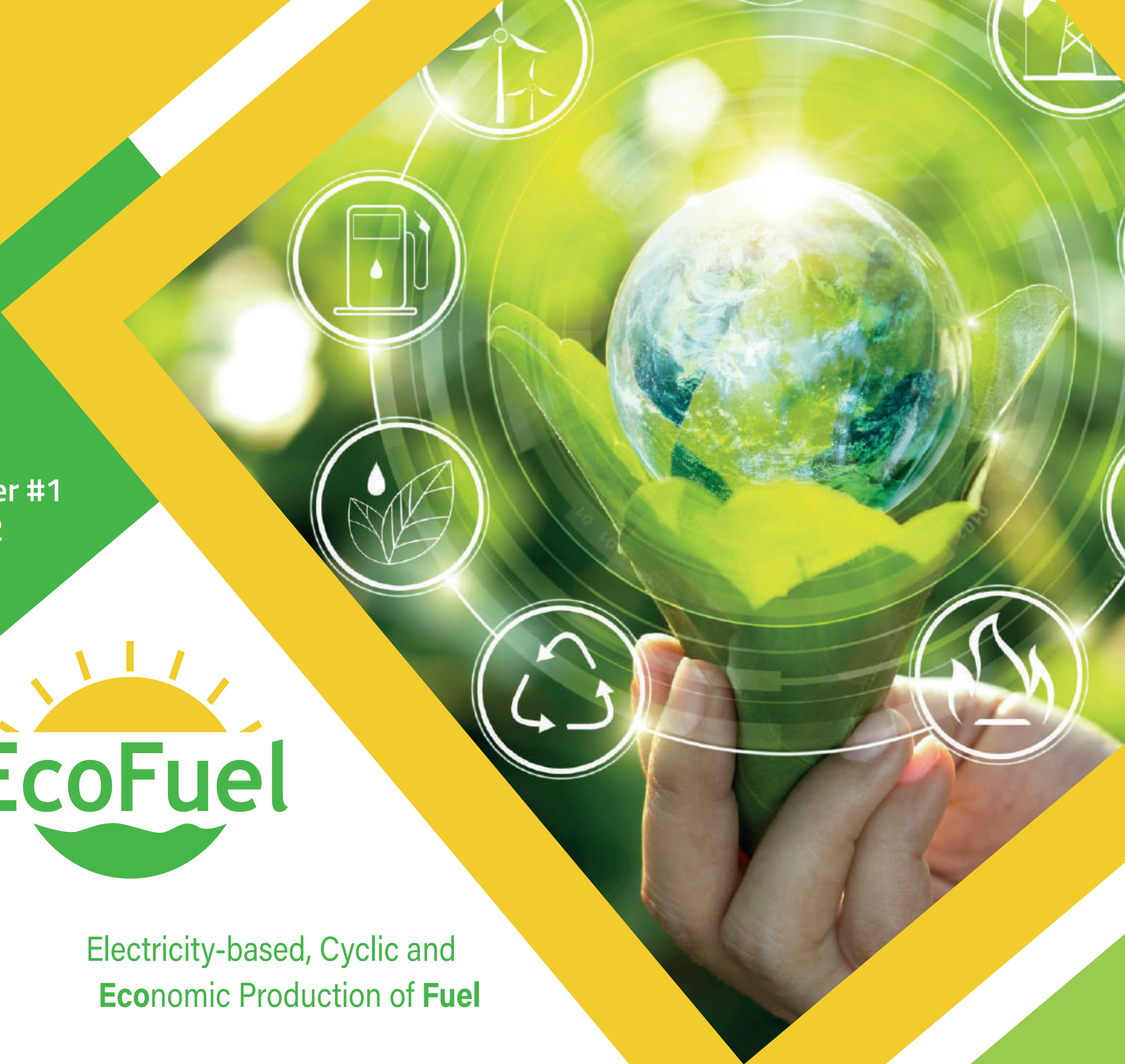
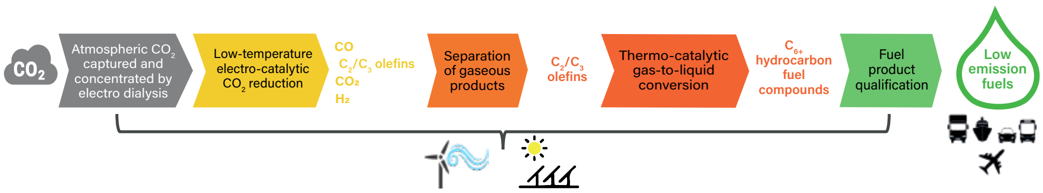
Newsletter #1
May 2022



EcoFuel

Electricity-based, Cyclic and **Eco**nomic Production of **Fuel**

Carbon neutral fuels constitute a core element to reach our goals for the decarbonisation of air and maritime transport as well as Europe's independence on fossil energy carriers. To do so, the EU-funded EcoFuel project creates a disruptive process for production of synthetic fuel and will demonstrate it on each individual element of the value chain.



The main achievements during the first project phase:

- An energy saving Direct Air Capture (DAC) process based on electrodialysis planned to go in pilot operation in the second half of 2022,
- An improved electrocatalyst's performance for CO_2 reduction to ethylene,
- New anode catalysts for the oxygen evolution reaction saving Iridium while showing greater intrinsic activity compared to the commercial benchmark,
- A selective multistep membrane upgrading process enriching the ethylene concentration leaving the electrochemical cell to 97% ready for the next process step,
- Potential evaluation of catalysts containing active nickel sites supported on acidic substrates for improving the thermo-catalytic oligomerization of ethylene.

These achievements are supposed to lay the foundations to develop next generation renewable fuel technologies solely based on atmospheric CO_2 and renewable energy.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101006701.

Feed gas purification process and potential catalysts for the thermo-catalytic oligomerisation of ethylene

Fraunhofer IGB has investigated, in cooperation with Axiom, the feed gas purification process and potential catalysts for the thermo-catalytic oligomerisation of ethylene. In a first step, it was found that materials containing active nickel sites supported on acidic substrates, such as zeolites, catalyze the reaction. In such catalytic composites, nickel is required to activate and dimerize ethylene in a first reaction step while the acidic function catalyzes in a second reaction step the oligomerization of the dimers.

A second central objective of this work was to purify the product stream of the electro-catalytic process step, in which carbon dioxide (CO_2) was reduced ethylene. Besides ethylene, this stream was composed of mainly carbon monoxide (CO), hydrogen and unreacted CO_2. CO is known to form volatile carbonyls with nickel, therefore acting as a catalyst poison by leaching active nickel sites from the catalytic material. Hence, Axiom suggested a multistep upgrading process for the gaseous product stream leaving the electrochemical cell based on a selective membrane separation cascade. First, hydrogen is separated from the mixture, followed by separating ethylene from carbon monoxide. After the membrane cascade, the product gas contains 97% ethylene and 2% carbon monoxide. The processed gas stream will be fed into the catalytic oligomerization process, where it will be converted into liquid hydrocarbons in the middle distillate range.

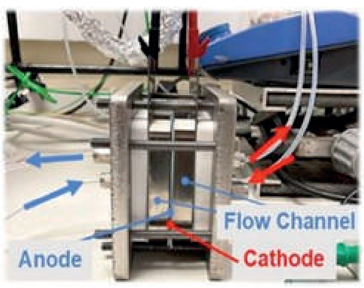
New Direct Air Capture (DAC) technology to recover CO_2 from air

Within the EcoFuel project, Axiom angewandte Prozeßtechnik together with Siemens Energy, AVL List and Fraunhofer Institute for Interfacial Engineering are developing a new Direct Air Capture (DAC) technology to recover CO_2 from air. The process embraces the application of an aqueous solution of alkali metals to bind the atmospheric CO_2 and subsequently enriching it in the electrodialysis step. The ultimate objective of the R&D efforts is to construct and operate an experimental unit to capture and store a stream of $1 m^3/h$ of air-sourced CO_2. The pilot unit is to start its operation in the second half of 2022 and is aimed to provide valuable information on process performance and costs.

EcoFuel Main Achievements

Synthesis and characterisation of copper-based electrocatalysts for the reduction of CO_2 to hydrocarbon products

So far in Work Package 3, the partners have collaborated on the synthesis and characterisation of copper-based electrocatalysts for the reduction of CO_2 to hydrocarbon products – targeting ethylene for subsequent oligomerisation to higher carbon number hydrocarbons. Research has focused on two strategies for improving Faradaic Efficiency to ethylene: modification by the addition of second metals, and control of nanoparticle morphology. Several cathode electrocatalysts have been evaluated in flow CO_2 electrolyser cells with promising results achieved in comparison to commercially available benchmark materials. At the anode side of the cell, several precious metals based electrocatalysts were synthesised and tested for durability and intrinsic activity for the oxygen evolution reaction, which supplies electrons to the cathode. Many of these exhibited greater intrinsic activity and comparable or superior durability when compared to a commercial benchmark material. Furthermore, efforts have been made to reduce dependence on iridium, a critical raw material, by partially substituting it with less costly metals. Taking this further for anode catalysts, nickel-based materials have been synthesised and tested in near-neutral and alkaline conditions. Bringing the pieces together, efforts have also begun to enhance the performance of cathode catalysts by improving the way they are integrated into gas diffusion electrodes. Work in this area has focused on concurrently improving the hydrophobicity and conductivity of gas diffusion layers and optimising catalyst loading and catalyst binder.



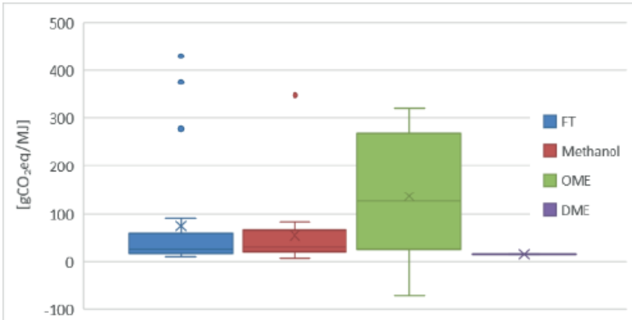
Economic and ecological assessment of EcoFuel

The innovative, in-development process chain of EcoFuel will be validated by an in-depth ecological (LCA) and techno-economic assessment (TEA) to demonstrate the real advantage of the improved process and its energy efficiency. As baseline, an extensive literature review on LCA and techno-economic studies conducted on alternative and fossil fuel production pathways was performed by AVL and Johnson-Matthey. While biomass cultivation is identified to be the GWP-, water depletion-, acidification- and eutrophication-hotspot in bio-based fuel production, land use change, the change in natural carbon stocks, potentially places bio-based fuels far above traditional fossil fuels from a carbon footprint perspective. Synthetic fuels carbon footprints depend greatly on the carbon intensity of electricity for CO_2 and H_2 provision, as their production comes with a high energy demand. Still, the results for synthetic fuels vary widely and show great dependency on the feedstock used. In best case scenarios, synthetic as well as bio-based fuels replacing traditional gasoline and diesel offer huge potential for emission reduction in already operational transport vehicles.

The TEA section of this report is a comparative discussion of process routes from CO_2 to hydrocarbon fuels (i.e. "drop in" fuels). Several TEA are reviewed comparing promising processes covering a wide range of TRLs, with a focus on routes involving electrolysis.

The report is publicly available on the project website.

As the next step specific models for LCA and TEA will be set up, the models will be parametrized with the thorough EcoFuel process chain.



Meet EcoFuel at Electrochemistry 2022

ELECTROCHEMISTRY 2022 - At the Interface between Chemistry and Physics
27-30 September 2022, Berlin, Germany

Electrochemistry is a successful series of conferences, held every other year where scientists working in the various areas of electrochemistry joined for discussing cutting-edge trends and applications.

The conference is jointly organized by GDCh Division Elektrochemie, GDCh Arbeitskreis Elektrochemische Analysenmethoden, DBG, DECHEMA, AGEF, GfKORR and DGO.

Outstanding electrochemists from Germany and from abroad will highlight research results and current trends. Parallel sessions will cover nearly all topics of electrochemistry from fundamental science to technical applications.

Chair: Prof. Dr. Peter Strasser - Technical University of Berlin
Contact: Antje Hannebauer - a.hannebauer@gdch.de
Website: https://veranstaltungen.gdch.de

Consortium

AVL List GmbH

Siemens Energy

Johnson Matthey Plc

University of Oxford

Budapest University of Technology and Economics

Pretexo

Technical University of Berlin

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