catalyst to boost investments in the critical climate technologies that will enable the net-zero economy. Presented on the occasion of the sixth Mission Innovation Ministerial meeting, the new partnership aims to mobilize new investments of up to €820 million/\$1 billion between 2022-26 to build large-scale, commercial demonstration projects for clean technologies – lowering their costs, accelerating their deployment, and delivering significant reductions in CO<sub>2</sub> emissions in line with the Paris Agreement. This new partnership intends to invest in a portfolio of high-impact EU-based projects initially in four sectors with a high potential to help deliver on the economic and climate ambitions of the European Green Deal: Green hydrogen, Sustainable aviation fuels, Direct air capture and Long-duration energy storage. [For more information](#)

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#### **Pre-announcement of the Transnational Access calls of the EU Horizon 2020 funded ECCSELERATE project lead by ECCSEL ERIC**

Deadline date: June 2022

The first ECCSELERATE Transnational Access call offers access to ECCSEL ERIC facilities dedicated to researchers or research teams from industry and small and medium size enterprise (SME). The target of the call is to extend the ECCSEL ERIC user base to industry to meet identified needs of industry within CCUS research. [For more information](#)

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#### **HORIZON-CL5-2022-D3-02-08 Demonstration of complete value chains for advanced biofuel and non-biological renewable fuel production**

Deadline date: 27/10/2022

Proposals should demonstrate innovative and cost effective sustainable value chains for advanced biofuels or synthetic renewable fuels of non-biological origin (other than for hydrogen as a final product), over the entire cycle from feedstock to end use. Any sustainable biomass feedstock including residues and wastes, or biogenic CO<sub>2</sub> or industrial CO<sub>2</sub> and renewable hydrogen, as well as input energy to the conversion should be addressed. Pathways which are biochemical, thermochemical, biological, chemical, electrochemical or combinations of them should be considered. Proposals should aim at improved performance in terms of increasing the efficiency and sustainability and reducing the cost, while evidencing the value creation along the value chain steps. Complete value chains may address any relevant end use. [For more information](#)

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#### **HORIZON-CL5-2022-D3-03-07: Development of algal and renewable fuels of non-biological origin (RIA)**

Deadline date: 10/01/2023

Proposals will develop and improve algal and/or non-biological renewable fuel technologies (other than for hydrogen as a final product), through developing synthetic pathways including biological, biochemical, thermochemical, electrochemical processes or combinations of them. Improving the performance of the conversion process by increasing the efficiency, reducing the cost and

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decreasing the GHG emissions from the production should be addressed beyond the current state of the art. Implementing and improving circularity for energy and material use should be considered, also as means to enhance sustainability and economic feasibility of the proposed concepts. Proposals should also address systemic constraints and opportunities for scaling-up algal and non-biological renewable fuel technologies. [For more information](#)

## CCU ONGOING PROJECTS

### EUROPE

#### HORIZON 2020 – Strategic Planning of Regions and Territories in Europe for Low-Carbon Energy and Industry Through CCUS

Carbon capture, utilization and storage (CCUS) is expected to play a key role in the decarbonizing of Europe’s industry and energy supply. The EU-funded STRATEGY CCUS project will design economic evaluations at regional and national scales for CCUS deployment in seven southern and eastern EU Member States. The aim is to elaborate scenarios taking into account the needs and concerns of key regional and national stakeholders, as well as the positive environmental impact of CCUS in the lifecycle of carbon. Currently, advanced CCUS clusters are mainly concentrated in western Europe around the North Sea. The project will consider transport corridors between local CCUS clusters and the North Sea infrastructure. [For more information](#)

Project Information

**STRATEGY CCUS**

Grant agreement ID: 837754



**Start date**

1 May 2019

**End date**

31 July 2022

**Funded under**

H2020-EU.3.3.

H2020-EU.3.3.2.

**Overall budget**

€ 3 069 473,75

**EU contribution**

€ 2 959 533,75

**Coordinated by**

BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES

France



#### Horizon 2020 - Providing access to cost-efficient, replicable, safe and flexible CCUS

The ACCSESS concept is centered around the project vision to Develop replicable CCUS pathways towards a Climate Neutral Europe in 2050. ACCSESS will improve CO2 capture integration in industrial installations (20-30% cost cuts) as a key element to accelerate CCUS implementation, address the full CCUS chain and the societal integration of CCUS. ACCSESS has the ambition unleash the ability of CCUS to contribute to the ambitious EU Green Deal transformation strategy. The project is dedicated to developing viable industrial CCUS business models. ACCSESS will engage with citizens and citizens, explaining how CCUS can contribute to the production of climate neutral or climate positive end-products in a sustainable cities' context. [For more information](#)

Project Information

**ACCSESS**

Grant agreement ID: 101022487

**Start date**

1 May 2021

**End date**

30 April 2025

**Funded under**

H2020-EU.3.3.

H2020-EU.3.3.2.

**Overall budget**

€ 18 427 186,75

**EU contribution**

€ 14 983 874

**Coordinated by**

SINTEF ENERGI AS

Norway



### Horizon 2020 - Implementation Plan for Actions on CCUS Technologies in the SET Plan Support for low-carbon energy technologies

Carbon capture, utilisation and storage (CCUS) can be applied across the energy system. While CCUS technologies will no doubt play a big role in decarbonization of the European energy and industrial sectors, they have not been developed in Europe to the extent required. The EU-funded IMPACTS9 project will support the EU's implementation of the Strategic Energy Technology (SET) Plan – a major tool to contribute to cost reduction and improve performance of low-carbon energy technologies through impactful synergetic innovation actions. The project consortium is composed of organizations highly representative of the related stakeholders and will engage with them for their active contribution in implementation of the SET Plan. [For more information](#)

**Project Information**

**IMPACTS9**  
Grant agreement ID: 842214

<b>Start date</b> 1 May 2019	<b>End date</b> 30 April 2022
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**Funded under**  
H2020-EU.3.3.

**Overall budget**  
€ 1 100 298,75

**EU contribution**  
€ 1 100 298,75



**Coordinated by**  
THE CARBON CAPTURE AND STORAGE ASSOCIATION  
 United Kingdom

### Horizon 2020 - Demonstrating a Refinery-Adapted Cluster-Integrated Strategy to Enable Full-Chain CCUS Implementation - Novel technology could sequester 90 % of CO2 emissions from refineries

Almost everyone now agrees that we should decrease the amount of atmospheric carbon dioxide (CO2) to mitigate climate change. Reducing CO2 production is not the only way to reduce emissions. Carbon capture, use and storage (CCUS) refers to an integrated set of technologies to prevent the CO2 produced during the combustion of fossil fuels from entering the atmosphere. Currently, these technologies focus on the greatest sources of CO2 in a process, ignoring smaller ones. The EU-funded REALISE project is developing a way to capture up to 90 % of CO2 from multiple sources in operating refineries at a cost that is 30 % lower than existing capture methods. The project will include the evaluation of the entire CCUS chain from emitter to storage as well as socio-political aspects and social readiness assessments based on three business cases in the EU and China. [For more information](#)

**Project Information**

**REALISE**  
Grant agreement ID: 884266

<b>Start date</b> 1 May 2020	<b>End date</b> 30 April 2023
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**Funded under**  
H2020-EU.3.3.2.

**Overall budget**  
€ 7 131 752,50

**EU contribution**  
€ 6 444 163,75



**Coordinated by**  
SINTEF AS  
 Norway



### Advanced Carbon Capture for steel industries integrated in CCUS Clusters (Full-scale integration in iron, steel plants)

The Paris Agreement sets out a global framework to avoid dangerous climate change by limiting global warming to well below 2 °C and pursuing efforts to limit it to 1.5 °C. Without carbon capture, utilisation and storage (CCUS), it is difficult to realise the temperature levels indicated in the Paris Agreement. In the context of the European Energy Union, CCUS is a vital research and development priority to achieve 2050 climate objectives in a cost-effective way. With the focus on the iron and steel industry as part of the CCUS chain, the EU-funded C4U project will work with eight European countries and Mission Innovation countries (Canada, China and the United States) to address all the essential elements required for optimal integration of CO2 capture into the North Sea Port CCUS cluster. [For more information](#)

Project Information

**C4U**

Grant agreement ID: 884418

**Start date**  
1 April 2020

**End date**  
31 March 2024

**Funded under**  
H2020-EU.3.3.  
H2020-EU.3.3.2.

**Overall budget**  
€ 13 845 496,89

**EU contribution**  
€ 12 499 083,27

**Coordinated by**  
UNIVERSITY COLLEGE LONDON

United Kingdom



### Creating added-value chemicals from bio-industrial CO2 emissions using integrated catalytic technologies

The European Green Deal sets the blueprint for making Europe the first climate neutral continent in the world. The goal is to reduce greenhouse gas emissions (GHGs) to at least 55 % below 1990 levels by 2030. The EU-funded CATCO2NVERS project will develop and optimize technologies that convert waste CO2 into useful bio-origin chemicals to produce plastics, methanol, cosmetics, and renewable feedstocks for industrial processes. The project's overall vision will be to use waste CO2 energy- and resource-efficiently in bio-based industries to produce zero GHGs and reduce the quantity of CO2 released into the atmosphere. [For more information](#)

Project Information

**CATCO2NVERS**

Grant agreement ID: 101000580

**Start date**  
1 May 2021

**End date**  
30 April 2025

**Funded under**  
H2020-EU.3.2.4.2.  
H2020-EU.3.2.

**Overall budget**  
€ 6 641 111,25

**EU contribution**  
€ 6 641 110,75

**Coordinated by**  
FUNDACION PARA EL DESARROLLO Y LA INNOVACION TECNOLOGICA

Spain



### CLEAN clinker production by Calcium looping process

The CLEANKER project aims at demonstrating at TRL7 the CaL concept in a configuration highly integrated with the cement production process, making use of entrained flow reactors. The highly integrated configuration allows achieving high energy efficiencies, with CO2 capture efficiency over 90%. The adoption of entrained flow gas-solid reactors is particularly suitable - and familiar - to the cement industry. The core activity of the project is the design, construction and operation of a CaL demonstration system comprising the entrained-flow carbonator (the CO2 absorber) and the entrained-flow oxyfuel calciner (the sorbent regenerator). This demonstration system will capture the CO2 from a portion of the flue gas of the cement plant in Vernasca (Italy) operated by Buzzi Unicem, using as CO2 sorbent the same raw meal used for clinker production. [For more information](#)

#### Project Information

##### CLEANKER

Grant agreement ID: 764816



**Start date**  
1 October 2017

**End date**  
31 March 2022

**Funded under**  
H2020-EU.3.3.  
H2020-EU.3.3.2.

**Overall budget**  
€ 9 237 851,25

**EU contribution**  
€ 8 972 201,25



**Coordinated by**  
LABORATORIO ENERGIA AMBIENTE PIACENZA  
 Italy

### Horizon 2020 - Production of synthetic renewable aviation fuel from CO2 and H2 - A high-efficiency, low-cost alternative to produce sustainable aviation fuels from CO2 and H2

Aviation fuels derived from non-fossil resources are the only way to diminish the hefty carbon footprint of air transport. The EU-funded TAKE-OFF project will bring together leading industrial players and prominent research institutes to develop an innovative process for producing sustainable aviation fuels with higher efficiency and lower costs compared to other power-to-liquid alternatives. State-of-the-art successful attempts to turn carbon dioxide into jet fuel involve complex processes such as the Fischer-Tropsch process. The unique TAKE-OFF technology will be based on converting carbon dioxide and green hydrogen into fuel via ethylene as an intermediate. In this process, carbon dioxide is captured from industrial flue gases and reacts with hydrogen produced by renewable electricity to create light olefins. [For more information](#)

#### Project Information

##### TAKE-OFF

Grant agreement ID: 101006799

**Start date**  
1 January 2021

**End date**  
31 December 2024

**Funded under**  
H2020-EU.3.3.3.

**Overall budget**  
€ 5 340 538,75

**EU contribution**  
€ 4 998 788,25



**Coordinated by**  
NEDERLANDSE ORGANISATIE VOOR TOEGEPAST  
NATUURWETENSCHAPPELIJK ONDERZOEK TNO  
 Netherlands



## FRANCE

### CO2 capture by accelerated carbonation of recycled concrete aggregates – Co2ncrete – ANR

The CO2NCRETE project focuses on CO2 sequestration through accelerated carbonation of recycled aggregates with industrial gases. Recent literature reviews show that this approach is the most promising of the strategies being considered to reduce the carbon footprint of concrete construction. Most studies also show that carbonation improves the properties of crushed aggregates and thus their recyclability. Carbonation of crushed aggregates is therefore a step towards the circular and carbon-neutral economy that Europe has been calling for. [For more information](#)

## UPCOMING EVENTS

### World Hydrogen Summit Exhibition 08- 10 March in Rotterdam Ahoy, Netherlands : <https://www.world-hydrogen-summit.com/>

Produced by the Sustainable Energy Council (SEC) in partnership with the Province of Zuid-Holland, the City of Rotterdam and the Port of Rotterdam, World Hydrogen 2022 is the place to meet with government and private sector leaders to showcase, discuss, collaborate and do business, driving the hydrogen industry forward.



### Conference on CO2-based Fuels and Chemicals 23 and 24 March in Cologne, Germany : <https://co2-chemistry.eu/>

The conference is one of the most established worldwide and has developed into a unique meeting and networking place for the entire Carbon Capture & Utilisation (CCU) and Power-to-X industry and its customers. The first day will focus on green hydrogen production, carbon capture and CO2-based transport and aviation fuels, the second especially on CO2-based bulk and fine chemicals. CCU technologies are essential to meet the future demand for carbon from renewable sources. Take a look into the near future and exchange ideas with the leading pioneers.



### The Europe CCUS & Hydrogen Decarbonization Summit, 30-31 March 2022, Brussels, Belgium

<https://chameleonevents.co.uk/events/europe-ccus-hydrogen-decarbonisation-summit/>



The Europe CCUS & Hydrogen Decarbonisation Summit will address the latest developments and opportunities across the Carbon Capture, Utilisation & Storage (CCUS) and Hydrogen sectors, and determine strategies for greater decarbonisation of the energy intensive industries. Bringing together decarbonisation policy makers, industry and innovators, the two-day summit will address approaches for accelerating the rollout of innovative decarbonising technologies.



## Europe Conference CO<sub>2</sub> Capture, Storage & Reuse, 17-18 May 2022, Copenhagen, Denmark

<https://fortesmedia.com/co2-capture-storage-reuse,4,en,2,1,19.html>

During this 2-day event rich in presentations from industry end-users and running projects case studies you will gain a comprehensive overview of the carbon capture technology. You can hear experts focusing on new regulations, changing market situation and more. Get an opportunity to network and exchange views with industry leaders.



## CO<sub>2</sub> Carbon Capture technology North America EXPO 14-16 June 2022, Houston, Texas, USA

<https://www.ccus-expo.com/>

Carbon Capture Technology Expo North America will unveil the very latest current and emerging technologies from some of the sector's leading experts and energy leaders while providing a showcase for innovative models that can capture carbon's potential by turning CO<sub>2</sub> by-products into profitable applications for concrete, carbon fiber, polymers, food, fertilizers, liquid fuels, chemicals, graphene and more.



## 2nd International Conference on Negative CO<sub>2</sub> Emissions 14-17 June, 2022 GOTHENBURG, Sweden

<https://negativeco2emissions2020.com/>

The purpose of this conference series is to bring together a wide range of scientists, experts and stakeholders, in order to engage in various aspects of research relating to negative CO<sub>2</sub> emissions. This will include various negative emission technologies, climate modelling, climate policies and incentives



## 16th Greenhouse Gas control technologies conference, 23-27 October 2022 Lyon , France

<https://ghgt.info/>

As this conference will be the first time ever held in France, it will truly showcase France's (and more broadly Europe's) expertise in CCUS and support the future CCUS developments across Europe, especially regarding applications in the industry sector. The Conference host Club CO<sub>2</sub>, with a French consortium composed of: ADEME, BRGM, IFP Energies nouvelles and Total Energies, is committed to support the organization of GHGT-16 in Lyon, the 2nd largest metropolitan area (after Paris) in France and the 1st European capital of smart tourism (voted in 2019). The planning is now in place to hold an in person event (subject to Covid 19 restrictions) in Lyon at the extensive Lyon Convention Center (Cité Internationale). The location offers affordable and accessible travel and accommodation to all delegates now eager to connect in a safe face to face conference environment, and enjoy the heritage and gastronomy of this fabulous city.



## INTERESTING SITES

PYROCO<sub>2</sub> Project - <https://www.pyroco2.eu/>

CO<sub>2</sub> Value Europe - <https://www.co2value.eu/>

Club CO<sub>2</sub> - <https://www.club-co2.fr/fr>

International Energy Agency - <https://www.iea.org/>

Zero Emission Platform - <https://zeroemissionsplatform.eu/>

Strategy CCUS - <https://www.strategyccus.eu/>

Global CCS Institute - <https://www.globalccsinstitute.com>

France Hydrogen - <https://www.france-hydrogene.org/>

