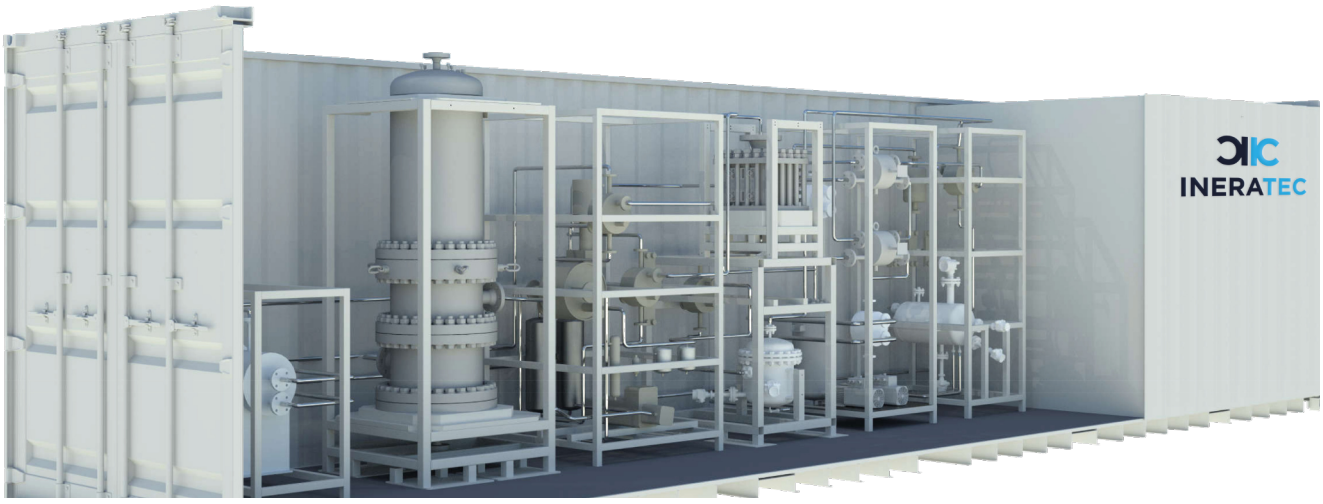
Synthetic Fuels from CO_2 and Renewable Electricity Can Make a Significant Contribution to Achieving CO_2-neutral Mobility.

The E-fuel Synthesis Plant (Power-to-Liquid)

In order to drastically decrease the CO_2 emissions of the transport sector while still ensuring the global transportation of goods and people, CO_2-neutral alternatives to fossil fuels are required. While e-mobility will play a significant role in the future of individual mobility, heavy-load and long-distance transportation as well as aviation will depend on the high energy density of liquid fuels. This is why CO_2-neutral synthetic fuels are urgently needed.

With the Power-to-Liquid synthesis plant, CO_2 together with H_2 can be converted first into synthesis gas (H2/CO mixture) and then into hydrocarbon molecules in a second reactor. These molecules can be considered as a raw product for the final synthetic fuels.
In order to increase the yield of the desired liquid product and optimize the fuel properties, the containerized synthesis plant features a product upgrade step.



Simplified representation of the E-fuel synthesis plant
Source: Ineratec GmbH

The centerpiece of the e-fuel synthesis plant is an ultra compact microstructured chemical reactor, which was developed and commerzialized by INERATEC GmbH, a spin-off company of KIT. The special features of the reactor allow for a highly efficient conversion of the synthesis gas into hydrocarbon molecules. The microstructured reactor module shown in the photo can produce up to 200 liters of the product per day. More modules can be added and combined, and thus, the capacity can be tailored easily.

Photos: C. Ruf, KIT

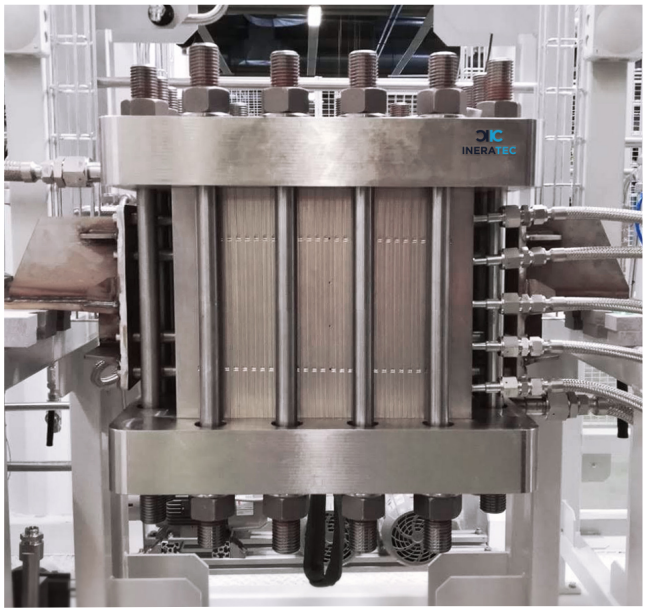
The E-fuel Synthesis Plant (Power-to-Liquid)

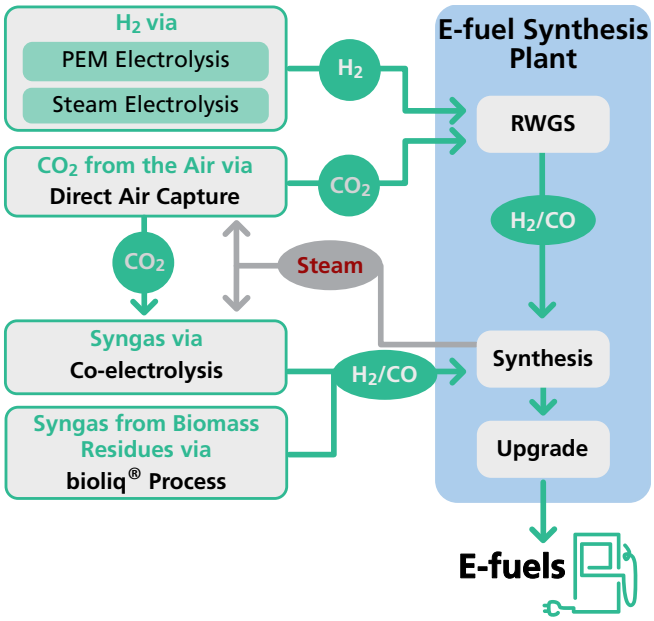
Environment-friendly Resources

The e-fuel synthesis plant produces liquid fuels from CO_2 and H_2. In order to obtain CO_2-neutral fuels, carbon dioxide has to be extracted from a non-fossil source. Most consequently, CO_2 is captured from the air by means of the Direct Air Capture (DAC). Following the Power-to-Fuel concept, the H_2 used is generated by an electrolysis process using green electricity.

First Step: Synthesis Gas Generation

In a first chemical reactor (RWGS reactor), CO_2 and H_2 is being converted into the so-called syn-thesis gas, a reactive gas mixture of H_2 and CO. This happens in the e-fuel synthesis plant.
Alternatively, the RWGS reactor can be bypassed and synthesis gas from other sources of the Energy Lab 2.0 – for example from co-electrolysis or biogenic sources (e.g. bioliq®), can be investigated.





The Microstructured Synthesis Reactor

The synthesis gas from the first step is then transferred to the ultra-compact microstructured synthesis reactor. Here, via the Fischer-Tropsch synthesis, hydrocarbon molecules of different chain lengths are produced. These are the raw product for the final e-fuels.
One key feature of this advanced reactor technology is that the heat, which is generated during the chemical reaction, is extracted efficiently by generating steam. This does not only allow to precisely control the reaction but also to use the steam in other steps of the Power-to-Liquid process chain and, thus, helps to increase the overall efficiency.

The Product Upgrade

The last step in this process chain within the containerized synthesis plant of the Energy Lab 2.0 is the product upgrade, which not only increases the yield of the desired liquid e-fuel but also optimizes the fuel properties. After a final distillation, the different e-fuels, i.e. synthetic kerosene, diesel, or gasoline are obtained.

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