Three Phase Process:
A technology for producing liquid biomethane (LBM)

An new approach for intensifying biogas production in regions remote from the gas grid

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Liquid biomethane (LBM; also called bio-LNG) has a 600 times higher energy density than biomethane at atmospheric conditions and can be easily transported on the road system via trucks. For decentralized production of LBM the Lucerne School of Engineering & Architecture has developed a new concept, the Three Phase Process.

MOTIVATION

In times of depleting fossil energy sources the production of biogas has increased in importance. Consequently, biogas upgrading to biomethane has become very attractive. Biomethane is a renewable and effective substitute for natural gas and can be used in a versatile manner. However, for the transportation of biomethane to the customer conventional upgrading plants are bound to an available connection on the local gas grid. Therefore, in regions remote from the gas grid, biogas upgrading is presently not done. Inspired by enabling decentralized biogas upgrading, we have developed the concept of the **Three Phase Process** for the production of LBM.

ADVANTAGES OF LBM

➔ **Energy density**
LBM has a 600 times higher energy density than biomethane at atmospheric conditions. It has a three times higher energy density than compressed natural gas (CNG) at 200 bar.

➔ **Transportability**
Because of its high energy density LBM is suitable for being transported on the road via trucks (same as for LNG).

➔ **Storability**
LBM is stored at -145 °C in cryogenic tanks. A storage period of up to 10 days does not cause significant boil-off rates.

MARKETABILITY OF LBM

➔ **LBM as vehicle fuel**
At fuel stations LBM can be converted to compressed biomethane (CBM) in high pressure evaporators to fill the CNG tanks of natural gas driven vehicles. Alternatively, LBM can be fueled directly in LNG driven trucks.

➔ **LNG blue corridors**
This EU project advances the establishment of LNG fuel stations in Europe (first fuel stations already exist in the Netherlands).

➔ **First cryogenic upgrading plants are operating**
First cryogenic biogas upgrading and liquefaction plants in Sweden, England and the USA are in operation.

OUR INNOVATIVE TECHNOLOGY

The main step of the upgrading and liquefaction process is CO_2 separation. Our concept, the **Three Phase Process**, is based on CO_2 desublimation (direct phase change from a gas into a solid) by cooling the gas in a special separation column. The solidified dry ice is afterwards melted at -56 °C and absorbs energy from the incoming biogas to cool it. Thus, the overall energy demand of the process is reduced. The liquid CO_2 is then used as refrigerant for other pre-cooling purposes. Finally, the upgraded biogas is liquefied in a low-maintenance refrigerator. Further advantages:

➔ **Production of a high valuable by-product**
The liquid CO_2 can be sold or used for dry ice production.

➔ **Purity of LBM**
The produced LBM has a purity of over 99.9%.

ENERGY CONSUMPTION

To compare the energy consumption of the Three Phase Process with other conventional methods, the common production of CBM vehicle fuel is considered. The alternatives are:

➔ **Conventional upgrading + compression**
Biomethane is produced by conventional upgrading and compressed at fuel stations to 200 bar.

➔ **Three Phase Process + evaporation**
LBM is produced via the Three Phase Process and evaporated at 200 bar at fuel stations using ambient heat.

For both alternatives, the energy demand for producing CBM vehicle fuel is between 7-10% of the energy content of the biomethane.

ROAD MAP

We are aiming at developing our innovative Three Phase Process in collaboration with an industrial partner. The envisaged next steps are:

➔ **Simulation study [2015]**
Process simulation study

➔ **Founding a co-operation**
Founding a co-operation with an industrial partner

➔ **Experimental study [2016-2017]**
Setup of a labor / pilot plant for experimental testing

➔ **Protection of intellectual property rights**
Submission of patents

For more detailed information please contact us.

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