Until recently, the emphasis in most biogas projects has been on utilising methane, its primary energy component, writes Tobias Eckhof, project engineer at Krieg & Fischer Ingenieure GmbH. With the increased use of biogas in the form of biomethane, carbon dioxide can now be effectively harnessed as a by-product of biogas upgrading

Capture and liquefication of CO_2 from biogas plants

Instead of being viewed as a waste product, the carbon dioxide stream from the biogas plant can be valourised in different sectors. CO_2 is traditionally used in various industries, such as food and beverages (for cooling and carbonisation), agriculture, fire suppression, medicine and so on. Most of the commonly used production technologies rely on fossil fuels and contribute to the release of CO_2 into the atmosphere.

Biogas plants are a source of biogenic (biomass-based) CO_2 and are part of the natural short carbon cycle, which starts with extraction of atmospheric CO_2 through photosynthesis. As companies seek to reduce their carbon footprint and demonstrate their commitment to sustainability, the demand for biogenic CO_2 is rising, as well as new applications in the production of fuels, chemicals and building materials.

The combination of feeding the upgraded methane into the gas grid and using the by-product CO_2 makes it possible to operate biogas plants with virtually no emissions and no losses. In this way, a major contribution can be made to reducing greenhouse gas emissions in the fuel and energy sectors. It also creates local synergies with CO_2-consuming industries.

The use of liquefaction in the biogas sector is relatively new, because the technological application of electricity and fossil CO_2 was very cheap until last year.

For plants that possess biogas-to-biomethane upgrading, the process includes the collection of gaseous CO_2 from biogas, its purification and liquefication. Depending on the biogas upgrading technology, the separated CO_2-stream already has a quality of 95-98%. In the liquefaction it is purified to 99-99.9% depending on industrial or food grade applications. Methane in the raw CO_2 stream can be returned to the upgrading plant, resulting in a methane yield of almost 100%.

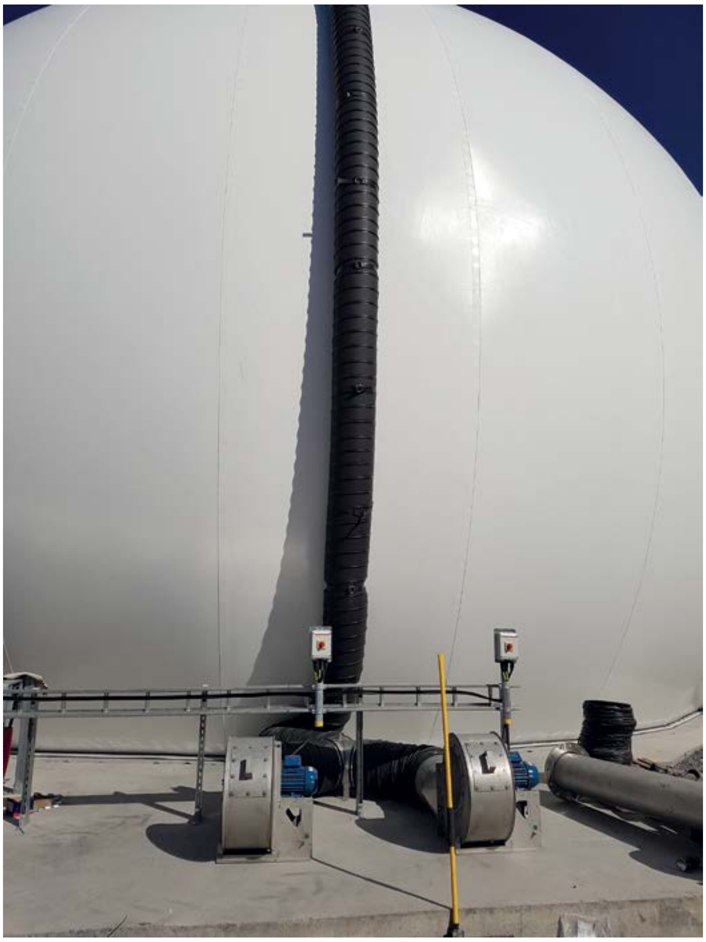
In the latest example from Germany, CO_2 liquefication will be implemented alongside installing a biogas upgrading system for two already existing biogas plants owned by LSW Energie GmbH, an energy distribution network operator in North Germany. The investor aims to further transform and enhance its current network infrastructure into a strong and sustainable energy system with sector coupling.

The project will replace the existing biogas processing plant, and involves the installation of a biogas-to-biomethane upgrading and CO_2 liquefaction plant producing food-grade quality CO_2.

The project will source 1,400 Nm³/h of biogas from two existing plants that use renewable raw materials and manure, as well as biogas from a nearby wastewater treatment plant (200 Nm³/h primarily from potato processing waste). These three biogas flows will be integrated into the processing plant to produce 750 Nm³/h of biomethane, which will be fed into the local natural gas network. The separated CO_2 will be liquefied, stored temporarily on site, and sold. Production of liquefied CO_2 will be about 1.1 t/h. The project also plans to implement a dry-ice production of 1.000 t/a. The proximity allows otherwise emitted Off-Gas to be reliquefied in the liquefaction plant.

Krieg & Fischer will be responsible for the integration of the biogas upgrading and CO_2 liquefaction with the pre-existing biogas plants.

According to Tobias Eckhof,


Biogas storage

project engineer, when engineering this system for biogas plants, multiple recirculations and interfaces must be considered and coordinated to prevent accumulation of undesired components, make the most of the synergistic effects and reduce the emissions to a minimum. Coordinating between multiple heat and electricity consumers and producers and using heat from the biogas processing plant is one of the challenges.

CO_2 liquefication consumes quite a bit of electricity (0.21 kWh/kg liquid CO_2) and, at the same time, produces heat that comes from the compressor. To supply the plants on site with electricity, part of the biogas is used at the existing CHPs. Waste heat from the biogas upgrading and CO_2-liquefaction plant's compressors will be used to heat the digesters. The remaining heat needed for the digesters will be supplied from CHPs.

Krieg & Fischer Ingenieure strives to optimise process technology for every project, but also places a significant emphasis on safety technology to mitigate the impact on the environment caused by emissions and improve overall work safety.

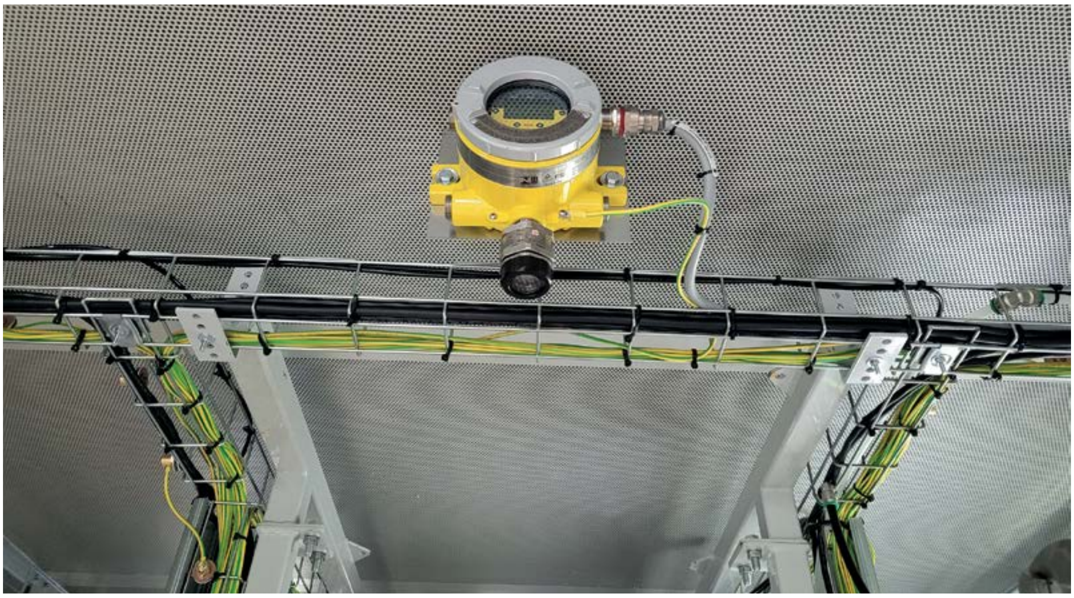
In the present project, the firm's responsibility is the safety of biogas upgrading and CO_2 liquefaction, so both biogas and CO_2 have to be monitored. The biogas plants in operation already have gas monitoring system and safety protocols in place. With this extension, each unit is equipped with control and gas warning systems, but the systems are also connected and communication between them is established.

Since the new upgrading plant will be containerised, a focus needs to be on the detection of gas leaks in the upgrading containers. The control rooms are strictly separated from the rooms with pipes and components that carry biogas. The parts of the container with biogas-carrying equipment, gas detection equipment and gas alarms will be installed, as is standard in CHPs as well. The gas warning system includes a 2-step alarm, which is initiated when 10/20% or 20/40% of the LEL (lower explosive limit) is measured. The first one activates the ventilation of the container to prevent the build-up of a dangerous atmosphere and the second one shuts down the plant safely.

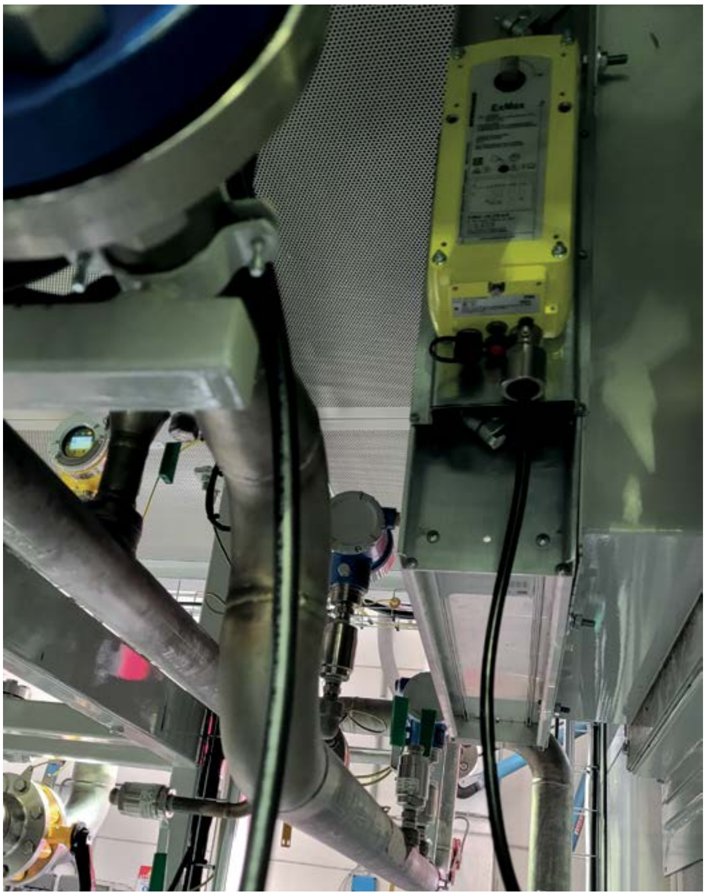
For the raw-CO_2, formerly off-gas from the biogas upgrading system, a consideration is that methane detection is unsuitable to wholly detect a dangerous atmosphere. Because of the high CO_2 and low CH_4 content, CO_2 sensors have to be installed where a leak and/or accumulation of CO_2 may occur. The CO_2 liquefaction is also containerised and in the container there needs to be CO_2 detection. Where CO_2 may occur in a closed room it depends on the technology and specific configuration. Two alarm levels are set at 1.5% and 3% CO_2, and optical and acoustical alarms must be installed to prevent personnel from entering potentially dangerous atmospheres.

With the growing demand for biogenic CO_2, its capture and utilisation are points to address when investing in a biogas plant. Moreover, established biogas businesses looking to expand their existing CHP biogas plants with biomethane production or already equipped with an upgrading system should consider effectively utilising the CO_2 stream as a promising opportunity.

Just as with biogas production and its use for generating electricity or producing biomethane, detecting leaks, implementing gas monitoring systems and safety protocols are integral components of capturing and utilising CO_2.



Methane detector



Actuator for ventilation system

For more information
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