Statement of Verification

EU Environmental Technology
Verification pilot programme

Technology:	PURROT®
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This Statement of Verification summarises the main results from the verification of PURROT®.

The verification was performed under the EU Environmental Technology Verification (ETV) Pilot Programme. The EU ETV Pilot Programme was established to help innovative environmental technologies reach the market by providing a framework for independent evaluation of the performance of such technologies.

This verification was undertaken by the Danish verification body, ETA-Danmark A/S. ETA-Danmark is accredited by the Danish Accreditation body, DANAK, according to EN 17020 for performing environmental technology verifications. This Statement of Verification is available on the website of the EU ETV Pilot Programme: http://iet.jrc.ec.europa.eu/etv/verified-technologies

1. Technology description

PURROT® is intended for separation of dry matter from liquid wastes in order to facilitate a more effective utilisation of the dry matter for production of bioenergy. At the same time a more effective utilisation of the liquid waste´s nutrients is achieved thereby reducing nutrient losses to the environment. Examples of such liquid wastes are slurry from livestock houses or digestate from biogas plants. It could also be liquid wastes from different types of industrial production.

In the typical situation treatment of liquid wastes with PURROT® results in two output fractions: 1) A solid fraction and 2) A liquid fraction. However, it is possible to change the settings of the PURROT® technology so that a third output fraction is produced as a result of the treatment.

PURROT® operates without addition of chemical additives like polymers and coagulants. PURROT® operates automatically and no persons are needed to manually start and stop the separator. Figure 1 is a photo of PURROT®.

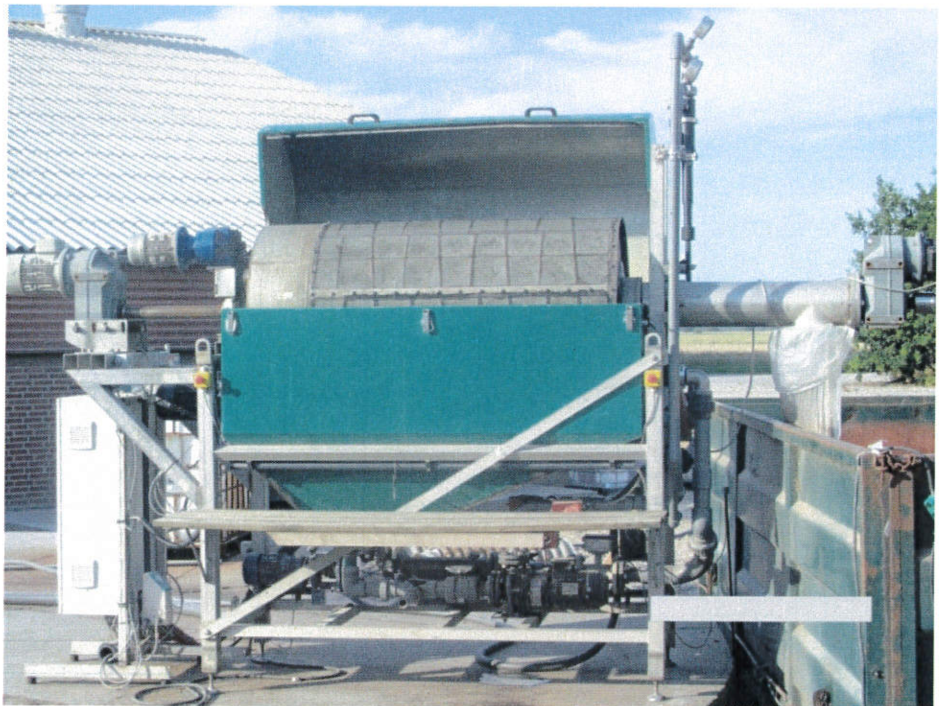

Figure 1. Photo of PURROT®. The solid output fraction is collected in the container to the right of PURROT® whereas the liquid output fraction is pumped to a storage tank.

With PURROT® five separation principles are integrated into one machine:

1. A vertical curved sieve. The liquid waste is pumped to the inside wall of the filter screen.

2. A drum (rotor filter). The filter screen itself is placed around a drum. The screen has small holes (40 microns or less). The drum is rotating slowly. A spiral is fixed at the inside wall of the screen. The dryer and dryer sludge is moved from one end to the other end of the drum. A flow meter installed at the inlet is measuring the actual flow and the total amount of liquid waste treated. Data from the flow meter is used for controlling the speed of the pump for the liquid waste to be fed into the separator. Further, an ultra-sound level-transmitter inside the drum is measuring the actual liquid level. Data from these measurements are used for regulating the speed of the inlet pump, so the desired level can be obtained inside the drum.

3. A horizontal vibration sieve. The drum is vibrating with an amplitude of 2 mm as fast as 60 Hz (3000 times/minute) in a circular (tangential) direction. As a result the screen around the drum is acting as a normal self-cleaning vibration sieve.

4. A high pressure screw press. Integrated in the drum filter, the primarily drained solution is lifted up into a funnel above and entering a screw press. Here the solid content can be raised from approximately 10 % to more than 40 % of total solids (TS). The draining takes place in a perforated pipe where excess liquid is recycled to the drum without using any pumps. The modules are mounted with both a pressure screw and a back-pressure screw. These are coordinated in relation to each other by the programmable logic controller (PLC). It means that it is possible via the PLC to adjust the total solids content of the solid output fraction to a lower level, if this is requested by the customer.

5. A hydro cyclone. Finally, before the liquid fraction (filtrate) is leaving the PURROT® smaller sediments (like clay) can be separated from the filtrate using a hydro cyclone. These sediments can be recycled and absorbed in new dry matter. Alternatively, the sediments can be taken out as a third output fraction from PURROT®.

2. Application

2.1. Matrix
PURROT® was verified for treatment of two types of liquid wastes: 1) Digested biomass from a biogas plant and 2) cow slurry from a dairy farm.

2.2. Purpose
The overall purpose of PURROT® is to upgrade liquid wastes to useful products with added value. This is done by separating the liquid wastes into a solid fraction and a liquid fraction. As a result dry matter and organic bound nutrients are concentrated in the solid fraction. This facilitates an effective utilization of the individual components in the solid fraction. Such components are for instance, organic dry matter for energy purposes and phosphorous for fertiliser products.

2.3. Conditions of operation and use
PURROT® was tested and verified under normal operation conditions similar to what can be expected if the technology is installed on a commercial biogas plant or a commercial dairy farm.

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2.4. Verification parameters definition summary

In Table 1 the performance parameters are presented together with a description of the applied test or measurement methods.

Table 1. Overview of performance parameters evaluated as part of the present verification of PURROT®.

Parameter	Test or measurement methods
Share of the organic dry matter (volatile solids) in the liquid waste recovered in the solid fraction.	The same test method was used for all four parameters. A series of batch tests were undertaken. In each batch test the volume of liquid waste treated was measured. Also the weight of solid fraction produced during the batch was determined. From these data it was calculated how the weight of the treated liquid was distributed on the output fractions after separation assuming that no losses took place during the treatment. During the batch test samples were taken from input flow and output fractions coming from the separator. After chemical analyses were undertaken it was possible to establish mass balances for the four performance parameters. Based on the mass balances the separation efficiencies could be calculated.
Share of the total-nitrogen (total-N) in the liquid waste recovered in the solid fraction.	
Share of the organic bound nitrogen (organic-N) in the liquid waste recovered in the solid fraction.	
Share of phosphorous (P) in the liquid waste recovered in the solid fraction.	

3. Test and analysis design

3.1. Existing and new data

PURROT® has not been tested previously. Therefore, this verification is based on new data only since no existing data were available.

3.2. Laboratory or field conditions

A full scale version of PURROT® was used for the test. The test activities took place at the biogas plant of Aarhus University. It is judged that this biogas plant is managed in a way that the digested biomass is representative for commercial biogas plants where PURROT could be installed. Samples taken during the test were analysed by Agrolab, which is 17025 accredited.

3.3. Matrix compositions

The dry matter content of the two matrices has been analysed and the results were as follows:

- Digested biomass: 6.2 – 6.4 %
- Cow slurry: 7.0 – 8.0 %

Additional data on matrix compositions are presented in section 4.4 below.

3.4. Test and analysis parameters

The analysis parameters and the respective analytical methods are presented in Table 2.

Table 2. Overview of analysis parameters applied for the test of PURROT®.

Parameter	Analytical method	Unit
Total solids (TS)	DIN EN 12880	%
Volatile solids (VS)	DIN 19684-3	%
Total nitrogen (total-N)	DIN ISO 13878	Kg/ton
Ammonium nitrogen (NH4-N)	DIN 38406-5-2 (E 5-2)	Kg/ton
Phosphorous (P)	DIN EN ISO 11885 (E 22)	Kg/ton
Potassium (K)	DIN EN ISO 11885 (E 22)	Kg/ton

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3.5. Tests and analysis methods summary

For each of the two matrices 3 batch tests were undertaken, that is 6 batches in total. The duration of each batch test was 180 minutes. In each batch test a certain amount of liquid waste was treated in PURROT® and the amount of resulting output fractions was determined. During the batch tests samples were taken from input flow and output fractions coming from the separator. After chemical analyses were undertaken it was possible to make mass balances on the four performance parameters. Based on the mass balances separation efficiencies were calculated.

3.6. Parameters measured

In addition to the performance parameters listed in section 2.4 the following parameters were measured and evaluated as part of the verification:

- Capacity of PURROT® expressed in terms of tons liquid treated per hour in operation.
- Electricity consumption of PURROT® expressed in terms of kWh per ton of liquid treated.

4. Verification results

4.1. Performance parameters

In Table 3 the verified performance is presented as a mean value together with the respective 95 % confidence intervals.

Table 3. Verified performance. 95 % confidence intervals are shown in brackets.

Parameter	Cow slurry	Digested biomass
Share of the organic dry matter (volatile solids) in the liquid waste recovered in the solid fraction.	60 % [47 - 73]	62 % [60 – 64]
Share of the total-nitrogen (Total-N) in the liquid waste recovered in the solid fraction.	19 % [10 – 27]	22 % [18 – 26]
Share of the organic bound nitrogen (organic-N) in the liquid waste recovered in the solid fraction.	29 % [15 – 42]	33 % [22 – 45]
Share of phosphorous (P) in the liquid waste recovered in the solid fraction.	23 % [16 – 31]	46 % [35 – 58]

4.2. Operational parameters

Results from measurements of the capacity and electricity consumption of PURROT® are presented in Table 4.

Table 4. Measured capacity and electricity consumption of PURROT®. 95 % confidence intervals shown in brackets.

Matrix	Capacity (tons of input biomass treated per hour)	Electricity consumption (kWh/ton treated biomass)
Cow slurry (TS = 7.6 %)	0.64 [0.54 – 0.74]	5.4 [3.6 – 7.2]
Digested biomass (TS = 6.3 %)	0.92 [0.87 – 0.96]	3.4 [3.0 – 3.8]

4.3. Environmental parameters

The relevant environmental parameters are included as performance parameters described in section 4.1.

4.4. Additional parameters

In order to facilitate an evaluation of the solid output fraction as a fuel for bioenergy samples from separation of the two matrices with PURROT® have been analysed for key parameters. Table 5 shows the average content of main nutrients and solids in the input cow slurry and in the solid output fraction resulting from separation with PURROT®.

Table 5. Cow slurry. Content of main nutrients and solids in input slurry and solid output fraction from PURROT®. 95 % confidence intervals are shown in brackets.

Cow slurry	Total solids (%)	Volatile solids (%)	Total nitrogen (kg/ton)	Ammonium nitrogen (kg/ton)*	Organic nitrogen (kg/ton)	Phosphorous (Kg/ton)	Potassium (kg/ton)
Input slurry	7.63 [6.20-9.07]	6.33 [5.07-7.59]	3.06 [2.82-3.30]	1.67 [1.59-1.75]	1.39 [1.07-1.71]	0.62 [0.60-0.65]	3.57 [1.57-5.57]
Solid fraction	38.4 [29.8-46.7]	35.6 [27.6-43.7]	4.77 [3.89-5.64]	1.65 [1.51-1.80]	3.11 [2.30-3.92]	1.23 [0.89-1.56]	2.95 [1.27-4.63]

*The content of ammonium-N is not analysed in laboratory but calculated as the difference between content of total nitrogen and ammonium-N.

Table 6 shows the average content of main nutrients and solids in the input digested biomass and in the solid output fraction resulting from separation with PURROT®.

Table 6. Digestate biomass. Content of main nutrients and solids in input and solid output fraction from PURROT®. 95 % confidence intervals are shown in brackets.

Digested biomass	Total solids (%)	Volatile solids (%)	Total nitrogen (kg/ton)	Ammonium-N (kg/ton)	Organic N (kg/ton)	Phosphorous (Kg/ton)	Potassium (kg/ton)
Input biomass	6.30 [5.97-6.63]	5.06 [4.86-5.25]	2.33 [2.12-2.55]	1.52 [1.46-1.58]	0.81 [0.61-1.01]	0.62 [0.52-0.72]	2.43 [2.32-2.55]
Solid fraction	35.3 [22.0-48.6]	32.0 [19.1-44.8]	4.84 [4.06-5.62]	2.09 [1.72-2.46]	2.75 [2.21-3.29]	2.85 [2.05-3.66]	2.64 [2.44-2.85]

**The content of ammonium-N is not analysed in laboratory but calculated as the difference between content of total nitrogen and ammonium-N.*

5. Additional information

Additional information is found in the verification report.

6. Quality assurance and deviations

The test and verification activities were planned and undertaken to satisfy the requirements on quality assurance described in the General Verification Protocol developed for the EU ETV Pilot Programme (Version 1.1 – July 7th, 2014).

Test activities were undertaken by AgroTech Test Centre (test body). AgroTech has a quality management system in place that follows the principles of EN ISO 9001 and it is judged that it fulfils the requirements of the EU ETV General Verification Protocol (Chapter C.III). Laboratory analyses were performed by Agrolab, which has an accreditation for the relevant analyses.

An external review was performed for the specific verification protocol and the verification report. The external review was done by Bjørn Malmgren-Hansen from Danish Technological Institute.