This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691911

Technology Description (TD) for

Biogas Upgrading Technologies

Contact Information:

TECHNOLOGY/ EQUIPMENT SUPPLIER	*Name of institution:*	Cryo Pur		
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	Date (of filling the TD):	23.11.2017		

Technology Description:

NAME OF TECHNOLOGY	Cryo Pur (biogas to bio-LNG) system
ASSIGNMENT OF TECHNOLOGY	Biogas upgrading and biomethane liquefaction
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)	1 2 3 4 5 6 7 **8 - 9**
What is the core innovation? (Please explain here what is innovative on this technology and which problem does the	Using cryogenic processes, upgrading and liquefaction can be integrated to make the whole transformation from biogas to bio-LNG more efficient and economically available

technology solve.)		from 250 Nm^3/h of biogas.
Vision of the innovation (Please describe here what impact you see for the future)		Improving the efficiency of liquid biomethane production and enabling it for small-medium-large scale biogas projects
What are the R&D needs for your technology? (Are there any barriers or challenges which still need to be overcome?)		First commercial plant in operation end of 2017. Need for more national value chain demonstration projects for (small-scale) biogas to truck fuel.
TECHNOLOGY/EQUIPMENT AVAILABILITY		Commercial.
PATENT RIGHTS		YES
METHOD OF MAKING THE TECHNOLOGY AVAILABLE	*Licence selling*	NO
	Licence granting	Could be considered outside Europe.
POSSIBLE END USERS OF TECHNOLOGY	*Please name end users/ contacts that should be invited to project workshops*	

Description of the technology/equipment:

Cryo Pur has developed an innovative, integrated system for transforming raw biogas into liquid biomethane (bio-LNG) and liquid CO_2. The technology is based on cryogenic upgrading of biogas, i.e. frosting and defrosting of CO_2 between -90°C and -120°C to separate it from methane. CO_2 is recovered as a pure liquid. Pure biomethane is subsequently liquefied. The system includes a pre-treatment (H_2S, water, VOC and siloxane removal).

This enables the efficient production of bio-LNG at 14 barg/-120°C or 1 barg/-160°C. Bio-LNG can be used as a renewable fuel for trucks (in the colder, lower pressure liquid form) or transported for remote injection or combustion when the grid is not available locally (in the warmer, higher pressure form). In addition, Cryo Pur produces liquid CO_2, which is easy to transport for use in greenhouses, transport refrigeration and other industries.

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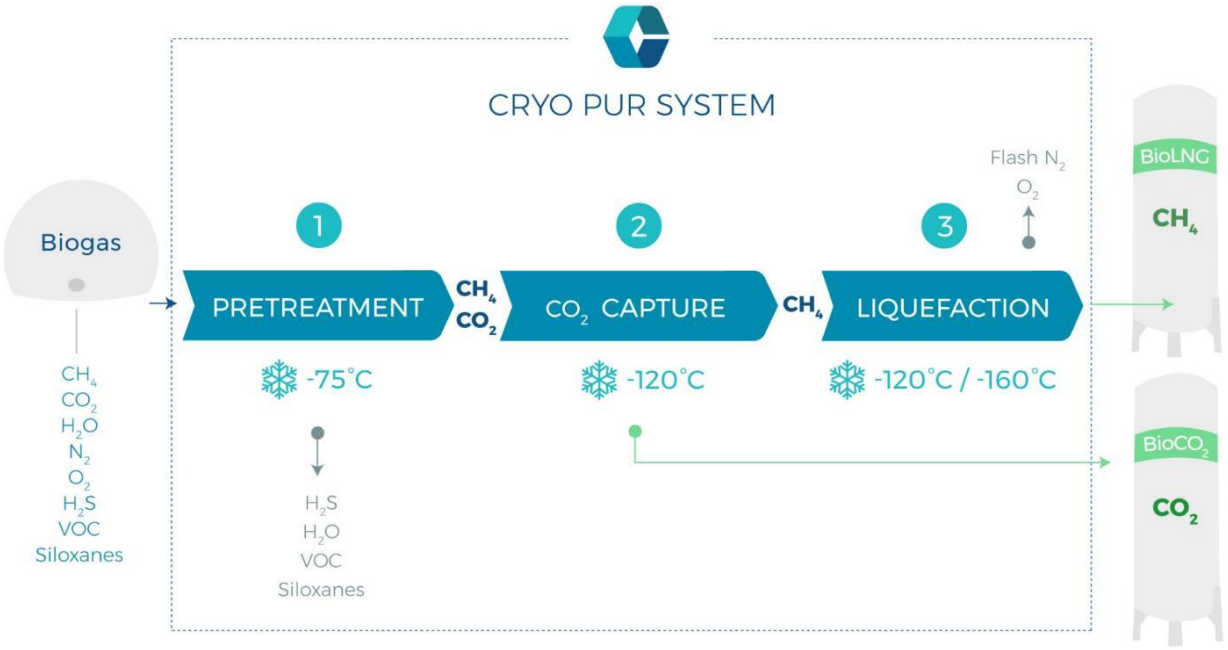

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Technical Data:

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)	300	Capacity of first commercial plant installed
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% +/-10 pp	Adapted to variable CH4 content
	Methane content in product gas (%)	>99,7%	In absence of air gases. Higher for bio-LNG at 1 barg.
Capacity	Flow rate (range) /upgrading capacity (Nm³ raw gas/ h)	150 – 340	
	Flow rate biomethane (Nm³/h)	90 – 204	
	Possible range for upscaling	100 – 2,000 Nm3/h raw gas	Range of units designed
Data for assessment of economical added value, possible contribution to GHG-reduction	Electricity demand (kWh$_{el}$/Nm³ raw gas)	0.6 – 0.7	Depends on pressure/temperature of bio-LNG product
	Heat demand (kWh$_{th}$/Nm³ raw gas)	0	
	Chemical/additives demand (kg/h or kg/Nm³ raw gas)	Activated carbon only	Depends on H_2S content in the raw gas.
	Demand of other substances (kg/h or kg/Nm³ raw gas)	-	

and availability	Biomethane slip (range in % of biomethane production)	0%	No methane slip
	Delivery pressure at exit of upgrading plant (bar $_{abs}$)	14 barg or down to 1 barg	After liquefaction
	Full load hours (h/a)	>8585	>98% availability
	Exhaust gas treatment	Pure liquid CO_2 as by-product (included).	Cryogenic upgrading produces liquid CO_2 that can be sold.
	Usable heat (external) through heat extraction (kWh_{th}/Nm^3 raw gas)	>0.2 by default. Can be significantly increased.	55°C/45°C by default – can be increased depending on heating requirements
	Space requirement (m^2)	300 m^2	
	Staff requirement (excluding maintenance) (h/a)	500	Visual inspection and calibration of analyzers.
	Specific capital costs (excluding project development, planning, permission and additional building costs) (€/Nm³ raw gas)	Please give exact specific cost if possible, if not please specify range. About 6,000 €/Nm3 for a 340 Nm3/h unit ☐ < 4.000 €/Nm³ ☐ 4.000 - 6.000 €/Nm³ ☐ 6.000 € - 8.000 €/Nm³ ☐ > 8.000 €/Nm³	Goes down to < 3,000 €/Nm3 for larger units (> 1,500 Nm3/h raw gas)
	Maintenance costs (including spare parts such as new membranes, staff) (€/a or €/operating hour)	About 100 k€/y full service including availability guarantee	Full service agreement including maintenance, replacement of spare parts, remote monitoring and availability guarantee.
	Production costs (€/Nm³ biomethane)		Depends on electricity price and cost of biogas production
	Expected lifetime of unit (years)	20 years	
Flexibility	Start-stop-flexibility	Cold start-up 1-2h, warm start-up 5h	Linear ramp-up behaviour

	Part-load possibility	☒Yes, 50 % of full capacity ☐ No	Customized unit can run with lower part-load
	Is self-maintenance of technology possible?	☐Yes, ...% of total maintenance hours per year that can be done by operator himself ☐ No	Depends on operator. Requires training.
	Does the upgrading technology remove also H_2S or is this necessary in a separate unit?	Yes ☐Yes, ...% of total H_2S-content of rawgas ☐ No	Activated carbon filters included, economical to remove H_2S up to about 200 ppm/Nm^3
	Necessity for adaptions of other parts of the plant	No	Heat recovery can be included

	Advantages/disadvantages of technology	'- Integrated unit: - No interface between upgrading and liquefaction. - Low power consumption (combined cryogenic upgrading and liquefaction). - No methane slip - Only consumable = activated carbon - Heat recovery for heating the AD - Production of liquid CO_2 as a valuable by-product - Operation flexibility from 50% to 120% of the nominal flow rate - Automated operation - Availability and performance guarantees Disadvantage: 'New technology (though already demonstrated and already commercial).	
	Special application area of technology	Bio-LNG production / liquid CO_2 production for all kind of biogas / landfill gas treatment	