The Importance of Europe Leading the Way in Turning CO_2 Emissions into Chemicals

Discover the ambition behind CATCO2NVERS, CO2SMOS and VIVALDI

CATCO2NVERS

CO2SMOS
Solutions for a circular biobased industry

vivaldi
Turns CO_2 emissions into sustainable bioproducts

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1. The need to investigate in CCU

In recent years, **climate change** has become a major concern for the world. Uncontrolled emission of **carbon dioxide (CO_2)** into the atmosphere is one of the major contributions of climate change. Along with the avoidance and reduction of CO_2 emissions, scientists and researchers are exploring ways to turn unavoidable CO_2 into a valuable resource. This concept is known as "**Carbon Capture and Utilization**" (**CCU**).

While Europe generates a significant amount of CO_2 from non-fossil sources (biogas, bioethanol and other fermentation processes, solid biomass combustion), the region is committed to reducing its carbon footprint and has set ambitious targets to become **carbon neutral by 2050**. Being among the most advanced in the field, European chemical industries can lead the way in the adoption of CCU technologies, helping reduce CO_2 emissions, but also creating **new business opportunities and jobs**.

One of the main challenges in implementing CCU technologies in the chemical industry is the cost. Currently, it is more expensive to produce chemicals from CO_2 than from traditional fossil fuels. However, with continued investment and technological advancements, the cost is expected to decrease in the future. While substantial research and development effort has been devoted to the use of CO_2 as a feedstock for fuels, research organisations and their industrial counterparts are now turning their attention to the pathway to (longer-life) added-value chemicals. This is particularly the case in bio-based industries.

CATCO2NVERS, CO2SMOS and VIVALDI are three European initiatives that are aiming to develop:

- Innovative technologies for converting CO_2 from industrial plants processing biomass into bio-based products.
- Biotechnological processes for the conversion of CO_2 into added-value chemicals.
- Solutions to advance the circularity of bio-based industries.

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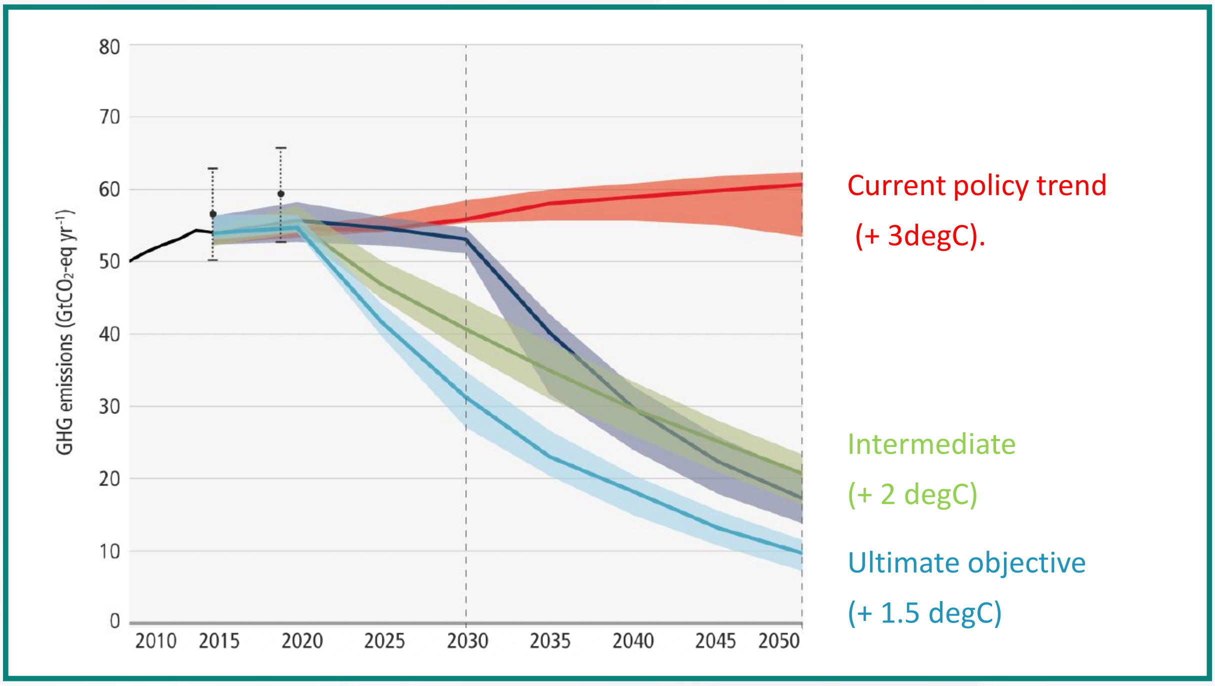
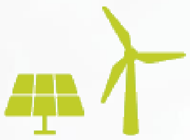
As reported in the 6th Assessment published by **the Intergovernmental Panel on Climate Change (IPCC)**, human-induced greenhouse gas (GHG) emissions have never been as high as they are today.



To keep climate change within 'manageable' limits, total global warming **should not exceed 1.5°C**. This implies:

- **Inverting the emission trend by 2025.**
- **Halving global GHG emissions by 2030.**
- **Reaching climate neutrality by 2050.**

The priorities required to drastically reduce GHG emissions are:



- Move away from fossil fuels
- Focus on solutions based on:
  - Sobriety
  - Energy and material efficiency
  - Circularity
- Improve cooperation between industries and sectors

According to the IPCC assessment report, mitigating climate change requires the creation of a circular carbon economy "*wherein CO_2 is converted into reusable materials. This is especially relevant for the transition of economies dependant on fossil fuel revenues.*"

Source: *Climate Change Mitigation: The contribution of Carbon Capture and Utilisation (CCU)*

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2. The ambition of three European Solutions

2.1 CATCO2NVERS

The overall idea of CATCO2NVERS is to reduce greenhouse gasses emissions from the Bio-Based Industries transforming waste-CO_2 from 2 bio-based industries into 5 added-value chemicals: glyoxylic acid (GA), lactic acid (LA), furan dicarboxylic methyl ester (FDME), cyclic carbonated fatty acid methyl esters (CCFAMEs) and bio-methanol, with application in the chemical, cosmetics and plastic industry, the project will process bio-based products replacing fossil material with a zero or negative greenhouse gas emissions.

OBJECTIVES

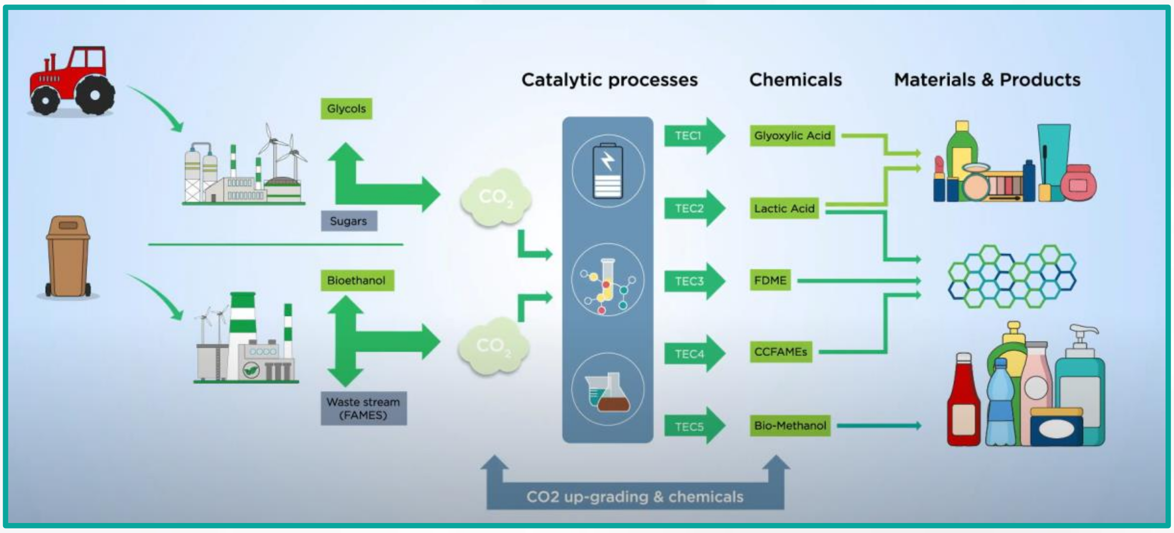
Developing and applying catalyst-based technologies for CO_2 conversion to added-value chemicals.

Validating technologies with industrial synthetic off-gases and providing sustainability and proofing socioeconomic and industrial feasibility.

PROCESS

The core purpose of CATCO2NVERS is to reduce greenhouse gas emissions from the biobased industry by developing five innovative and integrated technologies based on three catalytic processes (electrochemical, enzymatic, and thermochemical).

The project aim is to transform waste-CO_2 from two biobased industries into five added-value chemicals: glyoxylic acid, lactic acid, furan dicarboxylic methyl ester, cyclic carbonated fatty acid methyl esters, and bio-methanol, with application in the chemical, cosmetics, and plastic industries.



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YES, BUT....

What is a Bio-Based Industry?

A bio-based industry is a sector of the economy that uses living organisms or their derivatives to produce various goods and services. This can include industries that produce food, beverages, chemicals, fuels, and other products. reusing CO_2 in the bio industry has the potential to provide numerous environmental, economic, and social benefits, making it an important area for continued research and development.

What is a catalytic process?

A catalytic process is a chemical reaction that is facilitated or accelerated by a substance called a catalyst. A catalyst works by lowering the activation energy required for a reaction to occur, allowing it to proceed at a faster rate or under milder conditions than would be possible without the catalyst. In other words, is a chemical reaction that is made faster, more efficient, or more environmentally friendly by the presence of a catalyst.

Do I see those chemicals in my day to day?

Glyoxylic acid (GA) is used in the production of pharmaceuticals, dyes, resins, and other chemicals. It is also used as a reducing agent in the synthesis of a variety of organic compounds.

Lactic acid (LA) is used in the production of biodegradable plastics, as well as in the food industry as a flavoring agent and preservative. It is also used in the cosmetic and personal care industry as a pH adjuster.

Furan dicarboxylic methyl ester (FDME) It can be used to produce polymers, resins, and other materials with improved performance and sustainability compared to traditional petroleum-based products.

Cyclic carbonated fatty acid methyl esters (CCFAMEs) are used as starting materials for the production of bio-based chemicals and materials, such as surfactants, lubricants, and biodegradable plastics.

Bio-methanol is a renewable alternative to petroleum-based methanol. It is used as a fuel, solvent, and starting material for the production of chemicals, such as formaldehyde and acetic acid. Bio-methanol can also be converted into biofuels, such as bio-diesel and bio-jet fuel.

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2. The ambition of three European Solutions

2.2 CO2SMOS

The overall idea of the CO2SMOS project is to develop a platform of innovative and cost-competitive technologies that transform bio-based industrial CO_2 emissions and renewable sources (green hydrogen and biomass) into added-value bioproducts: durable polymers, renewable biochemicals and biodegradable materials. With these compounds, it is possible to produce greener end-products such as packaging, coatings, and textiles.

OBJECTIVES

Develop breakthrough technologies for the conversion of CO_2 into high added-value chemicals. Define targets to reduce the energy requirements and production costs of the conversion process.

Design an integrated process that help bio-based industries to achieve zero or even negative GHG emissions, while boosting their competitiveness.

PROCESS

The goal of the CO2SMOS project is to develop a toolbox of 5 innovative technologies for bio-based industries to recycle their carbon emissions. Two primary conversion technologies transforms the CO_2 into bulk chemicals: bio-acetate and syngas. The 3 final conversion technologies transform these simple chemicals into more complex products with various industrial applications: polyhydroxyalkanoates (PHA, PHB), 2,3-butanediol, long chain dicarboxylic acids C16-C18, BTEX, cyclic carbonates and hydroxycarboxylic acids.

FIGURE

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YES, BUT....

Why using CO_2 for the production of chemicals?

Using biogenic CO_2 to produce chemicals is beneficial because it allows industries to use waste materials (the CO_2), together with hydrogen coming from renewable sources, to produce green and valuable products while reducing their emissions. The chemicals produced are very versatile and have a direct impact and applications in everyday products.

What are the 5 CO2SMOS technologies?

Tech 1: Gas fermentation is a process that uses bacteria to convert gaseous feedstocks (CO_2, hydrogen and CO) into added-value chemicals (acetate). Thanks to bioengineering, CO2SMOS aims to increase the yield of this process.

Tech 4: The CO_2-derived acetate produced by Tech1 is a key starting material that can be transformed, by means of a second stage **liquid fermentation**, into high added-value chemicals.

Tech 2: Electrocatalytic reduction is a chemical reaction that uses a catalyst and electricity to convert biogenic CO_2 and water into green syngas and added-value chemicals.

Tech 5: In a **Catalytic membrane reactor**, it takes place the direct conversion of the green syngas (produced with Tech3) to aromatics.

Tech 3: Thermocatalytic conversion is a chemical reaction occurring by the action of thermal energy. CO2SMOS develops reusable organic catalysts for a conversion that uses CO_2 as reagent for the synthesis of new bio-polymers.

What are the benefits of collaborating in a EU-funded project?

CO2SMOS is a collaborative project that includes 15 partners across 7 countries, representing all key stakeholders within the value chain: research centers, academia, large industries, SMEs and a think tank. Thanks to this close collaboration the consortium can bring together multidisciplinary expertise to create an innovative solution that will be transferred to the industry and finally to the society.

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2.3 VIVALDI

The overall idea of the VIVALDI project is to help bio-based industries embracing circularity by implementing a process that transforms their off-gas emissions into 4 organic acids (lactic acid, succinic acid, itaconic acid and 3-hydroxypropionic), essential raw material for the manufacturing of bioproducts like bioplastics. The VIVALDI concept will not only allow bio-based industries to reduce CO_2 emissions, but to reuse them as a novel feedstock, lowering the dependency on fossil import and the exploitation of natural resources.

OBJECTIVES

Develop, upscale and validate CO_2 conversion technologies that reaches negative to neutral carbon emissions for the production of organic acids.

Ensure the positive impact of VIVALDI's solutions from an environmental, economic and social point of view, and facilitate their replicability in other industries.

PROCESS & FIGURE

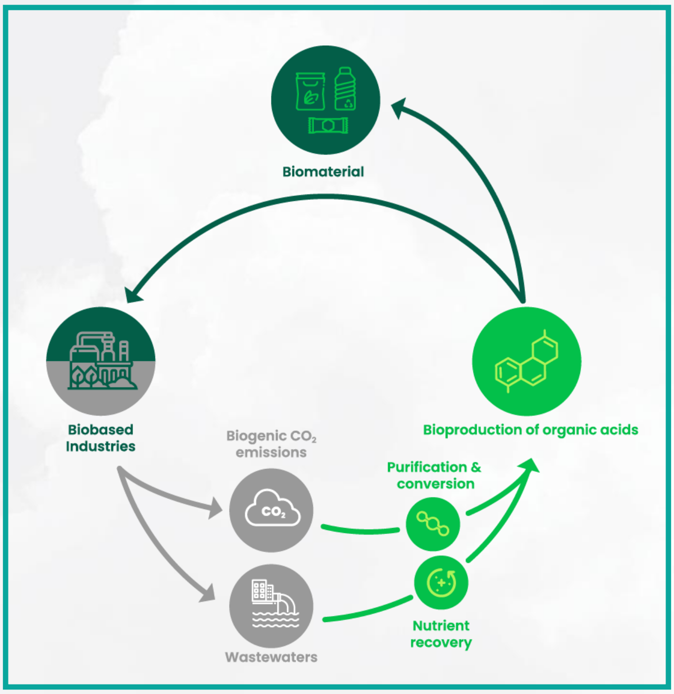
In a nutshell, the VIVALDI process is composed by 4 steps:

1. The biogenic CO_2 emissions are captured and transformed into methanol and formic acids via electrochemical reduction.

2. To increase the plant's circularity, nutrients contained in wastewaters are recovered using bioelectrochemical systems.

3. Thanks to a new fermentation process, organic acids are produced using the chemical components and the nutrients produced in step 1 and 2.

4. The organic acids produced are industrially validated complying with current industrial standards.



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YES, BUT....

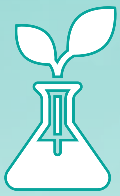
What are the reasons to replace plastics with bioplastics?

Common plastics are derived from fossil fuel-based chemicals. Replacing fossil resources with CO_2 to produce bioplastics makes the industries independent from the current fluctuations of fossil fuel prices, reduce their carbon footprint, decrease the costs of production and makes them reuse local materials and wastes. The challenges faced to go full-scale are the yield and the products' specifications if compared with current technologies. That is why further research, such as the VIVALDI project, is needed to bring these products to the market.

How industrial wastewaters can be reused?

In view of adopting circular economy strategies, VIVALDI uses the industrial wastewater from the same CO_2-producers or from a close company (promoting industrial symbiosis) to recover nutrients (NH_3, Ca^{2+}, Mg^{2+}, K^+) using novel bioelectrochemical systems. The benefits of doing this are double: it will avoid the release of nitrogen and phosphorus into water bodies, which can affect the quality of freshwater and marine water, and will provide to the industry a valuable resource that can be used to produce chemical products with market value.

What is the impact of the VIVALDI project?



The development of a novel and sustainable CO_2-based platform for the production of added-value acids with negative to neutral CO_2 emissions.

The production of organic acids is today very energy-intensive. VIVALDI solutions will lower by 20% the cost & energy demand for their production if compared to fossil-based industries.

VIVALDI will reach a 25% reduction of the cost for ammonia recovery from industrial wastewater (50 g N/m2/d) thanks to a novel bioelectrochemical methodology.

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3. Expected impacts and contributions

Turning CO_2 from bio-based industries into added-value chemicals is a promising area of research and development in Europe, with the potential to bring significant environmental, economic, and social benefits. Here we can explore some of the expected impacts of this technology on the European continent.

ENVIRONMENTAL BENEFITS

One of the most significant environmental benefits of turning CO_2 into added-value chemicals is the reduction of greenhouse gas emissions. CO_2 is a major contributor to climate change, and by capturing and reusing it, we can help reduce the amount of CO_2 released into the atmosphere. This not only helps to combat climate change but also protects air quality and reduces emissions from industrial processes.

ECONOMIC BENEFITS

The production of bio-based chemicals and materials from CO_2 is a growing market, and by developing this technology, European industries can become more competitive and create new jobs in the bio-based sector. Moreover, by reducing their reliance on petroleum-based chemicals, European industries can become more resilient to the volatility of oil prices, providing a more stable source of raw materials and reducing costs.

SOCIAL BENEFITS

The production of bio-based chemicals and materials can create new job opportunities in rural areas, boosting local economies and reducing urban-rural migration. In addition, by reducing greenhouse gas emissions and promoting sustainability, this technology can help create a better future for future generations, ensuring that our planet remains a safe and healthy place for everyone.

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4. Discover more

The three projects have presence in social media: Twitter, LinkedIn, YouTube as well as their own websites and newsletters. Make sure you follow us in all our different channels to stay tuned about the progress and activities carried out by CATCO2NVERS, CO2SMOS and VIVALDI.

www.catco2nvers.eu

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CO2SMOS Project

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