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News

Issues and Foresight

Climate, environment and circular economy

CO2 capture, utilization and storage

EP#5 - FROM FUELS TO CHEMISTRY: HOW CAN WE USE CAPTURED CO_2? | CATHERINE LAROCHE AND JEAN-PHILIPPE HÉRAUD (IFPEN)

What should be done with the CO_2 captured in industrial emissions? We’ve seen that it's possible to isolate it from the atmosphere by storing it underground. Now we also need to consider it as a resource in the context of “CCU”: CO_2 Capture and Utilization. In France today, 0.8 Mt of CO_2 is used per year, with the food processing industry behind 70% of that. From chemical products to construction materials, there are many ways to use CO_2. There is particular potential in synthetic fuels, an area that is still being studied. Catherine Laroche, CCU R&D Project Manager, and Jean Philippe Héraud, Advanced Biofuels Project Manager, both with IFPEN, explain all of this in detail in our 5th episode.

Points to remember

The circular carbon economy: CO_2 as a resource

We tend to see CO_2 as waste. But **the CO_2 molecule is also a resource that**, when it reacts with other substances (water, energy, hydrogen), can be used to synthesize or produce other molecules.

That is what the term **circular carbon economy** refers to. It refers to technologies that transform CO_2 into useful synthetic products. Using CO_2 improves the carbon footprint of these products when the CO_2 is produced with renewable or low-carbon energy.

What is CO_2 used for?

- **CO_2 can be used as a raw and chemically "reactive" materia**l through a range of techniques. Using CO_2 chemically thus enables the production of chemical compounds, medication, construction materials, etc.

Not all of these products are at the same stage of development. Among the products already being manufactured using CO_2 are urea, which is used in the production of fertilizer (100 million tonnes per year) and plastics, and salicylic acid, used as a medication (in aspirin, for example). Many other combinations are being studied for feasibility (carboxylic acids, organic carbonates and isocyanates, compounds used in plastic production).

- **CO_2 can also be used as a nutrient by living organisms that use photosynthesis** (such as algae). This is biological use.

According to IEA estimates, CO_2 use represents **8% of the reduction potential attributed to CCUS** for the period 2020-2070.

CO_2 can also be used to make fuel. Using CO_2 in this way could encourage more conversion. It is estimated that **between 1 and 4 Gt of CO_2/year** could be used. However, it should be remembered that 32 Gt of CO_2 is currently being emitted annually.

How can CO_2 be converted? The case of synthetic fuels

CO_2 is a stable molecule, meaning **it is difficult to cause it to react with other molecules**. So a two-step procedure is used to transform it into fuel.

1/ Transforming CO_2 into an intermediate, more reactive molecule: carbon monoxide (CO)

To use CO_2 for fuel, the approach adopted by IFPEN consists of transforming the CO_2 into a more reactive intermediate molecule, carbon monoxide, CO. Combined with hydrogen, **synthesis gas** (also known as syngas) is formed, and this can be used to make liquid or gas fuels.

The CO_2 into CO conversion reaction requires hydrogen and the addition of energy. To do this, hydrogen is obtained by electrolysing water (H_2O), which is then transformed into H_2 and oxygen (O_2) (see glossary).

The electrolysis uses renewable electricity, from wind, solar, hydraulic, geothermal or nuclear power. That way, the energy contained in the fuel produced from CO2 comes from electricity. That's why we talk about **electro-fuel, or e-fuel**.

2/ Recombining carbon monoxide (CO) and hydrogen (H_2)

This involves obtaining hydrocarbon molecules (comprised of carbon, C, and hydrogen, H) similar to crude oil, then converting them into fuel. Recombination requires a reaction that was discovered between the two wars by two German scientists, Franz Fischer and Hans Tropsch: **the Fischer-Tropsch process**.

This industrial process, which today is applied industrially to a synthesis gas obtained from fossil-fuels, can be assimilated to a polymerization reaction (see glossary) in several steps:
1- **Initiation**: bonding of two hydrogen atoms, H, to a carbon atom, C;
2- **Propagation**: addition of the carbon chain – also called a ring - forming very long molecules;
3- **and Termination**: products resulting from Fischer-Tropsch synthesis are similar to candle wax but are not immediately usable as fuel in the transport sector. They must therefore be made to conform to requirements for kerosene or diesel-type fuels.

To do this, the molecule chains are cut to the right length:
- between 10 and 13 carbon atoms for kerosene
- between 14 and 22 atoms for diesel

They are then isomerized (see glossary), which gives them **the cold properties required for use at high altitudes**, for kerosene, and in winter, for diesel.

IFP Energies Nouvelles developed the Fischer-Tropsch process in partnership with Axens and Eni, the Italian energy firm, starting in the late 90s. Today, the process is marketed by Axens under the name Gasel®

Unlocking the potential of synthetic fuels to decarbonize transport

With the need to decarbonize the transport sector, synthetic fuels represent a particularly attractive option. **Their chemical structure is comparable to that of conventional fuels**, which they can therefore be directly mixed with. Called **"drop-in" fuels**, they can replace fossil fuels without the need to change the engine specifications in the existing distribution infrastructure.

Today, the deployment of the e-fuel sector is driven by social demand and European regulations as part of the fight against climate change. It is one of the main ways for the aviation sector to decarbonize - and aviation represents **15% of the transport sector's emissions**, for both passengers and freight.

The European ReFuel EU Aviation initiative, an outgrowth of the European **Fit for 55** regulatory package, which aims to reduce greenhouse gas emissions by at least **55% by 2030**, calls for synthetic fuels to comprise **at least 0.7% of all fuel by 2030, rising to 5% in 2035**. The maritime sector may also prove to be in a consumer of such synthetic fuel.

To meet the 2030 objectives, industrial projects must be started now. While the technological solutions are already on the market, or will be soon, we must also:
- support investment in the initial industrial units;
- draught stable legislation, especially concerning the origin of the CO_2 used;
- make sure we have the means to produce hydrogen in gigafactories to both manufacture electrolyzers and ensure the supply of low-carbon electricity

To find out more :
>> What futur for biofuels ?

Glossary

Biogenic CO_2: carbon contained in organic soil matter and in agricultural and forest biomass, emitted during combustion or degradation
Electrolysis of water: process that breaks water (H_2O) down into dioxygen and dihydrogen gas using an electric current
Isomerization: principle of transforming a chemical body into an organic molecule which has the same basic composition, but a simplified or different structure
Example: The isomerization of glucose into fructose
Polymerization: process of transforming a monomer (a building block of matter, often organic in origin, comprised of a single molecule) into a polymer (a chain of several monomers, like a string of pearls)
Fischer-Tropsch reaction: reduction of carbon monoxide (CO) using hydrogen (H_2) to obtain hydrocarbons
Syngas: another way of saying synthesis gas

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