IEA Bioenergy
Technology Collaboration Programme

Production of food grade sustainable CO_2 from a large biogas facility

GO'CO_2 at The Korskro Biogas Plant, Denmark.

Case Story

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Figure 1: The Korskro Biogas Plant, Denmark. *Source: Nature Energy*

From residual CO2 to GO' CO2

Strandmøllen A/S developed Denmark's first biogas-based CO_2 plant at one of the world's largest biogas plants, built by Nature Energy in Korskro, outside the city of Esbjerg (Figure 1). Biogas typically consists of 60% biomethane which is used as a renewable fuel, while the remaining 40% is a natural residual product in the form of CO_2. Instead of wasting this residual CO_2 and emitting to the atmosphere, a specially built unit was designed to recover and recycle all of the CO_2 enhancing the sustainability and the circular economy credentials of the facility.

CO_2 recovery is part of the circular economy

The biogas plant processes around 1 million tonnes of biomass per year, of which 85% is composed of animal manure and slurries; this is co-digested with animal bedding, industrial waste, food waste and small amounts of energy crops. The biogas plant produces c. 49 million Nm^3 of biogas each year. The produced digestate is returned to the farmers, to be applied on their crops as plant biofertilizer while the produced biogas is upgraded to biomethane quality and injected in the gas grid, to be used as a renewable substitute for natural gas and as a means of "greening" the gas grid. The upgrading process removes the CO_2 from the biogas.

Instead of release to the atmosphere, CO_2 is captured and transferred to the CO_2 facility (Figure 2), where it undergoes a complex, seven-step process of purification. The seven step purification process consists of filtering, washing, distillation, compressing, condensation, drying and cooling. These steps remove all unwanted residues and impurities from the CO_2, producing a product of quality and purity suitable for use in the food industry. The produced purified CO_2 trades as *GO' CO_2*. It is also used in other industries and sectors beyond the food industry. The residual CO_2 from the biogas production which would have been emitted to the atmosphere is now captured, reused and integrated into a circular economy system.

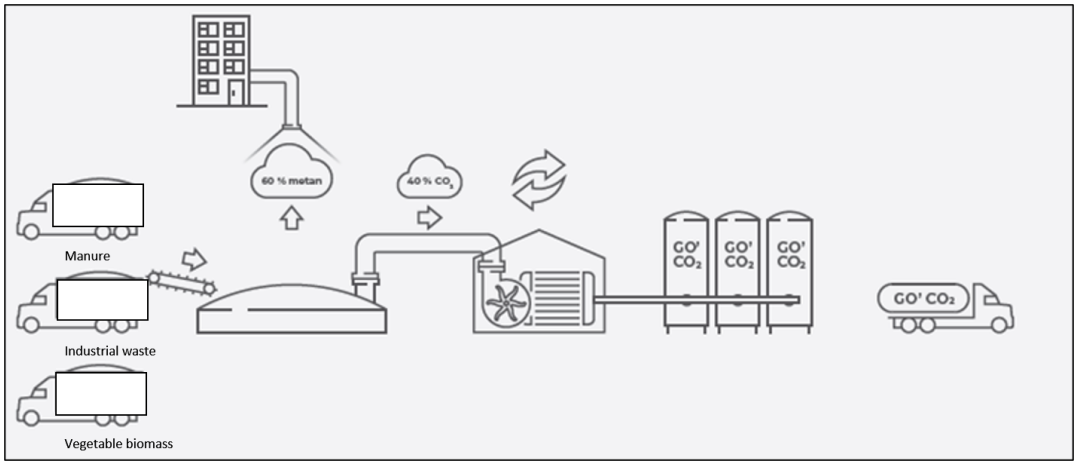

Figure 2: General diagram of GO' CO_2 production at Korskro Biogas Plant.
Source: Strandmøllen A/S

Security of supply

Denmark imports about 65,000 tonnes of CO_2 each year. It is typically sourced from fertilizer production, which is based on fossil energy systems. Capture and reuse of CO_2 from biogas production generates a sustainable CO_2 market and reduces dependence on imports. In recent years, the high demand of various beverages during summer months has created a shortage of CO_2 in Europe. An accessible sustainable source of CO_2 not only increases security of supply but also removes the threat of CO_2 shortage in the summer season. The CO_2 plant at Korskro, produces 16,250 tonnes of CO_2, equivalent to 25% of Denmark's CO_2 consumption each year (Figure 3). Not all the CO_2 produced at the biogas plant is purified for the CO_2 market; there is still spare capacity at the Korskro Biogas Plant to expand production and deliver food grade CO_2 to more customers who wish to avail of this circular economy system.

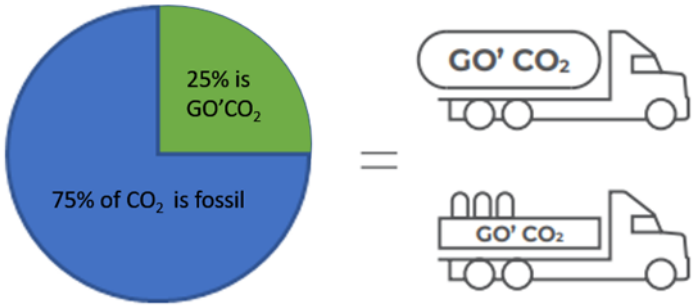

Figure 3: Up to 25 % of the CO2 consumption in Denmark is covered by sustainable GO' CO2. *Source: Strandmøllen A/S*

Suitable purity for all sectors

The biogas plant operates mainly on livestock manure, deep litter from stables, organic waste from industry and retail and a small amount of energy crops. The CO_2 from the GO' CO_2 unit has the same purity and quality as traditionally produced CO_2; however it is sustainable. The complex purification process ensures the CO_2 is free of unwanted microorganisms, and that it is odourless, tasteless and meets all the standards required for utilisation in many sectors and activities, including the food industry. GO' CO_2 is ideal for carbonation in the soft drink and beer industry, as well as for cooling and freezing food, because it is odourless and tasteless. GO' CO_2 has a wide range of applications beyond the food and beverage industry, because of its high quality and because it can be produced in a variety of forms and degrees of purity (Table 1).

Food industry • Cooling food • Modified Atmosphere (MA) packing of minced meat • Supplement to soft drinks and beer • Stunning animals before slaughter.	Iron & machine industry • Laser cutting • Welding in black steel • Shielding gas.
Healthcare sector • Laparoscopy (surgical procedure) • Dry ice for sending samples • Cooling eggs and sperm in fertility clinics.	Pharmaceutical industry • pH control • Dry ice for the transport of stem cells • Controlling oxygen levels in cell culture.

Table 1: The multiple uses of GO' CO_2

A sustainable future

Environmentally sustainable CO_2 always was a desirable comodity, but it is only now that a biogas plant of the scale of the Nature Energy facility in Korskro can facilitate economic sustainability in the production of biogenic sustainable CO_2 of a purity standard that can be used in the food and beverage industry.

When the residual CO_2 is separated from methane in the biogas by upgrading, instead of emission to the atmosphere it is captured, reused and substitutes the use of fossil CO_2 in the considerable market for CO_2; in Denmark this market is 65,000 tonnes per annum.

GO' CO_2 in Power to X projects

The GO' CO_2 concept has also found its way into the research world, where it is applied in Power to X projects, focusing on the transition to green renewable gas and advanced gaseous biofuels and/or renewable fuels. Here, the researchers combine hydrogen produced from electrolysis and GO' CO_2 to produce sustainable electro-fuels based on renewable electricity and biogenic CO_2. The electro-fuels produced include for renewable methane (such as from the exothermic Sabatier process; $4H_2 + CO_2 = CH_4 + 2\ H_2O$), methanol and ammonia. These advanced electro-fuels can be used as a propellant in particular for applications in the hard to decarbonize heavy transport sector. These processes and methods are already implemented at larger demonstration scale. A new Danish consortium plans for very large-scale electrolysis facilities in the metropolitan area. The GO' CO_2 systems intend to expand their production capacity, to meet the future demands for green CO_2.

IEA Bioenergy Task 37 "Energy from Biogas" http://task37.ieabioenergy.com

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A substantial amount of information was drawn from the brochure "GO'CO2 fra restprodukter til ressourcer og større forsyningssikkerhed" published by Strandmøllen A/S.

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