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):	08.03.2017		

Technology Description:

NAME OF TECHNOLOGY	Methane production in 4 section module anaerobic digester
ASSIGNMENT OF TECHNOLOGY	Efficient methane production from biomass of small farms too
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	The innovation is obtained by separating the different anaerobic fermentation

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explain here what is innovative on this technology and which problem does the technology solve.)		microorganisms and creating a better living environment for them.
Vision of the innovation (Please describe here what impact you see for the future)		Such digester can be used as module for small biogas plants
What are the R&D needs for your technology? (Are there any barriers or challenges which still need to be overcome?)		It is need to build digester from plastic and use in practice
TECHNOLOGY/EQUIPMENT AVAILABILITY		yes
PATENT RIGHTS		YES
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 biologically degradable waste

Description of the technology/equipment:

The invention relates to a biogas production plant. The invention is to increase production and improving the quality of higher-biohydrogen and biomethane production. The aim is achieved by separating the different anaerobic fermentation microorganisms and creating a better living environment for them. In practice, this is realized in creating a bioreactor four sections, whose dimensions are appropriate for each section, mostly living in micro-organisms (MO) growth rate. Traditional production of biogas digester is full of confusion bioreactor, where a diverse groupof MO are mixed. It is an optimal operating environment and the conditions are very different. Thus, for example CH_4 producing strict anaerobes die in the presence of O_2, but is often mixed into the area where O_2 is still. Acid forming MO operate under acidic conditions, but CH_4–producing optimally 7.0 - 7.4. In this bioreactor can also provide a high conversionof biomass and that the biomass stays in the required time. Often in completely fermented biomass are removed from the bioreactor. In order to prevent large gas losses, manyc ompanies continue to digestion in 2 bioreactor - postdigester.   This would significantly raise the cost of plant construction. Module bioreactor difference from the traditional is that its setup so that the four main groups of MO is separated into four sections, which are setup on the basis of the different MO life cycle and reproduction speed. For each group is created optimal conditions. CH_4 production section further being installed device for MO immobilization to make the more they stay into the bioreactor and would not be eliminated along with the digestate. The first two sections of the biochemical processes are produced H_2. Catalysing

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reactions that benefit can be greatly increased. CH_4 yield will increases significantly, because the MO to create optimal conditions. processes happen faster, bioconversion deeper and it will make a significant economic effect.

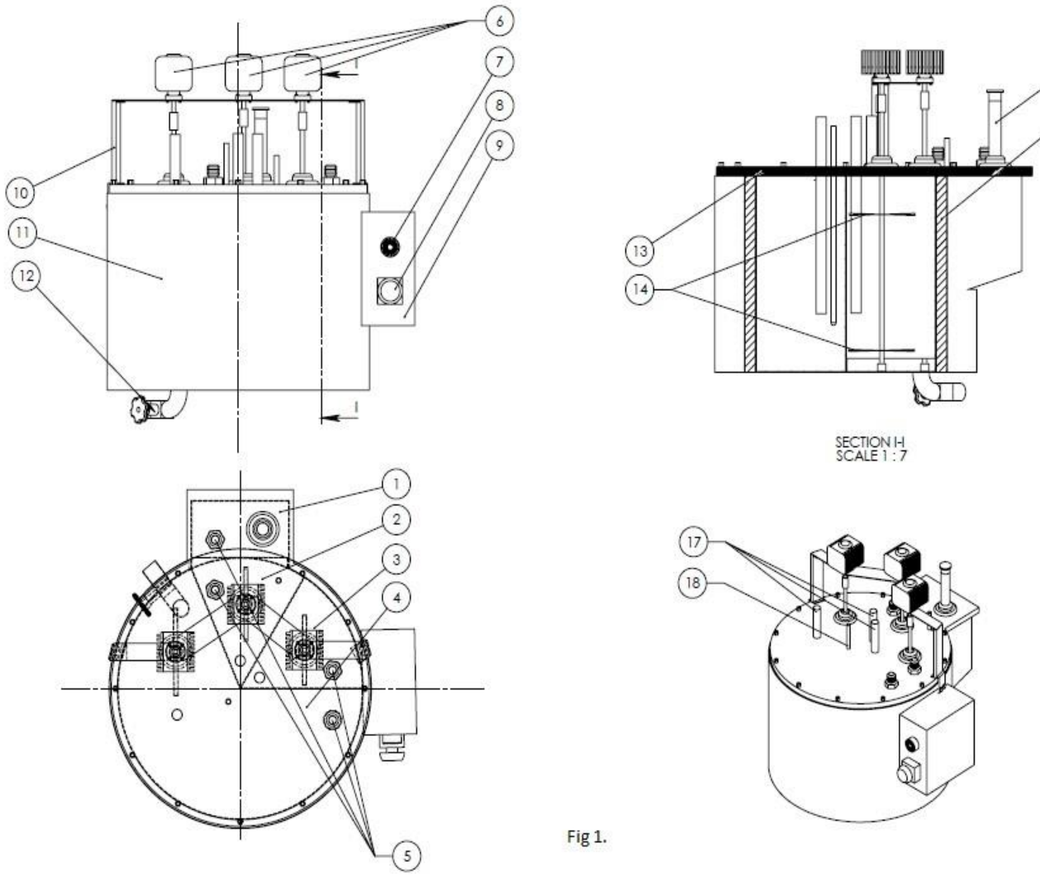

Fig 1.

The device Biohydrogen energy and biomethane produced from organic substances made up of the digester tank 19 with cladding 11, which is divided into four sections (1,2,3,4). The tank is sealedlid 13. It is equipped with a temperature system 20 and covered with a thermal insulation 16. The raw material (biomass) are loaded through a pipe 15 in the first section and the second section mixed with the biomass. These sections leading to hydrolysis and acid formation. The main gas emitted CO_2, O_2, N_2, H_2. The second section connected to the third section and there occurs the formation of acids, in particular acetic acid formation. Filling up fresh biomass dose of the same amount of flow into the fourth section where the acetic acid used for CH_4-producing bacteria. Since the operation is slower then more space and environment them optimal. Each section has a pH sensors and inputs 17, and 18 ° (temperature sensor)- input and the ability to pick up the substrate samples for analysis. Of each section of the gas outlet 5. Each section has a mixer (14 blades, drive 6, the drive mount 10). Mixer provides fresh and current mixing of the substrate. Stirring and temperature maintained at the automatic mode with automatic devices stand 9 assistance, but it can also be operated manually with the device 8. The digestate is eliminated from the 4 sections automatically when packed into a new biomass through outlet 12. The temperature mode can be sett of a device 7.

Digester advantages:

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1.Digester difference from the traditional is that the main microbial groups are partially enclosed and have a life according to the circumstances. For example the fourth section, where most strictly anaerobic methanogenic is completely off the substrate oxygen ingress, but the traditional reactor after each fresh biomass portions filling takes oxygen into contact with these microorganisms and then they die.

2. In conventional reactor cannot be excluded that some of the little separated biomass out of it be fore the scheduled time and as a result, gas is not obtained. Proposed digester difference from the traditional is that the fresh biomass to pass sequentially through all the sections, where it is processed and microorganisms bioconversion ratio is higher and more gas is produced.

3. If the biomass is used with great a difficult biodegradable substances, then it is used in addition to enzymes process optimization. Similarly, the process of optimizing the use of micronutrient supplements. They must be accompanied by a traditional bioreactor biomass before filling the reactor, but the reactor biomass filling and immediately mix additives distributed in a large room, the effect decreases.
Digester different from traditional options are entering enzymes or other catalysts process into the desired section and trace directly to those belonging to the group, which they are required. This gives these substances economy and the ability to quickly achieve optimal process.

4. sections module type bioreactor design is implemented in vertical (Fig.1) and horizontal (Fig.2) performance. Bioreactors used for laboratory research.

Fig.2

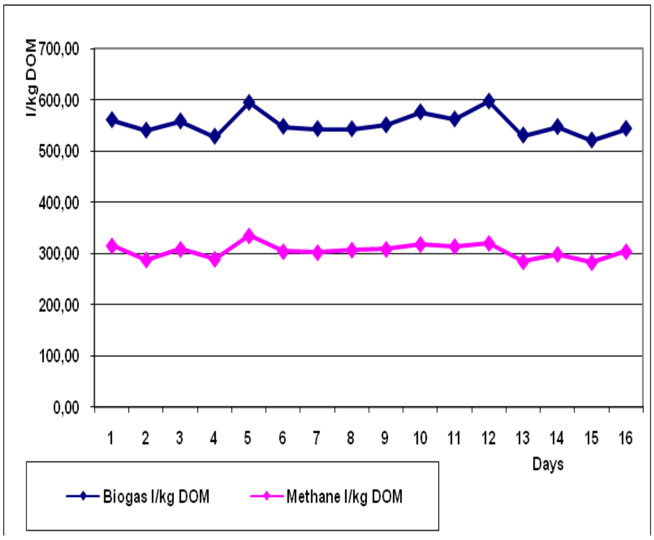

Fig. 3

The results of convincing advantages of this technology. So, fo rexample horizontal bioreactor (Fig.2) with OLR 5,6-6,5 kg / m^3 filled whey, sludge and corn silage, average gained 304 l / kg_{dom} methane (Fig.3) or 2,4L/Lday biogas and 1,54 L/Lday methane. HRT was 16 days at 38°C average temperature. Drawings for 100 m^3 horizontal module type bioreactor is ready for the manufacture of steel. Now being prepared drawings for the manufacture of plastics, it has an agreement with the manufacturer.

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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 (Nm^3/h)	250-500 Nm^3/day	According to working temperature
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 (%)	50-70%	According to raw biomass (cows, pigs, poultry manure, silages, etc. Organic wastes)
Capacity	Flow rate and type per substrate (Mg/h)	8-15Mg/day	According to working temperature
	Biogas production rate (range) (Nm^3/h)	250-500 Nm^3/day	According to working temperature
	Possible range for upscaling	yes	According to raw material volume is possible to use 1,2,3 ..n digesters
Data for assessment of economical added value, possible contribution to GHG-reduction and	Fermenter and biogas process technology (e.g. continuously stirred reactor, plug flow digester, box or garage type)		Continuously stirred reactor
	Electricity demand (kWh_{el}/Nm^3 biogas)	0,02	
	Heat demand (kWh_{th}/Nm^3 biogas)	0,23	
	Chemical/additives demand (kg/h or kg/Nm^3 biogas)	Not need	Desirable micronutrients, if raw materials has deficit of them

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availability	Demand of other substances (kg/h or kg/Nm³ biogas)	Not need	Desirable biocatalyst
	Temperature in fermenter (°C)	38-54	It is possible to use mesophilic or thermophilic regime
	Pressure of biogas at exit of fermenter (bar $_{abs}$)	300 mmH_20	
	m³ fermenter volume used	80	20m³space for gas
	Full working hours (h/a)	8500	
	Hydraulic retention time (days)	5-16	According to temperature and raw material used
	Max. dry matter content (%)	10	DM in digester
	Organic loading rate (kg VS/m³d)	3-6	According to biomass
	Space requirement (m²)	40	
	Staff requirement (excluding maintenance) (h/a)	8500/1460	If biogas plant is big , desirable 1 operator presence, if small then 4h/day
	Specific capital costs (excluding project development, planning, permission and additional building costs) (€/Nm³)	Please give exact specific cost if possible, if not please specify range. ☒**< 5.000 €/Nm³** ☐ 5.000 - 10.000 €/Nm³ ☐ 10.000 € - 15.000 €/Nm³ ☐> 15.000 €/Nm³	<5000 euro/Nm3
	Maintenance costs (including spare parts, staff) (€/a or €/operating hour)	nd	Costs can be calculated when plant design
	Production costs (€/Nm³ biogas)	nd	Costs can be calculated when production data are known
	Expected lifetime of unit (years)	20	

Flexibility	Types of substrate (solid and liquid)	both	Solid substrate must be chopped
	Start-stop-flexibility	Possible, but long starting period	Normally working without stopping
	Part-load possibility	☐Yes, ...% of full capacity ☒ No	Part load is possible but with loss of gas yield
	Is self-maintenance of technology possible?	☒ Yes, 100% of total maintenance hours per year that can be done by operator himself ☐ No	
	Necessity for adaptions of other parts of the plant		It is possible to use biogas for electricity and heat producing or for gas upgrading for gas grid or transport
	Advantages/disadvantages of technology		See upper
	Special application area of technology		For farmers or SME, which have biodegradable waste