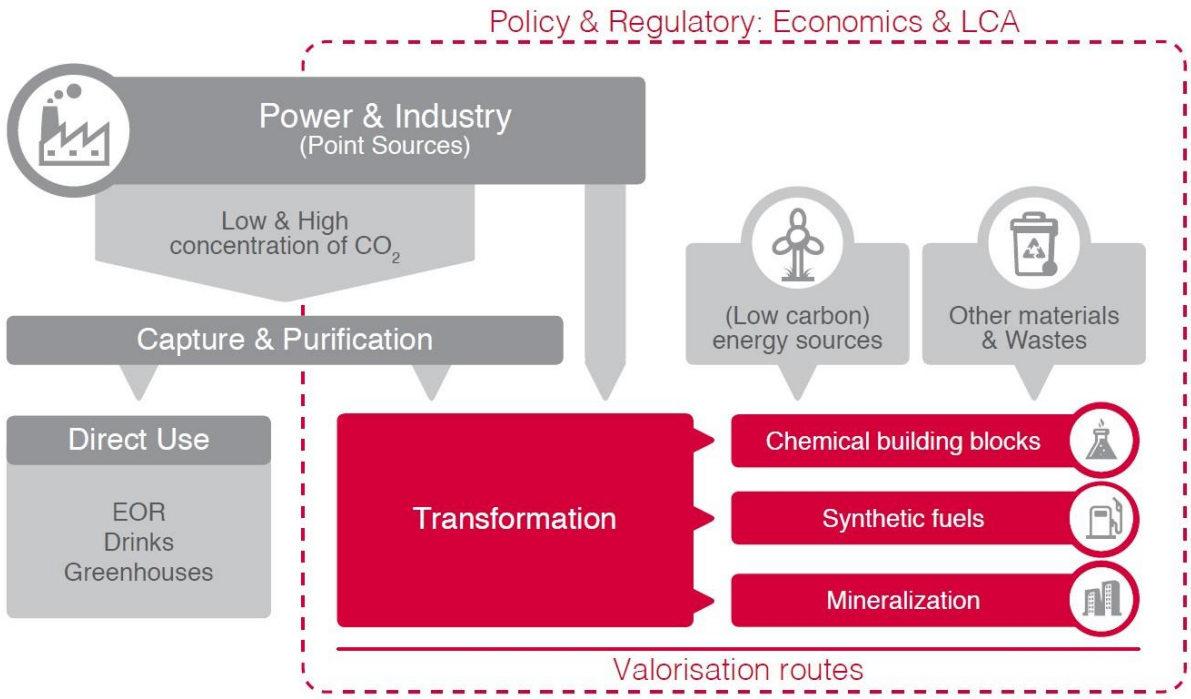
# $CO_2$ UTILISATION IN A NUTSHELL

## WHAT IS $CO_2$ UTILISATION?

$CO_2$ utilisation is the process of using (emitted) carbon dioxide ($CO_2$) as a feedstock for new products. The $CO_2$ is fed back into the production process and is treated as a carbon resource, rather than a polluting emission. There are two main routes in $CO_2$ utilisation: direct use of the $CO_2$ or transformation of $CO_2$ by a biological or chemical process into a new product.




## $CO_2$ UTILISATION WITHOUT TRANSFORMATION

$CO_2$ can be used directly in numerous applications. For several decades, $CO_2$ has been used for Enhanced Oil and Gas Recovery (EOR/EGR) and coalbed methane (ECBMR). In these processes, a percentage of the $CO_2$ will stay in the reservoir and is therefore considered as a form of long-term storage. $CO_2$ is a key component of photosynthesis and by adding additional $CO_2$ to greenhouses the growth of plants can be enhanced. $CO_2$ is also used in products such as carbonated beverages and fire extinguishers and as a solvent.

## $CO_2$ UTILISATION WITH TRANSFORMATION

$CO_2$ can be used as a source of carbon and can be biologically or chemically transformed into new products. In biological transformation $CO_2$ is transformed by algae into new organic compounds. In chemical transformation $CO_2$ is transformed into chemical building blocks for the chemical industry or synthetic fuels for the transport sector. It can also be used for mineralisation, e.g. for making building materials. These last three processes were the main focus of the **Smart $CO_2$ Transformation (SCOT)** collaborative project.

## WHAT ARE THE BENEFITS OF $CO_2$ UTILISATION?

The SCOT **Vision for Smart $CO_2$ Transformation in Europe** sets out a long-term vision for $CO_2$ utilisation. It has identified three core benefits of $CO_2$ utilisation for Europe:

## GROWTH AREA IN EUROPE'S CIRCULAR ECONOMY

**$CO_2$ utilisation can be one of the major growth areas in Europe's future low-carbon circular economy.** Using $CO_2$ as a feedstock for chemical products, synthetic fuels and building materials can improve the circular economy in various ways. By using $CO_2$ as the source for carbon instead of extracting more fossil hydrocarbons, $CO_2$ emissions can be considerably reduced, contributing to a more circular and sustainable economy.

Gradually, $CO_2$ will grow in importance as an input for many industrial sectors, offering opportunities to increase their resource efficiency, sustainability and competitiveness through innovation. Europe will increasingly benefit from developing internal supply chains based on $CO_2$ utilisation processes and products, rather than continuing to import fossil fuels and other feedstocks.

$CO_2$ utilisation is beginning to create new opportunities for economic growth, greater innovation and boosting Europe's competitiveness, whilst supporting its transition to a circular, low-carbon economy. In addition, $CO_2$ utilisation can also help to support Europe's decarbonisation and resource efficiency agendas, and provide a route to become less dependent on the imports of fossil fuels. To realise these aims, the sector needs to mature and develop further.

CO2-derived synthetic fuels will reduce import dependency on fossil fuels and possibly reduce price volatility too. If Europe is able to stabilise and increase its energy autonomy, it will also shift resources away from imports to internal low-carbon energy providers thus creating jobs, strengthening economies and energy security. It thereby decouples economic growth from $CO_2$ emissions. Additionally, innovative technologies for $CO_2$ utilisation could become a new export product to the rest of the world, with a high added value.

## FACILITATE EUROPE'S ENERGY TRANSITION

**$CO_2$ utilisation can help to facilitate Europe's energy transition.** The biggest challenge in the transition to low-carbon energy sources is how to manage the balance between energy supply and demand. The supply of solar and wind energy is dependent on the weather and therefore does not always match the demand for energy which depends on the time of day (short term balance) and the season (long term balance). There are a variety of techniques that can provide solutions to this challenge, such as transmission-grid interconnections between different countries, demand side management, and energy storage. The creation of synthetic fuels is well suited to provide stored energy at a large scale, offering a solution to the inter-seasonal challenge of supply and demand.

## REDUCING $CO_2$ EMISSIONS

**$CO_2$ utilisation can contribute to achieving Europe's aims for decreasing $CO_2$ emissions.** $CO_2$ utilisation can help in reducing emissions: either by processes that 'store' $CO_2$ for a very long time (like in mineralisation) or through reducing $CO_2$ emissions from chemical industry by using $CO_2$ as the source for carbon rather than using new hydrocarbons from underground. Technologies for $CO_2$ utilisation are varied and each process will have a different carbon footprint. Factors to consider are the permanence of storage, the energy intensity of the process, the source of the energy, the amount of avoided $CO_2$ emissions and the end use of the product. Certain pathways (like $CO_2$-based fuels) are highly energy intensive, and only with low-carbon energy and $CO_2$ not originating from fossil sources they can become carbon neutral. A full life-cycle assessment (LCA) is required to assess the avoided $CO_2$ emissions for each specific technology.

$CO_2$ utilisation should clearly aim for reduced net emissions or be carbon neutral. But in the near future we also foresee the strong need for negative $CO_2$ emissions. This can be realised amongst others by using $CO_2$ originating from biomass or by Direct Air Capture (DAC), where $CO_2$ is removed from the atmosphere, and then used for $CO_2$ processes.

## WHAT IS NEEDED TO ACHIEVE THIS VISION?

We recycle metals, plastics and paper, so why not carbon dioxide? Well, it's not that simple. Many challenges need to be tackled before $CO_2$ utilisation can be deployed at large. The **Strategic Research and Innovation Agenda for Smart $CO_2$ Transformation in Europe** has identified the following challenges:

### TECHNICAL CHALLENGES

The technical and innovation challenges for the $CO_2$ utilisation sector are focussed on increasing the efficiency of chemical processes and innovation for new $CO_2$ utilisation pathways. Through intensified research better catalysts and better process designs must bring higher efficiency levels, lower costs and lower material consumption or waste production. New and innovative ways of using $CO_2$ and the use of non-purified $CO_2$ will open the door for more applications. For mineralisation, the main challenges are the reduction of processing cost and the widening of the range of (waste) materials that can be used as input. The challenges for the creation of synthetic fuels regard the final carbon footprint: the efficient production of hydrogen from low-carbon sources and the use of non-fossil $CO_2$ are crucial to achieve a net $CO_2$ reduction. Finally, research is required to make Direct Air Capture technically possible at large scale and economically viable.

$CO_2$ utilisation has the potential to shift the way we view carbon dioxide. If we manage to develop affordable technologies, a new industry will arise that values $CO_2$ emissions, encouraging investments in innovation and reducing $CO_2$ emitted to the atmosphere.

### ECONOMIC CHALLENGES

Many technologies are newly emerging and face a financial hurdle to advance successfully from lab to the market. Funding programmes enabling $CO_2$ utilisation technologies to reach higher Technology Readiness Levels (TRL), including commercialisation (TRL9), are an important economic lever for the acceleration of the sector. The financial hurdle is partly due to the low prices of fossil alternatives (helped by subsidies or not including the pollution costs in the price). Long-term funding commitments from various public and private sources ensure a continuity of research programmes and are necessary in the development of $CO_2$ utilisation.

### REGULATORY CHALLENGES

Due to the early stage nature of the $CO_2$ utilisation sector, many (European) policies do not include the emerging technologies of utilisation of $CO_2$.[i] The potential interplay of legislation can be confusing, and the impact of regulations on the market development of the $CO_2$ utilisation sector is still not well understood. Legislative changes need to be checked on conformity with the $CO_2$ utilisation agenda.

$CO_2$ utilisation is not currently cost competitive in several areas, due to the comparative 'cheap' cost of fossil fuels. If as a society we wish to move away from fossil fuel consumption there is likely to be a powerful legislative role for policy makers to encourage a greater uptake of $CO_2$ utilisation in certain markets, allowing costs to improve through deployment at scale, e.g. $CO_2$ derived fuels and $CO_2$ derived chemical feedstocks.

## SOCIAL CHALLENGES

Presently there has been little or no research undertaken on how different groups in society perceive $CO_2$ utilisation. It is important to gain this insight, as those views have the potential to accelerate or slow market deployment. For example, potential public concerns about $CO_2$ utilisation could be identified in time and addressed via campaigns to raise general awareness, and by education of specific groups. In order to increase the eventual market demand of $CO_2$ utilisation products, societal awareness of the risks and benefits of the products and the technologies will be crucial. The emphasis for $CO_2$ utilisation should not only be on mitigation, as in most uses $CO_2$ is only stored temporarily. The strengths of $CO_2$ utilisation are in resource efficiency (preventing the use of fossil feedstocks), feedstock diversification and decoupling economic activity from GHG emissions, instead of $CO_2$ mitigation *per se*.

## ADDRESSING THE CHALLENGES

The **Joint Action Plan for Smart $CO_2$ Transformation** sets out the steps that can be taken to address the challenges:

### UNDERPINNING ACTIONS

1. **The establishment and sustainment of a European $CO_2$ Utilisation Association** to provide an increased level of advocacy for the $CO_2$ utilisation community.
2. **The creation of a number of European Modular Pilot Plant and Verification Centres for $CO_2$ utilisation** to enable industry and academia to test out, compare and validate various processes and technologies.

### CONSOLIDATION ACTIONS

3. **Continued and preferably increased funding for fundamental $CO_2$ utilisation research (TRLs 1-4)** to develop new $CO_2$ utilisation routes/technologies.
4. **Establishing a support programme for the demonstration of the most promising $CO_2$ utilisation technologies** to accelerate $CO_2$ utilisation market deployment.
5. **Capacity building and raising awareness of the $CO_2$ utilisation sector** to increase understanding and appreciation of the opportunities that $CO_2$ utilisation offers.
6. **Greater clarity of the impacts of wider European policies on the $CO_2$ utilisation sector** to make sure the opportunities afforded by $CO_2$ utilisation are supported by forthcoming European Commission proposals.
7. **Increased transparency and harmonisation in Life Cycle Analysis (LCA)**, Validating and proofing sustainability, and techno-economic capability to answer questions surrounding the various technologies within the CO2 utilisation sector.

### WIDENING ACTIONS

8. **Building a European $CO_2$ utilisation eco-system through a new Joint Technology Initiative** to pursue common ambitious research objectives of industry, the research community, and public authorities.

[i] EU ETS Directive, Renewable Energy Directive, Fuel Quality Directive, Circular Economy Package, ETS innovation funds, Important Projects of Common European Interest, SET Plan, Industrial Emissions Directive