How can you make more out of your biogenic CO_2?

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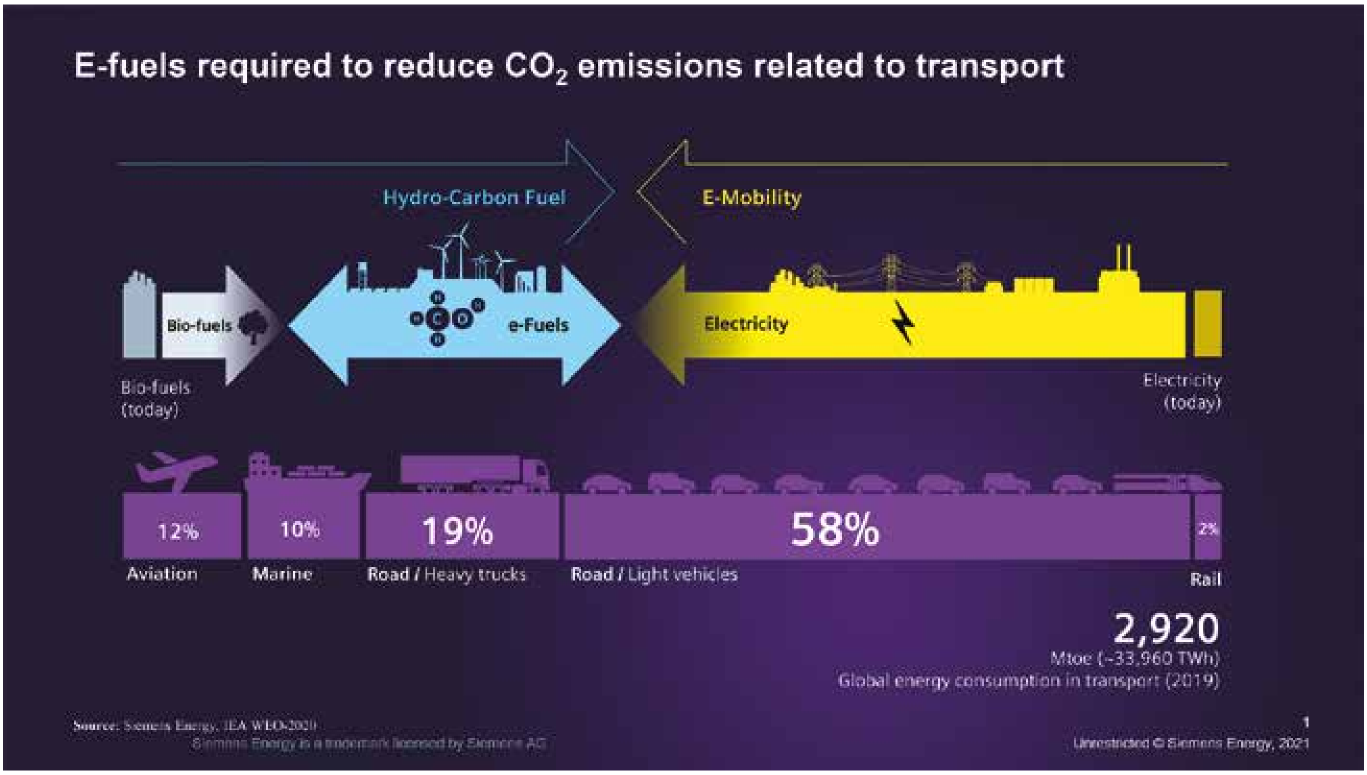
INTRODUCTION:

The answer to this question, which is asked inside the Pulp & Paper Industry more and more frequently, is given by Siemens Energy and Liquid Wind, who partnered up to use renewable energy and biomass based (biogenic) CO_2 to produce eMethanol for e.g., the shipping industry.

Methanol synthesis, based on green hydrogen and CO_2 from biomass-based flue gas, raises the prospect of a carbon-neutral industrial system. As a fuel for mobility applications and feedstock for the chemical industry, green methanol can decisively drive the de-fossilization of the shipping industry and other industry sectors. At the same time, integrating green methanol production into existing industrial facilities, such as pulp mills or combined heat and power plants, creates an opportunity to re-use a valuable resource like biomass-based CO_2.



As you can see in the picture above, the transformation of the transportation industry, from one heavily dependent on fossil fuel to an, at least, CO_2 neutral industry requires all kinds of different technologies and solutions, for example eMethanol, which can replace ship fuel as one of the worst fossil-based fuels in use today. The clients of the big logistic carriers are already demanding a change, to a climate friendly alternative to transport their goods. So, the precondition for the transformation of the shipping industry was never better than before, even though there is still a long way to go. The Pulp & Paper industry can play an important role by using their biogenic CO_2 emissions to support this transformation.

Production from water, green electricity, and biogenic waste gases

eMethanol is produced by chemically combining CO_2 and hydrogen. First, hydrogen is produced by an electrolyzer. The hydrogen is converted into methanol in a reactor by catalysis with carbon dioxide (CO_2). To produce 'green' (i.e. carbon-neutral) eMethanol, hydrogen from renewable energy is used, in combination with biogenic CO_2.

The potential of this method lies in the fact that the biogenic CO_2 emitted from e.g. biomass-based boilers or a lime kiln, can be obtained via a carbon-capture process. This process avoids the emission of further climate-damaging carbon dioxide and uses it as a valuable resource and raw material for a new green energy carrier, like eMethanol, a sustainable energy.

In addition, methanol synthesis produces water, oxygen (from the electrolyzers), and waste heat, which in turn can be used within a closed-loop system in the pulp mills. Oxygen is a valuable raw material in the pulp and paper industry for e.g. the bleaching process, wastewater treatment, or efficiency increase of other processes. The oxygen must be either produced on site with a high energy expenditure, or must be bought as a raw material from the market. Demineralized water from the Pulp & Paper process can be used in the electrolysis process, where it serves as feedstock for further hydrogen production.

Last, but not least, modern pulp mills are producing, due to highly efficient process and state of the art technologies, much more electrical energy than needed for the pulp production itself. Today the surplus is either used in integrated pulp and paper mills (board and paper production at the same location as the pulp mill), or sold on the energy market for sometimes more, sometimes less profit. This happens already e.g. in Uruguay, where a significant amount of modern pulp mills went into operation during the last couple of years (and therefore the market price for electrical power is rather low). Integration of eMethanol production into the pulp production would be even more efficient in such cases. The picture below shows an example of how it could be integrated:

Production on an industrial scale

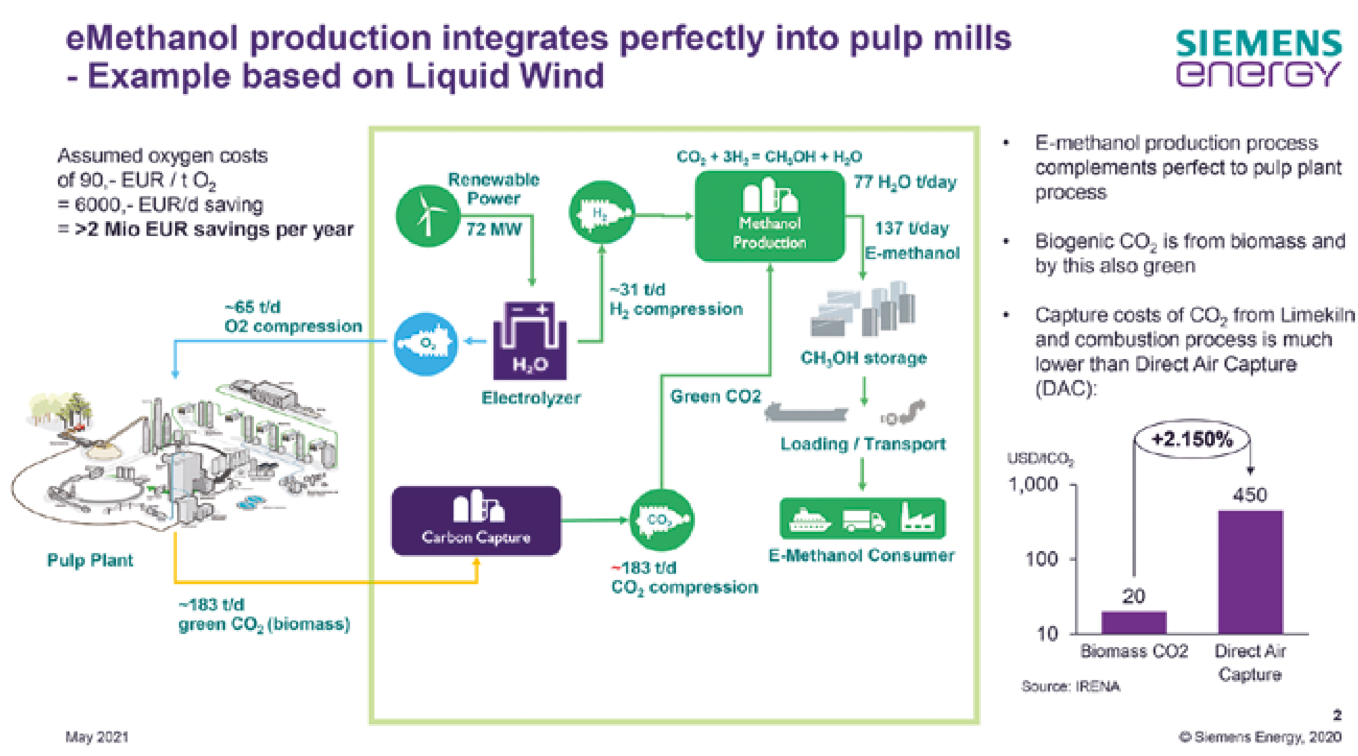
Against the background of energy transition and national/international climate targets, a worldwide, concentrated, expansion of capacity for renewable energy is not only to be expected, but essential. Efficient solutions that store renewable energy seasonally in large quantities are vital, given the natural fluctuations in the production of wind and solar power.

The production of eMethanol on an industrial scale offers a promising and economical solution to this challenge. Electrolysis from sustainable energy sources produces hydrogen, which is converted into methanol by reaction with carbon dioxide. Like gasoline or diesel, the liquid eMethanol is comparatively easy to store, transport and use.

The first pilot plants for this purpose, particularly in Iceland, have now been in operation for several years.

Proven “Power to X” portfolio from Siemens Energy

The technologies required for all process steps in the industrial production of eMethanol are already available and well-proven. In recent years, Siemens Energy has been developing customized “Power to X” solutions for the decarbonization of various industries, and established partnerships with the world’s leading suppliers of e-fuel synthesis technologies. From wind power, green hydrogen, and e-fuels production, to carbon-free re-electrification, Siemens Energy benefits from many years of experience in the oil and gas industry, so that most of the relevant plant components have been available, are proven in use and been established for years. With the “Proton Exchange Membrane” (PEM) electrolysis, Siemens Energy is a leading supplier for the most promising Electrolyzer technology for sustainable hydrogen production. This PEM-technology, in comparison to the classical Alkaline Technology, matches perfectly to cope with the highly volatile renewable energy market, and just needs power and water, and no additional toxic chemicals, for the production of green hydrogen.



Siemens Energy has been a leading supplier for Electrification, Automation, and Digitalization solutions in the pulp and paper industry for decades, is well connected in the landscape of the global pulp and paper community, and therefore is a perfect match for the add on of Power2X or eFuel projects, such as Liquid Wind, into existing or new pulp and paper mills. Beyond this, Siemens Energy is also implementing for the Liquid Wind project the same Automation System, PCS7, the same drives, motors, transformers, switchgears, and other electrification equipment as has been used for years in countless pulp and paper mills around the world. Also, COMOS will play a significant role as the backbone of the entire Liquid Wind approach: implementing the Data Digital Twin, SIMIT, and other simulation tools, will help to generate the Process Digital Twin for the entire production chain of eMethanol. In addition, a Digitalization toolbox will prepare the production facilities for Autonomous Operations and Predictive/Remote maintenance services.

Global roll-out of a model project

Liquid Wind, a Swedish power-to-fuel development company, is currently planning the worldwide first large-scale industrial roll-out of eMethanol production facilities. The first plants will be built in Sweden, with additional plans to roll out the so-called Flagship facilities in Europe and on a global scale, in partnership with pulp and paper mills and CHP plants. The eMethanol produced can be used to power all kinds of ships, and replace marine fuel oil.

Ten Flagships, with an annual production volume of a minimum 50,000 metric tons of eMethanol each are to be built by 2030. The company is planning to scale rapidly, targeting the development and implementation of 500 plants worldwide by 2050. The production facilities will use Siemens Energy's Electrolyzer of the newest generation, Silyzer 300, which is highly adaptive and matching the requirements of the specific value chains.

This scaling is made possible thanks to a standardized and modular facility model, based on the latest digitalization technology, for the efficient replication of eMethanol facilities. The entire planning and integration are carried out with the help of licensing, a so-called Digital Twin, for data (COMOS), process and operations, which is also provided by the Siemens Ecosystem. This means that all plants can be planned, tested, and efficiently operated via Digital Twin implementations. This offers great development opportunities for scaling up in countries that are rich in renewable energy and, with the synthesis from hydrogen and CO_2, meet the growing demand for green methanol.

Closed production cycles

Liquid Wind's first eMethanol plant, FlagshipONE, will be co-located with a combined heat and power plant (CHP) from Övik Energy in Örnköldsvik, north-east Sweden, making use of biogenic CO_2, sustainable energy, and other utilities. The biomass-based flue gases will form the green raw material for a carbon neutral fuel. In the process, the CO_2 for the methanol synthesis is captured from the plant's biomass-based flue gas. The purified water is used for the hydrogen electrolysis, as is the water produced as a by-product during the methanol synthesis. The waste heat is used to concentrate the CO_2.

The pulp and paper industry is an ideal industry partner for the production of eMethanol for several reasons:

1. The oxygen produced can be returned to the pulp mill or CHP.
2. Mills can use the on-site eMethanol to replace diesel for trucks, fork lifters or caterpillars in their distribution chain to further reduce CO_2 emissions.

Each Liquid Wind facility will produce 50,000 tons of eMethanol per year. To achieve this, 75 MW of renewable energy from wind power will be used to produce green hydrogen, and 70,000 tons of industrial CO_2 will be upcycled.

Four Siemens Silyzer 300 units will be used as Electrolyzers for producing hydrogen. Siemens Energy is also responsible for the plant-wide electrification, instrumentation & automation, including engineering and services, as well as digitalization with Digital Twin implementation, Industrial Internet of Things (IIoT), analytics, and AI applications. Production from FlagshipONE in Sweden is scheduled to start at the beginning of 2024.

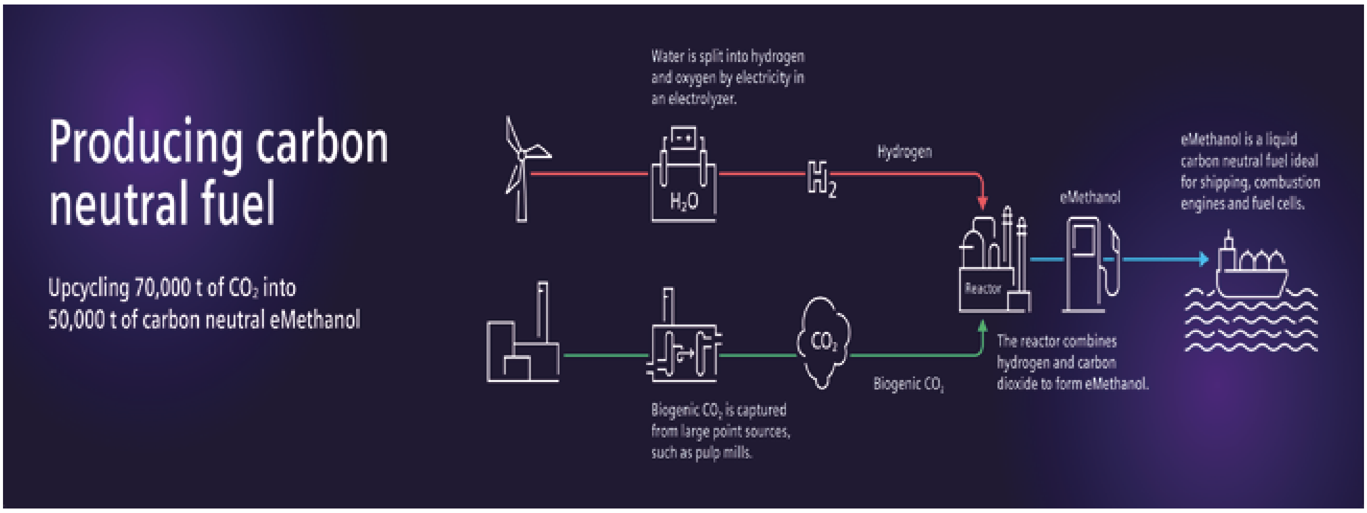


Figure 1: FlagshipONE Visualisation, Örnsköldsvik, Sweden

eMethanol, a green alternative for marine propulsion and industry

eMethanol is a sustainable fuel option, especially for ship propulsion systems, that are predominantly operated using so-called 'marine diesel' (heavy fuel oil). Due to marine diesel's poor ecological assessment, its use cannot be reconciled with international climate targets.

Of the approximately 98 million metric tons of methanol produced worldwide each year, around 85% is used as a feedstock in the chemical industry, for synthesis, or as a solvent. Several countries, for example Taiwan, import large quantities of methanol for their chemical industry. At the same time, it is those countries with few raw materials that are investing heavily in renewable energy, such as photovoltaics and wind power. The synthesis of methanol, based on hydrogen and CO_2, offers these markets the opportunity to substitute the demand for their own industry.

Fair competition needs fair conditions

The integration of eMethanol production can already be made economically profitable in many industrial areas. Furthermore, all technologies are available at the required scale and have been proven over many years, as the Siemens Energy portfolio proves, from technical applications to the complete digital toolset. Research and development costs are therefore limited to optimizing existing technologies, achieving an even higher level of integrated operations, and maximizing the use of Digitalization tools.

The widespread success of eMethanol as a raw material and energy carrier essentially depends on whether it can be offered at competitive market conditions. Above all, this requires appropriate legal and fiscal framework conditions for carbon-neutral methanol. To date, synthetic fuels have generally been more expensive for the consumer than fossil or oil-based energy sources and fuels.

Fossil fuels are subsidized to a large extent, and have historically been offered tax breaks. For example, the environmentally harmful marine diesel is not subject to CO_2 tax and can be used tax-free, in accordance with Section 27 of the German Energy Tax Act (EnergieStG).tax breaks.

To make lower-carbon and zero-carbon alternatives attractive, and help the corresponding technologies achieve a breakthrough, economic incentives and tax relief are needed, as the example of successful wind power subsidies shows.

Solutions to climate policy challenges

In the short and medium term, the production of eMethanol from renewable energy offers the opportunity to establish new, largely carbon-neutral economic cycles.

In the long term, the conversion of renewable energy reserves into eMethanol, hand in hand with other application-specific technologies, such as hydrogen, and an expansion of power grids, raises the prospect of an energy economy that is no longer dependent on fossil fuels. Not only will this avoid greenhouse gas emissions, it will in fact also absorb CO2 as a raw material for applications in industry, mobility, and energy.

A methanol economy, based on renewable energies, therefore creates the solutions for many environmental challenges which, although already addressed in some way today, require a better conceived and far more integrated approach.