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

Anaerobic Digestion Technologies

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	Date (of filling the TD):	28.09.2017		

Technology Description:

NAME OF TECHNOLOGY	
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)	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	The new digester works completely without agitation units (no energy consumption) and interfering fractions can be separated during

technology solve.)		ongoing operation. The new digester is completely prefabricated in the factory, transported ready for operation, set up and connected at the site. Due to a special design and the plug flow technology, very high space loads can be used and the discharge of fresh material is prevented.
Vision of the innovation		Biogas plants can be installed locally at the producer. The recycling of organic residues and energy supplies can be organized decentrally.
What are the R&D needs for your technology?		preparation and optimization of digester production
TECHNOLOGY/EQUIPMENT AVAILABILITY		
PATENT RIGHTS		NO
METHOD OF MAKING THE TECHNOLOGY AVAILABLE	*Licence selling*	NO
	Licence granting	NO
POSSIBLE END USERS OF TECHNOLOGY	*Please name end users/ contacts that should be invited to project workshops*	Farmers, SME with biological degradable pumpable waste

Description of the technology/equipment: (Pls. describe the technology. You may include pictures or graphics.)

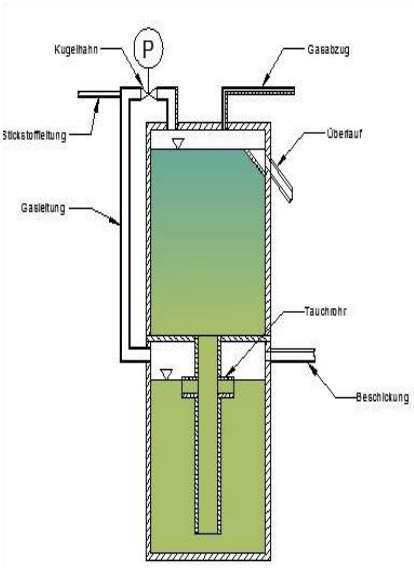
A hydraulically-mixed high organic loading plug-flow Digester (HPF) in combination with a digestate separation system was developed to ferment biomass. The boundary conditions require a low-cost silo-type digester built from steel, which is easily transportable to the site. A scaling of the small digester on plant sizes of less than 100 kW installed electrical capacity was made. On the basis of the characteristic geometries of conventional digesters, parameters were derived and transferred to the new digester type.

Tests were conducted on a semi-technical scale of 400-l-digerster.

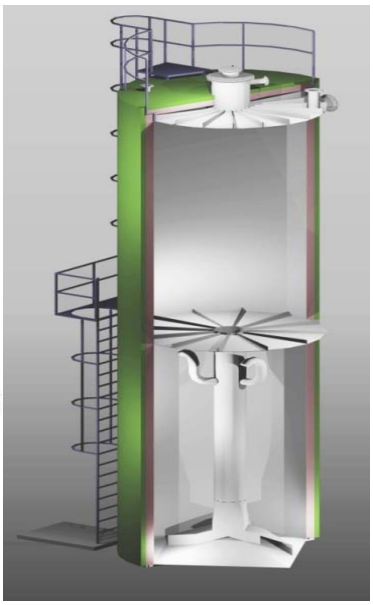
To illustrate the effectiveness of the hydraulic mixing, the method was compared and ranked in terms of energy use and mixing result with the conventional mixing types of biogas digesters. Based on existing hydraulically-mixed digester in reinforced concrete, the scaling of the small digester on plant sizes of less than 100 kW installed electrical capacity was made. These'll

formed characteristics of the geometries of conventional digester and transferred to the new digester type.

There has arisen an innovative design of a digester. This digester consists of two identical vein set cylinders, which are connected by mixing tubes. The digester requires no electro-mechanical agitators. The mixing is generated by the pressure of the produced biogas. It is a plug flow digester which effectively prevents the excess of unfermented substrate. Ground sludge and scum can without interruptions permanently discharged during operation.



digester process design



rendering of digester design

laboratory system

The digester is to feed via the lower chamber. The lower chamber is gas-tight, so can biogas accumulate and compress under the false floor. This substrate is displaced from the lower chamber and pressed through the dip tube into the upper chamber. Due to openings in the immersion tube, the lifting height is limited by design, so that produced biogas continues flow to the unpressurized surface of the upper cylinder. This in turn ensures a thorough mixing of the upper fermentation chamber. The gas spaces of the two chambers are connected to a gas line. The valve located therein is opened and the pressure compensation between the gas chambers takes place. With the biogas balancing flows also the raised substrate via the dip tube from the upper to the lower digester. It flows on the one hand via the openings to limit the stroke in the upper region of the fermenting chamber bottom, on the other hand it flows through the dip tube and is brought via the mixing blades at the bottom of the tube back into the lower fermenting chamber. The content of the chamber is set into a rotating movement, whereby a mixing can be achieved.

The advantage of this concept is that higher lifting heights can be achieved by the small diameter-height ratio. This allows the mixing intensity increased.

A disadvantage is the impact of the resulting hydrostatic pressures, because these must be compensated by a correspondingly higher digester wall thickness.

In order to verify the functioning of this new type of reactor and to win other characteristic values for the design of small digester, was a laboratory system designed and manufactured consisting of feeding system, digester and peripheral elements in semi-industrial scale.
With the laboratory system, the function and the dimensions of the new HPF-digester could be confirmed.

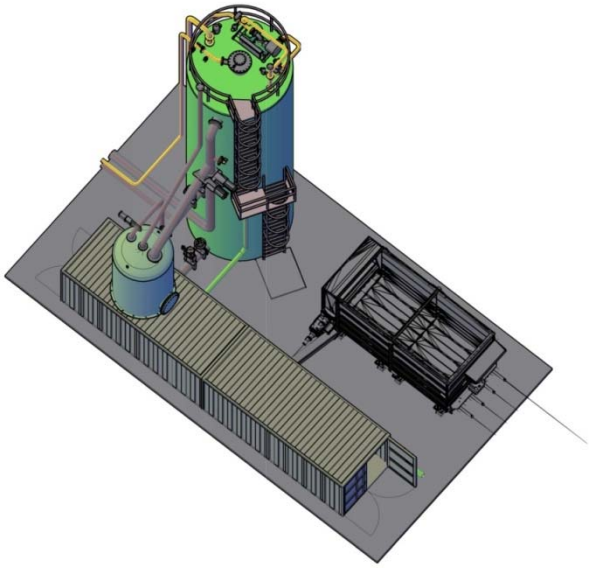
One possible application is the use as compact biogas digester for the privileged in Germany 75 kW biogas plants.
For a standard design with at app. 80% manure + renewable primary products the digester volume can be very compact with app. 150-200 m³.
The investment costs are identical to conventional plant designs. In this case, however, a number of
technical and economic advantages of this digesters possible.
These consist in:
- The very compact design (D ~5 m, H ~11 m)
- The plug flow and therefore no discharge of fresh material (better substrate efficiency)
- The high organic loads about 5 kgOTS / m³d
- Unneeded mechanical mixer (no cost of power consumption and maintenance)
- No operating risks due to ground sludge and scum formation

Thus, an operating cost savings of approximately 12,000 € / a over conventional systems is possible, which represents about 10% of annual revenue from electricity production.

The construction of the digester is factory based on low manufacturing cost, so that expensive concrete or steel construction an site can be minimized.

Combination with effluent und sludge separation system:
The by ventury developed solution allows in contrast to the conventional systems of digesters a permanent and on-demand extraction of the impurities in regular operation
The in the new digester system integrated radial flow process can be permanent prevented a sedimentation. With the help of one or more discharge nozzle in this area sediment mass can be discharged without costly and interference-prone handling equipment. The pressure from existing digester level is used as driving energy for discharging. The discharge process is fully automated by a pneumatically actuated slide valves and transmit the effluent in a collection system.
The second impurity group is scum. These swims in the process due to density differences supported by the flotation of the ascending biogas to and accumulate on the surface of the filling.
A discharge nozzle in the zone of floating layer formation allows analog ground sludge removal system a cyclic discharge of scum. The sludge be (5-10 m³) conveyed in a closed tank, which is

right next to the digester. It has a pressure proof vent, which is higher than the digester level, so that a clearly limited amount of sludge is discharged and leakage of the entire digester contents is reliably prevented.
The collection tank may be used as a gravity separator. After filling with sludge the individual fractions can be discharged and discharged separately after a settling time. Scum can after crushing again be feeded to the fermentation in order to compensate the encountered in these fiber fractions longer processing times.



3d-modelling of a exemplary digester plant with periphery components

The result is a very compact system concept that the construction of a small biogas plant in accordance with the project goals allowed.
In addition to the multi-functional and efficient versions of Digester- and sludge separation technology, this system is characterized by a very costs saving implementation. Much of the components can be prefabricated in the factory and partially functional assembled already in the container, so that can be limited on-site assembly to a minimum.
For variations in the digester size or execution with several digesters the periphery is performed almost identical and should be supplemented by additional connections in the pipe system.

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Technical Data (for 100kW electr. power):

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 (Nm^3/h)	20 Nm^3/h per digester	
Data basis for following data list	1.: market ready stage of technology (based on test runs of current techn.) 2.: market ready stage of technology (based on estimate) 3.: current level (TRL) of technology	1	
Technical efficiency	Methane content in biogas (%)	~58	Digestate of another biogas plant
Capacity	Flow rate and type per substrate (Mg/h)	0,75	20 litre/d tested on a 400-litre-reactor
	Biogas production rate (range) (Nm^3/h)	~50	
	Possible range for upscaling	modul multiplication	
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)		Plug flow
	Electricity demand (kWh_{el}/Nm^3 biogas)	only for control system	
	Heat demand (kWh_{th}/Nm^3 biogas)	0,2	
	Chemical/additives demand (kg/h or kg/Nm^3 biogas)	no	
	Demand of other substances (kg/h or kg/Nm^3 biogas)	no	
	Temperature in fermenter (°C)	~40	
	Pressure of biogas at exit of fermenter (bar_{abs})	0,005-0,6 (alternating)	pressureless, pressure peak during mixing

	m³ fermenter volume used	170	
	Full load hours (h/a)	8760	
	Hydraulic retention time (days)	flexible	
	Max. dry matter content (%)	Up to 18	
	Organic loading rate (kg VS/m³d)	~10 kgVS / (m³d)	
	Space requirement (m^2)	25	
	Staff requirement (excluding maintenance) (h/a)	0	
	Specific capital costs (excluding project development, planning, permission and additional building costs) (€/Nm³/h)	the specific cost for digester without all other parts of plant: app. 500 €/m³ digester volume, 9.000 €/Nm³/h	
	Maintenance costs (including spare parts, staff) (€/a or €/operating hour)	3.000	
	Production costs (€/Nm³ biogas)	0	
	Expected lifetime of unit (years)	20	
Flexibility	Types of substrate (solid and liquid)	pumpable	
	Start-stop-flexibility	Yes, an interruption is possible at any time. But the biological process must be preserved. (Cyclic charging, heating, gas discharge)	
	Part-load possibility	Yes, app. 50% of full capacity	

	Is self-maintenance of technology possible?	Yes, 100% of total maintenance hours per year that can be done by operator himself	
	Necessity for adaptions of other parts of the plant	No	
	Advantages/disadvantages of technology		The very compact design (D 4-5 m, H ~11 m) - The plug flow and therefore no discharge of fresh material (better substrate efficiency) - The high organic loads about 10 kgVS / (m³d) - No mechanical mixing (no cost of power consumption and maintenance) - No operating risks due to sedimentation and scum layer formation.
	Special application area of technology		For small sites

Data Usage:

I agree that the above data can be published on the "Biomethane Map" www.biomethane-map.eu and to the further use for other possible scientific purposes.

Signature: