



## Technology Description (TD) for Biogas Upgrading Technologies

### Contact Information:

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<i>Date (of filling the TD):</i>	2017-09-27			

### Technology Description:

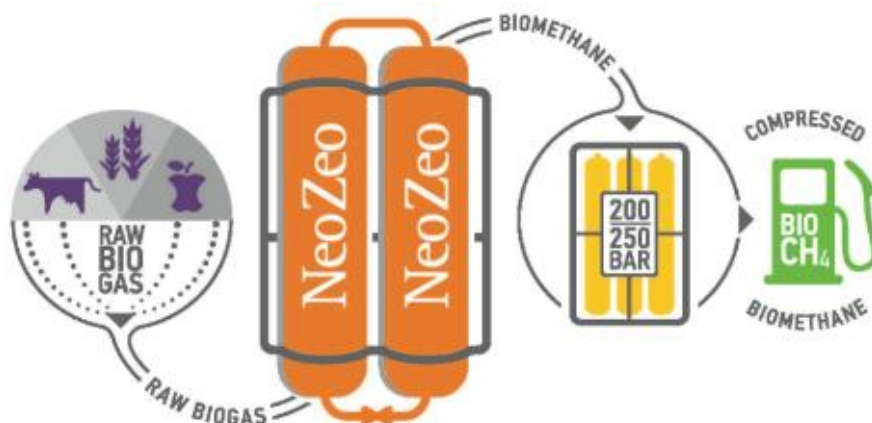
<b>NAME OF TECHNOLOGY</b>	Vacuum Pressure Swing Absorption – VPSA
<b>ASSIGNMENT OF TECHNOLOGY</b>	Biogas Upgrading
<b>TECHNICAL READINESS LEVEL</b>	<p>1 2 3 4 5 6 <b>7</b> 8 9</p>
<p><b>TRL 1</b> - basic principles observed  <b>TRL 2</b> - technology concept formulated  <b>TRL 3</b> - experimental proof of concept  <b>TRL 4</b> - technology validated in lab  <b>TRL 5</b> - technology validated in relevant environment (industrially relevant environment in case of key enabling technologies)  <b>TRL 6</b> - technology demonstrated in relevant environment (industrially relevant environment in case of key enabling technologies)  <b>TRL 7</b> - system prototype demonstration in an operational environment  <b>TRL 8</b> - system completed and qualified  <b>TRL 9</b> - actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)</p>	
<b>What is the core innovation?</b> (Please explain here what is innovative on this technology and which problem does the	NeoZeo's biogas upgrading module is based on vacuum pressure swing absorption (VPSA) technology combined with novel sorbent and specially designed process which result in high



technology solve.)		biomethane purity and low methane slip.
<b>Vision of the innovation</b> (Please describe here what impact you see for the future)		NeoZeo aims globally to make small-scale biogas producers to become renewable vehicle fuel suppliers i.e. wastewater treatment plants, food waste companies and small farms become producers of biomethane.
<b>What are the R&amp;D needs for your technology?</b> (Are there any barriers or challenges which still need to be overcome?)		Operate and demonstrate the NeoZeo's biogas upgrading module in 24/7 continuous process and supply the biomethane to end users.
<b>TECHNOLOGY/EQUIPMENT AVAILABILITY</b>		Available
<b>PATENT RIGHTS</b>		<b>YES/NO</b>
<b>METHOD OF MAKING THE TECHNOLOGY AVAILABLE</b>	<i>Licence selling</i>	<b>YES/NO</b>
	<i>Licence granting</i>	<b>YES/NO</b>
<b>POSSIBLE END USERS OF TECHNOLOGY</b>	<i>Please name end users/ contacts that should be invited to project workshops</i>	Small- and medium scale agricultural enterprises, farms, industrial plants, and municipal wastewater treatment plants, where the production of raw biogas intended for upgrading into biomethane with biogas flow between 10 Nm <sup>3</sup> /h and 200 Nm <sup>3</sup> /h.

### Description of the technology/equipment:

Based on world class inventions in the preparation of durable adsorbent materials, NeoZeo has developed a cost-efficient upgrading solution to tap the enormous potential source of clean biogas fuel: farms and small towns - the biomethane supply of the future!





Raw biogas comprises a mixture of methane ( $\text{CH}_4$ ) and carbon dioxide ( $\text{CO}_2$ ) and small amount of oxygen ( $\text{O}_2$ ), in addition to some minor components such as  $\text{H}_2\text{O}$ ,  $\text{H}_2\text{S}$ , and siloxanes. These components can be removed by NeoZeo's equipment. NeoZeo's complete and integrated Biomethane Production solution includes: preconditioning of raw biogas: e.g. removal of impurities and moisture; desulphurisation; separation of  $\text{CO}_2$ ; and distribution of pure biomethane to gas fuel stations.

NeoZeo biogas upgrading modules are suitable for small- and mid-sized flows of raw biogas produced on farms and in small towns, where raw biogas flow is between 10 and 200  $\text{Nm}^3/\text{hour}$ . Larger biogas flows can be upgraded using NeoZeo' biogas upgrading design on a skid or utilizing more than one module.

NeoZeo biogas purification process relies on unique adsorbent materials in combination with Vacuum Pressure Swing Adsorption (VPSA) technology that are particularly applicable to small-scale raw biogas producers - small farms and agricultural enterprises and small municipal wastewater treatment plants.





### 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?)
<i>Current technology</i>	Upgrading capacity of technology at current TRL-level (Nm <sup>3</sup> raw gas/h)	5 – 200*	*Larger biomethane flows can be generated using NeoZeo' custom biogas upgrading design on a skid or utilizing more than one module.
<i>Data basis for following data list</i>	1.: market ready stage of technology (based on test runs of current techn.)  <b><u>Please only use 2. or 3. if 1. not at all possible.</u></b>  2.: market ready stage of technology (based on estimate) 3.: current level (TRL) of technology	1 <input checked="" type="checkbox"/> (preferably)  2 <input type="checkbox"/>  3 <input type="checkbox"/>	
<i>Technical efficiency</i>	Methane content in raw gas (%)	50 – 65%	NIL
	Methane content in product gas (%)	97 ± 1%	Oxygen and nitrogen concentration <0.3% in the biogas
<i>Capacity</i>	Flow rate (range) /upgrading capacity (Nm <sup>3</sup> raw gas/ h)	10 – 200*	*Larger biogas flows can be upgraded using NeoZeo' custom biogas upgrading design on a skid or utilizing more than one module.



	Flow rate biomethane (Nm <sup>3</sup> /h)	5 – 100*	*Larger biomethane flows can be generated using NeoZeo' custom biogas upgrading design on a skid or utilizing more than one module.
	Possible range for upscaling	200 – 2000 Nm <sup>3</sup> /h	NIL
<i>Data for assessment of economical added value, possible contribution to GHG-reduction and availability</i>	Electricity demand (kWhel/Nm <sup>3</sup> raw gas)	0.28	This is the energy required to upgrade biogas to biomethane.
	Heat demand (kWhth/Nm <sup>3</sup> raw gas)	No Heat Demand	No Heat Demand
	Chemical/additives demand (kg/h or kg/Nm <sup>3</sup> raw gas)	None	None
	Demand of other substances (kg/h or kg/Nm <sup>3</sup> raw gas)	1. 6 kg/Nm <sup>3</sup> of adsorbent material for carbon dioxide removal 2. H <sub>2</sub> S filter material	1. The biogas enters in contact with adsorbent material – which selectively traps CO <sub>2</sub> . The amount of adsorbent needed per module depends on the biogas flow rate as well as the design of the module. A rough estimation is 600 kg of adsorbent for treatment of 100 Nm <sup>3</sup> /h of biogas. The adsorbent is continuously regenerated with guaranteed working life time of 4 years;  2. H <sub>2</sub> S filter material for H <sub>2</sub> S removal. Amount of the filter material depends on H <sub>2</sub> S concentration in biogas and biogas conditions e.g. moisture content and temperature.
	Biomethane slip (range in % of biomethane production)	<1%	NIL



Delivery pressure at exit of upgrading plant (bar <sub>abs</sub> )	>3	NIL
Full load hours (h/a)	8327 hours/year	95% of working time
Exhaust gas treatment	Optional*	*Biomethane in exhaust gas – slip can be burned in catalytic oxidizer
Usable heat (external) through heat extraction (kWh <sub>th</sub> /Nm <sup>3</sup> raw gas)	No external usable heat	No external usable heat
Space requirement (m <sup>2</sup> )	14.76 m <sup>2</sup> or 29.33 m <sup>2</sup>	NeoZeo's Biogas Upgrading Module, depending on the selected capacity range, can fit into a 20' or 40' standard sea container. The characteristic dimensions for a <b>20'</b> standard sea container: Height (excluding venting and cooling) 2,896 mm Width 2,438 mm Length 6,058 mm The characteristic dimensions for a <b>40'</b> standard sea container: Height (excluding venting and cooling) 2,896 mm Width 2,438 mm Length 12,031 mm
Staff requirement (excluding maintenance) (h/a)	No*	Fully automatized system No need for staff requirement Monitoring of module is optional and can be performed by owner of plant – 30 min per day



	Specific capital costs ( <u>excluding</u> project development, planning, permission and additional building costs) (€/Nm <sup>3</sup> raw gas/h)	Please give exact specific cost if possible, if not please specify range.  <input checked="" type="checkbox"/> < 4.000 €/Nm <sup>3</sup> /h <input type="checkbox"/> 4.000 - 6.000 €/Nm <sup>3</sup> <input type="checkbox"/> 6.000 € - 8.000 €/Nm <sup>3</sup> <input type="checkbox"/> > 8.000 €/Nm <sup>3</sup>	
	Maintenance costs (including spare parts such as new membranes, staff) (€/a or €/operating hour)	<a href="#">Request A Quote</a>	NeoZeo Biogas Upgrading Module requires minimal maintenance costs
	Production costs (€/Nm <sup>3</sup> biomethane)	<a href="#">Request A Quote</a>	NeoZeo Biogas Upgrading Module provide low energy consumption
	Expected lifetime of unit (years)	20 years or more*	The pipes and fittings, operational valves, pressure vessels (VPSA and buffer) are made of Stainless Steel. If the module is operated according to our guidelines, and maintained yearly, the module should be operational for 20 years, if not more.
<i>Flexibility</i>	Start-stop-flexibility	Yes	
	Part-load possibility	<input checked="" type="checkbox"/> Yes, > 50 % of full capacity <input type="checkbox"/> No	> 50%
	Is self-maintenance of technology possible?	<input checked="" type="checkbox"/> Yes, > 90% of total maintenance hours per year that can be done by operator himself <input type="checkbox"/> No	> 90%



	Does the upgrading technology remove also H <sub>2</sub> S or is this necessary in a separate unit?	<input checked="" type="checkbox"/> Yes, ...% of total H <sub>2</sub> S-content of rawgas <input type="checkbox"/> No	< 99% (if H <sub>2</sub> S concentration is below 100 ppm)
	Necessity for adaptations of other parts of the plant	No	
	Advantages/disadvantages of technology	Brief list of advantages – see in the comments side.	<ul style="list-style-type: none"> <li>• Enables value-added revenue generation from sale of pure biomethane as vehicle fuel</li> <li>• Generates a higher profit margin compared to selling biogas generated electricity</li> <li>• Low energy consumption and maintenance costs</li> <li>• Water-free and chemical free upgrading process.</li> <li>• 2 hours start-up time.</li> <li>• Mobility and security – all equipment for Biogas Upgrading is placed inside a standard sea container for easy transportation and equipment security.</li> <li>• Short return on investment</li> <li>• No requirement for concrete installations.</li> </ul>





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	Special application area of technology	<ul style="list-style-type: none"><li>• Biomethane</li><li>• As substitute for natural gas</li><li>• Storage of electricity and heat</li><li>• Electricity production for peak demand</li><li>• Production of renewable Hydrogen and graphene</li></ul>	
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