

# MIDTERM OUTPUT REPORT – PILOT B IN ESTONIA

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## **1. Technical report**

The technical report will deal with all aspects of on-site testing and the research on biogas potential of the different substrates used in the corresponding testing period. For detailed information on Pilot B operation see output report O.4.2.

### **1.1 Introduction, description of roadmap for report**

First of all a short description will be given concerning the developed scenarios for Estonian case. Afterwards the issues of location, transportation and plant setup of Pilot B will be described.

#### **1.1.1 Scenarios for Estonian case study**

The use of cow manure as single substrate was the main scenario for the Estonian operation period. For the last twelve days of operation, minor amounts (0.7 – 2.1 % of total feeding amount) of silage have been added.

#### **1.1.2 Location**

During ABOVE project application process, the Estonian partners were looking for potential interested partners. A main focus was set on the area of Central Estonia, where most of the agricultural used territories are situated. Karli Farm OÜ was the only farm with interest to participate in the ABOVE project as Associated Partner.

(Lõõnik, 2014)

The plant was set up on a big farm (Kaarli Farm OÜ, 44212, Kaarli, Estonia) (see Figure 1) next to the city of Rakvere.

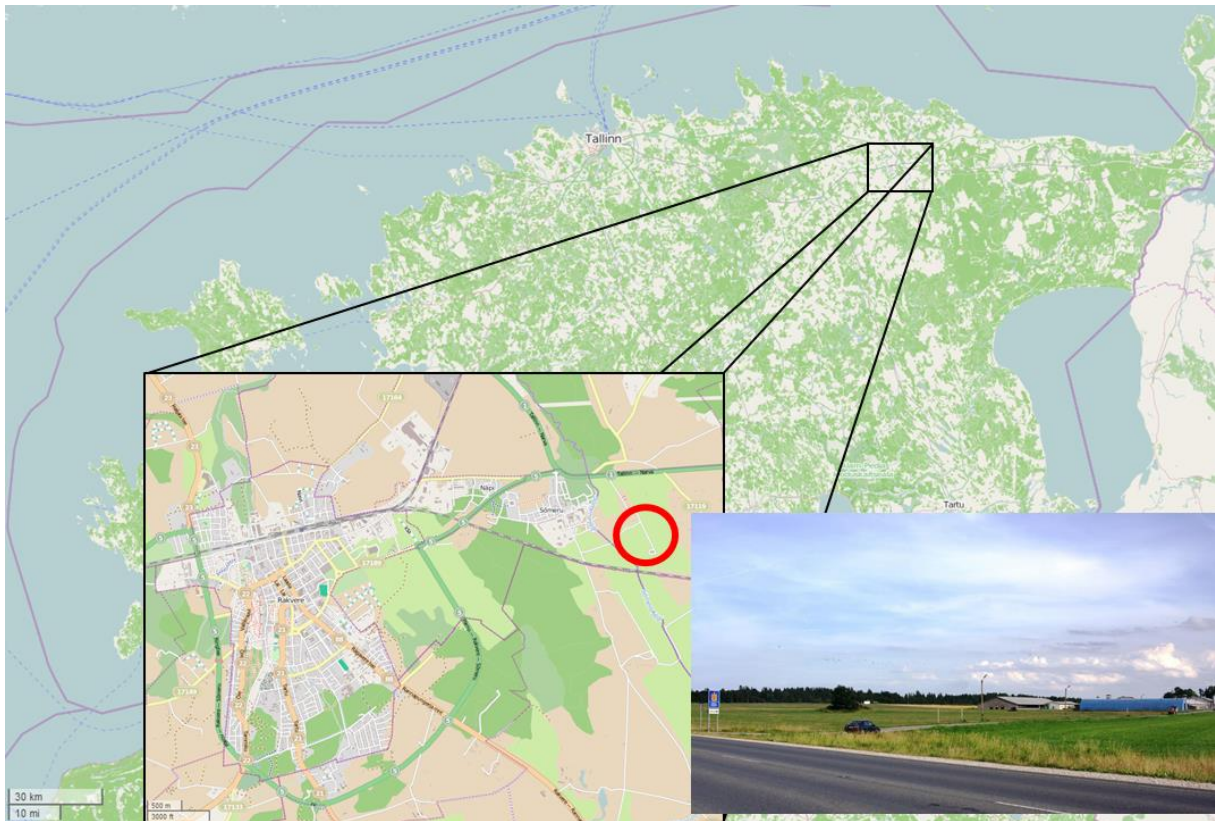


Figure 1: Pilot B location in Estonia

The farm itself owns approx. 1500 cows whose manure currently is stored in one big lagoon (see Figure 2) and one big concrete storage tank.





Figure 2: One of Karlii Farm OÜs manure storage lagoons

The inoculum as well as most of the daily fed substrate was taken from the slurry pit as seen in Figure 3.



Figure 3: Slurry pit at Karlii Farm OÜ



### 1.1.3 Transportation

The lesson learned from the previous transport to Lithuania was to use a trailer without truck superstructure. This made the loading procedure much easier, see figure 4, which shows pilot B during loading procedure in Lithuania.



Figure 4: Loading of the container in Lithuania for the transportation to Estonia.

Sanitation of the equipment was performed by heating the cleaned fermenter with water at a temperature of 60°C for at least 24 h. Inner surfaces have been sanitized with a surface disinfectant. These preparation steps were done due to consultancy by Estonian partners. During transportation and crossing of borders no problems or obstacles occurred. Unloading and installation of pilot B in Estonia went well without any problem, see figure 5.





Figure 5: Unloading of Pilot B at Karlii Farm OÜ

### 1.1.4 Positioning

Metal wire strengthened rubber mats have been positioned under the corners of the container in order to get a bigger supporting surface. The container was already levelled afterwards, so that no further levelling was necessary, see figure 6.



Figure 6: Levelling of the container with rubber mats.

### 1.1.5 Electrical connection

Via two 30 m cables, the container had to be connected to the local electricity grid, figure 7.



Figure 7: Connecting the pilot plant to the local electricity grid.

### 1.1.6 Check-up

After setting up the equipment, an inventory check was performed to make sure everything (lab equipment, additional tools, etc.) was in its place (see also output report O.4.3.). As no major damages occurred during the Lithuanian operating period, no repair work was necessary.

### 1.1.7 Pilot B process technology

The operators' manual for Pilot B is part of output report O.4.2. It contains:

- General plant description
- Equipment description
- Program description
- Work instructions for Pilot B
- Troubleshooting advices

## 1.2 Materials and methods

This chapter has not been updated. Since no sample could be sent from Estonia, no batch or continuous test could be performed in Ostfalia laboratory. The original content can be found in output report O.4.3. In behalf of report authors the missing correlation to lab experiments causes no problems regarding reliability of results, because manure is well known as a good substrate for biogas production.

### 1.2.1 Batch tests

No batch tests have been performed during the Estonian operating period. For detailed information of batch test operation see output report O.4.3.

### 1.2.2 Continuous tests

No continuous tests have been performed during the Estonian operating period. For detailed information of continuous test operation see output report O.4.3.

## **1.3 Definition of general regional challenges regarding technical implementation of biogas technology**

### **1.3.1 Transfer of knowledge concerning biogas technology**

As there are already existing biogas plants in Estonia and as well in the region around Kaarli Farm OÜ, the biogas process is well known in Estonia. One big issue is the way how to treat the digestate. At the moment the digestate is not commonly accepted as a good quality fertilizer. This is a problem for plant operators, as they have problems to get rid of their digestate (also see chapter 1.4 . (Asadov, 2013)

### **1.3.2 Estonian testing period substrates**

The main substrate during the Estonian testing period was cow manure gathered from the slurry pit as seen in Figure 3. Due to rain water flowing into this pit the dry matter content of the material varied a lot. Some results of lab analysis made by the Estonian Agricultural Research Centre (Põllumajandusuuringute Keskuse) can be found in the Appendix (see 4.1 ). For the last 3 weeks of operation minor amounts of corn silage have been added as a substrate (0.7 – 2.1% of the overall daily feeding amount).

## **1.4 Regional feedback regarding pilot plant operation**

In the nearby region of the plant site, several farms and possible producers of raw material for biogas production are situated. Besides agricultural waste, also companies producing food could be possible suppliers for biogas substrates.

Stakeholders from this sector, and also local waste management and biogas plant operators had been invited to the stakeholder events.

As a feedback, the waste management plant was mainly interested in the use of waste water sludge for biogas production whilst the biogas plant operator was interested in lab-test to enhance the process of his plant.

One main issue (as mentioned in chapter 1.3.1 ) is the handling and utilization of the digestate. The prevailing opinion is that the fertilizing qualities of the digestate are worse than the original manure. In case of a lower share of lower nutrient content this would cause additional costs for the farmers to fertilize their fields with digestate. A solution for this could be to dewater either the digestate after fermentation of the manure before fermentation.

Another idea is to use the self-produced biogas to substitute liquid fuels for heating the farm. So the challenge is to find a profitable combination of fertilizing and heating needs.

(Lõõnik, 2014)



## 1.5 Timeline of the Lithuanian operating period

Table 1 gives an overview over mentionable events during the Estonian operating period. Major events will be described below.

Table 1: Timetable of mentionable events during the Lithuanian operating period.

Date	Event
18.10.2013	Initial filling of the fermenter with approx. 550 liters of cow manure
from 29.10.2013	Forming of floating layer consisting mainly of straw
01.12.2013	Thunderstorm causing shutdown of the plant
17.12.2013	Stakeholder event in Rakvere with visit to the plant site
16.01.2014	Stirrer 3 starting to leak
07.04.2014	Check-up, boxing of material and disconnection of the plant
08.04.2014	Loading and transport to Sweden

In the following a more detailed description of some of the major events (see Table 1) will be given.

### 18.10.2014: Initial filling of the fermenter with approx. 550 litres of cow manure



Figure 8: Initial filling of the fermenter. Pumping from the slurry pit, Filling with manure pump, Filled fermenter (left to right).

For initial startup the fermenter has been filled via a manure pump with material from Karlii Farm OÜs manure pit, see figure 8.

**From 29.10.2014: Forming of floating layer consisting mainly of straw**



Figure 9: Floating layer forming in the fermenter contents surface.

Because of the low dry matter content of the manure, leftovers from grass and straw started forming a floating layer (see Figure 9). This layer could have caused problems for the gas to pass over to the gaseous phase. To avoid this, the filling level has been lowered so far that the stirrers reached out of the liquid phase. Result of this was a reduction of the thickness of the floating layer and a better gas transfer to the gaseous phase.

**01.12.2013: Thunderstorm causing shutdown of the plant**

Similar to events in Lithuania (see O.4.3) a thunderstorm caused a shutdown of the plant due to electrical problems. Due to this event happening on a Sunday, the emergency batteries for the computer could not compensate this time span. The only implication of this event was a cooling down of the fermenter content of about 10 K.

After restarting the system, the temperature went back to the set point temperature of 55°C.

**17.12.2013: Stakeholder event in Rakvere with visit to the plant site**



Figure 10: Stakeholder event in Rakvere with visit to the plant site.

To allow stakeholders to get a more detailed view on the technologies and possibilities of Pilot B a visit was organized as part of the stakeholder event in Rakvere, figure 10.

**16.01.2014: Stirrer 3 starting to leak**



Figure 11: Leaking stirrer No. 3.

During operation in Estonia Stirrer No.3 started to leak (see Figure 11). As the level of the stirrers is underneath the gaseous phase, no gas can leave the system via this leak. Experiences from the past show, that these minor leakages do not cause any problems. The self-drying of leaking material outside of the gasket led to a self-sealing effect.



**07.04.2014: Check-up, boxing of material and disconnection of the plant**



Figure 12: Broken stirrer paddle in pilot B

During check-up it turned out that a paddle of the first stirrer was broken during the Estonian operating period, see figure 12. Due to unavailable equipment to weld stainless steel, the stirrer has not been repaired for the Swedish operating period.

**08.04.2014: Loading and transport to Sweden**



Figure 13: Pilot B on its way to Sweden.

Before the transport the fermenter had been cleaned and sanitized. A crane for loading the pilot plant in Estonia had to be organized by the Estonian partners. The logistics company to ship the container to Sweden was Hellmann East Europe GmbH & Co. KG again, so transportation went well without any problems, figure 13.



## 1.6 Conclusion of testing period regarding envisaged roadmap

In Table 2 you can see an overview of the main performance data of Pilot B during the Estonian operating period.

Table 2: Overall data for Pilot B operating period in Lithuania

Overall mass manure	2606 kg
Overall mass silage	4,3 kg
Overall volume of produced biogas	54,103 Nm <sup>3</sup>
Overall volume of methane	30,78 Nm <sup>3</sup>
Resulting average methane concentration	56,9 %
Resulting methane volume per Mg fresh substrate	11.8 Nm <sup>3</sup> /Mg(FM)
Fermenter temperature	55°C
Overall electricity consumption	3778 kWh
Total plant runtime	approx. 21 weeks

## 1.7 Technological up-scaling to implementation scenarios “farm scale” and “large scale”

Referring to the data given in Table 2 the following calculations will show the dimensions of a 100 kW electrical power farm scale plant. These calculations have been made on the basis of Pilot B data from the Estonian operating period. Financial calculations for a similar plant can be found in chapter 2.3 . These calculations are based on analytical results from the Lithuanian operating period.

Table 3: Assumptions made regarding up-scaling calculations.

Full load operating time CHP unit	8,760 h/a (7,900 – 8,200 h/a realistic)
Electric efficiency CHP unit	40% (100 kW)
Energy content methane	9.97 kWh/m <sup>3</sup>
Organic loading rate fermenter	3 kg(oDM)/m <sup>3</sup> *d

The following calculation gives an example for plant design calculations for a farm size plant (100 kW CHP unit) operated with manure as the only substrate.

From the assumed operating time of the CHP unit and its power, the overall power can be calculated:

$$W_{overall} = P_{CHP} * t_{runtime,CHP} = 100 \text{ kW} * 8,760 \frac{h}{a} = 876,000 \frac{kWh}{a}$$

With the efficiency of the CHP unit, the true energy demand (from the biogas) can be calculated:

$$W_{biogas,demanded} = \frac{W_{overall}}{\eta_{CHP}} = \frac{876,000 \text{ kWh}}{0.4a} = 2,190,000 \frac{kWh}{a}$$

With the energy content of the methane the corresponding methane volume can now be calculated:

$$V_{methane} = \frac{W_{biogas,demanded}}{W_{CH4}} = \frac{2,190,000 \text{ kWh } m^3}{9.97 \text{ kWh } a} = 219,659 \frac{m^3}{a}$$

The estimated methane productivity of manure makes it possible to calculate the necessary manure amount:

$$m_{manure} = \frac{V_{CH_4}}{Productivity_{CH_4,per\ substrate}} = \frac{219,659\ m^3\ Mg(FM)}{11.81\ m^3/a} = 18,600\ \frac{Mg}{a}$$

The assumed organic loading rate of 3 kg (oDM)/m<sup>3</sup>\*d for the fermenter, as well as the organic dry matter content of the substrate allows calculating the necessary fermenter volume:

$$V_{fermenter} = \frac{m_{manure} * w_{oDM}}{oLR * 365\ d} = \frac{18,600\ Mg * 0.1066\ m^3 * d * 1,000\ kg\ a}{3\ kg(oDM) * 365\ d\ a\ Mg} = 1,810\ m^3$$

Calculation of the remaining residues after fermentation can be done with the density of CO<sub>2</sub> and CH<sub>4</sub>. This will give the mass of the produced biogas. The amount of water leaving the process is calculated via the partial pressure of water steam (157,37 mbar at 55°C) in the gaseous phase (55°C, 1013,25 mbar) and the density of dry steam (0.768 g/l at 1013,25 mbar and 0°C).

$$m_{residues} = m_{substrate,input} - (V_{CH_4} * \rho_{CH_4} + V_{CO_2} * \rho_{CO_2} + \frac{p_{H_2O}}{p_{amb}} * \frac{V_{CH_4}}{\varphi_{CH_4}} * \rho_{steam})$$

$$m_{residues} = 18,600\ Mg - \frac{(219,659\ m^3 * 0,7168\ \frac{kg}{m^3} + [\frac{219,659}{57\%} - 219,659\ m^3 * 1,9769\ \frac{kg}{m^3}] + \frac{157,37\ mbar}{1013,25\ mbar} * \frac{219,659\ m^3}{57\%} * 0,768\ \frac{kg}{m^3})\ Mg}{1000\ kg} = 18,100\ Mg$$

Table 4 summarizes the calculations given above. This would be the necessary plant size for a farm based, manure operated biogas plant with a 10 kW CHP unit (electric power).

Table 4: Manure only; 100kW CHP unit

Estimated methane production manure	11.81Nm <sup>3</sup> /Mg(FM)
Average methane content	57 %
Organic dry matter content manure	10.66 % <sup>1</sup>
Resulting energy demand	876,000 kWh
Resulting methane volume	219,659 m <sup>3</sup> /a
Resulting annual feeding amount	18,600 Mg/a
Remaining residues after fermentation	18,100 Mg
Resulting fermenter volume	1810 m <sup>3</sup>

The necessary fermenter size is very big. This results from the low dry matter content of the manure used. This leads to a low biogas yield as well. Both of the factors result in the big fermenter size necessary to be able to produce the required biogas amount for the 100 kW CHP unit.

To solve this problem a dewatering of the substrate would be a possible solution. This would result in a smaller fermenter size (with a “real” dry digestion with dry matter content of ~25%) as well as in a reduced amount of digestate. The lower amount of digestate would then

<sup>1</sup> Based on results from Lithuanian operating period (see O.4.3)

result in less material to fertilize the fields (see also chapter 1.4 . Due to the still existing liquid phase, it could be a possible strategy to utilize it in a separate fixed bed reactor.

## **1.8 Summary and Outlook**

This report describes the technical aspects of Pilot B (pilot scale dry digestion biogas reactor) testing period in Estonia from October 2013 till May 2014. It deals with the evaluation of a manure based scenario for full scale biogas implementation in Estonia.

In order to gather the required information, a long term process examination with cow manure has been realised with good fermenter performance during the whole period of time. On the basis of these data a theoretical fermenter dimensioning has been calculated to power a 100 kW CHP unit.

For further calculations a more detailed analysis on fertilizing qualities should be taken into consideration. Under the aspect of dewatering the digestate and/or the manure (as a substrate) more detailed information on the decision of wet or dry digestion can be given.



## 2. Financial implementation report

The financial implementation report for the project phase in Estonia considers similar aspects as for the project phase in Lithuania. Here especially the requirements which are set by the location and operation of the farm where Pilot B was located as well as the specifications of the Estonian project partners are taken into account.

### 2.1 Introduction

The financial implementation report aims for answering the question, if the implementation of biogas technology operated with cow manure of the farm where Pilot B was located is attractive.

Therefore different scenarios for the realisation of the implementation under different aspects were made.

With reference to these scenario (see 1.1.1 ) and the results which arose from the operation of Pilot B this report will among others be basis for the consideration of farm scale biogas plants.

The main target of the financial report is to constitute which way is attractive for investors to build biogas plants in the partner regions (here: Estonia).

Compared to output report 4.3 there are some changes in the layout. The chapter “General information to financial and economic implementation of biogas technology” has been shortened, because no newer data were available or they were adapted.

The chapter “Economic and financial implementation in reference to existing German biogas plants” has been abstracted because the information given there are already valid and not adaptable at this moment. Parts of this chapter (e.g. proceeds and subsidies) can be found in chapter 2.3.1 .

Anyhow it is also in this project phase important to notice, that biogas plant Pilot B is an experimental plant and not for commercial production of biogas.

#### 2.1.1 General overview of the national political and legislative framework in Estonia regarding waste and energy

Referring to unpublished data of the Estonian Statistical Office in 2012 the population covered by waste collection in Estonia is about 95%. [2]

Recycling of MSW has within 10 years increased from 5% to 20% in 2013, recycling of organic materials from 2% to 8% from 2001 to 2010. [E1]

The EU-requirement for recycling of MSW decrees 50% in 2020. Because of the high share of biodegradable waste in the MSW Estonia has to implement more options for the use of biowaste [2].

The Directive 2009/28/EC decrees a RES (Renewable Energy Sources) target by 2020 of 25% for the final energy consumption with at least 10% renewable energy in the transport sector. [3]

### **Landfilling of biodegradable municipal waste**

Just like in Lithuania the aim of the 1999 Landfill Directive was to reduce the amount of biodegradable waste going to landfills to 35% by 2016 (based on the amount of biodegradable municipal waste produced in 1995). Estonia belongs to these countries which got an extension of four years to reach this target. [4]

Referring to EEA (European Environment Agency) Estonia already fulfilled the targets for 2009 set by the Landfill Directive of reducing the landfill of BMW to 50% in 2013. With the implementing of an incinerator near Tallinn Estonia will probably reach the EU requirements which are set for the year 2020. [1]

## **2.1.2 Biogas production in Estonia – actual situation and theoretical production volume**

### **Waste water sludge**

Biogas from wastewater sludge is actually (2013) produced from biogas plants in Tallinn, Narva and Kuressaare. In addition two biogas plants are under construction in Tartu and Rakvere. The theoretical biogas potential from wastewater sludge is 9 mio. Nm<sup>3</sup>, the practicable available amount 4.5 mio. Nm<sup>3</sup>, resulting 30 GWh/a (it was estimated that 50% of the sewage sludge is used for biogas production). [5]

### **Manure and slurry**

In Estonia 60% of all registered cattle are in farms over 500 livestock units. It is assumed that 60% of the total manure and slurry (from the total number of pigs and cows) could be used for the production of biogas. Starting from 364,900 pigs and 237,900 cattle in 2009 the total amount of slurry and manure was 3,968,421 t/a and thus the theoretical biogas production 111 mio. Nm<sup>3</sup>/a. Consequently there would be an applicable biogas amount of 66.6 mio.Nm<sup>3</sup>/a (60% of theoretical), the energy potential 441 GWh/a. [5]

### **Biowaste**

Only 10% of biowaste is collected separately and thus only 10% of biowaste is applicable for biogas production. The theoretical biogas potential was calculated as 25 mio.Nm<sup>3</sup> and the applicable biogas production as 10% from theoretical (18 mio.Nm<sup>3</sup>), the energy potential 109 GWh/a, because the amounts of potential available biowaste is very small and scattered. [5]

### 2.1.3 Description and evaluation of implementation Scenario: Treatment of cattle manure

Because of the high potential of manure the anaerobic digestion will above all be considered by the use of that substrate. The transportation of the manure would be too expensive and the feed-in tariffs are rather low, therefore the biogas plants should be placed near to the farms, which are suitable as location.

So it is worth investing in a biogas plant provided that the anaerobic digestion is fully integrated as a part of the milk production residues treatment and not as a separate production business. The process optimally has to be adapted to the farm and the use of the digestate has to be assured.

It is absolutely important for the farmers to know, that the quality of the digestate is not worse than the manure itself, but that it is in many aspects better (especially the nutrient content). For more detailed information see 1.3.1 )

#### **Analytics at Ostfalia labs**

Ostfalia University analysed the biogas potential of the manure in lab.

Biogas yield:

- cow manure: about 20 Nm<sup>3</sup>/t fresh mass.

The results of the laboratory tests are listed in output report 4.3.

#### **Kaarli Farm**

In Estonia Pilot B was located at a farm with approximately 1500 cows near Rakvere, a town with about 17,000 inhabitants. Detailed information about the farm where Pilot B was located can be found in 1.1.2 .

The advantage of the simple use of manure during the operation time of Pilot B is that the system operation is for a reliable time. Besides that it is proved that Pilot B behaves exactly as a full scale plant. That means the results of the operation of the Pilot B are replicable and transferable to the operation of full scale biogas plants.

The results of the operation of Pilot B are described in chapter 1.6

## 2.2 General information to financial and economic implementation of biogas technology

This chapter is absolutely corresponding to Output Report 4.3, the case of the operation of Pilot B in Lithuania.

In the following the possible cost factors of biogas plants are according to output report O4.3 partly updated. Most of the information given in output report 4.3 are further valid.

### 2.2.1 Specific investment costs

Concerning the specific investment cost there are no changes in between the time from the last output report. Therefore the table with the actual specific investment costs are again listed below.

Table 5: specific investment costs related to biogas plant size [8] (German literature source)

Size of biogas plant	Specific investment costs
75 kWel	ca. 9,000 €/kWel
150 kWel	ca. 6,500 €/kWel
250 kWel	ca. 6,000 €/kWel
500 kWel	ca. 4,500 €/kWel
1 MWel	ca. 3,500 €/kWel

### Cost items in general

Table 6 contains a summary of necessary items of a biogas plant and the average costs for these items. In addition it was estimated which plant components are easily producible on site.



Table 6: Cost items of a biogas plant

plant component	Acquisition and construction in Estonia estimated economically			
	Probably yes	Depending on quality/availability	Share of the costs for devices (approx. for 75 kW plant) [%]	Share of the costs for devices (approx. for 500 kW plant) [%]
<p><b>Substrate storing and loading:</b></p> <p><u>substrate storage tank:</u> silo slabs of concrete, where appropriate with concrete walls, steel tank for intermediate storage of substrates delivered in liquid form</p> <p><u>receiving tank:</u> concrete tank, stirring, comminution and pumping equipment, where appropriate with filling shaft, substrate pipes, level measuring system, leak detection</p> <p><u>solids loading system:</u> screw conveyor, plunger or feed mixer loading, loading hopper, weighing equipment, digester charging system loader</p>	x		25	27
<p><b>Digester:</b> concrete container, heating, insulation, cladding, agitator equipment, gas-tight cover (gas storage), substrate/gas pipes, biological desulphurisation, instrumentation &amp; control and safety equipment, leak detection)</p>	x	x x x	21	26
<p><b>Gas storage</b> <b>Biogas treatment</b> <b>Flare</b> <b>CHP unit</b></p>	x	x x x	22	28
<p><b>Digestate storage and conditioning:</b> concrete tank agitator equipment, substrate pipes, unloading equipment, leak detection, gas-tight cover, instrumentation &amp; control and safety equipment, gas pipes, where applicable with separator</p>	x	x x x x	32	19

## 2.2.2 Operating costs

Concerning the specific operating costs there are no updates available. Therefore the information given in O 4.3 is valid further on.

## 2.2.3 Personal costs

For the required working time for plant supervision and maintenance new data are available from the Agency for Renewable Resources, Germany (FNR). Figure 14 shows the connection between size of the plant and required working time. Compared to the figure which was shown in output report O 4.3 there are obvious adjustments made.

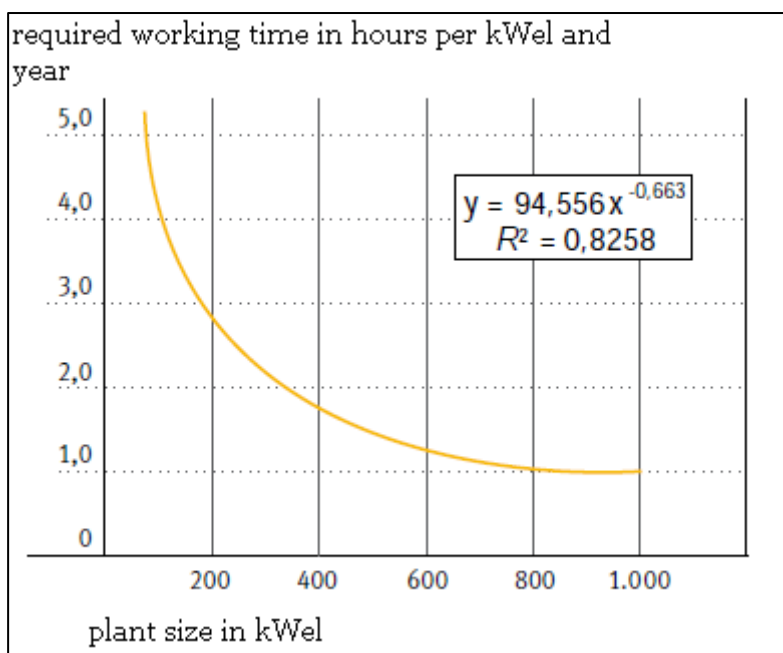


Figure 14: required working time for maintenance (without feeding) [9]

Figure 14 shows the dependency of the required working time on the power of the installed CHP unit. The feeding with solid substrates is not considered. The higher the nominal capacity the higher the total required working time for supervision of a biogas plant, but the more automated the biogas plant is, the less personal is needed. Many of the required works are necessary, independent from the size of the plant.

There is additional working time necessary when solid substrates have to be fed in by wheel loader or the like.

In comparison to figure 43 in O 4.3 the specific required working time has been decreased. The reason therefor is that the operation of biogas plant is increasingly going to be automated in many plant sections.

## **2.3 Economic and financial implementation in reference to Estonian models and conditions**

Referring to output report O 4.3 this chapter describes the development of a biogas plant model on the basis of the given conditions in Estonia. Especially the conditions given on the farm Pilot B is located serve as basis for the following calculations.

Some of the used operating numbers are based on costs from German biogas plants. They are especially marked and explained. Where it was possible Estonian data were used as basis for the calculation of the model plant.

Fundamentally the general statements which were made in O4.3 are also valid for Estonia. Therefore they are described again hereafter:

The calculation is based on some specific data which vary according to the relevant countries. Therefore some general consideration before:

- Investment costs: it has to be considered which parts of the plant are most cost-effective producible in Estonia (see also Table 6)
- Operational costs: these are the most specific costs depending on the relevant countries and percentile on the investment costs; especially the personal costs are varying strongly
- Revenues: the prices for the sale of electricity and heat are country-specific, also the sale of digestate

### **Example calculations for farm scale biogas plants (with sale of products)**

Based on the given conditions of the Kaarli farm in Estonia a biogas plant-model was developed. Different scenarios are described and calculated. This represents a real theoretical model, because actually the farm uses the manure for its own needs and would also use the digestate as fertilizer. Consequently there would be no sale of digestate and therefore no revenues out of the sale of digestate.

Nevertheless these examples present possible solutions for small scale farm based biogas plants and the economic efficiency. Therefore they should be helpful for making decisions in investing in biogas technology.

#### **2.3.1 Reporting under consideration of on-site operational data**

As mentioned above the investigations concerning the energy situation in Estonia were made in strong correlation to the situation given on Kaarli farm. The data and especially prices were worked out together with the Estonian project partners and during Estonian project meetings.

## Investigated data concerning tariffs and prices

In Table 7 the actual tariffs and prices in Estonia are listed.

Table 7: Estonian tariffs

electricity	natural gas	manure
0.097 €/kWh (industry) [7]	0.40320-0.70800 €/m <sup>3</sup> [6]	16 €/t (20% DM) [7]
fresh water	feed-in tariff electricity biogas AD	Waste water
0.764 €/m <sup>3</sup> + VAT [7]	0.093 €/kWh [10]	0.645 €/m <sup>3</sup> + VAT [7]
Landfill gate fee		
50 €/ton [1]		

## Pilot B

Target goal in Estonia was as well as in Lithuania to perform full practical process simulation from advanced laboratory scale to pilot scale under consideration of regional implementation and knowledge generation.

The operating costs for Pilot B, which occurred in the location in Estonia, are listed in Table 8.

Table 8: operating costs Pilot Plant B

	amount	expenses in €/month
Electricity consumption	720 kWh/month	69.12
Water consumption	75 l/month	0.07
Consumable lab materials		20.96
Required working time	1 h/day	ca. 120.00
Substrates: Cow manure	2,606 kg (21 weeks)	-
Total produced biogas amount	54 Nm <sup>3</sup> (21 weeks)	
total		ca. 210.15

## Electricity

The feed-in tariffs in Estonia are very much depending on the respective conditions. The grid connection depends on how far the site is away and on the size of the plant respectively the produced electricity. The Estonian Energy Company calculates the prices individually. The costs for a grid connection for a so called micro-level producer of electricity (11 kW) are at about 8,000 Euros, provided that there is no need to build new connections. In that case additional costs would arise and the grid connection might cost more than 100,000 Euros.

Feeding-in of electricity in Estonia is subsidized. The feed-in tariff actually is 0.093 €/kWh<sub>el</sub>. The subsidy rate is 5.3 cents per kWh and the difference between subsidy rate and market price is compensated by the energy companies (as fees for the customers). [10]

Based on analytical results of Lithuanian manure, the theoretical revenue from the sale of the produced electricity has been calculated in Table 9.

Table 9: theoretical revenue calculations (sale of electricity)

Substrate	methane yield [Nm <sup>3</sup> /ton]	Energy production [kWh <sub>el</sub> /ton]	Revenue (theor. max.) [kWh <sub>el</sub> ] [€/ton]	Heat production [kWh <sub>th</sub> /ton]	Revenue (theor. max.) [€/kWh <sub>th</sub> ]
cow manure (Lithuania)	19	77	7.16	77	3.08

## Heat

One of the main products of the biogas process is heat. Because a direct heating grid would be necessary in most cases the own use of the produced heat will be economically reasonable. If sale of heat is possible the feed-in tariff would be 0.04 €/kWh<sub>th</sub>.

## Digestate

The farmers in Estonia are prejudiced when thinking about the use of digestate as fertilizer. Therefore the sale of the digestate constitutes a special difficulty. The farmers have to be convinced that the digestate has a better quality than the single use of the manure.

Residues of the biogas process are principally suitable for use as fertilizer and soil conditioner. Disposal of digestate as fertilizer is conceivable. The composition depends among others essentially on the used substrates. The quality of the produced digestate is higher than of manure. The nutrients are easier available for the plants and digestate causes fewer odours than the use manure.

Referring to the price for manure a calculation was made based on the nitrogen-content of manure and digestate. Therefor analytics were made in an Estonian laboratory. The results of these analytics can be found in the appendix, chapter 4.1 .



Table 10: Calculation of manure and digestate price (data base: 16 €/t M manure (20% DM)) [7]

manure: 3.0 kg N/m <sup>3</sup> , 6.7 % DM	
digestate (Pilot B): 2.0 kg N/m <sup>3</sup> , 2.8 % DM (based on analysis made by the Estonian Agricultural Research Centre, see appendix chapter 4.1 )	
manure:	$3 \text{ kg N}/67 \text{ kg DM} = 44.8 \text{ g N/kg DM}$ $6.7/20 * 16 \text{ €/ tFM} = 5.36 \text{ €/t FM}$ $1.79 \text{ €/kg N}$  $5.36 \text{ €} / 6.7\% = \mathbf{0.8 \text{ €}/(\%*tFM)}$
digestate:	$2 \text{ kg N}/28 \text{ kg DM} = 71.43 \text{ gN/kg DM}$ $1.79 \text{ €/kg N} * 2 \text{ kg N/t FM} = 3.58 \text{ €/t FM}$  $3.58 \text{ €/t FM} / 2.8\% = \mathbf{1.28 \text{ €}/(\%*tFM)}$

The results of the calculation in Table 10 show that the value of the digestate related to the amount of nitrogen generates a higher proceed than manure.

### Funding for biogas

There are some support schemes of ERDF (European Regional Development Fund) concerning the funding of investment in biogas technology. The investment into production of bioenergy will be supported, if all of the produced bioenergy will be consumed in one's own household or agricultural enterprise (project-based). [7]

The subsidy rates for the production of biogas can be found in the Estonian Electricity Market Act (§57 and following.) [12]

Producer of biogas can be supported in following cases:

- For electricity generated from RES, except from biomass
- For electricity produced from biomass in an efficient cogeneration process, except in a condensation process
- For electricity in an efficient cogeneration regime from waste, peat or carbonization gas (as an result of oil shale processing)
- For electricity generated in an efficient cogeneration process, installation with a capacity of not more than 10 MW [12]

### Requirements for sale of products/taxes

In Estonia it is not possible to sell electricity directly to end-consumers. The produced energy has to be sold to a network operator who is allowed to sell it to end-consumers. Biogas can only be fed into a grid when it has the same consistency than natural gas.

Electricity and biogas are both liable for excise duty. The rates are 4.47 Euros per one megawatt-hour of electricity and 367 Euros per one thousand cubic meters of natural gas. [13]

## **2.4 Farm scale biogas plant models – Estonian biogas cases**

As described in Output report O 4.3 the discounted cash flow constitutes a calculation method to estimate the attractiveness of an investment opportunity. The discounted cash flow method is often used in investment finance calculating the future cash flows present values. [11]

Based on the data in Table 11 and the conditions given on the Estonian farm cumulative discounted cash flows of a biogas plant with different scenarios were calculated by an excel tool. The results are shown in Figure 15.

Table 11: Database for the calculation of the model biogas plant

<b>size of the plant: 96 kW, 830 m<sup>3</sup> digester, 211,773.00 m<sup>3</sup> CH<sub>4</sub>/a (378,166.00 m<sup>3</sup> biogas/a (56% CH<sub>4</sub>, 19 Nm<sup>3</sup>/ton; based on Lithuanian analytical results), 10.950 m<sup>3</sup>/a manure, 842.009 kWhel/a (40% el. efficiency rate); 40 % th. efficiency rate</b>			
	<b>specific costs</b>	<b>costs for the plant</b>	literature source/database
<b>total investment costs<sup>1</sup></b>	7,000€/kW (averaging)	700,000.00 €	[8]
Digester <sup>2</sup>	1,500€/kW, (estimation)	200€/m <sup>3</sup> 160,000.00 €	[9]
CHPunit incl. control and torch <sup>3</sup>	1,750€/kW	175,000.00 €	[8]
personnel costs <sup>4</sup>	0.25 work day	3,000.00€/year	[7, 9 and own calculations]
maintenance and repair <sup>5</sup>	0.02*378166	7,563.00 €	0.02€/m <sup>3</sup> biogas [own calculations]
service contracts <sup>6</sup>	0.03*378166	11,345.00 €	0.03€/m <sup>3</sup> biogas [own calculations]
purchased services and goods <sup>7</sup>	0.01*378166	3,782.00 €	0.01€/m <sup>3</sup> biogas [own calculations]
purchased electricity <sup>8</sup>	0.096€/kWh (6% increment rate)	6,099.06 €	7.5% electricity demand (plant)=63531,9kWh [own calculations]
replacement of CHPunit every 6 years			
<b>revenues:</b>			
Electricity <sup>9</sup>	0.093€/kWh (6 % increment rate)	78,306.88 €	electricity price [10];
Digestate <sup>10</sup>	3.58€/t (2 % increment rate)		[own calculation]; (16€ per t of manure (20%TS)) [7]
Heat	0.04 €/kWh (6% increment rate)		620561 kWhth (heat demand of the plant (26.3 %) excluded)
first revenues in year 1, after construction in year 0			

<sup>1</sup> database [9], average value (75kW-, 150 kW-plant); value reduced, because plant operated only with manure has less investment costs than average [8]

<sup>2</sup> estimation based on costs for digester (plants of different sizes) [9]

<sup>3</sup> average value [8]

<sup>4</sup> required working time based on Figure [9]; average wage level [7]

<sup>5,6,7</sup> calculated operating number, based on data of different German biogas plants

<sup>8</sup> price based on yearly electricity demand and costs for the farm

<sup>9</sup> feed-in tariff (subsidy included) [10]

<sup>10</sup> calculation based on the price for manure 16€/t (20% FM) [7]; here 6,7 % FM (see detailed calculation in Table 10)

### **Description of different models in Figure 15**

1. Model with sale of electricity and digestate: complete sale of the produced electricity and digestate, purchase of for the biogas plant needed electricity (0.096 €/kWh), farm demand of electricity not considered.
2. Model with sale of electricity, heat and digestate: complete sale of the produced electricity, recovery of heat demand of the biogas plant and sale of residual heat, sale of digestate, purchase of for the biogas plant needed electricity (farm electricity demand not considered).
3. Model with sale of electricity, without sale of digestate: complete sale of the produced electricity, no sale of digestate and purchase of for the biogas plant needed electricity (0.096 €/kWh), farm electricity demand not considered.
4. Model with covering of farm and plant energy demand, sale of remaining electricity and digestate: covering of electricity demand of biogas plant and farm, sale of remaining electricity, sale of digestate; conservation of electricity of the farm included as revenue (excise duty calculated as expenses).

✓

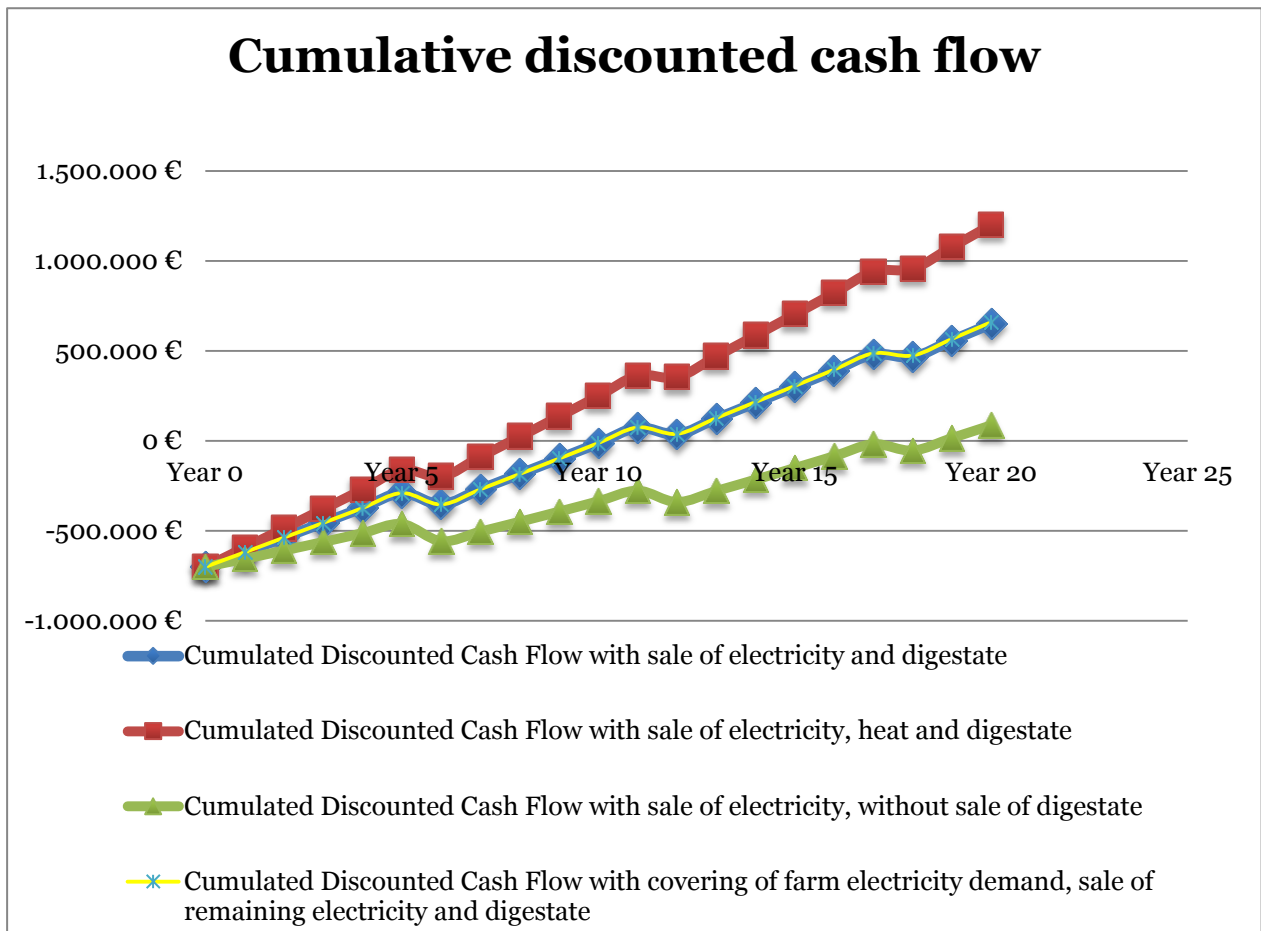


Figure 15: Cumulative discounted cash flows for different scenarios

In the calculation of the above described model biogas plants a discount rate of 5 % was set.

The increment rate regarding the sale of electricity was set to 6 %, because that is an average value based on the development of the electricity prices. The increment rate regarding the sale of digestate was set to 2%, according to general price rises (also of mineral fertilizers).

Also the increment rates of the single operating costs are set to 2 % because of the general average values concerning the price rises.

The calculation with covering of the farm and plant electricity demand with own produced energy excise duty was considered (4.47 Euros per MWh).

Additionally two models were calculated which show the differences caused by the size of the plant. They are shown in Figure 16.

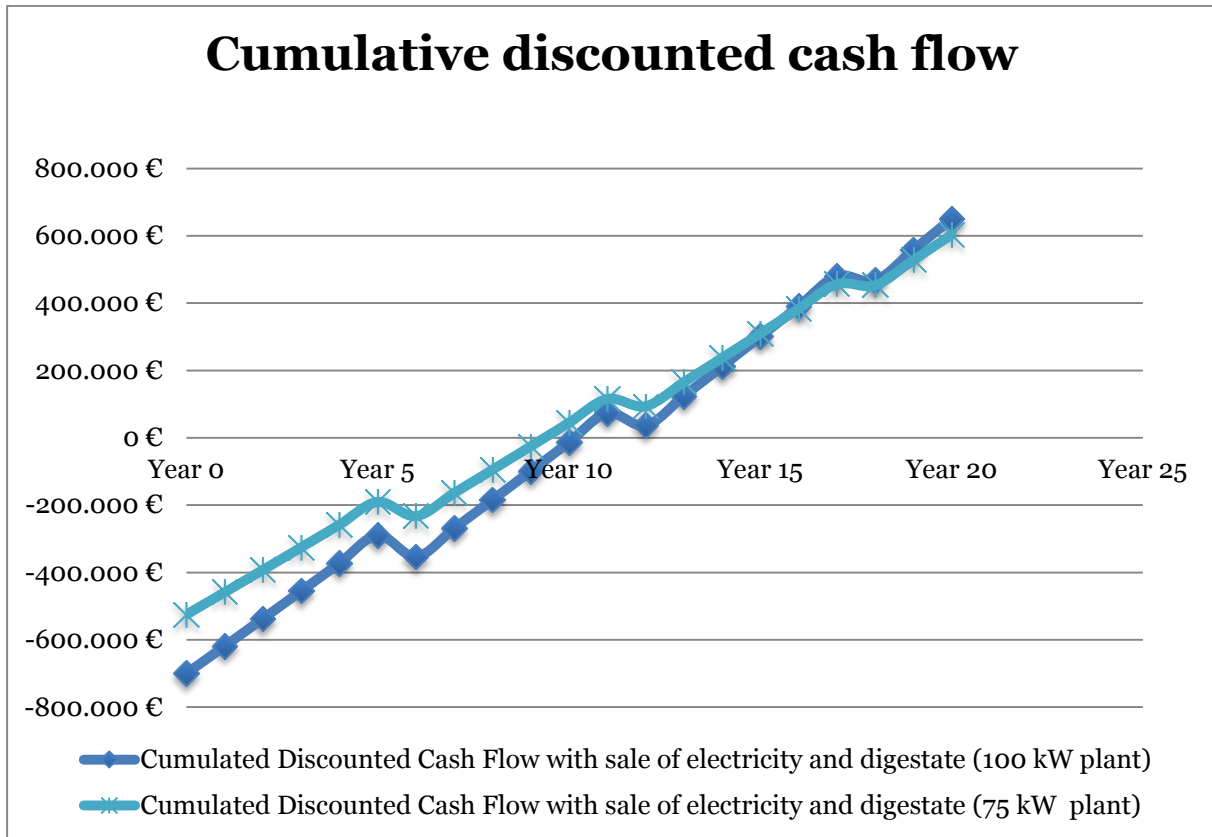


Figure 16: Cumulative discounted cash of exemplary manure based biogas plant (75 kW) in comparison to the manure based plant (100 kW)

As expected the two curves in Figure show comparable courses. The 75 kW-plant reaches one year earlier the zero line, because of the lower investment costs, but after reaching this point the curves approach and latest in year 16 the 100 kW-plant curve proceeds above the curve of the 75 kW-plant.

## 2.5 Summary and outlook

The chapter "financial implementation report" for the project phase in Estonia deals with the development of different models of small scale biogas plants. These models are developed on the basis of the data of the farm where Pilot B was located.

The different scenarios deal with different conditions concerning the use of the produced electricity, heat and digestate.

Based on data of existing German biogas plants the different models were developed and calculated with an excel tool, which was developed at Ostfalia. General operating numbers have been calculated by data of several existing German biogas plants. It can be supposed that the used operating numbers are applicable also for biogas plant in other countries. The operating numbers which are very country specific are adapted to the Estonian cases or otherwise as "not completely usable" marked.



Besides these actual scenarios and given conditions the general information and conditions concerning implementation of biogas technology are updated and adapted to the actual situation.

Therefore actual information about cost factors in general way as well as in reference to existing German biogas plants was used.

The used excel tool is actual under construction and will be developed further on. Therefore these models are the first creations and will be improved and developed further.

### **Outlook**

A possibility for saving of costs (given that transport costs for output of digestate is integrated into the calculation) is the drying of digestate e.g. by the use of a screw separator and therefore less effort and transport costs for output of the digestate.

In case of the farm model the incidental digestate with a DM-content of about 3 % could be dried up to a content of about 25 %. That means the digestate-amount of yearly 10,527 tons would be reduced to 1,263 tons.

The investment costs for a screw separator amount 16,000 to 25,000 € (according to construction) plus periphery which amounts 5,000 to 7,000 €.

The electricity consumption of a commercially available screw conveyer which would be necessary for drying the resulting digestate is negligible low. Only the investment costs have to be taken into account.

The scenario mentioned in chapter 3.4 doesn't include the output of digestate. Because the farm nearly has to spend the same costs for output of manure they were not considered for the calculation of the cash flows.

When thinking about drying of digestate by separation it has also to be taken into account that the nutrients, e.g. nitrogen would be merged up to 70 % into the liquid phase. [15] Nevertheless, related to the N-content, there would be a higher concentration of the nitrogen in the solid phase, because of the less solid mass. Besides the usage and potential treatment of the liquid phase has to be considered.

Some important key figures, analytical and literature values used for the exemplary and theoretical calculations are listed in Table 12.

Table 12: Some important key figures, analytical results and literature values

	literature value	own analytical results (Estonia)	own analytical results (Lithuania)	used for economic calculations
Methane content of manure	~56% [9]	57%	56 %	56 %
Methane yield of manure	~14 Nm <sup>3</sup> /ton [9]	11.8 Nm <sup>3</sup> /ton	19 Nm <sup>3</sup> /ton	19 Nm <sup>3</sup> /ton
Nitrogen content of manure	5.2 kg/m <sup>3</sup> [14]	3 kg N/m <sup>3</sup>	-	3 kg/m <sup>3</sup>
Nitrogen content of digestate	4.8 kg/m <sup>3</sup> [14]	2 kg N/m <sup>3</sup>	-	3 kg/m <sup>3</sup>
DM manure	10 % [14]	2.8 %	24.5%	2.8 %
DM digestate	6 % [14]	6.7 %	-	6.7 %

### **3. Strategy of Communication**

The pilot B plant was situated in Lithuania at the described farm nearby an operating full scale biogas plant. The stakeholders in that region are familiar with the technology a biogas process, the treatment of manure is common and the focus was on the usability of the digestate as a high quality fertilizer. The strategy of communication aimed in creating awareness that the quality of digestate as fertilizer is investigated, to evaluate if it is an attractive alternative to the commonly used untreated manure as fertilizer. This was communicated in a reluctant way.

#### **3.1 Stakeholders**

Marketing defines, that the media and the ways, which are used to inform and persuade possible buyers has to be chosen under consideration of the target group, which is in this case the group of stakeholders.

Responsible for the selection and naming of the stakeholders is the regional partner, which has the best insight into which person, which organisation and which association has absolutely to be involved. In the Lithuanian case this was the duty of Reljo Saarepera and Jaan Lõõnik who defined following organisations and invited the people personally.

##### **3.1.1 Stakeholder Identification**

The Identification of the stakeholders in Estonia was mainly done by the project partners in Estonia. Leading questions have been:

- Who is affected by the results of the project?
- The area of responsibility of which institution is affected?
- Which people with influence are interested in the technology?
- Which inspection authorities have to be involved in the decision process?
- Which institutions are able and willing to invest money into new technologies?
- Which people of the personal network of the local project partner could be involved?
- Who could be an obstacle?
- Who has a problem that could be solved by the technology of anaerobic digestion?

The better the identified stakeholders are affected by the topic, the better the personal relationship to the inviting local partner the more likely is, that the invited people will attend and actively participate.

#### **3.2 Local partners**

The local partner in Estonia has been ERKAS (Estonian regional and local development agency), represented by the lead partner Reljo Saarepera as well as Jaan Lõõnik and Priit Freienthal.

From the communicative point of view the local partner are designing the way of communication in the country, they bring in their personal and professional network as the source of all activities regarding presenting and representing the project.

### **3.3 Media**

In case of Lithuania following media has been used:

#### **3.3.1 Internet**

The newsletter and all reports are published on the ABOWE web site.

#### **3.3.2 Newsletter**

Using the template of the ABOWE project a national newsletter edition has been established, as a mixture of old style and new media. It is available as hardcopy and can be sent by mail. It is published on the project's web site, it is being sent via email and it could be posted on social media.

One newsletter were published during the period the pilot B has been in Estonia, it is available in English and in Estonian.

#### **First Newsletter**

Immediately after the kick-off workshop the Newsletter was sent to the participants and all the other stakeholders.

Content of the first Newsletter is:

#### **ABOWE in Estonia**

A short introduction into the ABOWE project and the aims of the stay of pilot B in Estonia.

#### **Priit Freienthal**

Introduction of the responsible operator of the pilot B in Estonia.

#### **First Estonian Workshop**

Summary of the first workshop, regarding programme, participants, discussions and results.

#### **First International project meeting for Pilot B in Estonia**

Announcement of the stakeholder event.

For the complete Newsletter, see appendix, chapter 4.2 .

### 3.3.3 Events

Two events were organized during the stay of pilot B in Estonia with the aims:

- To inform
- To activate
- To come into contact
- To learn

#### **Workshop**

First Estonian ABOWE workshop took place on Monday, October 28<sup>th</sup>. The day began with the site visit of pilot B and Kaarli farm followed by the visit to the nearby working biogas plant and a round table discussion. Representatives of ERKAS, as project partner and Kaarli Farm, as hosts of pilot plant had active discussion with expert from Tallinn Technical University, Peep Pitk, B.Sc., M.Sc. and representatives of the Ministry of environment. In his presentation Mr. Pitk gave practical advice on operation of pilot plant and how to carry out viable tests in Estonia that will meet the expectations of the project stakeholders.

Later discussion on biogas potential and production technologies suitable for Kaarli Farm and other similar farms in retrospect of waste to energy policies of Estonia, EU and socio-economic situation led to a conclusion that there are high expectancies on the quality of outcome of ABOWE and similar projects as stakeholders knowledge on the topic is relatively high and public sector as well as businessmen are looking forward to a viable solution that will balance biogas as part of waste treatment and biogas as an energy source in a long run.

#### **Stakeholder event**

In December 16-17, 2013 partners and leading stakeholders gathered for the first international Pilot B meeting in Estonia to discuss the initial progress of piloting as well as prospective for the business case in Estonia.

Presentations from Estonian experts led into the day, followed by a practical discussion amongst project partners and round table with the local stakeholders to define the expectations, technical realities and socio-economic situation for the successful business case. Discussions were followed by a joint on site visit to Kaarli Farm and Pilot B test plant (see also p. 15).

#### **Investor event**

For preparation of investor memo and to present the results of the pilot B operation time in Estonia at 25<sup>th</sup> and 26<sup>th</sup> of March the investor event took place. The results show that the course of the methane yield of pilot B is parallel to the course of a full scale plant.

After presentation of results the stakeholder discussed the impact of the results on the investment activities in Estonia and what expectations they have with regard to the investment memo. To round off the event a visit of pilot B was organized.



### **3.4 Curriculum**

Additional to the results, mentioned in O 4.3 the experience in Estonia shows, that the training programme for the operator had been optimized in a way, that Priit Freienthal after the introduction into the pilot B operation at Kaarli Farm immediately was able to operate the plant in a secure and stable way.

### **3.5 Summary**

The Estonian partners are strongly rooted in their local and national environment that included a solid way of communication with the relevant actors. For that reason a strategy for communication needn't to be invented. It was more effective to accompany the local partners and support them when demanded. This led to an adapted concept of the operation and an efficient way of communication that created sincere attention and concrete requests regarding investment possibilities.

## **4. Appendix**

### **4.1 Lab analysis made by the Estonian Agricultural Research Centre**



**Agrokeemia Laboratoorium**

Proovide vastuvõtt: Saku, Teaduse 4/6, Tel 6 729 112  
Proovide analüüs: Saku, Teaduse 4/6, Tel 6 729 116, 6 729 148

**KATSEPROTOKOLL NR 14 – 000564 AKL/VA**

**Kliendi nimi (kontaktisik):**

ERKAS  
Priit Freienthal  
Telefon: 5246017  
E-post: priit@erkas.ee

**Aadress:**

Kaarli küla, Sõmeru vald  
Läne-Virumaa  
Proovi vastuvõtmise kuupäev: 31.01.2014

**Proovi nimetus:** Vedel veisesõnnik

**Kliendi proovi number:** 1 (digestaat)

**Proovi analüüsi tulemused:**

Jrk. nr	Parameetri nimetus	Tulemused
1	Kuivaine	2,2 %
2	Kogulämmastik (N)	1,8 kg/m <sup>3</sup>
3	Lahustuv lämmastik (NH <sub>4</sub> <sup>+</sup> -N + NO <sub>3</sub> <sup>-</sup> -N) sh nitraatlämmastik (NO <sub>3</sub> <sup>-</sup> -N) ammooniumlämmastik (NH <sub>4</sub> <sup>+</sup> -N)	1,0 kg/m <sup>3</sup> Ei leitud 1,0 kg/m <sup>3</sup>
4	Kogufosfor (P)	0,32 kg/m <sup>3</sup>
5	Kogukaalium (K)	1,2 kg/m <sup>3</sup>
6	Kaltsium (Ca)*	0,10 kg/m <sup>3</sup>
7	Magneesium (Mg)*	0,27 kg/m <sup>3</sup>
8	Vask (Cu)*	Ei leitud
9	Mangaan (Mn)*	7,3 g/m <sup>3</sup>
10	Boor (B)*	Ei leitud

**Meetodid:** Kuivaine – gravimeetria; Kogulämmastik – Kjeldahl'i meetod; Nitraatlämmastik – Foss Tecator AN 5232; Ammooniumlämmastik – Foss Tecator AN 5226; Kogufosfor, kogukaalium, Ca, Mg, Cu, Mn, B – märgtuhastus + ICP/OES<sup>®</sup>.

Leht 2(2)

**Märkused:**

1. Katsetulemused kehtivad ainult analüüsiks toodud proovi kohta.
2. Katseprotokoll on lubatud kopeerida ainult tervikuna, osaliseks kopeerimiseks peab olema labori luba.
3. Katseprotokoll ei asenda müügi puhul sertifikaati.
4. \* Parameetri määramine ei ole akrediteeritud.
5. Proov on analüüsitud algniiskusel.
6. „Recommended Methods of Manure Analysis (A3769)“, 2003.

**Analüüsid tehtud:** 31.01. – 11.02.2014

**Väljaandmise aeg:** 11.02.2014

Väetiste sektori peaspetsialist:



*Darja Morozova*

Darja Morozova

Agrokeemia laboratooriumi juhataja

*Aivar Õispalu*

Aivar Õispalu





**Leht 2(2)**

**Märkused:**

1. Katsetulemused kehtivad ainult analüüsiks toodud proovi kohta.
2. Katseprotokolli on lubatud kopeerida ainult tervikuna, osaliseks kopeerimiseks peab olema labori luba.
3. Katseprotokoll ei asenda müügi puhul sertifikaati.
- 4.\* Parameetri määramine ei ole akrediteeritud.
5. Proov on analüüsitud algniiskusel.
6. „Recommended Methods of Manure Analysis (A3769)“, 2003.

**Analüüsid tehtud:** 31.01. – 11.02.2014

**Väljaandmise aeg:** 11.02.2014

Väetiste sektori peaspetsialist



*Darja Morozova*

Darja Morozova

Agrokeemia laboratooriumi juhataja:

*A. Öispalu*

Aivar Öispalu



**Agrokeemia Laboratoorium**

Proovide vastuvõtt: Saku, Teaduse 4/6, Tel 6 729 112  
Proovide analüüs: Saku, Teaduse 4/6, Tel 6 729 116, 6 729 148

**KATSEPROTOKOLL NR 14 – 000566 AKL/VA**

**Kliendi nimi (kontaktisik):**

ERKAS  
Priit Freienthal  
Telefon: 5246017  
E-post: priit@erkas.ee

**Address:**

Kaarli küla, Sõmeru vald  
Läne-Virumaa  
Proovi vastuvõtmise kuupäev: 31.01.2014

**Proovi nimetus:** Vedel veisesõnnik

**Kliendi proovi number:** 3 (läga pumplast)

**Proovi analüüsi tulemused:**

Jrk. nr	Parameetri nimetus	Tulemused
1	Kuivaine	8,6 %
2	Kogulämmastik (N)	4,1 kg/m <sup>3</sup>
3	Lahustuv lämmastik (NH <sub>4</sub> <sup>+</sup> -N + NO <sub>3</sub> <sup>-</sup> -N) sh nitraatlämmastik (NO <sub>3</sub> <sup>-</sup> -N) ammooniumlämmastik (NH <sub>4</sub> <sup>+</sup> -N)	1,9 kg/m <sup>3</sup> Ei leitud
		1,9 kg/m <sup>3</sup>
4	Kogufosfor (P)	0,64 kg/m <sup>3</sup>
5	Kogukaalium (K)	2,4 kg/m <sup>3</sup>
6	Kaltsium (Ca)*	1,80 kg/m <sup>3</sup>
7	Magneesium (Mg)*	0,51 kg/m <sup>3</sup>
8	Vask (Cu)*	3,6 g/m <sup>3</sup>
9	Mangaan (Mn)*	15,3 g/m <sup>3</sup>
10	Boor (B)*	4,7 g/m <sup>3</sup>

Meetodid: Kuivaine – gravimeetria; Kogulämmastik – Kjeldahl'i meetod; Nitraatlämmastik – Foss Tecator AN 5232; Ammooniumlämmastik – Foss Tecator AN 5226; Kogufosfor, kogukaalium, Ca, Mg, Cu, Mn, B – märgtuhaustus + ICP/OES<sup>o</sup>.

**Märkused:**

1. Katsetulemused kehtivad ainult analüüsiks toodud proovi kohta.
2. Katseprotokoll on lubatud kopeerida ainult tervikuna, osaliseks kopeerimiseks peab olema labori luba.
3. Katseprotokoll ei asenda müügi puhul sertifikaati.
4. \* Parameetri määramine ei ole akrediteeritud.
5. Proov on analüüsitud algniiskusel.
6. „Recommended Methods of Manure Analysis (A3769)“, 2003.

**Analüüsid tehtud:** 31.01. – 11.02.2014

**Väljaandmise aeg:** 11.02.2014

Väetiste sektori peaspetsialist:



Darja Morozova

Agrokeemia laboratooriumi juhataja:

Aivar Õispalu



**Leht 2(2)**

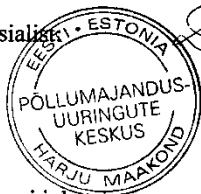
**Märkused:**

1. Katsetulemused kehtivad ainult analüüsiks toodud proovi kohta.
2. Katseprotokoll on lubatud kopeerida ainult tervikuna, osaliseks kopeerimiseks peab olema labori luba.
3. Katseprotokoll ei asenda müügi puhul sertifikaati.
- 4.\* Parameetri määramine ei ole akrediteeritud.
5. Proov on analüüsitud algniiskusel.
6. „Recommended Methods of Manure Analysis (A3769)“, 2003.

**Analüüsid tehtud:** 31.01. – 11.02.2014

**Väljaandmise aeg:** 11.02.2014

Väetiste sektori peaspetsialist



Darja Morozova

Agrokeemia laboratooriumi juhataja:

*A. Oispalu*

Aivar Oispalu





**Agrokeemia Laboratoorium**

Proovide vastuvõtt: Saku, Teaduse 4/6, Tel 6 729 112  
Proovide analüüs: Saku, Teaduse 4/6, Tel 6 729 116, 6 729 148

**KATSEPROTOKOLL NR 14 – 000568 AKL/VA**

**Kliendi nimi (kontaktisik):**

ERKAS

Priit Freienthal

Telefon: 5246017

E-post: priit@erkas.ee

**Aadress:**

Kaarli küla, Sõmeru vald

Läne-Virumaa

Proovi vastuvõtmise kuupäev: 31.01.2014

**Proovi nimetus:** Vedel veisesõnnik

**Kliendi proovi number:** 5 (läga pumplast)

**Proovi analüüsi tulemused:**

Jrk. nr	Parameetri nimetus	Tulemused
1	Kuivaine	6,7 %
2	Kogulämmastik (N)	3,0 kg/m <sup>3</sup>
3	Lahustuv lämmastik (NH <sub>4</sub> <sup>+</sup> -N + NO <sub>3</sub> <sup>-</sup> -N) sh nitraatlämmastik (NO <sub>3</sub> <sup>-</sup> -N) ammooniumlämmastik (NH <sub>4</sub> <sup>+</sup> -N)	1,3 kg/m <sup>3</sup>
		Ei leitud
		1,3 kg/m <sup>3</sup>
4	Kogufosfor (P)	0,57 kg/m <sup>3</sup>
5	Kogukaalium (K)	1,8 kg/m <sup>3</sup>
6	Kaltsium (Ca)*	1,30 kg/m <sup>3</sup>
7	Magneesium (Mg)*	0,41 kg/m <sup>3</sup>
8	Vask (Cu)*	3,1 g/m <sup>3</sup>
9	Mangaan (Mn)*	13,3 g/m <sup>3</sup>
10	Boor (B)*	Ei leitud

**Meetodid:** Kuivaine – gravimeetria; Kogulämmastik – Kjeldahl'i meetod; Nitraatlämmastik – Foss Tecator AN 5232; Ammooniumlämmastik – Foss Tecator AN 5226; Kogufosfor, kogukaalium, Ca, Mg, Cu, Mn, B – märgtuhastus + ICP/OES<sup>6</sup>.

**Leht 2(2)**

**Märkused:**

1. Katsetulemused kehtivad ainult analüüsiks toodud proovi kohta.
2. Katseprotokoll on lubatud kopeerida ainult tervikuna, osaliseks kopeerimiseks peab olema labori luba.
3. Katseprotokoll ei asenda müügi puhul sertifikaati.
- 4.\* Parameetri määramine ei ole akrediteeritud.
5. Proov on analüüsitud algniiskusel.
6. „Recommended Methods of Manure Analysis (A3769)“, 2003.

**Analüüsid tehtud:** 31.01. – 11.02.2014

**Väljaandmise aeg:** 11.02.2014

Väetiste sektori peaspetsialist:



Darja Morozova

Agrokeemia laboratooriumi juhataja

Aivar Õispalu



**Agrokeemia Laboratoorium**  
**Jääkide- ja Saasteainete Laboratoorium**

Proovide vastuvõtt: Saku, Teaduse 4/6, Tel 6 729 112  
Proovide analüüs: Saku, Teaduse 4/6, Tel 6 729 116, 6 729 148, 6 729 126

**KATSEPROTOKOLL NR 14 – 001312 AKL/VA – JSL/ME**

**Kliendi nimi (kontaktisik):**

Eesti Regionaalse ja Kohaliku Aarengu Sihtasutus  
Priit Freienthal  
Telefon: 5246017  
E-post: priit@erkas.ee

**Aadress:**

Kaarli küla, Sõmeru vald  
Lääne-Virumaa

**Proovi nimetus:** Läga

**Proovi vastuvõtmise kuupäev:** 27.03.2014

**Kliendi proovi number:** 10

**Määratud parameetrid:**

Jrk. nr	Parameetri nimetus	Tulemused
1	Kuivaine	5,6 %
2	Kogulämmastik (N)	2,8 kg/m <sup>3</sup>
3	Lahustuv lämmastik (NH <sub>4</sub> <sup>+</sup> -N + NO <sub>3</sub> <sup>-</sup> -N) sh nitraatlämmastik (NO <sub>3</sub> <sup>-</sup> -N) ammooniumlämmastik (NH <sub>4</sub> <sup>+</sup> -N)	1,1 kg/m <sup>3</sup>
		Ei leitud 1,1 kg/m <sup>3</sup>
4	Kogufosfor (P)	0,55 kg/m <sup>3</sup>
5	Kogukaalium (K)	2,2 kg/m <sup>3</sup>
6	Kaltsium (Ca) *	1,4 kg/m <sup>3</sup>
7	Magneesium (Mg) *	0,43 kg/m <sup>3</sup>
8	Vask (Cu) *	1,9 g/m <sup>3</sup>
9	Mangaan (Mn) *	14,9 g/m <sup>3</sup>
10	Boor (B) *	Ei leitud
11	Tsink (Zn)	14,0 ± 1,4 mg/kg

**Meetodid:** Kuivaine – gravimeetria; Kogulämmastik – Kjeldahl'i meetod; Nitraatlämmastik – Foss Tecator AN 5232; Ammooniumlämmastik – Foss Tecator AN 5226; Kogufosfor, kogukaalium, Ca, Mg, Cu, Mn, B – märgtuhaustus + ICP/OES<sup>6</sup>; Tsink - PMK-JJ-4C.

**Märkused:**

1. Katsetulemused kehtivad ainult analüüsiks toodud proovi kohta.
2. Katseprotokoll on lubatud kopeerida ainult tervikuna, osaliseks kopeerimiseks peab olema labori luba.
3. Katseprotokoll ei asenda müügi puhul sertifikaati.
4. \* Parameetri määramine ei ole akrediteeritud.
5. Proov on analüüsitud algniiskusel.
6. „Recommended Methods of Manure Analysis (A3769)“, 2003.

Analüüsid tehtud: 27.03. – 10.04.2014

Väljaandmise aeg: 10.04.2014

Väetiste sektori peaspetsialist:



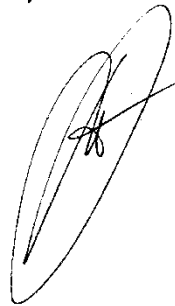
Darja Morozova

Agrokeemia laboratooriumi juhataja:



Aivar Õispalu

Jääkide- ja saasteainete laboratooriumi juhataja:



Ülle Püü



Agrokeemia Laboratoorium

Jääkide- ja Saasteainete Laboratoorium

Proovide vastuvõtt: Saku, Teaduse 4/6, Tel 6 729 112  
Proovide analüüs: Saku, Teaduse 4/6, Tel 6 729 116, 6 729 148, 6 729 126

KATSEPROTOKOLL NR 14 – 001311 AKL/VA – JSL/ME

**Kliendi nimi (kontaktisik):**

Eesti Regionaalse ja Kohaliku Aarengu Sihtasutus  
Priit Freienthal  
Telefon: 5246017  
E-post: priit@erkas.ee

**Aadress:**

Kaarli küla, Sõmeru vald  
Lääne-Virumaa

Proovi nimetus: Digestaat

Proovi vastuvõtmise kuupäev: 27.03.2014

Kliendi proovi number: 9

Määratud parameetrid:

Jrk. nr	Parameetri nimetus	Tulemused
1	Kuivaine	3,4 %
2	Kogulämmastik (N)	2,3 kg/m <sup>3</sup>
3	Lahustuv lämmastik (NH <sub>4</sub> <sup>+</sup> -N + NO <sub>3</sub> <sup>-</sup> -N) sh nitraatlämmastik (NO <sub>3</sub> <sup>-</sup> -N) ammooniumlämmastik (NH <sub>4</sub> <sup>+</sup> -N)	1,0 kg/m <sup>3</sup> Ei leitud 1,0 kg/m <sup>3</sup>
4	Kogufosfor (P)	0,43 kg/m <sup>3</sup>
5	Kogukaalium (K)	1,8 kg/m <sup>3</sup>
6	Kaltsium (Ca) *	1,2 kg/m <sup>3</sup>
7	Magneesium (Mg) *	0,34 kg/m <sup>3</sup>
8	Vask (Cu) *	1,9 g/m <sup>3</sup>
9	Mangaan (Mn) *	9,2 g/m <sup>3</sup>
10	Boor (B) *	Ei leitud
11	Tsink (Zn)	8,78 ± 0,88 mg/kg

Meetodid: Kuivaine – gravimeetria; Kogulämmastik – Kjeldahl'i meetod; Nitraatlämmastik – Foss Tecator AN 5232; Ammooniumlämmastik – Foss Tecator AN 5226; Kogufosfor, kogukaalium, Ca, Mg, Cu, Mn, B – märgtuhastus + ICP/OES<sup>6</sup>; Tsink - PMK-JJ-4C.

**Märkused:**

1. Katsetulemused kehtivad ainult analüüsiks toodud proovi kohta.
2. Katseprotokoll on lubatud kopeerida ainult tervikuna, osaliseks kopeerimiseks peab olema labori luba.
3. Katseprotokoll ei asenda müügi puhul sertifikaati.
4. \* Parameetri määramine ei ole akrediteeritud.
5. Proov on analüüsitud algniiskusel.
6. „Recommended Methods of Manure Analysis (A3769)“, 2003.

Analüüsid tehtud: 27.03. – 10.04.2014

Väljaandmise aeg: 10.04.2014

Väetiste sektori peaspetsialist:



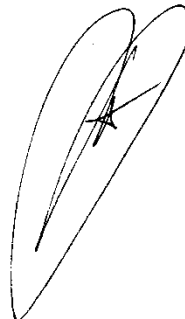
Darja Morozova

Agrokeemia laboratooriumi juhataja:



Aivar Õispalu

Jääkide- ja saasteainete laboratooriumi juhataja:



Ülle Püü



## 4.2 Newsletter

### In General

The dry digester pilot B has been installed in Estonia and will be there until the end of March 2014. This time shall be used to give the Estonian public as well as professionals a deeper insight into the digestion technology.

The local partner of the EU project, called ABOWE, is the Estonian regional and local development agency (ERKAS), represented by Reljo Saarepera, Jaan Löönik and Priit Freienthal.

First activities already took place and further are planned with the aim to give answers to specific questions regarding the anaerobic digestion technology in Estonia.

## ABOWE in Estonia

### Pilot plant just arrived

The main objective of ABOWE is the transfer of knowledge and pilot plant is our innovative solution that can be used as practical tool to promote biogas in Estonia. Therefore from mid October 2013 ABOWE is a lot more visible in Estonia as our project pilot biogas plant has arrived to Estonia.

Though there are many working biogas plants in Estonia they are not usually open for public due to safety reasons. Therefore a semi-industrial mobile pilot plant capable of regular and dry digestion that is meant for dissemination serves as an important educational and awareness raising tool for biogas in Estonia.

For its stay in Estonia pilot plant is hosted by Kaarli Farm, near medieval city of Rakvere. This is a modern farm with approx. 1500 cows and ambitious development plans.



The pilot plant at Kaarli Farm

The farm currently stores cow manure in big lagoons but is curious about practical implications of biogas. Therefore the pilot plant serves also as a practical testing ground to assist the farm with practical tests for getting more information on the potential of biogas plant as part of its manure management solution.

The site is quite close to Narva road – one of the main highways of Estonia and therefore easily accessible for visitors from near and far. High schools and universities in the region have already discovered the potential of the project and made contact requesting site visits.

### Priit Freienthal

#### Managing the plant in Estonia

For its stay in Estonia Pilot B test site is taken care by Priit Freienthal, B.Sc., M.Sc. mult, Dipl.-Ing., MBA. Priit comes from the background of physics, education and energy and today he is an expert in the fields of sustainable management and energy efficient solutions.

For ERKAS Priit is a valued member of the team, who serves as an expert in ABOWE project and with all activities related to engineering, sustainable energy and waste to energy. At the same time Priit gives lectures at universities and makes guest appearances in high schools, where he teaches physics and energy saving measures.

Previous long period of work as headmaster, teacher and electrical engineer has given him a good practical experience on how to popularize energy saving and alternative energy production issues among stakeholders be it the businessmen, engineers or students- the stakeholders of tomorrow.





Events

Stakeholder Meeting  
17<sup>th</sup> of December 2013  
in Rakvere

Contact

Reljo Saarepera  
reljo@erkas.ee

Jaan Löönik  
jaan@erkas.ee

Priit Freienthal  
priit@erkas.ee  
+372-5246017

website  
www.abowe.eu

## First Estonian Workshop

Plannings for pilot B in Estonia

First Estonian ABOVE workshop took place on Monday, October 28<sup>th</sup>. The day began with the site visit to the pilot plant and Kaarli farm followed by the visit to the nearby working biogas plant followed by round table discussion.

Representatives of ERKAS, as project partner and Kaarli Farm, as hosts of pilot plant had active discussion with expert from Tallinn Technical University, Peep Pitk, B.Sc., M.Sc. and representatives of the ministry of environment.

In his presentation Mr. Pitk gave practical advice on operation of pilot plant and how to carry out viable tests in Estonia that will meet the expectations of the project stakeholders. Later discussion on biogas potential and production technologies suitable for



Local farmer with biogas plants as partner for cooperation

Kaarli Farm and other similar farms in retrospect of waste to energy policies of Estonia, EU and socio-economic situation led to a conclusion that there are high expectancies on the quality of outcome of ABOVE and similar projects as

stakeholders knowledge on the topic is relatively high and public sector as well as businessmen are looking forward to a viable solution that will balance biogas as part of waste treatment and biogas as an energy source in a long run.

## First International project meeting for Pilot B in Estonia

December 16-17, 2013 partners and leading stakeholders gather for the first international Pilot B meeting in Estonia to discuss the initial progress of piloting as well as prospective for the business case in Estonia.

Presentations from Estonian experts will lead in the day,

followed by a practical discussion amongst project partners and round table with the local stakeholders to define the expectations, technical realities and socio-economic situation for the successful business case. Discussions are followed by a joint on site visit to Kaarli Farm and Pilot B test plant.



Priit Freienthal, B.Sc., M.Sc.  
mult. Dipl.-Ing., MBA.

