



# COZMOS A SUCCESS STORY FOR THE FUTURE

## Pioneering CO<sub>2</sub> Conversion into Valuable Fuels for Circularity and Decarbonisation

### Context



Energy-intensive industries represent around 19% of greenhouse gas emissions in the EU (source). Europe's drive towards a low-carbon, circular economy depends on finding practical ways to reduce CO<sub>2</sub> emissions in energy-intensive industries such as chemicals, steel and refining.

### COZMOS, a SPIRE cPPP Project



A promising project was launched to address this need. Funded by Horizon 2020 under a SPIRE (the predecessor of Processes4Planet) call, COZMOS (full title Efficient CO<sub>2</sub> conversion over multisite Zeolite-Metal nanocatalysts to fuels and OlefinS) aimed to develop a dual catalyst-one reactor system for the hydrogenation of CO<sub>2</sub> to C<sub>3</sub> hydrocarbons. COZMOS kicked off on 1 May 2019, with the ambitious goal of creating a technology which would contribute to a circular economy and the replacement of fossil fuels, leading to a decrease in CO<sub>2</sub> emissions and European dependence on fossil resources. COZMOS was implemented by a consortium of 11 partners and was a Research and Innovation Action (RIA).

### Goals and Vision



An initiative involving the chemicals, steel, refining, and engineering sectors, COZMOS developed a technology expected to decrease CO<sub>2</sub> emissions by 1.9 tons CO<sub>2</sub> for every ton of C<sub>3</sub> product produced, with projected reductions in CO<sub>2</sub> emissions of 0.4 Mtons CO<sub>2</sub>/yr in 2030 and 2.2 Mtons CO<sub>2</sub>/year from 2034. The starting point of the project was the fact that CO<sub>2</sub> can be a sustainable carbon source, replacing fossil fuels for energy consumption and chemical production.

However, its transformation into useful products is limited by its low energy content. To address this limitation, COZMOS proposed combining two reactions into one reactor, which translates into reduced energy consumption and increased CO<sub>2</sub> conversion. Thus, CO<sub>2</sub> and hydrogen sourced from renewable, carbon-neutral energy sources will be transformed into C<sub>3</sub> hydrocarbons, propane and propene. Propane can be used as a heating, cooking and transportation fuel, and propene is a valuable chemical building block for lightweight polymers and other chemical intermediates.

**The technology was demonstrated in a TRL 5 pilot.**

## Implementation and Next Steps

The project ended on 31 October 2023. The fourth and last newsletter of the project (available [here](#)), issued in the same month, goes over the project's achievements (especially the ones of the fourth year). One notable achievement was the completion of the installation and site acceptance test of the COZMOS TRL 5 pilot plant at the Turkish Petroleum Refineries Corporation ([Tüpraş](#)).



**Chemicals**



**Steel**



**Refining**



**Engineering**

COZMOS was presented at the [Second Process Industry Conference](#) organised by A.SPIRE in October 2024 as a success that has developed a one-reactor, two-catalyst technology for the hydrogenation of CO<sub>2</sub> to hydrocarbons.

The project issued a vast number of publications, available on the [project's website](#).

Ca. 40% of the leading positions in the COZMOS project were held by women.

Mr Richard Heyn (Chief Research Scientist at SINTEF and A.SPIRE Advisory and Programming Group Vice-Chair for Circularity Innovation) informed A.SPIRE of the intention to reuse that pilot in the next step of technology development.

Mr Heyn also stated that although the team encountered some catalyst upscaling challenges, the TRL 5 data showed successful conversion of CO<sub>2</sub> and H<sub>2</sub> to propane, in an overall product ratio that was promising for production of LPG (Liquefied Petroleum Gas).

A process for the production of propene could not be realised, since the catalyst has hydrogenated the propene to propane.

The overall gate-to-gate LCA of the process showed a carbon footprint slightly better than the current production of fossil propane, with further added environmental benefits expected with a cradle-to-gate analysis.

## Success Story: the state-of-the-art for the hydrogenation of CO<sub>2</sub> to light hydrocarbons

Asked about what makes COZMOS a one-of-its-kind success story, Mr Heyn said that “this project has essentially established the state-of-the-art for the hydrogenation of CO<sub>2</sub> to light hydrocarbons. The implementation of a two-catalyst, one-reactor concept shows that CO<sub>2</sub> conversions can be increased with this exploitation of Le Chatelier's principle.” (ED. NOTE: stating that if a dynamic equilibrium is disturbed by a change in concentration, pressure, or temperature, the equilibrium position shifts in a direction that tends to counteract the change and reestablish equilibrium).

**A.SPIRE considers COZMOS a success story demonstrating a tangible step towards a circular and low-carbon economy by converting CO<sub>2</sub> into valuable hydrocarbons, showcasing the potential of reducing reliance on fossil fuels, and lowering emissions. The project combined cutting-edge science (its innovative one-reactor, two-catalyst approach) with practical industrial application, achieving TRL 5 validation in a pilot plant (which might be reused in the next phase of technology development) and generating transferable knowledge through publications.**



*The TRL 5 pilot plant on the premises of Tüpras. Source: the project's website.*

Visit the COZMOS project's [website](#).

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