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

## Contact Information:

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|---|---|---|---|---|
| **TECHNOLOGY/ EQUIPMENT SUPPLIER** | *Name of institution:* | Czestochowa University of Technology<br>INSTITUTE OF THERMAL MACHINERY | | |
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| | *Date (of filling the TD):* | 07.03.2017, update 8 09 2017 | | |

## Technology Description:

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|---|---|
| **NAME OF TECHNOLOGY** | Mico-biogas plant |
| **ASSIGNMENT OF TECHNOLOGY** | Reactor for mico-biogas plant |
| **TECHNICAL READINESS LEVEL**<br><br>**TRL 1** - basic principles observed<br>**TRL 2** - technology concept formulated<br>**TRL 3** - experimental proof of concept<br>**TRL 4** - technology validated in lab<br>**TRL 5** - technology validated in relevant environment (industrially relevant environment in case of key enabling technologies)<br>**TRL 6** - technology demonstrated in relevant environment (industrially relevant environment in case of key enabling technologies)<br>**TRL 7** - system prototype demonstration in an operational environment<br>**TRL 8** - system completed and qualified<br>**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 |

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| **What is the core innovation?** (Please explain here what is innovative on this technology and which problem does the technology solve.) | | It is very useful for fermentation of lignocellulosic biomass.<br>Biogas discharge is integrated with the pressure in the fermentation reactors. |
| **Vision of the innovation**<br>(Please describe here what impact you see for the future) | | Competitive for small installations where biogas is use for heat. |
| **What are the R&D needs for your technology?**<br>**(Are there any barriers or challenges which still need to be overcome?)** | | High operating costs which should be reduced. |
| **TECHNOLOGY/EQUIPMENT AVAILABILITY** | | |
| **PATENT RIGHTS** | | ~~YES~~/NO |
| **METHOD OF MAKING THE TECHNOLOGY AVAILABLE** | *Licence selling* | ~~YES~~/NO |
| | *Licence granting* | ~~YES~~/NO |
| **POSSIBLE END USERS OF TECHNOLOGY** | *Please name end users/ contacts that should be invited to project workshops* | Technology for micro and small biogas plant. |

## Description of the technology/equipment:

Anaerobic digester is designed as the circulation chamber with a central baffle. The feedstock and anaerobic sludge are stirred *by* a submersible mixer. As the digester works in a batch-mode, the fresh feedstock feeding enforces the outflow of the fermented biomass.

It is planned to operate one-step anaerobic digester without separation of the hydrolysis and methanogenic phases. After the start-up period, the reactor will attain a *steady-state with* the equilibrium between individual groups of microorganisms involved in the digestion of organic matter.

Anaerobic digester is heated by water running in closed circuit between cogeneration heat exchanger and coils placed around the circumference inside the digester. The temperature in the reaction chamber is maintained at 35$^{o}$C.

The digester is covered by a gable roof with biogas output. The tightness of the digester near the feeding chamber is provided by a transverse baffle with its lower edge located below the liquid level. A water valve is used to collect biogas that is subsequently purified to remove moisture and to desulfurize. Then, biogas is introduced to the cogeneration system. Biogas is collected in the head-space of the reactor chamber. Thus, the cogeneration unit must correspond to the production of biogas. In case of cogenerator failure, the excess of biogas will be released into the atmosphere by the water valve. In the absence of biogas, the control equipment switches the cogeneration system to standby mode until the amount of biogas rises to allow a stable engine operation (0,05 bar).

The digestate leaves the digester by gravity flow through an effluent weir to the storage tank. The digestate can be directly applied as fertilizer and soil conditioner for agricultural applications or separated and additionally pretreated to discharge of the liquid fraction into the municipal sewerage system.

The anaerobic digester is designed as a steel rectangular container with a reaction chamber of 50 m3 inside. The walls of the container are made of steel and covered by water proof coatings inside and jacketed by mineral wool (optionally styrofoam) insulation with a thickness of 100mm outside. The digester has a durable, rigid cover with flame and overpressure protection. The feedstock inside the reaction chamber is stirred by a submersible mixer. Additionally, the tank should be equipped with a sludge discharge knife gate valve. The reactor has an openable lid to allow the introduction of fresh feedstock located on the shorter side of the tank.

<u>Design of anaerobic digester:</u>

- external lenght of the digester
- internal lenght of the digester
- external width of the digester
- internal width of the digester
- total height
- internal height
    - height of the liquid volume
    - height of the chamber head-space
- internal volume of the digester
    - volume of the liquid phase
    - volume of the head-space

<u>Construction</u>

- steel chamber
- steel for the base
- steel cover with the hatch inspection
- mineral wool (optionally styrofoam) insulation
- steel trapezoidal corrugated sheets for the outer jacket

<u>Heating:</u>

heating source – cogeneration system based on the IC engine

- method of heating – in-floor heating system filled with water to transfer heat from the heat exchanger

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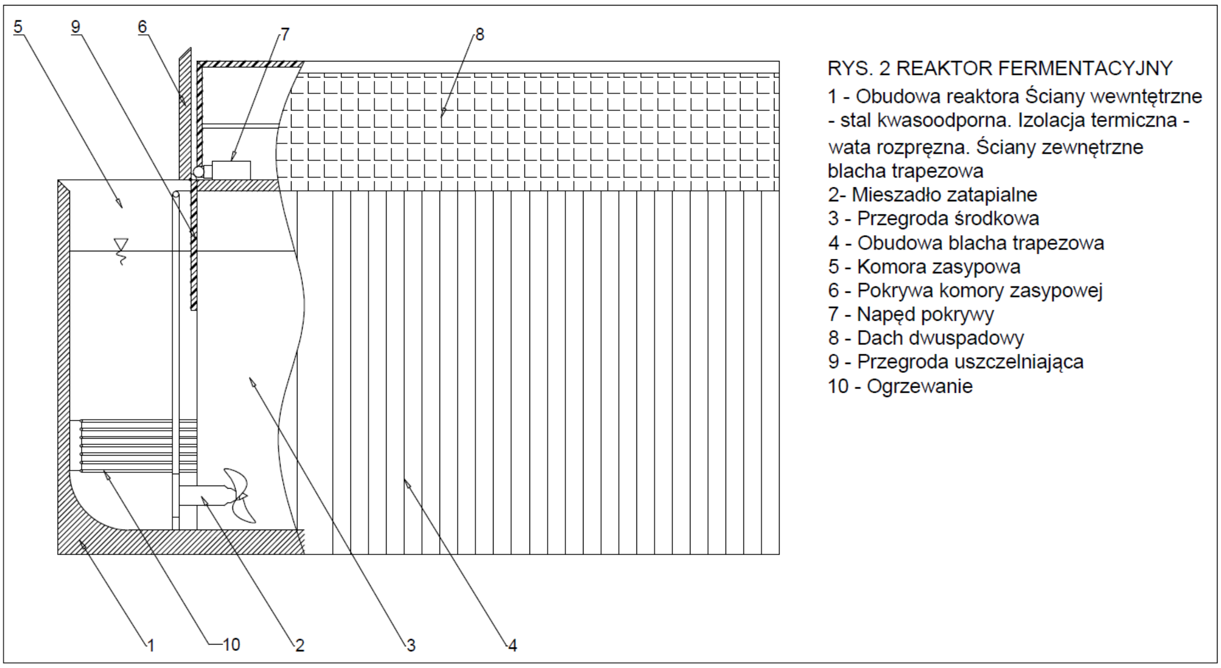
- in-floor heating system consists of pipes fixed to the floor surface inside the reaction chamber with clearance of 150 mm between the pipes, the heat exchanger inside the digester consists of seven coils (Ø 20 mm) with surface area approx. 131m2
- temperature inside the reaction chamber 35oC - 40 oC
- tank temperature control device managing a circulation pump transferring the heating medium from the buffer reservoir of the cogeneration system

The construction of the anaerobic digester was developed within the project entitled .: "Disposal of the digestate from the biogas plant for the electricity production" No. 210698 realized within the framework of the 2nd Programme for Applied Research financed by the National Centre for Research and Development




Anaerobic digester

1 – reactor covering and internal walls made of stainless steel with wool insulation, exterior walls made of steel trapezoidal corrugated sheets, 2 - submersible mixer, 3 – central baffle, 4 - outer jacket made of steel trapezoidal corrugated sheets, 5 – feeding chamber, 6 – cover of the feeding chamber, 7 – cover drive, 8 – gable roof, 9 – seal baffle, 10 – heating system

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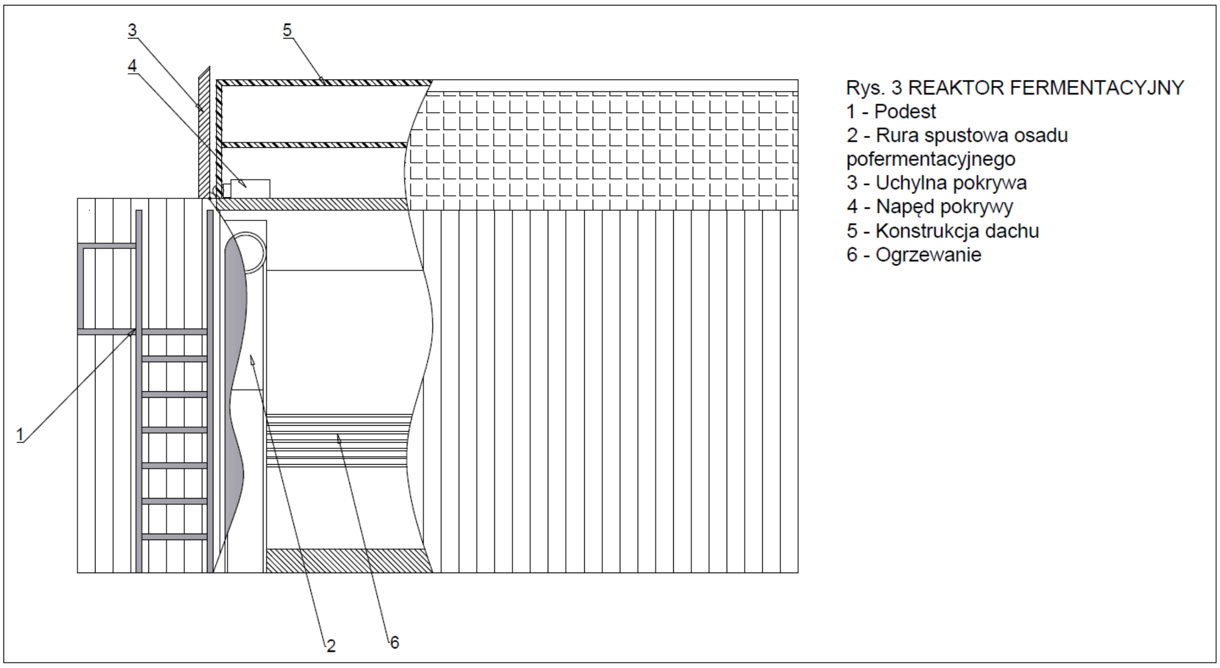
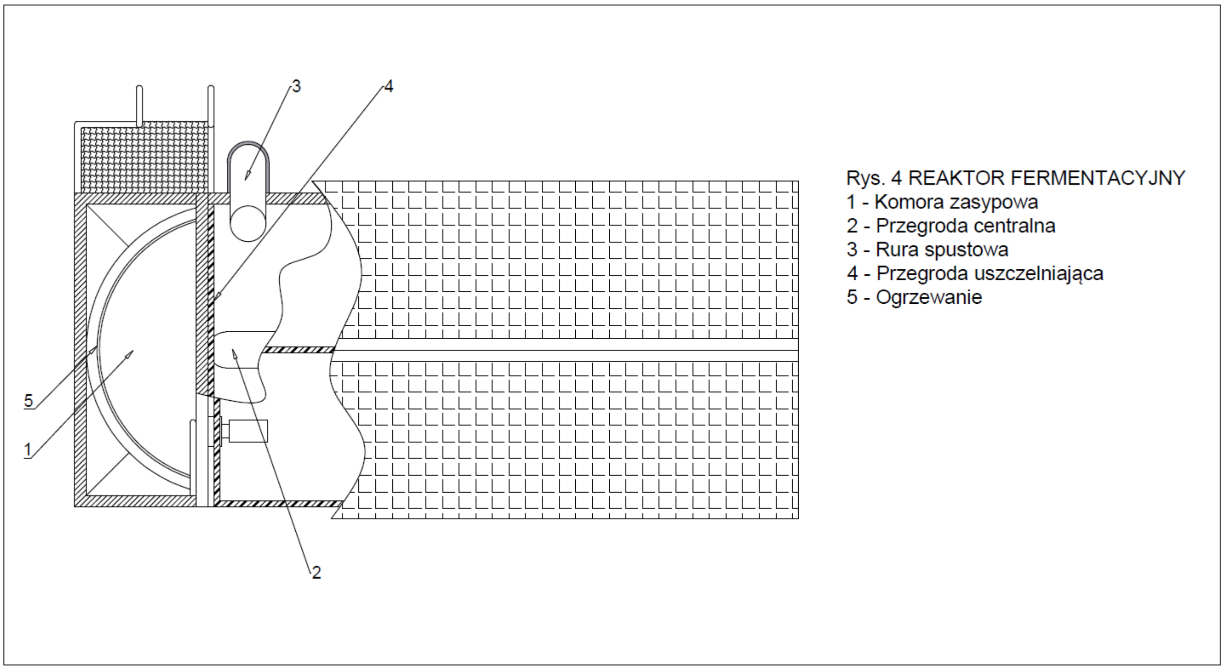



1 – platform, 2 – digestate discharge, 3 – cover, 4 – cover drive, 5 – roof construction, 6 – heating system




1 - feeding chamber, 2 – central baffle, 3 - digestate discharge, 4 - seal baffle, 5 – heating system

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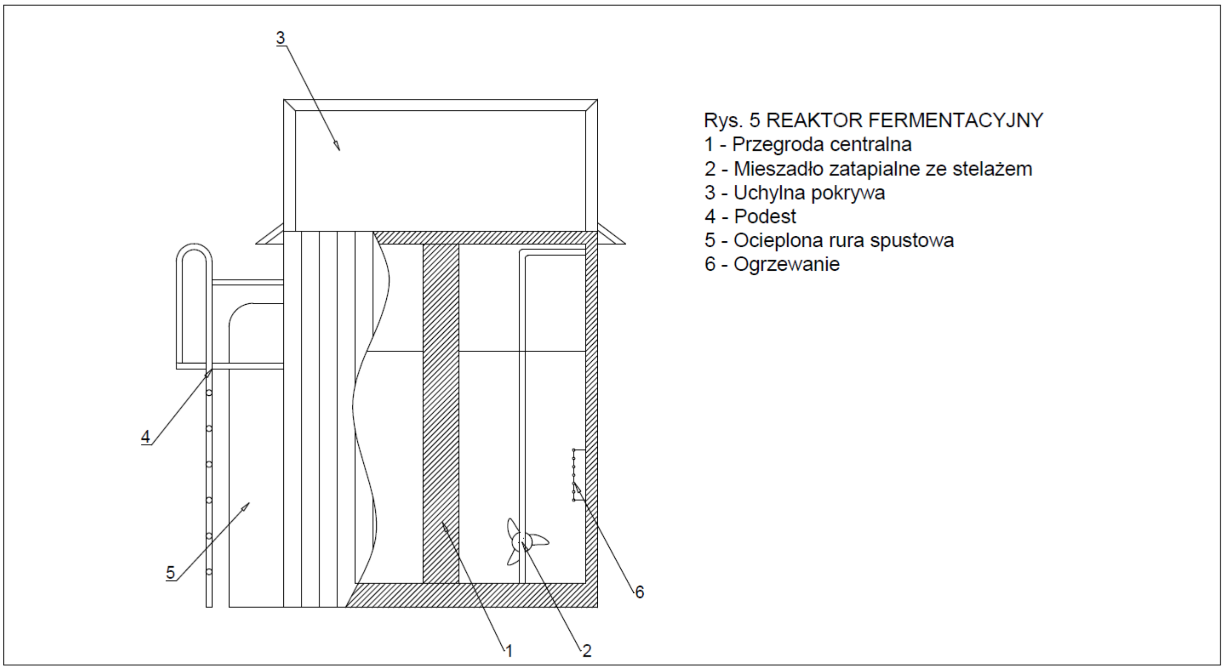
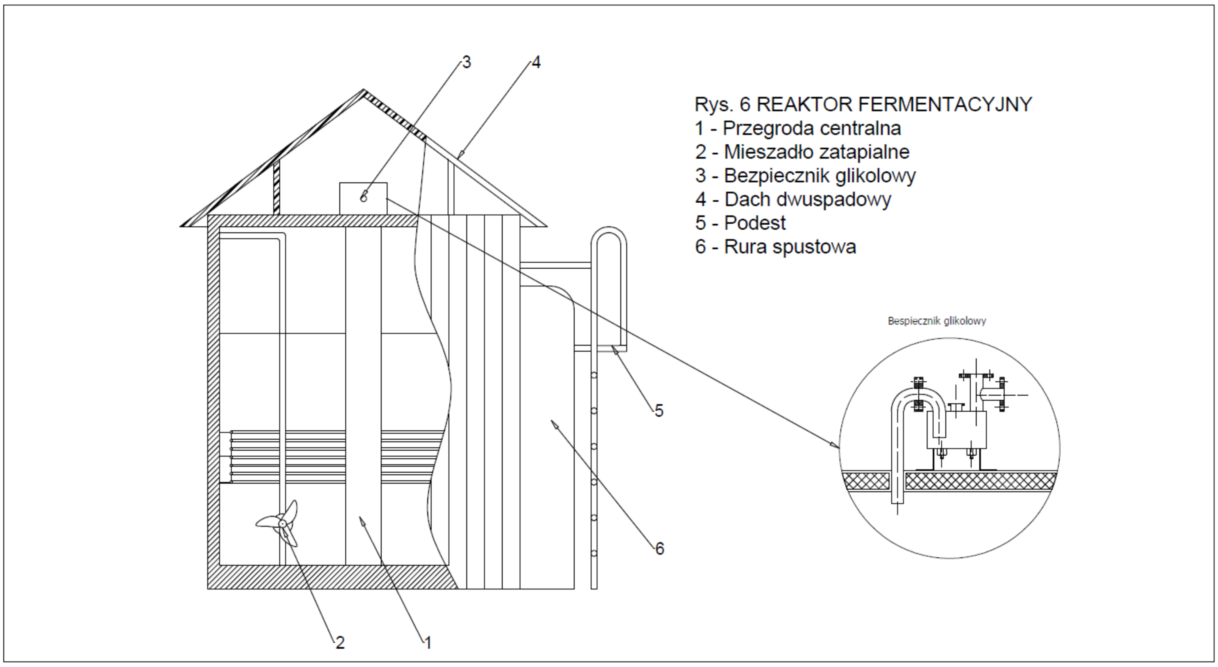



1 – central baffle, 2 - submersible mixer with frame, 3 – cover, 4 – platform, 5 - digestate discharge with insulation, 6 – heating system




1 – central baffle, 2 - submersible mixer, 3 – fuse, 4 - gable roof, 5 – platform, 6 – digestate discharge

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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 ($Nm^3/h$) | ≈ 2,1 | |
| *Data basis for following data list* | 1.: market ready stage of technology (based on test runs of current techn.)<br><br>**Please only use 2. or 3. if 1. not at all possible.**<br><br>2.: market ready stage of technology (based on estimate)<br>3.: current level (TRL) of technology | 1 ☐ (preferably)<br><br>2 ☒<br><br>3 ☐ | |
| *Technical efficiency* | Methane content in biogas (%) | 50-70% | Depending on the substrate |
| *Capacity* | Flow rate and type per substrate (Mg/h) | 0,025-0,050 | Calculation for cattle manure and corn silage |
| | Biogas production rate (range) ($Nm^3/h$) | ≈ 2,1 | Depending on the substrate |
| | Possible range for upscaling | up to 150 Nm3/day | Technology for little and middle biogas plant |
| *Data for assessment of economical added value, possible contribution to GHG-reduction and flexibility* | Fermenter and biogas process technology (e.g. continuously stirred reactor, plug flow digester, box or garage type) | CSTR | |
| | Electricity demand (kWhel/$Nm^3$ biogas) | 1,12 | |
| | Heat demand (kWhth/$Nm^3$ biogas) | 2,23 | |
| | Chemical/additives demand (kg/h or kg/$Nm^3$ biogas) | not necessary | |
| | Demand of other substances (kg/h or kg/$Nm^3$ biogas) | not necessary | |

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| | Temperature in fermenter (°C) | 35 - 45 | |
| | Pressure of biogas at exit of fermenter (bar $_{abs}$) | 0,05Ba | |
| | m³ fermenter volume used | 92 | |
| | Full load hours (h/a) | 8000 | |
| | Hydraulic retention time (days) | 30 - 60 | |
| | Max. dry matter content (%) | 85 | |
| | Organic loading rate (kg VS/m³d) | 2 - 4 | |
| | Space requirement (m$^2$) | 2 | |
| | Staff requirement (excluding maintenance) (h/a) | 500 | |
| | Specific capital costs (excluding project development, planning, permission and additional building costs) (€/Nm³/h) | ☐ < 5.000 €/Nm³/h<br>☐ 5.000 - 10.000 €/Nm³/h<br>☐ 10.000 € - 15.000 €/Nm³/h<br>☒ > 15.000 €/Nm³/h<br><br>100 000 | |
| | Maintenance costs (including spare parts, staff) (€/a or €/operating hour) | 3000 | |
| | Production costs (€/Nm³ biogas) | 0,3-0,5 | |
| | Expected lifetime of unit (years) | 10 | |
| *Flexibility* | Types of substrate (solid and liquid) | Solid and liquid | |
| | Start-stop-flexibility | low | |
| | Part-load possibility | ☒Yes, 40% of full capacity<br><br>☐ No | |

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| | Is self-maintenance of technology possible? | ☒ Yes, 75 % of total maintenance hours per year that can be done by operator himself<br><br>☐ No | |
| | Necessity for adaptions of other parts of the plant | not necessary | |
| | Advantages/disadvantages of technology | Advantages simple operation /disadvantages high cost of cogeneration engine | |
| | Special application area of technology | Technology for substrates with low level of hydration | |

## 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: