E-Methanol and Biomethane from CO_2 and Renewable Electricity: A Significant Contribution to Achieving CO_2 Neutrality

The Hybrid E-methanol Synthesis and Biomethane upgrading Process (ICODOS)

The climate crisis is coming to a head. Global warming, greenhouse gas emissions, and deforestation lead to weather extremes, food shortages, and health problems. Emissions mainly come from burning fossil fuels such as coal, oil, and natural gas. Commercially competitive solutions are needed to manage the transition to renewable fuels. Currently, e-fuels and biofuels are more expensive than fossil fuels and, therefore, not economically attractive. This challenge is addressed by the KIT spinoff ICODOS with an innovative solution.

ICODOS – Intelligent Carbon Dioxide Solutions – has developed a process to utilize biogas from waste streams such as sewage sludge and bio-logical waste in combination with renewable electricity to produce biomethane and e-methanol: Carbon dioxide (CO_2) is captured from the biogas and converted to methanol with additional green hydrogen (H_2) from water electrolysis in a combined process.

Biogas is a carbon-neutral source of energy and CO_2, but processing the gas for use as fuel is expensive. On the other hand, a CO_2 source is needed to produce e-fuels, which drives up costs. With the technology developed by ICODOS, biogas can be upgraded to high-quality biomethane; at the same time, green e-methanol can be produced from the resulting CO_2. This is a win-win situation.

The unique KIT patent combination of CO_2 capture and methanol synthesis is the most efficient CO_2 capture technology and the ultimate tool for achieving a circular bioeconomy, where CO_2 previously captured from the air by plants is converted into e-fuels. ICODOS will initially focus on biogas to implement the technology, but plans to make it available for other CO_2 point sources, such as the cement industry.

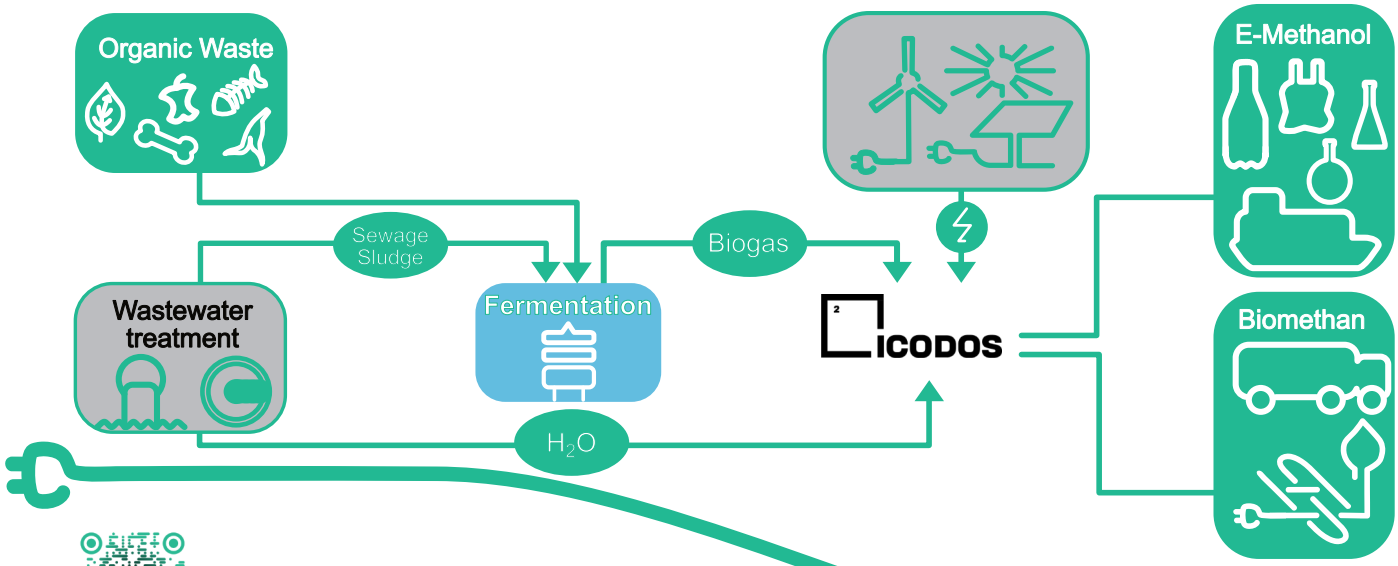


Figure 1 on this page illustrates the value chain with ICODOS' integrated technology

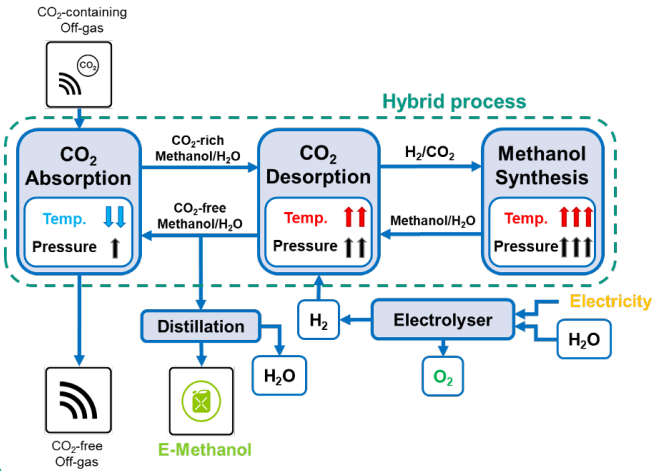
The Hybrid E-methane and Biomethane Synthesis

Brief Description of the Technology

The ICODOS innovation is the most efficient CO_2 capture technology available today. It is planned to use it in highly automated and mass-produced facilities. In the processes known to date for the production of e-methanol, CO_2 capture and methanol synthesis are separate. In the new process, for which a patent application has been filed, the two processes are combined to form a so-called hybrid process. Figure 2 on this page shows the combined process integrated into the other plant components.

The novel process lowers investment and operating costs by reducing the energy required for compres-sion as well as the overall equipment needed. The product of the methanol synthesis is used as a solvent for CO_2, and the process regenerates it continuously. Therefore, there is no performance degradation over time due to solvent degradation or loss, as is the case with competing amine-based CO_2 capture.

The life of the system is increased and maintenance is reduced because the problems common to amine scrubbing, such as corrosion or solvent degradation, do not occur. Additionally, the integration of the two processes reduces the number of instruments and interfaces. These advantages also facilitate the implementation of full automation of the process.



Quality control of the biomethane at the end of the process chain

Status of the Technology and the Spin-off

Funding of more than one million euros has been secured from the German Federal and Baden-Württemberg State Ministries to validate innovative integrated hybrid technology. In 2024, a modular proof-of-concept plant with a capacity of approximately 50 liters of methanol per day was constructed and integrated into the Energy Lab at KIT.

The plant incorporates CO2 capture via an absorber/desorber, H2 production through electrolysis, methanol reactors, and a distillation unit. Its operation is further supported by the European Horizon funding project, UP-TO-ME. In October 2024, the plant successfully completed a 100-hour steady-state campaign at KIT's Energy Lab, capturing 150 kg of CO2 from synthetic biogas and producing 100 kg of pure methanol. In November 2024, the plant was relocated to Mannheim for validation under realistic conditions, where biogas from anaerobic digestion will be utilized, and dynamic operation will be explored in 2025.

The ICODOS founding team is currently seeking startup funding to support business activities, scale the technology, and prepare for the manufacturing of the plant.

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