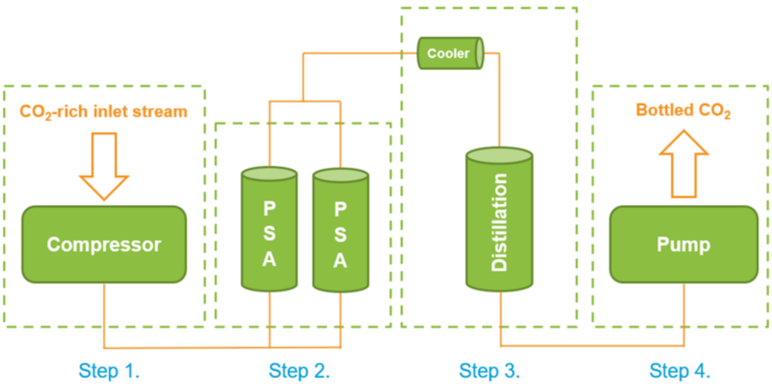
Capturing and utilizing carbon dioxide from biogas plants

Biogenic carbon dioxide is of particular interest from the perspective of carbon dioxide capture and utilisation (CCU), as biogenic carbon dioxide can be used in the production of carbon-neutral products. Biogas is an excellent source of biogenic carbon dioxide for CCU, as raw biogas itself contains a significant amount (approximately 40-50%) of carbon dioxide. Biogas refining technologies are already mature and available in the market: raw biogas upgrading for biomethane, to be used in transportation or distributed via natural gas networks, currently releases carbon dioxide into the atmosphere, which could be harnessed. The separated gas stream from raw biogas upgrading can be quite rich in CO_2, depending on the purification technology used. For example, with membrane technology commonly used in biogas plants, the concentration of carbon dioxide in the outlet gas can be over 95%. Commercializing this waste stream could provide new sources of income for a biogas producer.

VTT Technical Research Centre of Finland has piloted carbon dioxide capture and liquefaction from a municipal biogas plant as part of an ERDF-funded "Decentralized and resource-efficient production of biomethane in Central Finland" -project. The project is funded by the REACT-EU instrument supporting regions affected by COVID-19 pandemic. During the project, an investment and experiments were made with a container-based carbon dioxide purification and liquefaction (PuLi) unit. The PuLi unit can be used to pilot bottling of carbon dioxide into a product quality from volumetrically small but highly CO_2-concentrated carbon dioxide sources, such as from biogas plants. In the unit, the carbon dioxide-rich gas stream is first directed to a compressor, where the gas pressure is increased (70 bar). The pressurized gas is then directed to PSA purification columns, where, e.g., water vapor is separated into an adsorbent. After this, the gas is cooled and liquefied, and at the same time, the remaining gaseous impurities are removed. Finally, carbon dioxide is pumped into bottles and is ready to be sold and utilized.

During the experiments, carbon dioxide captured from the biogas plant was pressurized, dried, and liquefied into bottles with a modest financial investment. However, small traces of impurities, mainly methane, remained in the gas. Based on economic evaluations, capturing carbon dioxide could be quite profitable in larger municipal-scale biogas plants. The inlet stream of CO_2-rich gas can be from other sources than biogas plants as well. The PuLi unit has generated a lot of interest, and the experiments are planned to be continued in future joint research and development projects in collaboration with different business consortiums.



Operation principle of the a carbon dioxide purification and liquefaction (PuLi) unit. Source: VTT

Carbon dioxide purification and liquefaction (PuLi) unit. Source: VTT

KEY WORDS

Carbon dioxide, biogas

COUNTRY

Finland

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ADDITIONAL INFORMATION

Carbon dioxide has been captured and commercially utilized for a long time, and there are global markets for carbon dioxide. Currently, a significant portion of commercial industrial carbon dioxide is obtained as a by-product of hydrogen and ammonia production through steam reforming of natural gas. In this process, the CO_2-concentration in the resulting stream is very high, even exceeding 98%. However, in the long term, the carbon dioxide market is undergoing a transition. Electrolytic hydrogen production is seen as a replacement for fossil steam reforming of natural gas in the hydrogen and ammonia industry, reducing the amount of by-product carbon dioxide produced. There are also continuously emerging new applications for carbon dioxide, increasing the need to find new sources for carbon dioxide capture.

Globally, the largest current uses of carbon dioxide are in urea production for the fertilizer industry and enhanced oil recovery. Other significant and more localized applications can be found in the soft drink and food industry, where carbon dioxide is used for carbonating beverages, as a protective gas in packaging, and for cooling food products. Carbon dioxide can also be utilized in greenhouses to enrich the atmosphere to accelerate plant growth, as well as in applications such as welding gases or as a raw material in dry ice cleaning. Locally produced biogenic carbon dioxide separated from biogas could replace fossil-derived carbon dioxide in these applications.

Several new carbon dioxide utilization applications are also underway. A significant driver for this is the hydrogen economy, where hydrogen produced electrolytically from water and carbon dioxide captured from various processes are combined to create new products to replace fossil alternatives. Examples include synthetic methane and methanol, which can be used as fuel in passenger cars or heavy road and marine transportation and as raw material in the chemical industry. Utilizing carbon dioxide in concrete production is also under development: during mineralization, carbon dioxide reacts with different binders to form calcium carbonate, which strengthens the concrete and reduces the need for cement.

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ABOUT BRANCHES

BRANCHES is a H2020 "Coordination Support Action" project, that brings together 12 partners from 5 different countries. The overall objective of **BRANCHES** is to foster knowledge transfer and innovation in rural areas (agriculture and forestry), enhancing the viability and competitiveness of biomass supply chains and promoting innovative technologies, rural bioeconomy solutions and sustainable agricultural and forest management.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101000375

THE PARTNERSHIP

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