CO_2-based electrosynthesis of Ethylene oXIDE

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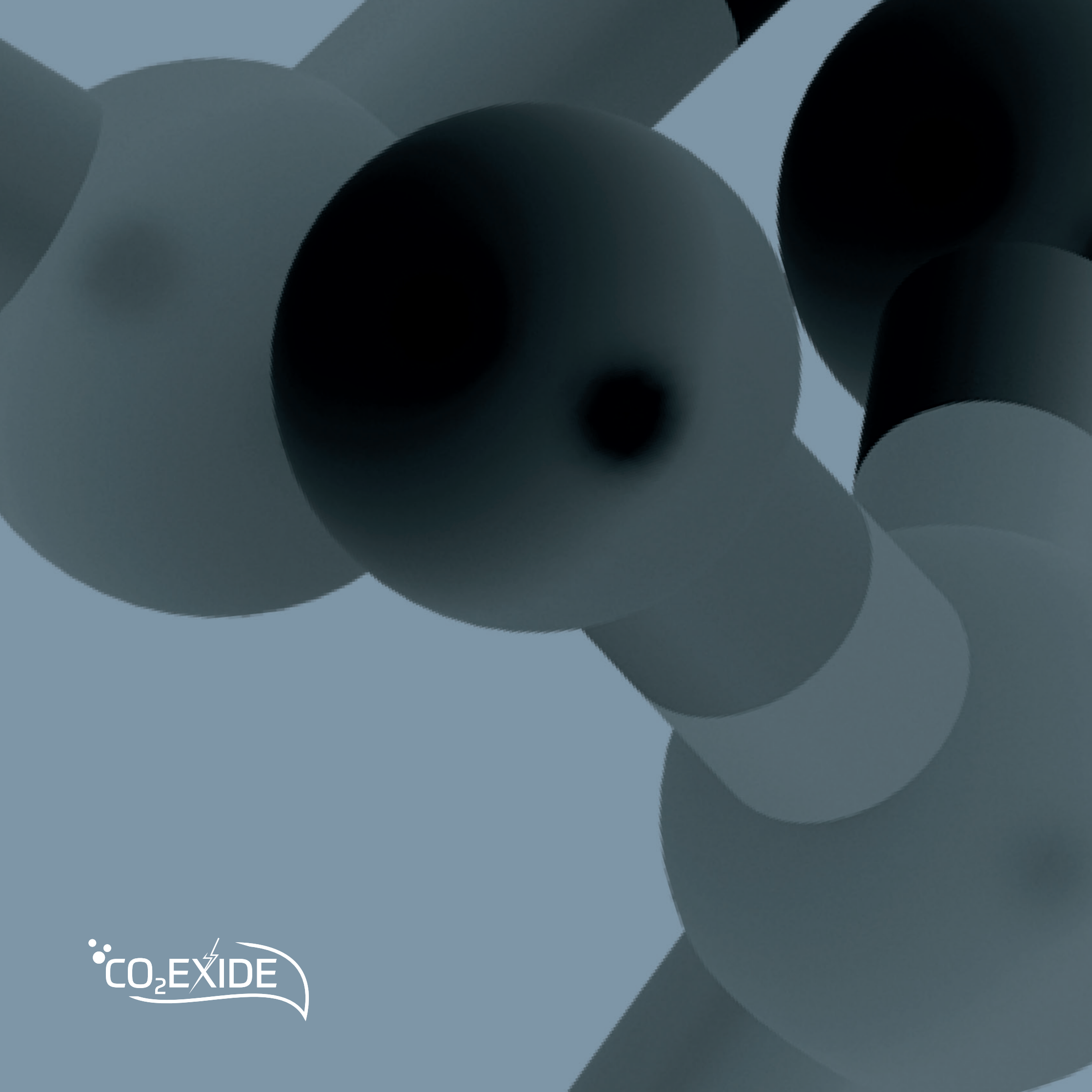

CO2EXIDE

Content

1. Introduction

Following the Paris agreement, the European Union's strategy pursues a climate neutral Europe by 2050.
In order to deliver the agreed targets, advisory bodies regard the serious consideration of all GHG prevention measures for absolutely necessary. Next to the reduction of consumption and the switch to renewable energy, these are CO_2 utilization (CCU) and CO_2 storage (CCS). To be embedded into a wide-ranging public debate, the German Academy of Science recommends to now start developing socially accepted, broadly suitable technologies that are then brought to market within the required timeframe so that the necessary infrastructure can be planned, approved, financed and built.

The H2020 research project CO_2EXIDE aims to establish such a flagship

technology. The process envisages the generation of the bulk chemical ethylene oxide by recycling biogenic CO_2-off-gas and using just renewable energy and water.

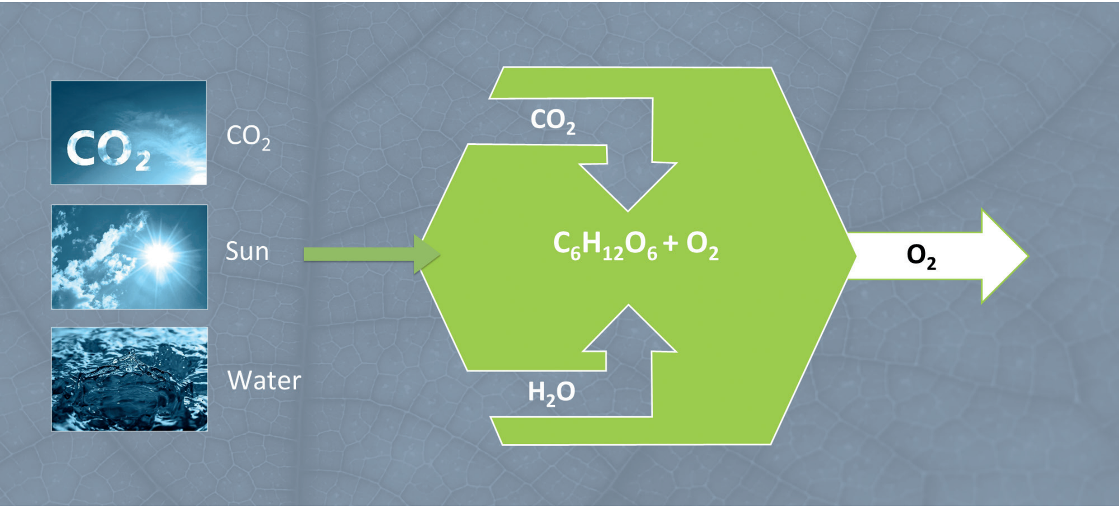
One of the most challenging points for a broad application of CCU technologies is the low reactivity of carbon dioxide: the conversion of the so-called „dead dog" is highly energy-demanding. However, catalyst performances in conversion processes of CO_2 have lately resulted in compelling energy savings, and the innovations developed within CO_2EXIDE will provide further process improvements.

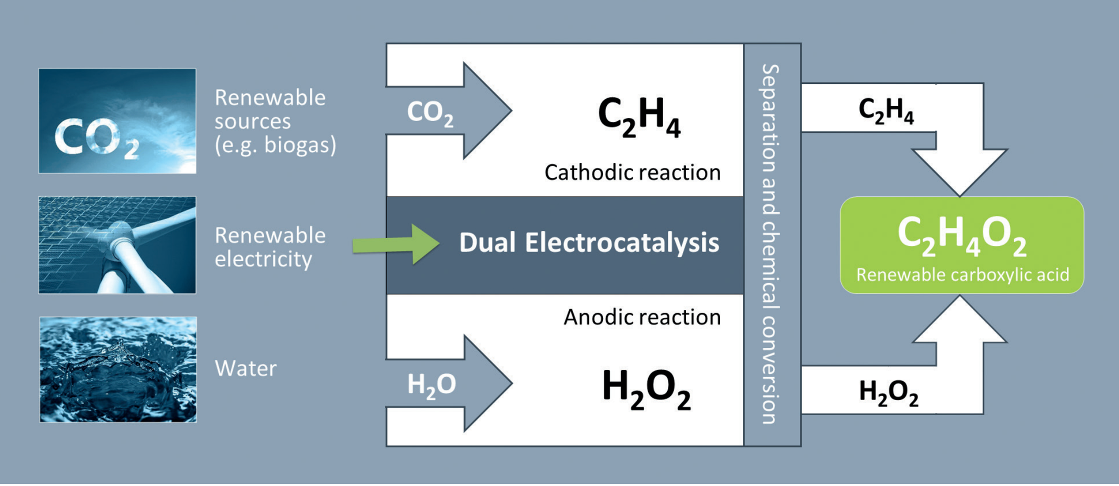
Suitable for the energy turnaround, the CO_2EXIDE process is feasible for the fluctuating supply of renewable sources like wind and solar power. Unlike the conventional production that depends on fossil supply routes, it is compatible for decentralised production sites.

The CO_2EXIDE technology could provide a climate-friendly, sustainable, cost and energy efficient alternative to the fossil-based production.

2. Technology

The technology of capturing and converting carbon dioxide to make it usable for energy storage or further utilisation as raw material follows an example provided by nature. In photosynthesis, plant cells use light energy to transform carbon dioxide from the air and water from the ground into the carbohydrate glucose and oxygen. Glucose serves as a building material and energy carrier for the plant. Oxygen, the waste product of this process, is released into the atmosphere.





For the experimental development in the project CO_2EXIDE, the biogenic CO_2-off-gas from a biogas plant acts as the single carbon source. The process is adapted to the utilisation of biogenic exhaust emissions from fermentation or biogas upgrading which produce a highly concentrated CO_2-offgas. Its relative purity makes the exhaust gas basically attractive for dual electrocatalysis. The off-gas will be captured, purified and stored. The CO_2-gas obtained is then fed into a novel electrochemical reactor based on PEM-cell design.

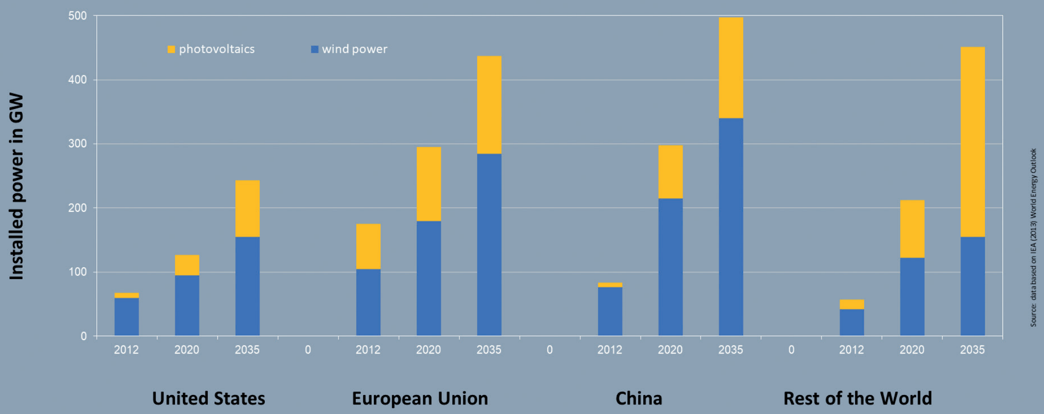
The catalyst-containing gas diffusion layers in the cathodic half-cell reduce CO_2 to ethylene. The anodic feed consists of an aqueous electrolyte as feedstock for the direct oxidation of water to hydrogen peroxide. The produced intermediates ethylene and hydrogen peroxide will finally be transferred into a chemical cascade reactor where they

are converted into ethylene oxide and different polyethylene glycols.

One of the central innovations of the process is the development of a new type of electrolyser that enables a simultaneous value-added reaction on both anode and cathode. This electrochemical application offers the ability to precisely tune the power input that is necessary for achieving the chemical reaction. The carbon capture and utilisation technology developed within the project CO_2EXIDE explores new and innovative production strategies for high-valued bulk chemicals.

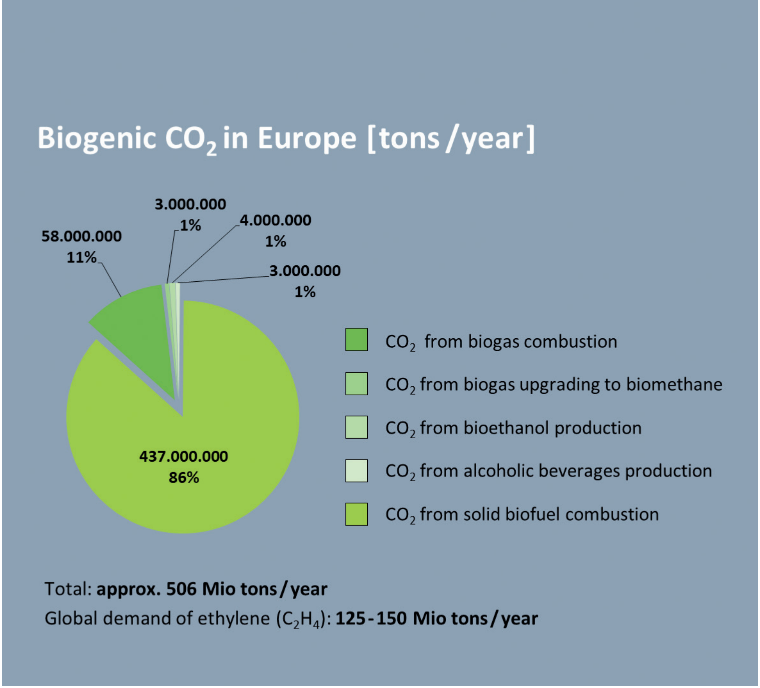
3. Impact

Global electricity generation is currently covered by 22.8 percent of renewable power sources, with hydropower being the most important (16.6 percent). Variable or fluctuating renewable power sources such as wind and photovoltaics only account for 3.1 % and 0.9%, respectively. However, the installed capacity of wind power and photovoltaics has grown very rapidly over the past decade. Currently, around 370 GW of wind power and 177 GW of photovoltaics are installed globally.



The expected strong growth of fluctuating renewable power sources (photovoltaics and wind power) will also lead to an increased demand for energy balancing and storage options. Whereas technologies such as flywheels or batteries are better suited for short-term energy storage, renewable chemicals like ethylene oxide with significant demand volumes produced from excess electricity via electrosynthesis can provide a promising long-term electricity storage solution.

The use of CO_2 as singular carbon source for the parallel production of ethylene and hydrogen peroxide opens the direct access to high volume bulk chemical ethylene oxide. With the various applications of ethylene oxide, electrosynthesis would enable an increasing percentage of renewables in the chemical sector und derived consumer products. The bulk chemical can fulfil a large part of the chemical requirements in Europe in many different applications.

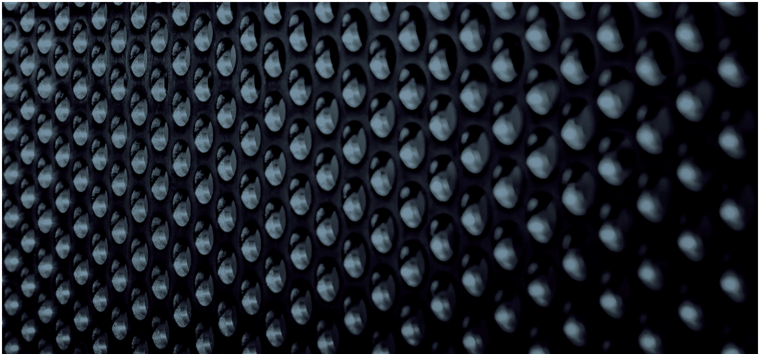


Ethylene oxide and its base ethylene are used in a multitude of industrial processes, including the fabrication of synthetic fibres, cosmetic products, or the ripening of fruits.

The global annual demand of ethylene is around 125 to 150 Mio tons. The technology developed within the CO_2EXIDE project aims at the conversion of exhaust gas from biogas upgrading and bioethanol production, which provides a high concentration of CO_2 by lowest possible capture costs. After passing an enrichment process, the exhaust gas from other biogenic processes could also be deployed. Another possible source is direct air capture, wich is expected to rapidly reduce its costs in the near future.

Until now, ethylene oxide is mainly derived from crude oil refinery processes. Carried out under high pressure and temperatures, the necessary cracking of the long-chain oil molecules consumes in itself huge amounts of energy.
The energy demand of CCU processes should therefore be seen in relative terms. Compared to the fossil-based production of ethylene oxide, the researchers involved in the project CO_2EXIDE expect savings of up to 100 percent of the emissions and at least 25 percent of the energy demand.

The expected long-term impact of the project CO_2EXIDE is the substitution of fossil-based production routes of ethylene oxide with new and innovative electrochemical synthesis strategies for regional supply of renewable bulk chemicals. A successful CO_2EXIDE project could provide a clean, sustainable and flexible way to transform renewable electricity into chemicals for various applications while helping to strengthen our independence from fossil resources.



4. The project in brief

The CO_2EXIDE technology will be developed by the collaboration of ten organisations from six European countries, bundling expert knowledge from the fields of surface physics, electrochemistry, apparatus engineering, energy management and communication. The project receives a three-year funding under Horizon 2020, the EU's research, innovation and societal challenges programme. It is assigned to the SPIRE initiative „Sustainable Process Industry".

Project Aim

The key objective of the project CO_2EXIDE is the development of an electro-chemical-chemical, energy efficient and near-to-CO_2-neutral process to produce the bulk chemical ethylene oxide from CO_2, water, and renewable energy.

Funding

3-years funding
Programme: EU Horizon 2020
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Call: Industry 2020 in the Circular Economy
H2020-IND-CE2016-17

Duration

January 2018 – December 2020

Partners

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ENERGIE INSTITUT an der Johannes Kepler Universität Linz

EPC

LATVIJAS UNIVERSITĀTES CIETVIELU FIZIKAS INSTITŪTS

Fraunhofer IGB

SIEMENS Ingenuity for life

SCHAEFFLER

UNIVERSITY OF Southampton

2nd projectpartner meeting at AGH, Krakow, 13th of December 2018

5. Contact and Imprint

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