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:

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	Date (of filling the TD):	04.04.2018		

Technology Description:

NAME OF TECHNOLOGY	Biological methanation
ASSIGNMENT OF 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)	7
What is the core innovation? (Please explain here what is innovative on this technology and which problem does the	The proprietary biocatalyst that is used by Electrochaea has been optimised to very high productivity. In combination with the patented bioreactor design and the specific

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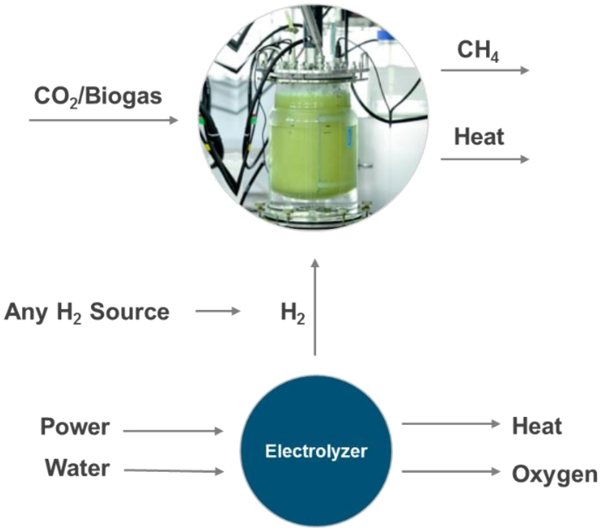
technology solve.)		operational process, we are generating very high volumetric productivities
Vision of the innovation (Please describe here what impact you see for the future)		Electrochaea will provide grid-scale biomethanation units which allow large-scale and long-term energy storage and will use significant amounts of CO_2 to generate Biomethane. This will enable the implementation of renewable energies and help to meet the climate goals in terms of CO_2 reductions
What are the R&D needs for your technology? (Are there any barriers or challenges which still need to be overcome?)		The challenges are not in the technology itself. It is fully scalable and can be implemented immediately. The challenge is the power price in most of the EU countries. There is currently no exemption from fees and taxes and the technology is not valued for providing energy storage or CO_2 emission reduction. In addition, the gas price is low at the moment. Therefore, the power price limits the implementation of the technology into the market.
TECHNOLOGY/EQUIPMENT AVAILABILITY		The technology and the equipment is available
PATENT RIGHTS		YES
METHOD OF MAKING THE TECHNOLOGY AVAILABLE	*Licence selling*	YES
	Licence granting	YES (for research purposes only)
POSSIBLE END USERS OF TECHNOLOGY	*Please name end users/ contacts that should be invited to project workshops*	Grid operators, biogas plant operators, utilities, waste water treatment plant operators

Description of the technology/equipment:

Electrochaea employs a power-to-gas technology based on biological methanation that is unique in the world and was developed by Electrochaea. A proprietary biocatalyst converts low-cost and stranded electricity from renewable energy sources and carbon dioxide into pipeline-grade renewable gas. The core of the system is a selectively evolved microorganism – a methanogenic archaea. The produced biomethane can be stored and directly be injected into the existing natural gas grid. The foundations of the technology were established at the University of Chicago. Electrochaea is successfully operating a grid-scale plant with a power consumption of one megawatt in Denmark since April 2016. Further plants in Switzerland and the USA are under construction. In the medium term, plants with up to a cumulative capacity of one gigawatt are targeted.

Two-step methanation process employed by Electrochaea:



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)	125 Nm³/h of raw gas (if raw gas contains 40% CO_2)	50 Nm³/h CO_2 and 200 Nm³/h of H_2 are required to convert the entire CO_2 content from 125 Nm³/h raw gas, assuming it contains 50 Nm³/h CO_2
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 ☐	Plant commissioned in April 2016 with intermittent daily operation since then. Several 24/7 campaigns carried out.

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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)	18…125 Biogas (40% CO_2)	Range limits determined by the balance of plant not by the reactor. Lower limit given by low flow instability in the H2 mass flow control valve and upper limit given by max Compressor capacity
	Flow rate biomethane (Nm^3/h)	50	The total flow of methane is $125Nm^3/h$, 60% of which was already present in the raw biogas
	Possible range for upscaling	350 Nm^3/h H_2 with Biogas 475 Nm^3/h H_2 with pure CO_2	
Data for assessment of economical added value, possible contribution to GHG-reduction and availability	Electricity demand (kWh_{el}/Nm^3 raw gas)	0.6 kWh_{el}/Nm^3 of BG	Excluding electricity for H2-production
	Heat demand (kWh_{th}/Nm^3 raw gas)	None required during operation, only on cold start-up to bring the reactor to operating temperature	
	Chemical/additives demand (kg/h or kg/Nm^3 raw gas)	Sulphur and nitrogen source required	
	Demand of other substances (kg/h or kg/Nm^3 raw gas)	De-foaming agent can occasionally be needed	
	Biomethane slip (range in % of biomethane production)	<0.5%	
	Delivery pressure at exit of upgrading plant (bar_{abs})	9 bar	
	Full load hours (h/a)		Continuous operation has so far only been tested in dedicated experiments. Further automation currently under development aims at unattended operation targeting >8000 h/y

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	Exhaust gas treatment	H_2S adsorption with an H_2S scavenger; H_2 excess recycling and de-watering with a membrane system	
	Usable heat (external) through heat extraction (kWh_{th}/Nm^3 raw gas)	2.8 kWth per Nm^3 of CO_2 converted	65°C
	Space requirement (m^2)	200 m^2	So far space optimization has not been a premise of design. Large room for space reduction is expected
	Staff requirement (excluding maintenance) (h/a)	Aim at unattended operation	
	Specific capital costs (excluding project development, planning, permission and additional building costs) (€/Nm^3 raw gas/h)	Please give exact specific cost if possible, if not please specify range. ☐ < 4.000 €/Nm^3/h ☐ 4.000 - 6.000 €/Nm^3/h ☒ 6.000 € - 8.000 €/Nm^3/h ☐ > 8.000 €/Nm^3/h	
	Maintenance costs (including spare parts such as new membranes, staff) (€/a or €/operating hour)	30…35k€/a	
	Production costs (€/Nm^3 biomethane)		
	Expected lifetime of unit (years)	>20 years	
Flexibility	Start-stop-flexibility	High	

	Part-load possibility	☒Yes, ...% of full capacity ☐ No	Full rangeability from the reactor perspective. As indicated earlier the flow range limits determined by the balance of plant not by the reactor
	Is self-maintenance of technology possible?	☒Yes, 90 % of total maintenance hours per year that can be done by operator himself ☐ No	Yes most of the maintenance activities (>90%) are passed on to the local operation crew during the training phase after commissioning. Only specific biology related issues might require direct support from Electrochaea
	Does the upgrading technology remove also H_2S or is this necessary in a separate unit?	☒Yes, ...% of total H_2S-content of raw gas ☐ No	Yes, the biological catalyst has an uptake rate of H2S
	Necessity for adaptions of other parts of the plant		Depending on the site
	Advantages/disadvantages of technology	High tolerance to contaminants, self-regenerating catalyst, high flexibility to load changes and very rapid start-up	
	Special application area of technology	Biogas-upgrading	