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Technology Description (TD) for

Anaerobic Digestion Technologies

Contact Information:

TECHNOLOGY/ EQUIPMENT SUPPLIER	*Name of institution:*	PRV Planungsbuero Rossow Gesellschaft für Versorgungstechnik mbH		
	Name of contact Person:	Norbert Rossow		
	Street:	Lindenhof 2c		
	Town:	Neubrandenburg	*Zip code:*	17033
	Country:	Germany		
	Phone:	+49 395 7074709		
	e-mail:	biogas@rossow.de		
	www:	www.rossow.de		
	Date (of filling the TD):	26.09.2017		

Technology Description:

NAME OF TECHNOLOGY	High-Performance-Digester (HPD)
ASSIGNMENT OF TECHNOLOGY	Digestion of organic suspensions with low content of volatile solids like cattle and pig slurry
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 technology solve.)		Decoupling of the hydraulic retention time between the liquid and the solid phase. Targeted recirculation and filter layer.
Vision of the innovation (Please describe here what impact you see for the future)		Use for slurry and sugar beet in small scale units. Use for substrates with low dry matter content.
What are the R&D needs for your technology? (Are there any barriers or challenges which still need to be overcome?)		Further tests with different kind of substrates. With adaptation and optimization of the process and operation.
TECHNOLOGY/EQUIPMENT AVAILABILITY		
PATENT RIGHTS		YES
METHOD OF MAKING THE TECHNOLOGY AVAILABLE	*Licence selling*	NO
	Licence granting	YES
POSSIBLE END USERS OF TECHNOLOGY	*Please name end users/ contacts that should be invited to project workshops*	Cattle and pig farmers, Sugar beet farmers Industrial food production

Description of the technology/equipment:

The functional principle of “High-Performance-Digester” (HPD) is patented in EP2314666A1. Main purpose is the digestion of pure pig or cattle slurry under mesophilic conditions. Nevertheless, it is also suitable for other organic suspensions with low concentrations of volatile solids as well as for sugar beet mono digestion.

One of the main problems in producing biogas from organic liquids with low organic content (odm) is the small space-time yield. Therefore, there should be the need of big digester volume to get sufficient biogas yield. However, this is too expensive, also coming along with a big ecological footprint.

Yet it is possible to get a small digester volume by reducing the hydraulic retention time (HRT) of the liquid substrate. Unfortunately, the doubling time of methane forming archaea is in the range between 10 and 12 days. That means

HRT should be at least 12 days under optimal conditions to prevent washout of these microorganisms.

Technical installations within the process, also can prevent washout of archae by keeping the methanogenic microbes in biofilms or filter beds. The patented HPD uses filter beds from organic substrates instead of plastics and internal recirculating of digester medium. Thereby the HRT of liquid is decoupled from the HRT of solids.

Filter bed layers

Additionally to the liquid substrate, one can feed a small amount of fibrous materials like cutted straw. After starting the digestion process during some weeks of succession, layers with different microbial populations and activities evolve. Within the digester medium, controlled pumping processes support this production of layers.

At the highest level the raw fibers with lowest density concentrate. In this region preferably hydrolytic processes proceed, also preventing foam. Beneath this level, smaller particles with higher density and surface exist, originated from semi-digested straw. This is also the layer with high amounts of fermentation acids. The subjacent zone contains the highest biological activity, forming a colonization surface and a reservoir for any kind of microorganism. This layer filters the non-digested solids as well as the slowly growing methanogens, keeping most of them within the process and preventing washout with the liquid phase.

The liquid below this filter bed is the digestate and can be pumped out of the process daily or hourly. Usually it contains the least concentration of organics.

Through decoupling of liquid and solid phase, the High-Performance-Digester is able to reduce the HRT of liquids like pig slurry significantly (to one third).

Stability

The methanogenic process is very stable – despite considerable daily changes in organic content (odm) of slurry. Because of cyclic operation, the whole digestion system acts as a substrate buffer. Amount of biogas production and methane concentration remain nearly constant.

Pre-treatment

It is possible to combine the HPD with the PRV technologies Wave-Box and the Kombi-Hydrolysis.

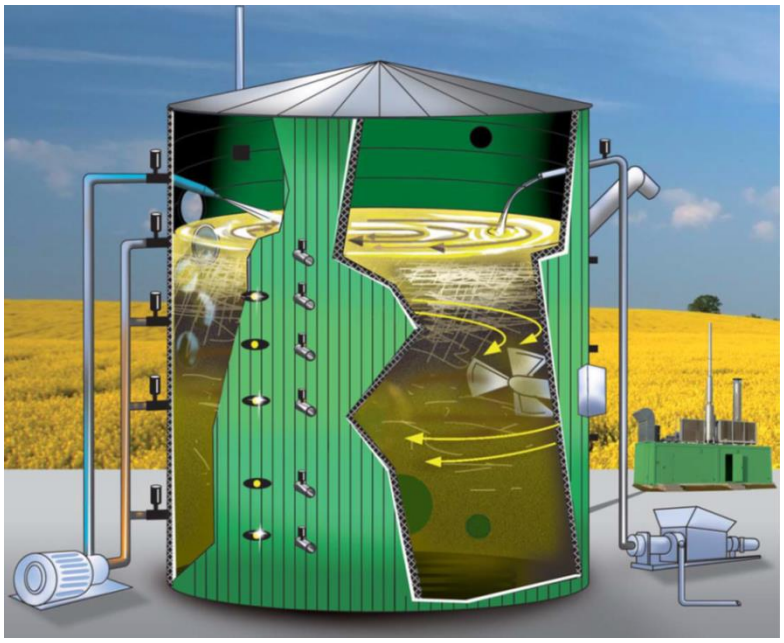

Fig. 1: Principle of High-Efficiency-Digester (Patent EP 2314666 A1)

Operation

Feeding is done by nozzles, directly onto the (straw-) surface, generating a slight rotation of the digester medium. The volume flow is a downstream, supported by biological degradation and different densities. Active mixing by stirring and pumping is reduced to minimum. Only cyclic pumping of liquid from the undermost levels up to the surface again brings semi-fermented substrate and micronutrients back to the active layers.

Fig. 2: Pilot plant (recent type) of High-Performance-Digester at pig farm

Fig. 3: Biogas plant (standard type) of High-Performance-Digester at cattle farm

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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	Biogas production rate of technology at current TRL-level (Nm³/h)	1 Nm³/h	For 45 m³ digester (pig slurry)
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 biogas (%)	60 %	Pig slurry
Capacity	Flow rate and type per substrate (Mg/h)	0.2 – 12 Mg/h	Pig slurry
	Biogas production rate (range) (Nm³/h)	2 – 120 Nm^3/h 16 – 1,000 Nm^3/h	Pig slurry Sugar beets
	Possible range for upscaling	100 – 1000 Nm³/h	4,000 m³ digester
Data for assessment of economical added value, possible contribution to GHG-reduction and availability	Fermenter and biogas process technology (e.g. continuously stirred reactor, plug flow digester, box or garage type)	Fluidized Bed Bioreactor (FBB) with organic based layers	For example: straw layers serve as filter bed for preventing washout of archaea
	Electricity demand (kWhel/Nm³ biogas)	0.025 kWh/Nm^3	e.g. for 500 kW_{el} cattle slurry
	Heat demand (kWhth/Nm³ biogas)	10 - 40 kWh_{th}/Mg substrate	Depending on feedstock and digester dimensions
	Chemical/additives demand (kg/h or kg/Nm³ biogas)	Not to determine	Desulphurization with iron compounds, depending on sulphur content
	Demand of other substances (kg/h or kg/Nm³ biogas)	0	

	Temperature in fermenter (°C)	40°C 55°C	Slurry mesophilic Sugar beets thermophilic
	Pressure of biogas at exit of fermenter (bar $_{abs}$)	0 - 5 mbar	Depending on technical equipment
	m³ fermenter volume used	50 - 3,000 m³	Flexible adjustable
	Full load hours (h/a)	8760 h/a	
	Hydraulic retention time (days)	8 - 15 days	HRT for the liquids, through filter function solids remain longer in process
	Max. dry matter content (%)	10 %	HPD is designed for low dm substrates
	Organic loading rate (kg VS/m³d)	2-12 kg VS/m³d	Low value with pure pig slurry high value with sugar beets,
	Space requirement (m^2)	Variable	e.g. 150 m^2 for 1,000 m^3 HPD
	Staff requirement (excluding maintenance) (h/a)	0	Only pumping processes
	Specific capital costs (excluding project development, planning, permission and additional building costs) (€/Nm³/h)	Please give exact specific cost if possible, if not please specify range. ☒ < 5.000 €/Nm³/h ☐ 5.000 - 10.000 €/Nm³/h ☐ 10.000 € - 15.000 €/Nm³/h ☐ > 15.000 €/Nm³/h	For 75 kWel biogas plant
	Maintenance costs (including spare parts, staff) (€/a or €/operating hour)	< 1,000 €/a	
	Production costs (€/Nm³ biogas)		Depending on feedstock and digester dimensions
	Expected lifetime of unit (years)	> 20 - 30 years	
Flexibility	Types of substrate (solid and liquid)		
	Start-stop-flexibility	No	

	Part-load possibility	☒Yes, 50 % of full capacity ☐ No	
	Is self-maintenance of technology possible?	☐Yes, 80 % of total maintenance hours per year that can be done by operator himself ☐ No	
	Necessity for adaptions of other parts of the plant	No	
	Advantages/disadvantages of technology	<u>Advantages</u>: 24h/7d operating, Low operating costs, Low wear and tear, Adjustable to different amounts, No feeding device necessary <u>Disadvantages</u>: High tanks (8 m min. necessary)	
	Special application area of technology	Pig slurry, cattle slurry, sugar beets, liquid residues from food production	