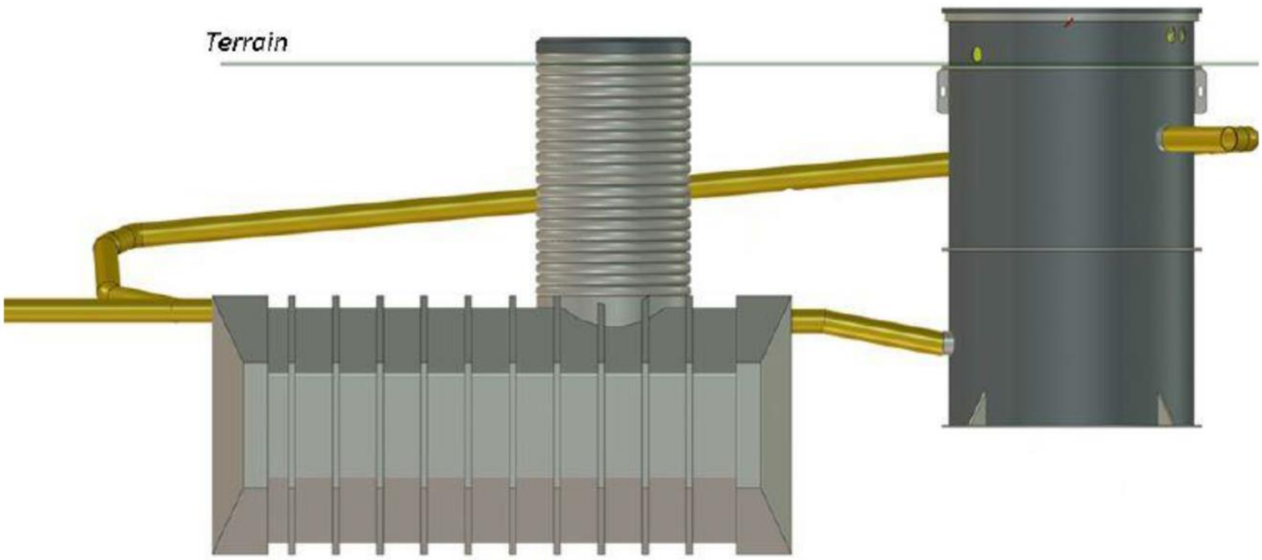
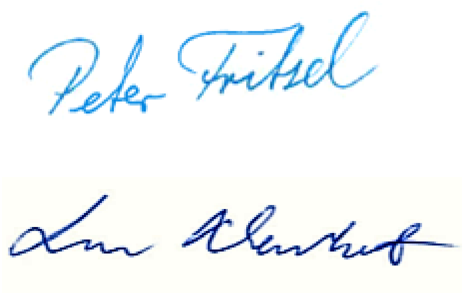
BioKube A/S

Summerhouses Wastewater System



Verification Report
December 2016

Approved by
Peter Fritzel (Verification responsible, ETA Danmark)
Lars Neubert (Head of Projects, Industry, DHI)



BioKube A/S

Summerhouses Wastewater System

Prepared for BioKube A/S

Represented by Peter Taarnhøj

Project No	11816627
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	Final 1.0

Authors	Gerald Heinicke

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Archiving: All standard project files (documents, *etc.*) are archived at ETA Danmark. Any other project files (set-up files, forcing data, model output, *etc.*) are archived with the institute performing the tests or analysis.

1 Introduction

Environmental technology verification (ETV) is an independent (third party) assessment of the performance of a technology or a product for a specified application under defined conditions and quality assurance.

The objective of this verification is to evaluate the performance of a BioKube small aerated wastewater treatment system (for 5 person-equivalents, PE), for use at summer cottages, occupied at irregular intervals. BioKube's Venus 1850 treatment system (hereafter: "ordinary treatment system") includes recirculation of treated wastewater to the septic tank, a patented feature that ensures that the wastewater treatment system is functional even after prolonged periods without wastewater inflow. The verification includes a scenario in which BioKube treatment plants are kept without influent for 6 months.

In the Venus 1850 version for summerhouses (hereafter "energy-saving treatment system"), a flow-switch is applied that reduces aeration in times without incoming flow.

This verification was performed under the EU ETV Pilot Programme.

This Verification Report and the verification of the technology are based on the Specific Verification Protocol (Appendix 4), the Test Plan (Appendix 6) and the Test report (Appendix 7) for the BioKube Summerhouses Wastewater System.

1.1 Name of technology

BioKube Summerhouses Wastewater System.

1.2 Name and contact of proposer

BioKube A/S
Centervej Syd 5
4733 Tappernøje
Denmark

Contact: Peter Taarnhøj, email: pt@biokube.dk, phone + 45 5598 9800.
Website: www.biokube.dk/

1.3 Name of Verification Body and responsible of verification

<u>EU ETV:</u>
ETA Danmark A/S
Göteborg Plads 1
2150 Nordhavn
Denmark

Person responsible for verification:
Peter Fritzel (PF), email: pf@etadanmark.dk, phone +45 7224 5900

Appointed verification expert:
Gerald Heinicke (GHE), DANETV, e-mail: ghe@dhigroup.com, phone: +45 4516 9268

1.4 Organisation of verification, including experts, and verification process

The verification was conducted by ETA Danmark A/S in cooperation with the Danish Centre for Verification of Climate and Environmental Technologies, DANETV.

The verification was planned and conducted to satisfy the requirements of the ETV scheme established by the European Union (EU ETV Pilot Programme) [1].

The verification was coordinated and supervised by ETA Denmark, assisted by an appointed DANETV verification expert, while tests were coordinated and supervised by the DHI DANETV Test centre with participation of the proposer, BioKube A/S, and designated test sites.

Concerning the test at existing treatment systems, the role of the proposer was to install the additional equipment systems and to accompany the sampling staff (DANETV and/or external laboratory) to the test sites, when necessary. The users of the cottages made their treatment systems available for the tests and informed about the use of their cottage.

As for the tests performed at a wastewater treatment plant, the role of the proposer was to start and stop the test systems at the designated times and to accompany the sampling staff (DANETV and/or external laboratory) to the test sites. The staff at the wastewater treatment plant made the site available for testing.

An internal and an external expert were assigned to provide independent expert review of the planning, conducting and reporting of the verification and tests:

- Internal technical expert: Bodil Mose Pedersen, DHI DANETV Test Centre, email: bop@dhigroup.com, phone: +45 4516 9433
- External technical expert: Henrik Rasmus Andersen, Associate Professor, DTU Environment, Department of Environmental Engineering, email: hran@env.dtu.dk, phone: +45 4525 1583

A detailed description of the tasks assigned to each expert are given in chapter 5.

The relationship between the organisations related to this verification and test is given in Figure 1-1.

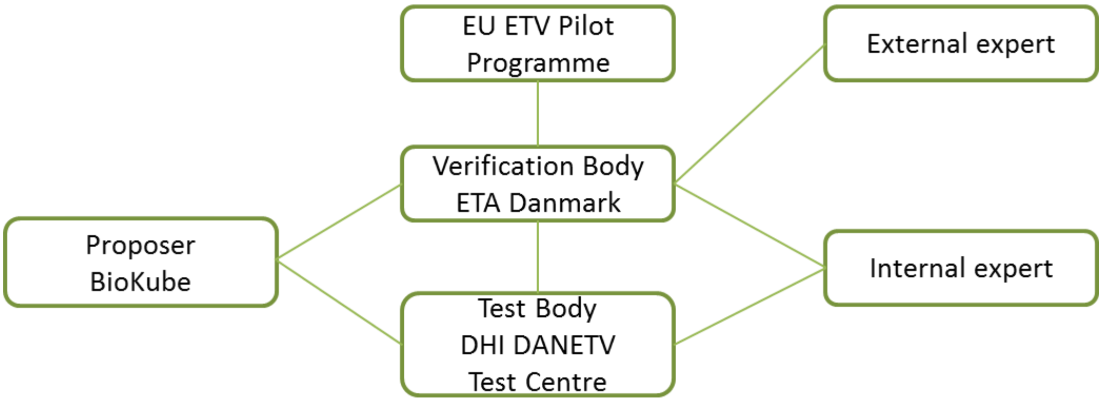


Figure 1-1 Organisation of the verification and test.

The operating principles of the DANETV verification process are given in Table 1-1. Verification and testing were divided between the verification and the test bodies.

Table 1-1 Simplified overview of the verification process.

Phase	Responsible	Document
Preliminary phase	Verification body	Quick Scan
		Contract
		Specific verification protocol
Testing phase	Test body	Test plan
		Test report
Assessment phase	Verification body	Verification report
		Statement of Verification

Reference for the verification process is made to the EU ETV General Verification Protocol [1] and the ETA Danmark internal procedure [2]. A Statement of Verification will be issued by the verification body after completion of the verification.

1.5 Deviations from the verification protocol

There were two deviations.

1. The specific verification protocol expected the logging of the points in periods where the flow-switch was activated in the eight existing plants at summer cottages. However, logging these points in time was not possible due to the lack of logging equipment in BioKube's existing plants. The flow-switch controls the activation of the energy-saving function. Therefore, the successful operation of the energy-saving function was evaluated based on the difference in the energy consumption between ordinary treatment systems and energy-saving treatment systems.

2. The specific verification protocol expected measurement of total phosphorous (total P) to be done in the effluent from all BioKube plants with precipitation of phosphorous. Due to an oversight made by the test body, no analyses for phosphorous were made of the influent and effluent to/from the two systems at Tappernøje WWTP.

This is further discussed in section 4.2.3 and documented in Appendix 5.

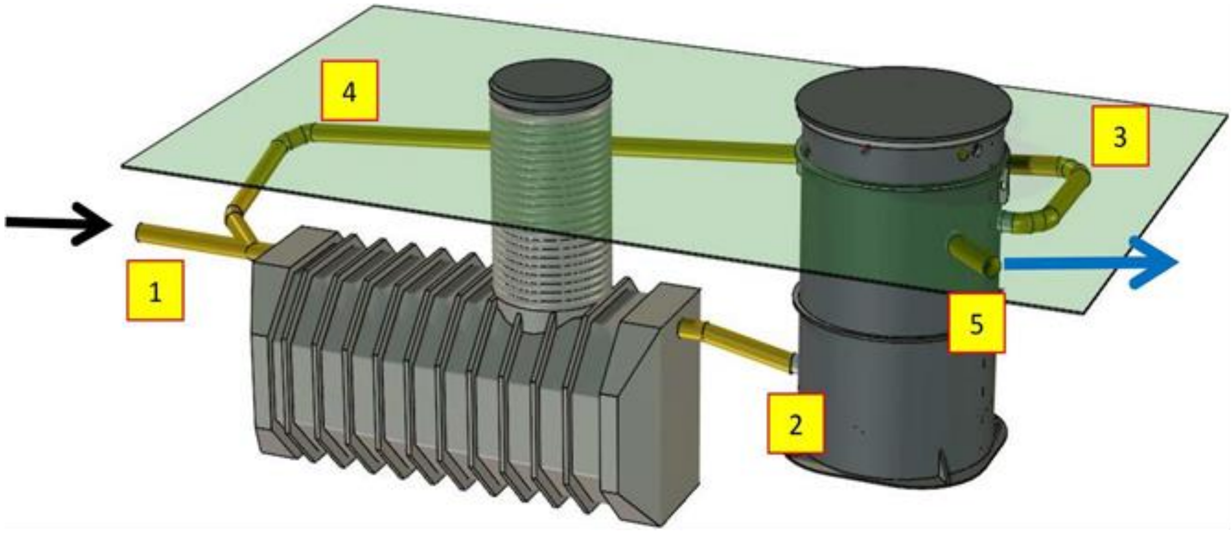
2 Description of technology and application

2.1 Summary description of the technology

The following description of the specific technology is based on information provided by the vendor and does not represent verified information.

BioKube has developed a technology where there is a continuous nourishment of the bacteria in small wastewater systems, even during periods of no wastewater inflow to the system, which is typical for summer cottages in the off season (*i.e.* mainly during the winter months from October to April). The technology is covered by patent WO 2005/026064 A1.

The BioKube Summerhouses Wastewater System is based on a BioKube Venus 1850 wastewater treatment system, designed for 5 person-equivalents (PE). Intended for use in summer cottages with irregular inflow of wastewater, the summerhouse version is equipped with an energy-saving control system, which is reducing aeration and pumping in periods without any incoming flow. The conceptual design is illustrated in Figure 2-1.



1. The sedimentation tank is fully integrated in the treatment process
Particles are removed in the septic tank upstream of the biological treatment zones. The large volume of water and the timed backwash of purified oxygen-rich wastewater from the last treatment chamber increase the efficiency of the sedimentation tank and evens out varying loads.
2. Timed inflow from the buffer tank ensures continuous nourishment to the biology (BioKube patent)
Wastewater is pumped into the first treatment chamber in the BioKube every 15 minutes for the full 24 hours day cycle. Biological nourishment is thereby fed continuously to the bacteria and not just in bursts as the wastewater is produced in the house. This also equalizes fluctuations in incoming detergents and other chemicals in the wastewater.
3. Timed backwash to the settling tank removes odour (BioKube patent)
During the treatment process, small air blowers supply oxygen to the bacteria. When the oxygen-rich treated wastewater is recycled to the settling tank every fifteen minutes, this prevents odour from toxic hydrogen sulfide in the settling tank. It provides better living conditions for the bacteria that cleans the wastewater by eliminating toxic hydrogen sulfide from developing in the settling tank.
4. Timed backwash ensures equal input of nutrition for the biology (BioKube patent)
By continuous backwash to the settling tank, it is ensured that nourishment from the settling tank is fed to the bacteria also during holiday periods. BioKube systems are therefore uniquely suitable for holiday homes and vacation hotels with large seasonal fluctuations in the incoming water.

Figure 2-1 Conceptual design of the BioKube Summerhouses Wastewater System: A Venus 1850 with energy-saving control system. The concept of the Venus 1850 is based on biological wastewater treatment using timed batch inflow to submerged aerated filters, with regular return flow of treated water back to the septic tank. (Figure and text provided by BioKube)

The Venus 1850 treatment system includes recirculation of treated wastewater to the septic tank (patent no WO 2005/026064 A1). The main effect of the recirculation is the supply of continuous nourishment to the bacteria, also in periods without inflow of new wastewater. In a single-family house (a 5 PE system), treated wastewater is recirculated to the septic tank every

15 minutes, resulting in recirculation of approximately 700 litres per day. There are further advantages of this recirculation such as the elimination of toxic hydrogen sulphide (H_2S) due to aerated water being added to the septic tank.

In locations where removal of phosphorous is mandatory, BioKube's wastewater treatment systems may be upgraded with a phosphate precipitation unit. Polyaluminium coagulant is dosed to the return flow to the septic tank. A flow activator shuts down chemical dosing, if no water has come to the system for a period of 24 hours.

The Venus 1850 used for the test contains 1570 litres of water and sludge. The septic tank upstream has a volume of 2300 litres.

Further technical information is available from BioKube's fact sheet [3], and the certification report for the original Venus 1850 [4], both appended, and from BioKube's website (www.biokube.dk and www.biokube.com).

For the BioKube Summerhouses Wastewater System, BioKube has developed an energy-saving control system based on flow through the system. If no flow is registered for a specific period of time, the house is assumed to be unoccupied and the power consumption reduced.

The monitoring of incoming flow is based on a flow-switch in the effluent pipe of the treatment system (Figure 2-2). If water leaves the system (*i.e.* after a flow from the house), the activator is lifted. The water slowly drains from the hole in the bottom of the yellow container. For the following 48 hours the system runs in standard configuration, (*i.e.* blowers on 24/7 and recirculation to septic tank of 7.5 litres every 15 min). After 48 hours, the system switches to "reduced power" mode; the blowers will run 10 min every hour and 7.5 litre of treated water will be recirculated to the septic tank every hour (180 l/day). This will reduce the power consumption by more than 50 %. When flow is registered again, the system returns to normal operation. Effluent flow may occur late compared to the inflow to the septic tank. This is due to the transport of a fixed amount of water from the buffer tank in the bottom of the treatment system and a possible evaporation from the system due to aeration.

Figure 2-2 Flow-switch (level activator) used to control the BioKube Summerhouses Wastewater System (photo provided by BioKube).

BioKube's claims for the system were:

"Summer cottage operation" – The BioKube Summerhouses Wastewater System will fulfil outlet requirements from day one after a pause in the incoming wastewater for 6 months. The control over the flow of water enables BioKube wastewater treatment systems to fulfill required outlet demands immediately on receiving incoming wastewater to be treated, despite the system having received no incoming wastewater for 6 months. This is equivalent to operation in a summer cottage closed for winter. The outlet requirements to be fulfilled are the Danish requirements of BOD < 10 mg/l, COD < 70 mg/l NH4 < 5 mg/l, and P<1,5 mg/l where relevant.

"Power Saving mode" – BioKube systems automatically power down and operate in power saving mode if there is no incoming wastewater. In power saving mode, the energy saving for use at a summer cottage is at least 50%, compared to normal (continuous) operation.

2.2 Intended application (matrix, purpose, technologies, technical conditions)

The intended application of the product for verification is defined in terms of the matrix, the purpose, the technology and related technical conditions.

Matrix
The technology is intended to treat household wastewater from summer cottages.

Purpose
The purpose is to treat wastewater from summer cottages[1], specifically reducing Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), ammonium (NH_4) and total phosphorous (P) to below the required values[2].

Technologies
BioKube wastewater treatment systems are supposed to reduce the concentration of organic matter and perform nitrification of ammonium. BioKube offers a separate phosphate removal unit (dosage of polyaluminium chloride), which was integrated in some of the tested treatment systems.

Technical conditions
BioKube has indicated that the Summerhouses Wastewater System is functioning also in winter conditions, because the treatment systems are located under ground. No limits are mentioned as for the temperature range in which the system can be used. However, it is stated in Danish guideline documents that the incoming water to the system should be between 7 and 80 °C [5].

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[1] House or cottage that is used mainly during the summer and that may be unoccupied for several weeks or months. In Danmark, many of these houses are quite large and designated *sommerhus.* These houses must not be used as permanent residence, unless the owner has received a dispensation from the authorities.

[2] In some areas of Denmark, reduction of P is not required. In this case coagulant dosage is not applied.

2.3 Verification parameter definition

2.3.1 Performance parameters

For the verification, the claims regarding the Summerhouses Wastewater System were defined as follows.

The first claim is the treatment result for the following parameters. It is claimed that the ordinary treatment system (*i.e.* ordinary Venus 1850) and the energy-saving treatment system (*i.e.* the BioKube Summerhouses Wastewater System) comply with the current Danish effluent quality standards[3] immediately, on receiving incoming wastewater again, after a period (of up to 6 months) without influent wastewater:

- Biochemical Oxygen Demand (BOD) < 10 mg/l,
- Chemical Oxygen Demand (COD) < 70 mg/l,
- Ammonium (NH_4) < 5 mg/l,

and for systems having the P precipitation system installed (see section 2.2.3):

- Total phosphorous (P) < 1.5 mg/l.

The second claim is that the use of a flow-switch will enable the energy-saving treatment system to power down parts of the system during periods without influent wastewater (up to 6 months), reducing the electric power consumption for use at summer cottages by at least 50%, compared to the ordinary treatment system.

2.3.2 Environmental parameters

During operation, the treatment system will cause emissions to water and use electric power. These parameters are included as performance parameters (Section 3.1).

2.3.3 Additional parameters

BioKube claims that the recirculation of treated wastewater and the reduction of electricity consumption can be achieved without any intervention by the operator.

[3] The legal requirements for small wastewater treatment plants in Denmark are in a transition phase. The national type-approval regulations [5] were withdrawn, effective June 1, 2015 [6]. While new regulations are developed, municipalities still refer to the effluent quality demanded in the in the national type-approval, *i.e.* appendix 3 in [5]

3 Existing data

The performance of the Venus 1850 (ordinary treatment system) was tested as part of the ISO CEN 12566-3:2005 certification [7]. The results are summarised in the certification report from CertiPro, Belgium [4]. This type-approval test did not include the phosphorous removal option.

The performance of BioKube's Pluto treatment system with phosphorous precipitation was tested as part of the EN 12566-6+A2 certification. The results are summarised in the certification report from CertiPro, Belgium (Appendix 9). This type-approval test included the phosphorous removal option.

The certification body, CertiPro, is accredited according to EN ISO/IEC 17065:2012 and EN ISO/IEC 17020:2012 (information from CertiPro website, visited 10.08.2015).

BioKube has provided effluent data from approximately 50 Venus 1850 systems, which are installed at summer cottages. According to grab samples taken during the mandatory yearly service, approximately 90% of the treatment systems complied with the regulations for the water quality parameters (data not shown). According to BioKube, the plants that do not comply typically have technical problems (such as broken air blowers or coagulant dosing pumps) and need to be repaired. According to BioKube's experience, there is no difference in performance between treatment systems installed at summer cottages and at houses which are continuously occupied.

BioKube has also provided data from a single Venus 1850 system that did not receive inflow of wastewater for 12 months. When the inflow of wastewater was resumed, the effluent complied with the Danish regulations [5] in 8 grab samples taken over a period of 6 weeks (data not shown). The data provided by BioKube regarding treatment systems with longer periods of no inflow were not controlled independently.

3.1 Accepted existing data

The data from the Venus 1850 type-approval could not be accepted as a test of the system's functionality with a long period of no occupancy, because it was done under conditions meant to resemble a permanent occupancy of the connected household. The maximum period without flow was 2 weeks, which does not represent the challenge of maintaining the necessary biological activity in a system connected to a summer cottage.

The data provided by BioKube regarding treatment systems with a long periods of no inflow could not be accepted for the verification, due to lack of third-party quality assurance.

The data from the Pluto system type-approval testing was accepted for the evaluation of the phosphorous removal unit. The phosphorous removal unit is identical in the Pluto and the Venus 1850 units, both designed for a 5 PE load with an inflow of 750 litres/day. The coagulant type (Polyaluminium chloride, PAX) and dosage are identical. In contrast to the removal of BOD, COD and ammonium, phosphorous removal occurs by chemical precipitation induced by the aluminium coagulant, and dosage activated by the flow switch. The duration of interruptions in inflow is therefore not an important factor for phosphorous removal.

Certripro tested the Pluto system in the period 23.01.2015 through 16.04.2016. The average concentration of total phosphorous in the raw wastewater was 10.9 mg/l P during the test phase. The concentration of total phosphorous in the treated wastewater was 0.50 mg/l P, as an average of 20 samples. The data is stated in the certification report (Appendix 9). All of the 20 effluent samples had P concentrations below the Danish guideline limit of 1.5 mg/l.

4 Evaluation

Detailed descriptions of the test design and test results are found in the Test Plan (Appendix 6) and in the Test Report (Appendix 7).

4.1 Calculation of verification parameters, including determination of uncertainty

The investigated water quality parameters were reported as mg/l.

For the investigated treatment systems, the energy savings due to using the control system with the flow-switch was calculated as:

$$Saving\ in\ \% = 100 - \frac{Consumption\ (kWh/d)\ for\ energy\ saving\ treatment\ system}{Consumption\ \ (kWh/d)\ for\ ordinary\ treatment\ system} \cdot 100$$

Energy consumption was measured as kWh during the test period for the field test, and during the dormant period (interruption phase) for the flow-controlled test with two treatment systems at Tappernøje WWTP.

The data is reported as average with standard deviations.

4.2 Evaluation of test quality

4.2.1 Control data

The occupancy of summer cottages is expected to vary, which was also reflected in the test. Some houses with existing BioKube units were not occupied at all during the whole test period, some were hired out more or less regularly, while only one was occupied continuously. Peak loads occurred during family gatherings, such as Easter holidays with many people using the houses. The pattern of occupancy was self-reported by the owners/users of the cottages.

The eight existing BioKube treatment systems at summer cottages (field test) and the two systens at Tappernøje WWTP functioned without any technical problems.

Control of the test systems

The eight existing installations at summer cottages were checked visually at the sampling occasions, and observations were written down. It was not possible to check the function of the flow-switches during the test period, as this would have affected the operation of these plants (*i.e.* activated the energy-saving systems from their dormant state).

The treatment systems at Tappernøje WWTP were controlled by reading the flowmeters and collecting water quality data. The inlet concentrations of COD, BOD and ammonia components to the two plants placed at Tappernøje WWTP were low compared to the concentrations recommended in EN 12466 (7), see Table 4-1. Total P was not measured during the test period. The flow measured at the inlet of the two test plants varied between 774 and 1102 l/d. Due to the high flow during the test period, the load of the test plants corresponded partly to the load recommended in EN 12466.

Table 4-1 Overview of the component concentration and load values at two BioKube systems tested at Tappernøje WWTP and the recommended test concentrations and loads. The inlet concentrations are calculated from the average of three data set and the EN 12466 loads are based on a flow corresponding to 750 l/d. The min. and max. load are based on 774 l/d and 1102 l/d, respectively.

Parameter	Wastewater composition	Inlet	Load min.	Load max.	Load min.	Load max.
	EN 12466	Tappernøje	EN 12466	EN 12466	Tappernøje	Tappernøje
	mg/l	mg/l	g/d	g/d	g/d	g/d
COD	300-1000	247	225	750	191	272
BOD	150-500	98	113	375	76	108
NH3-N + NH4-N	22-80	20	17	600	15	22
Total P	5-20		38	15		
Flow (l/d)		774-1102				

The flowmeter at the inlet was read on days with sampling of the effluent. The flow varied between 832 and 1102 l/d for the ordinary treatment system and between 774 and 835 l/d for the energy-saving system.

Performance evaluation audit
There were no online measurements to be controlled as part of a performance evaluation audit.

Control of analysis performed at external laboratory
All external analyses were carried out under accreditation, which requires participation in proficiency tests.

Control of the data quality and integrity
Spread sheets used for the calculations were subject to control on a sample basis (spot validation of at least 5% of the data).

4.2.2 Audits

An internal test-system audit was performed by Bodil Mose Pedersen from DHI on 8 April 2016. The verification body ETA Danmark, represented by Peter Fritzel, performed a test-system audit on 8 April 2016.

Notes from the internal audit (Bodil Mose Pedersen): "The operation and the sampling was done properly". A non-conformity was noted: "No collection of logged data during sampling", and a deviation report was prepared.

Conclusions from the audit by ETA Danmark (Peter Fritzel): "There is consistency with the test plan, and handling of samples is carried out in a safe manner."

4.2.3 Deviations

There were two deviations to the specific verification protocol and test plan (Appendix 5).

The specific verification protocol expected the logging of the points in time, when the flow-switch was activated in the eight existing plants at summer cottages. This was not possible, since there was no logging capability in BioKube's existing plants. The flow-switch controls the activation of the energy-saving function. Without logged data from the control system, the reported pattern of occupancy could not be compared with the flow-switch activation. Therefore, the successful operation of the energy-saving function was evaluated based on the measured energy consumption, combined with the users' self-reporting forms.

The specific verification protocol expected measurement of total phosphorous (total P) in the effluent from all BioKube plants with phosphorous precipitation. Due to an oversight made by the test body, no analyses for phosphorous were made of the influent and effluent to/from the two systems at Tappernøje WWTP. This mistake was not discovered until the reception of the analytical reports. The lack of total P analyses means that the claim related to total P had to be documented by using data from other tests that had been carried out, for instance certification test of the BioKube plant. Data from an identical phosphorous precipitation unit used for the certification of a BioKube plant was accepted for the present verification report (see section 3.1).

None of the two deviations were considered to have significant impact on the verification.

There were no amendments to the test plan.

4.3 Verification results (verified performance claim)

4.3.1 Description of statistical methods used

The average and standard deviations were calculated for the results of water quality parameters and energy consumption regarding the eight existing treatment systems at summer cottages.

4.3.2 Verification parameters

4.3.2.1 Flow controlled tests at Tappernøje wastewater treatment plant (WWTP)

At Tappernøje (WWTP), the wastewater inflow was controlled. Two treatment systems with pre-established biology and phosphorous precipitation (one ordinary treatment system, the other an energy-saving treatment system) were subjected to a 6-months interruption of inflow during the winter season. The raw wastewater had passed coarse screening before entering the two treatment systems. The operation of the two systems falls in two phases:

- Interruption phase with no flow: 30.09.2015 to 30.03.2016
- Post-interruption phase: 30.03.2016 to 12.04.2016

On 30.03.2016, the inflow was reumed and adjusted to approximately 750 l/d of wastewater after. This means that the treatment systems were subjected to their design load immediately from startup after the winter period. Spot samples from the inlet were taken three times within two weeks after restart. After restarting the wastewater inflow, the effluent quality was monitored for two weeks by taking five spot samples from the treated effluent.

Energy consumption

During the dormant period without inflow of wastewater, the ordinary treatment system consumed 331 kWh (1.83 kWh/d), while the energy-saving treatment system consumed 137 kWh (0.76 kWh/d). **This corresponds to a 59% reduction of electricity consumption.** When the plants received wastewater again, their electricity consumption was similar (Table 4-2).

Table 4-2 Energy consumption (kWh) by the energy-saving and ordinary treatment systems at Tappernøje WWTP during the dormant and active phases of the test period .

Treatment system	Start of test 01.10.2015	At re-start 30.03.2016	Consumption 181 days	End of active period 12.04.2016	Consumption 13 days
Energy-saving	0	136.9	136.9 (0.76 kWh/d)	160.2	23.3 (1.79 kWh/d)
Ordinary	0	330.7	330.7 (1.83 kWh/d)	352.8	22.1 (1.70 kWh/d)

Compliance with Danish effluent standards

When the treatment systems received wastewater again after 6 months without inflow, both systems (ordinary and energy-saving) complied with the Danish effluent standard from day one: BOD<10 mg/l, COD<70 mg/l, and ammonia-N <5 mg/l.

The inlet concentrations are presented in Figure 4-1, effluent concentrations of COD in Figure 4-2, COD in Figure 4-3 and ammonia-N in Figure 4-4.

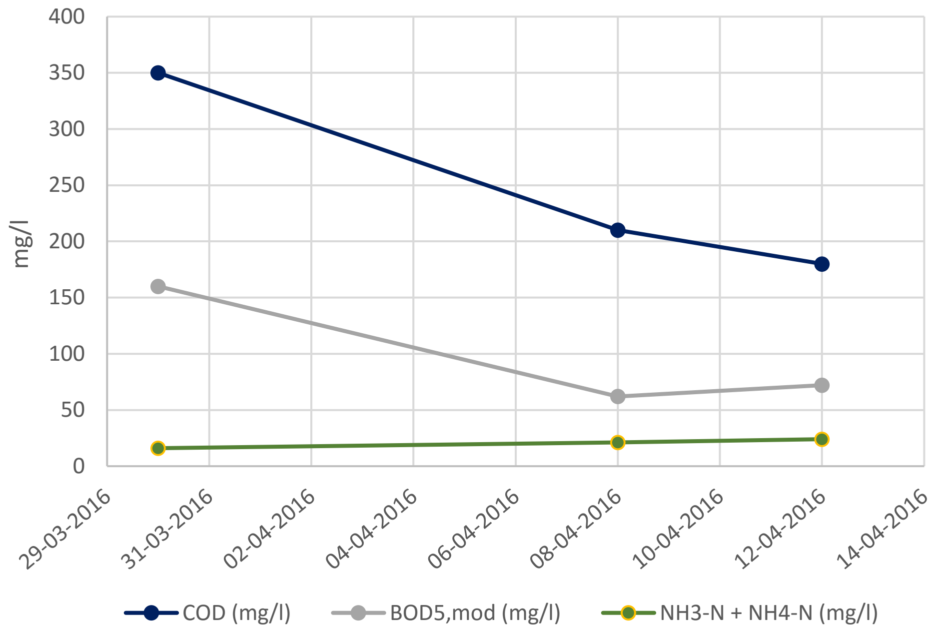


Figure 4-1: Development of inlet concentrations to test systems at Tappernøje WWTP.

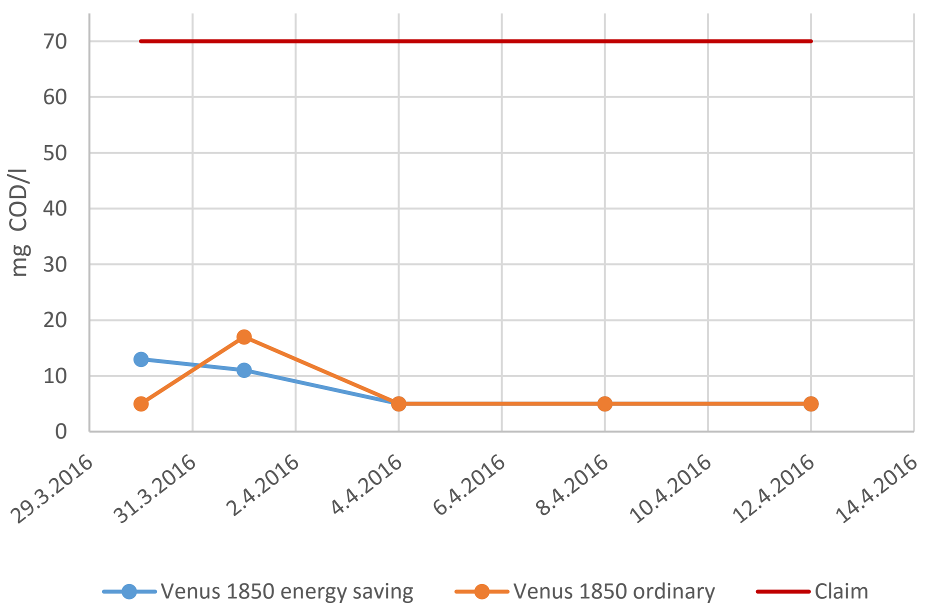


Figure 4-2: Development of COD concentration after restarting two BioKube systems (Venus 1850 ordinary and Venus 1850 energy-saving). When the analysed COD concentration was below the limit of quantification (<10 mg/L) 5 mg/L is marked on the diagram.

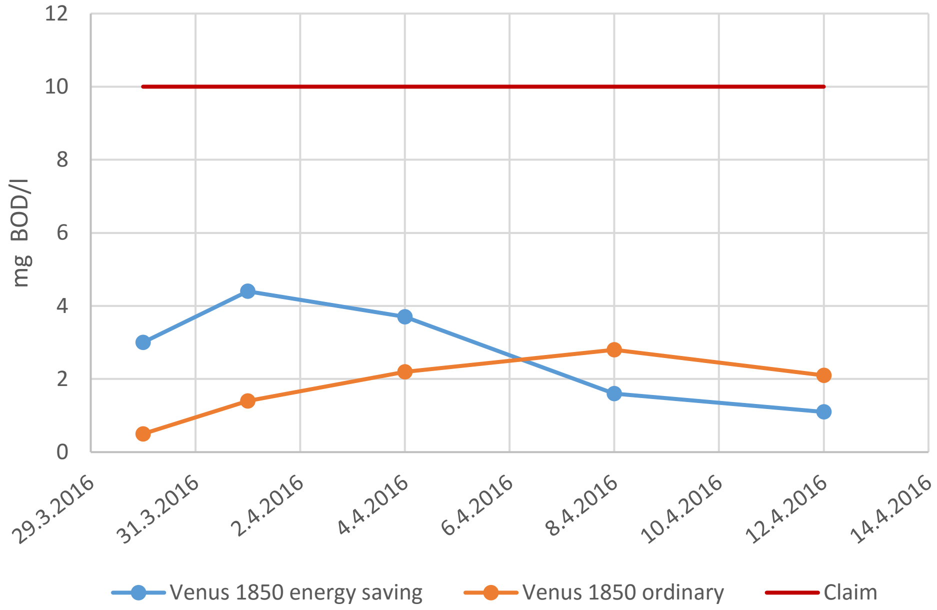


Figure 4-3: Development of effluent BOD concentration after restarting the inflow to two BioKube systems (ordinary and energy-saving).

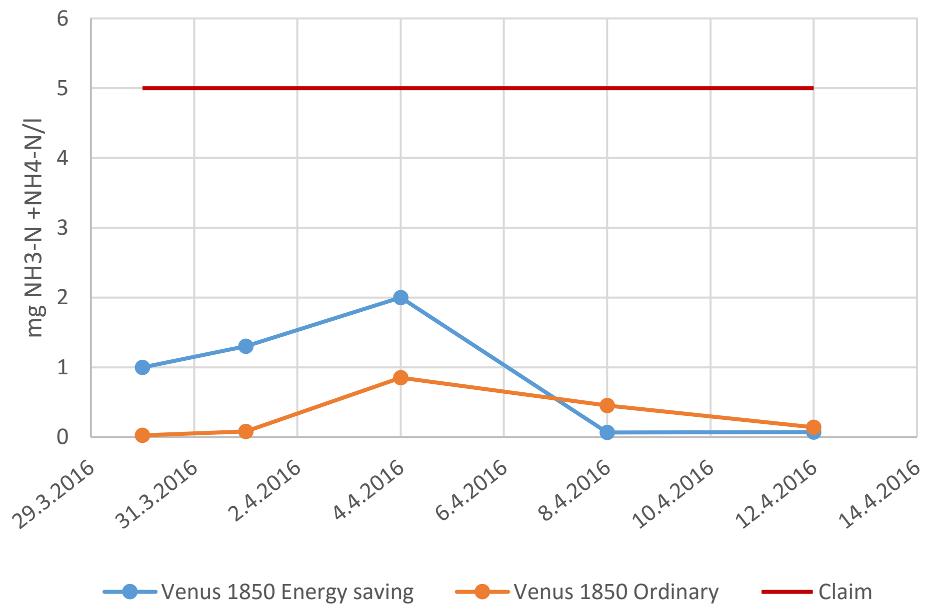


Figure 4-4: Development of effluent NH_3-N + NH_4-N concentration after restarting two BioKube systems (ordinary and energy-saving at Tappernøje WWTP.

The analytical results are for raw wastewater and effluent are presented in Table 4-3.

Table 4-3 Inlet and effluent quality from two treatment systems (ordinary and energy-saving) at Tappernøje WWTP.

Parameter	30-03-2016	30-03-2016	01-04-2016	04-04-2016	08-04-2016	08-04-2016	12-04-2016	12-04-2016
Energy-saving with P removal	**inlet**	**outlet**	**outlet**	**outlet**	**inlet**	**outlet**	**inlet**	**outlet**
COD (mg/l)	350	13	11	<10	210	<10	180	<10
BOD_5,mod (mg/l)	160	3	4.4	3.7	62	1.6	72	1.1
NH_3-N + NH_4-N (mg/l)	16	1.0	1.3	2	21	0.065	24	0.071
Ordinary with P removal	**inlet**	**outlet**	**outlet**	**outlet**	**inlet**	**outlet**	**inlet**	**outlet**
COD (mg/l)	350	<10	17	<10	210	<10	180	<10
BOD_5,mod (mg/l)	160	<1	1.4	2.2	62	2.8	72	2.1
NH_3-N + NH_4-N (mg/l)	16	0.024	0.079	0.85	21	0.45	24	0.14

4.3.2.2 Phosphorous removal with BioKube's phosphorous precipitation unit

The data regarding phosphorous removal was accepted from Certripro's type approval report (see section 3.1). The average concentration of total phosphorous in the raw wastewater was 10.9 mg/l P. The concentration of total phosphorous in the treated wastewater was 0.50 mg/l P, as an average of 20 samples (Appendix 9).

4.3.2.3 Field tests at eight summer cottage installations

The field test began in October 2015 and included four ordinary treatment systems and four energy-saving treatment systems. One treatment system was equipped with phosphorous precipitation. Spot samples were collected from the effluent four times during the test period, which started on 15.12.2015 and ended on 29.03.2016. Sampling and water analysis were performed by the external laboratory. When sampling took place, the electric meters were read.

<u>Energy consumption</u>

During the test period, the four ordinary treatment systems consumed 325 kWh on average (1.81 kWh/d, std.dev. 0.09 kWh/d), while systems with energy-saving technology consumed 113 kWh (0.62 kWh/d, std.dev. 0.17 kWh/d). **This corresponds to a 65% reduction of reduction of electricity consumption.**

The complete dataset with the results for individual treatment systems is presented in the test report (Appendix 7).

<u>Compliance with effluent standards</u>

One of the eight summer cottages (energy-saving) was not occupied at all during the test period. All four sampling occasions from this house were excluded, as there was no effluent. Another summer cottage (ordinary treatment system) was rarely in use until 19.12.2015. Then the house was locked, water disconnected and not used again during the remaining test period. From this house, only the first sampling occasion was included in the evaluation. At a third house, coolant from geothermal heating was discharged to the inlet of the BioKube plant which affected the treatment. COD and BOD from this sampling occasion were therefore removed from the data set. If all the houses and sampling occasions were included, there would have been 100 data points in total.

Based on the samples and parameters (77 data points) included in the evaluation, the existing plants complied with the standard for 87% of the data points (analysed for COD, BOD, ammonia and total P). The number of compliant data points and the total number of data points is shown in Table 4-4. The average concentrations and standard deviation of COD, BOD and NH3-N+NH4-N are also shown. Only one of the eight existing plants at summer cottages had phosphorous precipitation installed.

Table 4-4 Compliance of existing plants with effluent standards. The complete dataset is presented in the test report (Appendix 7).

Parameter	Claim mg/l	Average mg/l	Std.dev. mg/l	Compliant / data points	Data points when 5 PE design load exceeded / no. data points
COD	<70	46	32.3	22 / 24	2 / 24
BOD	<10	3.4	6.2	21 / 24	2 / 24
NH3-N + NH4-N	<5	5.5	13.9	21 / 25	2 / 25
Total P	<1.5	0.84	0.62	3 / 4	1 / 4

The claims for BOD and Total P are <10 mg/l and <1.5 mg/l respectively, and therefore concentrations of 10 mg BOD/l and 1.5 mg Total P/l do not comply. This applied to two data points.

At two summer cottages, the design load of 5 PE was exceeded during Easter holidays (19-28 April 2016), according to the selv-reported usage data. This coincided with five of the ten non-compliant data points. Both of these houses had the energy-saving version of the BioKube installed. For the remaining five non-compliant results (*i.e.* those that could not directly be explained by overloading), the energy-saving versions were not overrepresented (3 non-compliant data points from the ordinary treatment systems, and 2 non-compliant data points from the energy-saving treatment systems).

The complete dataset with the results for individual treatment systems is presented in the test report (Appendix 7).

4.3.3 Additional parameters, with comments or caveats where appropriate

BioKube claims that the reduction of electricity consumption in the systems with energy-saving function is achieved without any additional intervention by operators, compared to an ordinary BioKube system. No intervention by operators was required during the test period.

4.3.3.1 User manual

The verification criterion for the user manual is that the manual should describe the use of the equipment adequately and that it should be comprehensible for the typical user. This criterion was assessed through evaluation of a number of specific points of importance (Table 4-5).

A description is complete if all essential steps are described, if they are illustrated by a figure or a photo - where relevant - and if the descriptions are comprehensible without reference to other guides.

BioKube A/S has provided:

- User manual and advice [8]
- Installation guide for auhorized sewer contractors [9]

The sections *Product, Operation* and *Safety* were evaluated with regard to the user manual, which is meant to be read by the house owners. The section *Preparations* was evaluated with regard to installation by a sewer contractor. It is concluded that the user manual and the installation guide are complete and useful.

Table 4-5 Criteria for evaluation of user manual

Parameter	Complete description	Summary description	No description	Not relevant
Product				
Principle of operation		x		
Intended use	x			
Performance expected		x		
Limitations	x			
Preparations				
Unpacking	x			
Transport	x			
Assembling	x			
Installation	x			
Function test	x			
Operation				
Steps of operation	x			
Points of caution	x			
Accessories				x
Maintenance		x		
Trouble shooting	x			
Safety				
Chemicals	x			
Power		x		

4.3.3.2 Required resources

A list of capital cost items required for the installation of the treatment system and the resources for operation and maintenance are presented in Table 4-6. The information in this section was provided by BioKube.

Table 4-6 List of capital cost items and operation and maintenance cost items per product unit

Item type	Item	Number	None
Capital			
Site preparation	Prepare inlet and outlet pipes and power cable to the BioKube installation site. The cable should be of 5-conductor type, *i.e.* three for grounded 230V power and two for the alarm placed in the house.	1 cable, 2 pipes	
Buildings and land	Pit for BioKube system and sedimentation tank, with foundation	2	
Equipment	BioKube Wastewater System (incl. sedimentation tank)	1	
Utility connections	Power 230 V (grounded)	1	
Installation	By authorized sewage contractor	1–2 days for 1-2 persons	
Start-up/training	No training - the house owner receives a user manual		None
Permits	Building permission from municipality, incl. permission to discharge treated wastewater. Installation often takes place after an order from the municipality to implement wastewater treatment.	1	
Operation and maintenance			
Materials, including chemicals	Coagulant for precipitation of phosphorous, tank filled as part of yearly service. Only for units with phosphorous precipitation.	Once a year	
Utilities, including water and energy	Electric power	See section on power consumption	
Labor	Service	Once a year	
Waste management	2 m^3 septic tank emptied from sludge	Once a year	
Permit compliance	Yearly service check compulsory, incl. effluent analysis	In Denmark, yearly service check is compulsory by law; in other countries it is recommended.	

Resources used during production of the BioKube Summerhouses Wastewater System
Production of the BioKube system is primarily performed by two independent manufacturers in the Czech Republic. There are also local manufacturers in other countries: at present in India and Malaysia.

The mechanical parts like blowers, diffusers and water pumps are delivered by independent specialized manufacturers. Filter material is delivered from a specialized Danish company. The control box is manufactured by a Danish company. The system is delivered by truck to the end user/end location completely finished and ready to be installed.

Longevity of the equipment
The expected longevity of a BioKube wastewater system is 20-40 years. For mechanical parts, the standard warranty period is two years. The expected longevity is based on yearly service and pre-emptive maintenance as part of a service contract. For systems with an active service contract, BioKube offers a 20-year process guarantee that the required outlet demands will be met.

Robustness/vulnerability to changing conditions of use or maintenance
Operation of a BioKube wastewater system requires the user to behave responsibly. Easily biodegradable detergents[4] with eco-label should be used at the correct dose, and no hazardous chemicals should be poured into the toilet and drains. Hydraulic loads that exceed the dimensioned loads (750 litres/day for a 5-PE system) or addition of non-biodegradable chemicals may overload the treatment system and deteriorate the effluent quality. Lack of maintenance may lead to the breakdown of mechanical parts and interrupt the treatment. Lack of emptying the sedimentation tank may also interrupt the treatment.

Reusability, recyclability (fully or in part), End-of-Life decommissioning and disposal
All plastic parts are PP plastic, which can be recycled as reusabel granulate. The few mechanical parts can be reused independently as reconditioned parts or recycled.

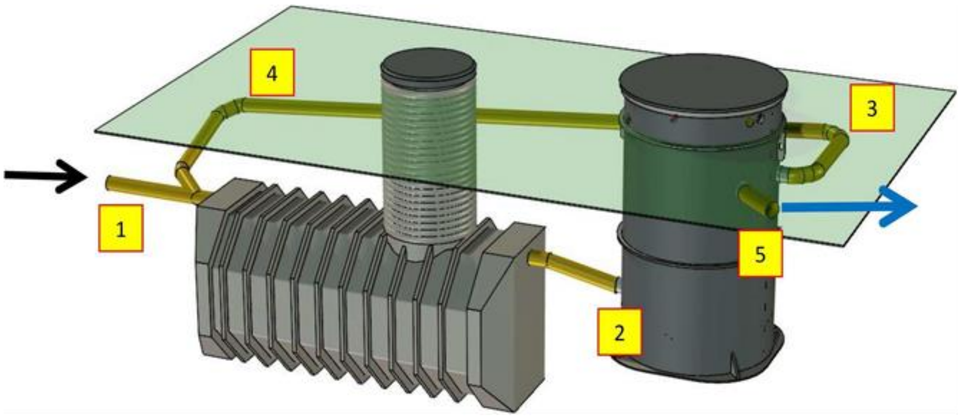
4.4 Recommendation for the Statement of Verification

4.4.1 Technology description

The description of the technology is based on information from BioKube A/S.

The BioKube Summerhouses Wastewater System (hereafter: energy-saving treatment system) is based on a BioKube Venus 1850 wastewater treatment system (hereafter: ordinary treatment system), designed for 5 person-equivalents (PE). The treatment system includes recirculation of treated wastewater to the septic tank, at regular intervals, a feature that should ensure that the wastewater treatment system is functional even after prolonged periods without wastewater inflow. In the version for summer cottages, the Venus 1850 sy4.stem is furthermore equipped with an energy-saving control system, which is reducing aeration and pumping in times without incoming flow. The conceptual design is illustrated in Figure 4-5.

[4] BioKube's user manual refers to the (Scandinavian) Swan label, or EU's "flower" eco-label as examples of suitable detergents.



1. The sedimentation tank is fully integrated in the treatment process
Particles are removed in the septic tank upstream of the biological treatment zones. The large volume of water and the timed backwash of purified oxygen-rich wastewater from the last treatment chamber increase the efficiency of the sedimentation tank and evens out varying loads.
2. Timed inflow from the buffer tank ensures continuous nourishment to the biology (BioKube patent)
Wastewater is pumped into the first treatment chamber in the BioKube every 15 minutes for the full 24 hours day cycle. Biological nourishment is thereby fed continuously to the bacteria and not just in bursts as the wastewater is produced in the house. This also equalizes fluctuations in incoming detergents and other chemicals in the wastewater.
3. Timed backwash to the settling tank removes odours (BioKube patent)
During the treatment process, small air blowers supply oxygen to the bacteria. When the oxygen-rich treated wastewater is recycled to the settling tank every fifteen minutes, this prevents odour from toxic hydrogen sulfide in the settling tank. It provides better living conditions for the bacteria that cleans the wastewater by eliminating toxic hydrogen sulfide from developing in the settling tank.
4. Timed backwash ensures equal input of nutrition for the biology (BioKube patent)
By continuous backwash to the settling tank, it is ensured that nourishment from the settling tank is fed to the bacteria also during holiday periods. BioKube systems are therefore uniquely suitable for holiday homes and vacation hotels with large seasonal fluctuations in the incoming water.

Figure 4-5 Conceptual design of the BioKube Summerhouses Wastewater System: Venus 1850 with energy-saving control system (Provided by BioKube).

4.4.2 Application

4.4.2.1 Matrix

The technology is intended for treatment of household wastewater from summer cottages.

4.4.2.2 Purpose

The purpose is to treat wastewater from summer cottages, reducing in particular Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), ammonium (NH_4) and total phosphorous (P) to below the required values.

4.4.2.3 Conditions of operation and use

BioKube stated that the Summerhouses Wastewater System is functioning also in winter conditions, because the treatment systems is located under ground. No limits are mentioned as for the temperature range in which the system can be used. Operation of a BioKube Wastewater system requires the user to behave responsibly. Only easily biodrgradable detergents should be used (products with eco-label recommended), and no hazardous chemicals should be poured into the toilet and drains. Hydraulic and pollutant loads that exceed the dimensioned loads (750 litres/day for a 5-PE system) or addition of non-biodegradable chemicals may overload the treatment system and deteriorate the effluent quality. The system requires a yearly service check to ensure maintenance of mechanical parts and filling of coagulant, where applicable. Emptying the sedimentation tank is normally done once a year.

4.4.2.4 Verification parameter definition summary

The first claim is the treatment result for the following parameters. It is claimed that the ordinary treatment system (*i.e.* ordinary Venus 1850) and the energy-saving treatment system (*i.e.* the BioKube Summerhouses Wastewater System) comply with the current Danish effluent quality standards[5] immediately, on receiving incoming wastewater again, after a period (of up to 6 months) without influent wastewater:

- Biochemical Oxygen Demand (BOD) < 10 mg/l,
- Chemical Oxygen Demand (COD) < 70 mg/l,
- Ammonium (NH_4) < 5 mg/l,

and for systems having the P precipitation system installed (see section 2.2.3):

- Total phosphorous (P) < 1.5 mg/l.

The second claim is that the use of a flow-switch will enable the energy-saving treatment system to power down parts of the system during periods without influent wastewater (up to 6 months), reducing the electric power consumption for use at summer cottages by at least 50%, compared to the ordinary treatment system.

4.4.3 Test and analysis design

Two separate tests were carried out: Flow controlled tests with municipal wastewater at a Wastewater treatment plant (WWTP), and field tests at eight existing summer cottage installations.

4.4.3.1 Existing and new data

BioKube had the performance of the phosphourous precipitation unit tested as part of the EN 12566-6+A2 type-approval, as documented in the certification report. The average concentration of total phosphorous in the raw wastewater during the test period was 10.9 mg/l P. The concentration of total phosphorous in the treated wastewater was 0.50 mg/l P, as an average of 20 samples. The data is stated in the certification report (Appendix 9). All of the 20 effluent samples had P concentrations below the Danish guideline limit of 1.5 mg/l.

4.4.3.2 Laboratory or field conditions

At Tappernøje WWTP (Denmark), two treatment systems with phosphorous precipitation (one ordinary, the other energy-saving) were operated with a 6-months interruption of inflow during winter season. When the inflow of wastewater to the treatment systems was resumed, the inflow was adjusted to about 750 l/d of raw wastewater (after having passed the coarse screen). Spot samples from the inlet and effluent were taken within two weeks after restart.

At the existing summer cottage installations, the flow and composition of wastewater was not manipulated. Occupation of summer cottages varies a lot, which was also seen in the test. Some of the houses were not occupied at all during the whole test period, others were rented out more or less regularly, while one was occupied continuously. According to the self-reporting schemes, peak loads occurred during Easter holidays. On some of the days, the houses were occupied by more people than the treatment system was designed for.

4.4.3.3 Matrix compositions

The raw wastewater at Tappernøje WWTP was relatively diluted. The average inlet concentration of COD, BOD and ammonia components were below the concentrations recommended in EN 12466. Due to the relatively high flow during the test period (above the

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[5] The legal requirements for small wastewater treatment plants in Denmark are in a transition phase. The national type-approval regulations [5] were withdrawn, effective June 1, 2015 [6]. While new regulations are developed, municipalities still refer to the effluent quality demanded in the in the national type-approval, *i.e.* appendix 3 in [5]

targeted 750 l/d), the pollutant load to the test plants corresponded to the recommended load for some of the sampling occasions.

4.4.3.4 Test and analysis parameters

The following tests parameters were investigated (Table 4-7).

Table 4-7 Test and analysis parameters overview

Wastewater parameters	Operational parameters
BOD COD	Flow of raw wastewater to the BioKube treatment systems at the WWTP
NH3-N + NH4-N Total P	**Environmental parameters** Power consumption

4.4.3.5 Test and analysis methods summary

Analyses were performed at the external laboratory. The choice of methods for each parameter is summarised in the section below.

4.4.3.6 Parameters measured

Table 4-8 gives an overview of the parameters analysed by an external laboratory. The two BioKube plants siturated at the WWTP received the the same wastewater.

Table 4-8 Overview of parameters analysed and sampling points

Parameter	Method	WWTP BioKube Inlet	WWTP BioKube Outlet	Field Bio-Kube Outlet
Biochemical Oxygen Demand (BOD)	Reflab method 2:2002	One sampling point	Two plants	Eight plants
Chemical Oxygen Demand (COD)	DS/ISO 15705:2006	One sampling point	Two plants	Eight plants
NH3-N + NH4-N	EN/ISO 11732, modified	One sampling point	Two plants	Eight plants
Total P	DS/EN ISO 6878:2004	-	-	One plant

4.4.4 Verification results

4.4.4.1 Performance parameters

Flow-controlled tests at WWTP - Compliance with effluent standards

When the treatment systems received wastewater again after 6 months without inflow, both systems (ordinary and energy-saving) complied with the Danish effluent standard from day one: BOD<10 mg/l, COD<70 mg/l, and ammonia-N <5 mg/l. Claim no. 1 regarding the effluent quality was therefore verified by the flow-controlled tests at the WWTP.

The inlet concentrations are presented in Figure 4-6, effluent concentrations of COD inFigure 4-7, COD in Figure 4-8 and ammonia-N in Figure 4-9.

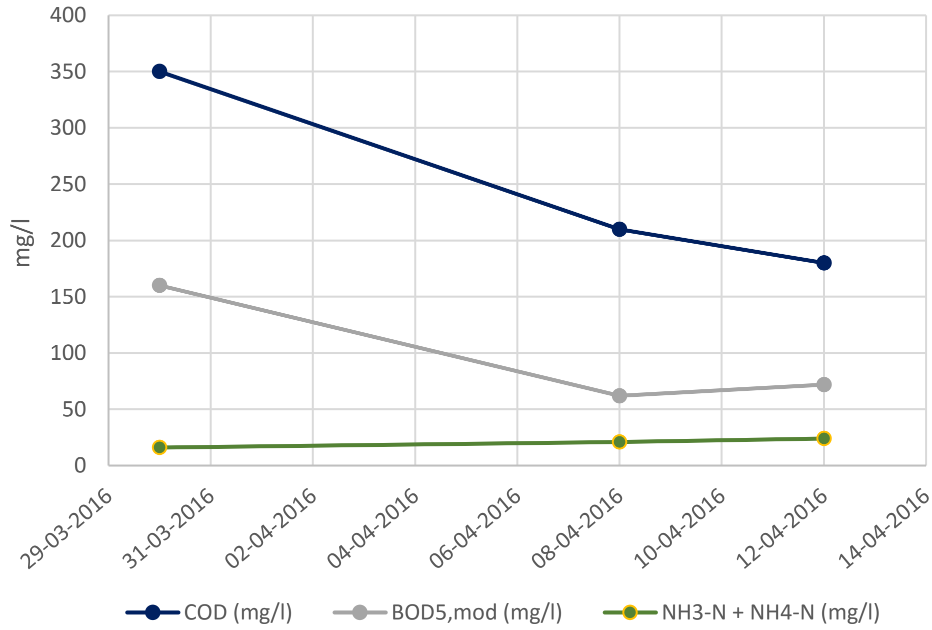

Figure 4-6: Development of inlet concentrations to test systems at Tappernøje WWTP.

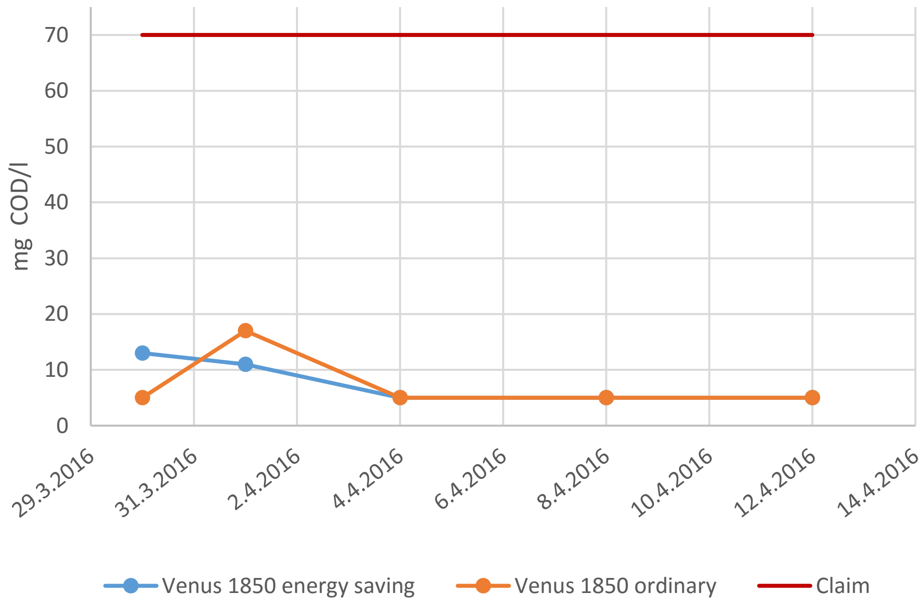

Figure 4-7: Development of effluent COD concentration after restarting the inflow to two BioKube systems (ordinary and energy-saving).

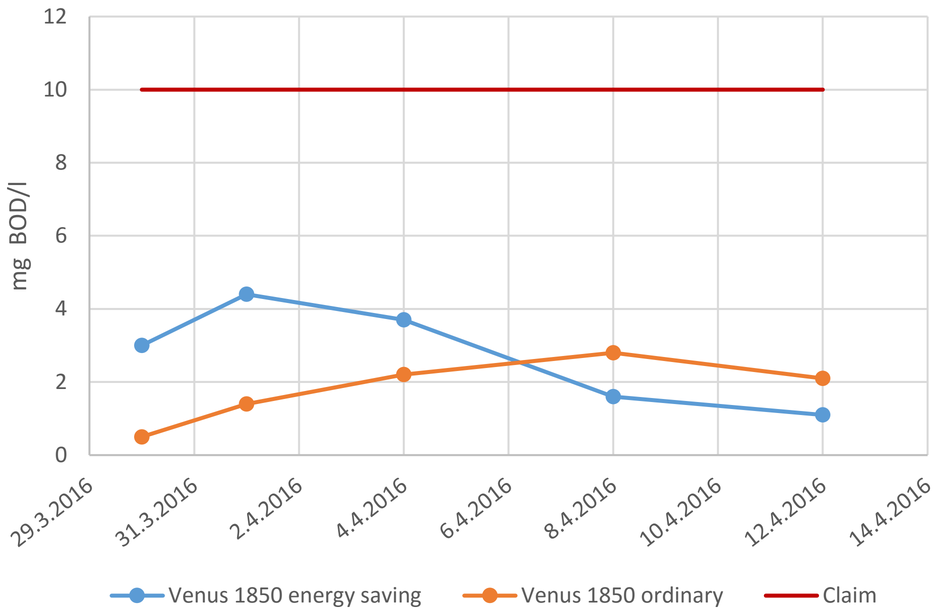

Figure 4-8: Development of effluent BOD concentration after restarting the inflow to two BioKube systems (ordinary and energy-saving).

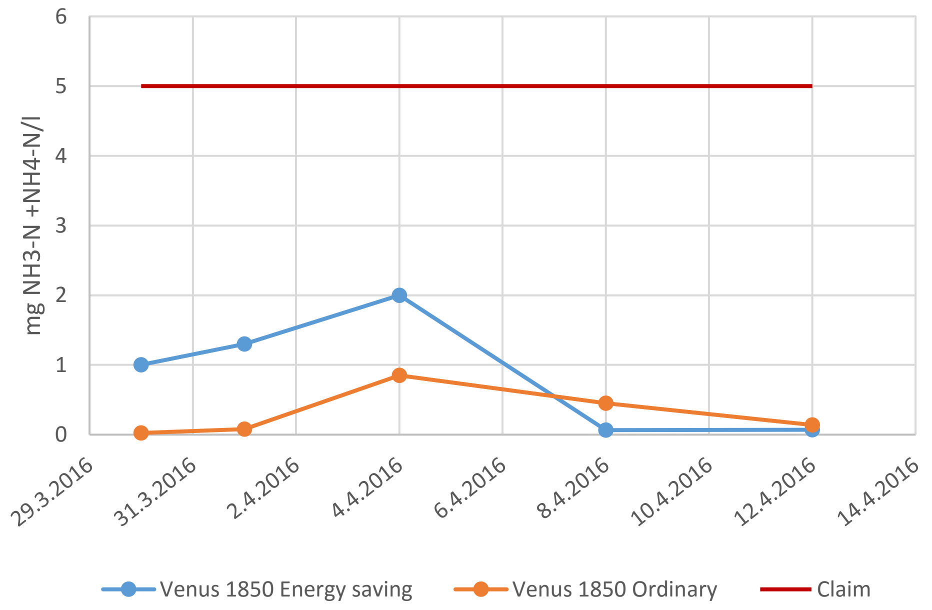

Figure 4-9: Development of effluent NH3-N + NH4-N concentration after restarting two BioKube systems (ordinary and energy-saving at Tappernøje WWTP.

The analytical results are for raw wastewater and effluent are presented in Table 4-9.

Table 4-9 Inlet and effluent quality from two treatment systems (ordinary and energy-saving) at Tappernøje WWTP.

Parameter	30-03-2016	30-03-2016	01-04-2016	04-04-2016	08-04-2016	08-04-2016	12-04-2016	12-04-2016
Energy-saving with P removal	**inlet**	**outlet**	**outlet**	**outlet**	**inlet**	**outlet**	**inlet**	**outlet**
COD (mg/l)	350	13	11	<10	210	<10	180	<10
BOD (mg/l)	160	3	4.4	3.7	62	1.6	72	1.1
NH_3-N + NH_4-N (mg/l)	16	1.0	1.3	2	21	0.065	24	0.071
Ordinary with P removal	**inlet**	**outlet**	**outlet**	**outlet**	**inlet**	**outlet**	**inlet**	**outlet**
COD (mg/l)	350	<10	17	<10	210	<10	180	<10
BOD (mg/l)	160	<1	1.4	2.2	62	2.8	72	2.1
NH_3-N + NH_4-N (mg/l)	16	0.024	0.079	0.85	21	0.45	24	0.14

<u>Flow-controlled tests at WWTP - Energy consumption</u>

During the dormant period without inflow of wastewater, the ordinary treatment system consumed 1.83 kWh/d, while the energy-saving treatment system consumed 0.76 kWh/d. **This corresponds to a 59% reduction of electricity consumption. Claim no. 2 regarding the energy-saving was therefore verified by the flow-controlled tests at the WWTP.** When the plants received wastewater again, their electricity consumption was similar (Table 4-10).

Table 4-10 Energy consumption (kWh) by the energy-saving and ordinary treatment systems at Tappernøje WWTP during the dormant and active phases of the test period.

Treatment system	Dormant period (181 days)	Active period (13 days)
Energy-saving	0.76 kWh/d	1.79 kWh/d
Ordinary	1.83 kWh/d	1.70 kWh/d

<u>Field tests at eight summer cottage installations - Compliance with effluent standards</u>

Based on the samples and parameters (77 data points) included in the evaluation, the existing plants complied with the standards for 87% of the data points. The number of compliant data points and the total number of data points are shown in Table 4-11**Error! Reference source not found.**. The average concentrations and standard deviation of COD, BOD and NH3-N+NH4-N are presented. Only one of the eight existing plants at summer cottages had phosphorous precipitation installed.

Table 4-11 Compliance of existing plants with effluent standards

Parameter	Claim mg/l	Average mg/l	Std.dev. mg/l	Compliant / data points	Data points when 5 PE design load exceeded / no. data points
COD	<70	46	32.3	22 / 24	2 / 24
BOD	<10	3.4	6.2	21 / 24	2 / 24
NH3-N + NH4-N	<5	5.5	13.9	21 / 25	2 / 25
Total P	<1.5	0.84	0.62	3 / 4	1 / 4

At two summer cottages, the design load of 5 PE was exceeded during Easter, according to the selv-reported usage data. This coincided with five of the ten non-compliant data points. Both of these houses had the energy-saving treatment system installed. For the remaining five non-compliant results, the energy-saving versions were not overrepresented. There were 3 non-compliant data points from the ordinary treatment systems, and 2 non-compliant data points from the energy-saving treatment systems.

Further details are explained in the Verification Report. The complete dataset with the results for individual treatment systems is presented in the Test Report.

<u>Field tests at eight summer cottage installations - Energy consumption</u>

During the test period, the four ordinary treatment systems consumed 325 kWh on average (1.81 kWh/d, std.dev. 0.09 kWh/d), while systems with energy-saving technology consumed 113 kWh (0.62 kWh/d, std.dev. 0.17 kWh/d). **This corresponds to a 65% reduction of**

reduction of electricity consumption. Claim no. 2 regarding the energy-saving was therefore verified by the field tests.

4.4.4.2 Operational parameters

Operational conditions during the tests are reported in the Test Report.

4.4.4.3 Environmental parameters

The main environmental parameters are effluent quality and energy consumption. These are reported as performance parameters.

4.4.4.4 Additional parameters

The user manual and the installation guide for sewer contractors were considered sufficient. No critical issues were identified with regard to use of resources.

4.4.5 Additional information

The treatment system depends on the function of electrical and mechanical parts and therefore requires yearly maintenance. The sedimentation tanks needs to be emptied, usually once a year.

4.4.6 Quality assurance and deviations

The verification was carried out according to the Quality Assurance Plan described in the verification protocol. During testing, internal and external audits were carried out by DHI and ETA Danmark, respectively. There were two deviations to the specific verification protocol and test plan:

1. The specific verification protocol postulated logging of the points in time, when the flow-switch was activated in the existing treatment systems used for the field test. This was not possible, since there was no logging capability in BioKube's treatment systems. Therefore, the successful operation of the energy-saving function was evaluated based on the measured energy consumption, combined with the users' self-reporting forms.

2. The specific verification protocol expected measurement of total phosphorous (total P) in the effluent from all BioKube plants with phosphorous precipitation. Due to an oversight made by the test body, phosphorous in the influent and effluent to/from the systems situated at the WWTP plants was not analysed by the external laboratory. Data from an identical phosphorous precipitation unit for the type-approval test (certification) of a BioKube plant was accepted for the verification.

None of two deviations were considered to have significant impact on the verification.

5 Quality assurance

The staff and the experts responsible for quality assurance as well as the different quality assurance tasks can be seen in Table 5-1. The reviews were prepared using the DANETV review report template. An audit of the test was performed by the DANETV verification body.

Table 5-1 QA plan for the verification

	Internal expert	Verification body		Proposer	External experts
Initials	BOP	GHE	PF	BioKube	HRAN
Tasks					
Specific verification protocol	Review			Review and approval	Review
Test plan		Review	Approval	Review and approval	
Test system at test site			Audit		
Test report		Review		Review	
Verification report	Review			Review	Review
Statement of Verification				Acceptance	Review

An internal review was conducted by Bodil Mose Pedersen (BOP) from DANETV, and a test system audit following general audit procedures was conducted by certified auditor, Peter Fritzel (PF). An external review was performed by Henrik Rasmus Andersen (HRAN), DTU.

The verification body reviewed and approved the test plan and reviewed the test report. The review was performed by Gerald Heinicke (GHE), while the approval was given by Peter Fritzel (PF).

6 References

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5. Guidance document on type-approval of small decentralised wastewater treatment plants (*Vejledning om typegodkendelsesordning for minirenseanlæg*, in Danish). VEJ nr. 11057 af 01/07/1999

6. Bekendtgørelse om ophævelse af bekendtgørelse om typegodkendelsesordning for mini-renseanlæg. BEK nr. 696 af 22/05/2015

7. EN 12566-3: Small wastewater treatment systems for up to 50 PT - Part 3: Packaged and/or site assembled domestic wastewater treatment plants

8. BioKube user manual (*BioKube biologiske minirenseanlæg - Brugerhåndbog og gode råd*, in Danish). Undated document, retrieved 2015.02.10 from www.biokube.dk

9. BioKube installation guide for authorised sewer contractors (*BioKube-venus-1850-installationsvejledning*, in Danish). Dated June 2015 , retrieved 2016.09.21 from www.biokube.dk

A P P E N D I C E S

APPENDIX 1

Terms and definitions

The terms and definitions used by the verification body are derived from the EU ETV GVP, ISO 9001 and ISO 17020.

Term	DANETV	Comments on the DANETV approach
Accreditation	Meaning as assigned to it by Regulation (EC) No 765/2008	EC No 765/2008 is on setting out the requirements for accreditation and market surveillance relating to the marketing of products
Additional parameter	Other effects that will be described but are considered secondary	None
Amendment	Is a change to a specific verification protocol or a test plan done before the verification or test step is performed	None
Application	The use of a product specified with respect to matrix, purpose (target and effect) and limitations	The application must be defined with a precision that allows the user of a product verification to judge whether his needs are comparable to the verification conditions
DANETV	Danish centre for verification of environmental technologies	None
Deviation	Is a change to a specific verification protocol or a test plan done during the verification or test step performance	None
Evaluation	Evaluation of test data for a technology product for performance and data quality	None
Experts	Independent persons qualified on a technology in verification	These experts may be technical experts, QA experts for other ETV systems or regulatory experts
General verification protocol (GVP)	Description of the principles and general procedure to be followed by the EU ETV pilot programme when verifying an individual environmental technology.	None
Matrix	The type of material that the technology is intended for	Matrices could be soil, drinking water, ground water, degreasing bath, exhaust gas condensate etc.
Operational parameter	Measurable parameters that define the application and the verification and test conditions. Operational parameters could be production capacity, concentrations of non-target compounds in matrix etc.	None
PE (population equivalent or person equivalent)	Wastewater load (volume and constituents) equivalent to one person.	The volume from 1 PE is assumed to be 150 litres/day.

Term	DANETV	Comments on the DANETV approach
Performance parameters	A set of quantified technical specifications representative of the technical performance and potential environmental impacts of a technology in a specified application and under specified conditions of testing or use (operational parameters).	The performance parameters must be established considering the application(s) of the product, the requirements of society (legislative regulations), customers (needs) and proposer initial performance claims
Procedure	Detailed description of the use of a standard or a method within one body	The procedure specifies implementation of a standard or a method in terms of e.g.: equipment used
Proposer	Any legal entity, which can be the technology manufacturer or an authorised representative of the technology manufacturer. If the technology manufacturer concerned agrees, the proposer can be another stakeholder undertaking a specific verification programme involving several technologies.	Can be vendor or producer
Purpose	The measurable property that is affected by the product and how it is affected.	The purpose could be reduction of nitrate concentration, separation of volatile organic compounds, reduction of energy use (MW/kg) etc.
(Specific) verification protocol	Protocol describing the specific verification of a technology as developed applying the principles and procedures of the EU GVP and the quality manual of the verification body.	None
Standard	Generic document established by consensus and approved by a recognised standardization body that provides rules, guidelines or characteristics for tests or analysis	None
Summer cottages	House of cottage that is used mainly during the summer, and that may be uninhabited for several weeks or months.	In Danmark, many of these dwellings are quite large and designated as summer cottages, *i.e. sommerhus.*
Test/testing	Determination of the performance of a product for measurement/parameters defined for the application	None
Test performance audit	Quantitative evaluation of a measurement system as used in a specific test.	E.g. evaluation of laboratory control data for relevant period (precision under repeatability conditions, trueness), evaluation of data from laboratory participation in proficiency test and control of calibration of online measurement devises.

Term	DANETV	Comments on the DANETV approach
Test system audit	Qualitative on-site evaluation of test, sampling and/or measurement systems associated with a specific test.	E.g. evaluation of the testing done against the requirements of the specific verification protocol, the test plan and the quality manual of the test body.
Test system control	Control of the test system as used in a specific test.	E.g. test of stock solutions, evaluation of stability of operational and/or on-line analytical equipment, test of blanks and reference technology tests.
Verification	Provision of objective evidence that the technical design of a given environmental technology ensures the fulfilment of a given performance claim in a specified application, taking any measurement uncertainty and relevant assumptions into consideration.	None

APPENDIX 2

Quick Scan

APPENDIX 3

Proposal

APPENDIX 4

Specific verification protocol

APPENDIX 5

Amendment and deviation report for verification

APPENDIX 6

Test Plan

APPENDIX 7

Test Report

APPENDIX 8

Test system assessment report

APPENDIX 9

CertiPro report Initial type test ”Treatment efficiency”

Initial type test ”Treatment efficiency” in accordance with CEN 12566-6+A2 Small wastewater treatment systems for up to 50 PT Part 6: Prefabricate treatment units for septic tank effluent. Range/model “Pluto” of BioKube. Report dated 10.06.2016. BES/N9902/PP/pp/16010. CertiPro, Certification and testing department of Vito, Boeretang 200, B-2400 Mol, Belgium.

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