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Technology Description (TD) for

Biogas Upgrading Technologies

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	Date (of filling the TD):	01.09.2017		

Technology Description:

NAME OF TECHNOLOGY	G-PUR
ASSIGNMENT OF TECHNOLOGY	Membrane technology
TECHNICAL READINESS LEVEL **TRL 1** - basic principles observed **TRL 2** - technology concept formulated **TRL 3** - experimental proof of concept **TRL 4** - technology validated in lab **TRL 5** - technology validated in relevant environment (industrially relevant environment in case of key enabling technologies) **TRL 6** - technology demonstrated in relevant environment (industrially relevant environment in case of key enabling technologies) **TRL 7** - system prototype demonstration in an operational environment **TRL 8** - system completed and qualified **TRL 9** - actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)	5
What is the core innovation? (Please explain here what is innovative on this technology and which problem does the	The G-PUR process combines the principle of Water Scrubbing for biogas upgrading to an innovative gas-liquid exchanger. Membrane

technology solve.)		contactors are replacing conventional packed columns and offer the following advantages: - Cost-competitiveness (manufactured products); - Compactness (higher gas-liquid interfacial area); - Ease of design (membrane technology); - Avoid operational problems of packed columns (flooding and channelling). **The main issue is to reduce the investment cost for biogas upgrading units at small biogas flowrates.**
Vision of the innovation (Please describe here what impact you see for the future)		This innovative process may divide the investment cost by a factor 2-3 (100 Nm3/h biogas), and offer an ease of operation for biogas operators.
What are the R&D needs for your technology? (Are there any barriers or challenges which still need to be overcome?)		The technology produces gas-grid quality biomethane (> 97%) with a satisfying recovery rate (> 98%). The next step is to validate the technology with a demonstration plant. We need industrial and financial partners for this project.
TECHNOLOGY/EQUIPMENT AVAILABILITY		
PATENT RIGHTS		YES (1 patent filled in February 2017)
METHOD OF MAKING THE TECHNOLOGY AVAILABLE	*Licence selling*	YES
	Licence granting	YES
POSSIBLE END USERS OF TECHNOLOGY	*Please name end users/ contacts that should be invited to project workshops*	Engineering design companies offering biogas upgrading services. Biogas plant operators.

Description of the technology/equipment:

The separation of CO2 and CH4 occurs by the difference of solubility of these two components in a mineral salt solution. As opposed to water scrubbing in which packed columns are used, the G-PUR process uses membrane contactors as a gas-liquid exchanger device (Figure 1). The hollow fiber membrane is microporous and hydrophobic. The gas may flow through the high porosity of the membrane

(contrary to dense gaseous permeation membranes). The hydrophobic nature of the membrane avoid phase mixing and offer a high and constant gas-liquid exchange area.

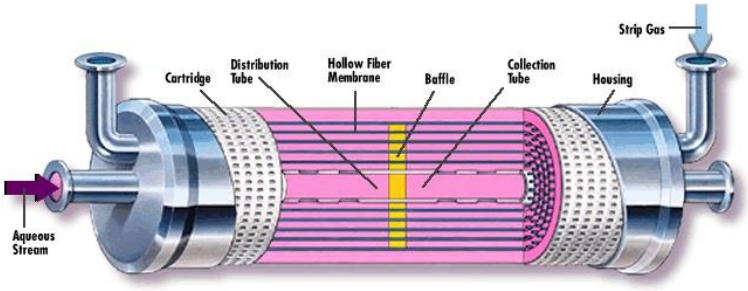

Figure 1 - Membrane contactor (source: Membrana)

The G-PUR process is a 3-stage process with a pressurized liquid closed-loop (Figure 2):

- CO2 is preferentially absorbed in the absorbent in the absorption step;
- Dissolved CH4 is degassed in the partial degassing step to minimize the methane slip and the degassed gas stream is recycled to the head of the process;
- The absorbent is regenerated through a final degassing step using a vacuum pump (or an air stripping technique). The offgas stream contains a high CO2 fraction since it has not been mixed with an air stream.

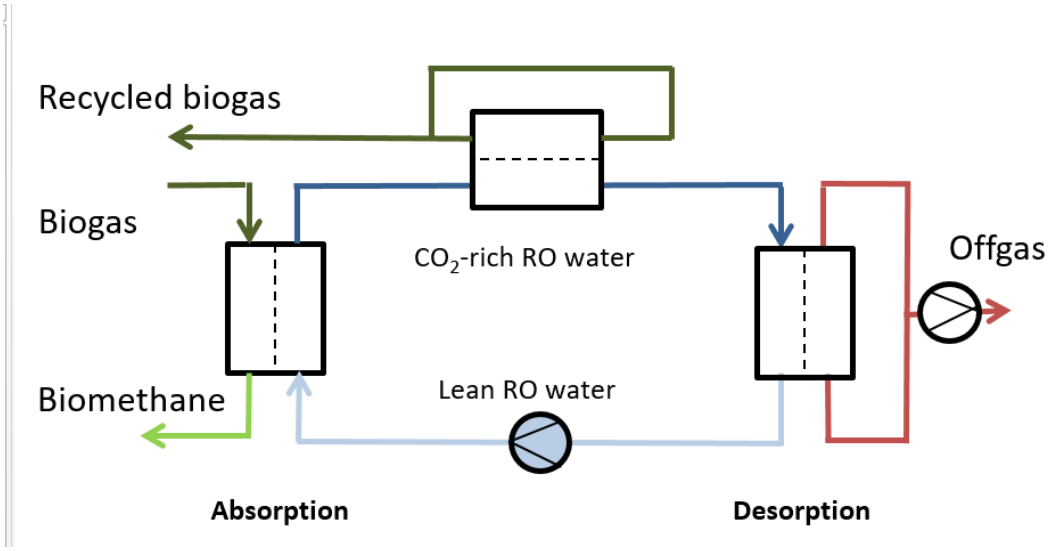

Figure 2 - Simplified flow diagram of the G-PUR process

Technical Data:

Parameter		Value (please fill or tick) If value not available, please give estimate (and indicate with *).	**Comments** (e.g. which condition does the entered value correspond to?)
Current technology	Upgrading capacity of technology at current TRL-level (Nm³ raw gas/h)	0.26	
Data basis for following data list	1.: market ready stage of technology (based on test runs of current techn.) **<u>Please only use 2. or 3. if 1. not at all possible.</u>** 2.: market ready stage of technology (based on estimate) 3.: current level (TRL) of technology	1 ☐ (preferably) 2 ☒ 3 ☐	
Technical efficiency	Methane content in raw gas (%)	60	

	Methane content in product gas (%)	>97	
Capacity	Flow rate (range) /upgrading capacity (Nm^3 raw gas/ h)	100	
	Flow rate biomethane (Nm^3/h)	59	
	Possible range for upscaling	>10	No technical limitation
Data for assessment of economical added value, possible contribution to GHG-reduction and availability	Electricity demand (kWh_{el}/Nm^3 raw gas)	0.22	
	Heat demand (kWh_{th}/Nm^3 raw gas)	0	
	Chemical/additives demand (kg/h or kg/Nm^3 raw gas)	0*	May require temporary addition of KCl to the absorbent
	Demand of other substances (kg/h or kg/Nm^3 raw gas)	0	
	Biomethane slip (range in % of biomethane production)	< 2	
	Delivery pressure at exit of upgrading plant (bar_{abs})	6	
	Full load hours (h/a)	8000*	
	Exhaust gas treatment		Atmospheric discharge
	Usable heat (external) through heat extraction (kWh_{th}/Nm^3 raw gas)	0	Please indicate temperature
	Space requirement (m^2)	< 16	
	Staff requirement (excluding maintenance) (h/a)	156*	
	Specific capital costs (excluding project development, planning, permission and additional building costs) (€/Nm^3 raw gas)	3.000 €/Nm^3 *	
	Maintenance costs (including spare parts such as new membranes, staff) (€/a or €/operating hour)		Unknown

	Production costs (€/Nm³ biomethane)		Unknown
	Expected lifetime of unit (years)		Membranes expected to be replaced every 7-10 years
Flexibility	Start-stop-flexibility	Yes	
	Part-load possibility	☒Yes, 50 % of full capacity* ☐ No	
	Is self-maintenance of technology possible?	☒Yes, 90 % of total maintenance hours per year that can be done by operator himself ☐ No	
	Does the upgrading technology remove also H_2S or is this necessary in a separate unit?	☐Yes, ...% of total H_2S-content of rawgas ☐ No	Unknown
	Necessity for adaptions of other parts of the plant		No
	Advantages/disadvantages of technology		- Cost-competitiveness (manufactured products); - Compactness (higher gas-liquid interfacial area); - Ease of design (membrane technology); - Avoid operational problems of packed columns (flooding and channelling).
	Special application area of technology		CO2/CH4 separation