

INVESTMENT MEMO ABOWE PILOT B SWEDEN

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1. Introduction

This report is one output of ABOWE project (Implementing Advanced Concepts for Biological Utilization of Waste), which belongs to EU Baltic Sea Region Programme 2007-2013. ABOWE works with two promising technologies to unlock investments. Two mobile pilot plants have been built and will be tested in several Baltic Sea regions. These pilots are based on a novel biorefinery concept from Finnoflag Oy, Finland, known as Pilot A as well as a German dry fermentation process, known as Pilot B. The pilots form the basis for compilation of Investment Memos and organizing Investor Events. Also a regional model is used to evaluate the new processes' economic and climatic impacts in each region. The desired outcome from ABOWE is implementer/investor driven continuation projects targeting full-scale plant investments of the two technologies.

The purpose of ABOWE Work Package 2 is to gather and communicate information from many aspects of technologies which are piloted with Pilot A and Pilot B to support investment decisions for full scale plants. In practice, a demo full scale plant would be needed in order to convince the commercial investors and implementers to full scale plants. This means that ABOWE provides with profound information and a step forward regarding the two technologies. After ABOWE, the technology will need development for full-scale, and the feasibility will need further analysis. An implementer and investor should be found to conduct development further towards full-scale demo plant. The following chart illustrates this idea.

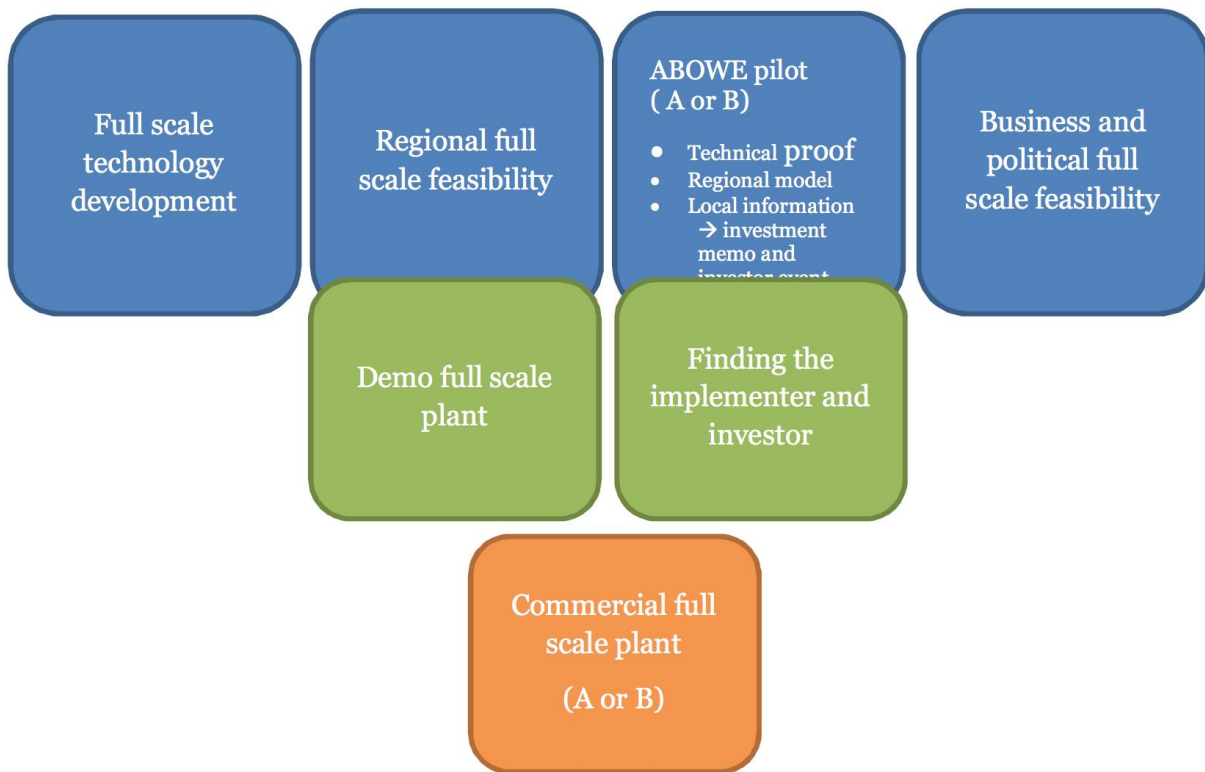


Figure 1. ABOWE in the path towards full scale plants.

Coming back to ABOWE, the following chart illustrates the process of Investment Memo and Investor Event.

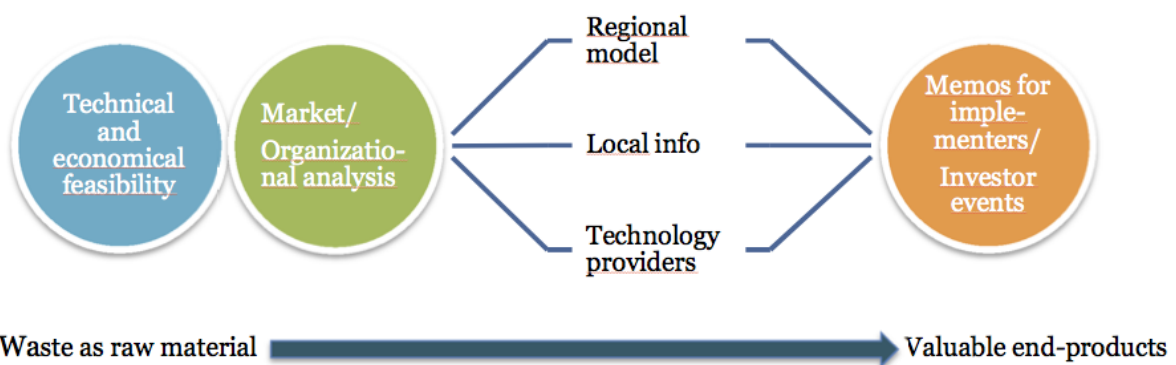


Figure 2. The process of Investment Memo and Investor Event.

In Business model creation, the Business Model Canvas with some added features is applied. The business model process includes evaluation and ranking of business model items, which is helpful and practical in the identification of the core business model.

This Investment Memo concerns the Swedish target region and Pilot B and has been

compiled in co-operation with Mälardalen University and VAFAB Miljö in Västerås, as the testing partners, Savonia University of Applied Sciences as a facilitator and University of Eastern Finland as a regional modeller. Ostfalia University of Applied Sciences as Pilot B provider and educator of the related dry digestion biogas technology has given essential information in their separate report about the Swedish Pilot B tests.

All ABOVE Reports are available at the project's web site www.abowe.eu

2. Executive Summary

The assessment of responses from key stakeholders representing academia, municipalities and/or the waste to energy sector suggests that the main customers in Västmanland are municipalities and waste handling companies.

The customer needs are improved solid waste handling and the need to produce products of higher value from the collected waste. A majority of respondents emphasised the need for improved technology that can increase the value of products produced from bio-waste.

There are several competitors in the waste to energy sector in Sweden, not least in Västmanland. There are several energy plants that use bio-waste to produce energy.

The most common value proposition suggested by the respondents related to the piloted technology was the need to enable a more efficient energy production from a more diverse composition of waste.

The most important resources required for a successful business were a reliable and sufficient supply of waste and finances allowing for investment, operations and maintenance of the technology.

The activities that were given highest priority before decision regarding construction of a full-scale dry digester can be made were to conduct extended technical and economic feasibility assessments, before any actual investment into a full scale plant based on the piloted technology would be realised.

The most important revenue streams were said to be waste handling fees collected from households and sales of produced energy, mainly to municipalities and companies with large vehicle fleets, e.g. bus and transport companies.

It can be concluded that all respondents consider that the construction of a biogas plant based on the piloted technology is a massive investment. Apart from the investment costs related to the construction the costs of administration, operations and maintenance in relation to the amount of waste treated and amount of gas produced have to be considered.

3. Operating environment

In 2011 the total energy use in Sweden amounted to 382 TWh, which is a decrease with 7% compared to 2010. The lower figure for 2011 is an effect of the winter being colder than average year 2010 and warmer than average in 2011 (ER, 2013). In 2014 the consumption is estimated to be 384 TWh (table 1). According to table 1 the energy use in industry has decreased slightly from 2012 as an effect of the uncertainty that the market is experiencing, as well as an effect of increased energy efficiency in the industry. The use of oil products, coal, electricity and central heating are all declining. On the other hand, use of biofuels and natural gas is increasing as an effect of the conversion of oil based fuels to renewable sources.

The transport sector used 94 TWh in 2011 and is on a decline due to more energy efficient transport vehicles together with weaker economic growth. The use of biofuels is increasing and Sweden is predicted to achieve the target of at least 10% renewable energy in the transport sector, set by EU. Bio-diesel and biogas are the two energy sources that increase the most. (ER, 2013)

Table 1. Energy consumption in Sweden 2011 – 2014 with a comparison of previous prognoses in parentheses (ER, 2013).

	2011		2012		2013		2014	
Inhemsk slutlig energianvändning	382	(382)	383	(384)	384	(387)	384	(388)
Varav:								
Industri	141	(141)	139	(138)	139	(138)	139	(139)
Transporter	94	(94)	92	(92)	92	(92)	92	(93)
Bostäder och service	147	(147)	152	(155)	153	(157)	153	(157)
Temp. korr. bostäder och service	155	(155)	153	(156)	153	(157)	153	(157)

3.1 Overall situation of biogas production in Sweden

3.1.1 Biogas in general

Biogas is a mixture of gases generated by the anaerobic fermentation of biomass degradation. Biogas contains 60-65% methane (CH₄) and 30-35% of carbon dioxide (CO₂). In addition, the biogas is, among other things: water (H₂O), nitrogen (N₂), oxygen (O₂), hydrogen (H₂), ammonia (NH₃) and hydrogen sulfide (H₂S), depending on feeds.

Biogas is a renewable energy source that could be central to stable economic, agricultural and rural processes and environmental protection. Producing biogas from livestock manure, municipal, organic waste and sludge contributes to energy diversification and increased energy supply protection, stability, competition and in addition provides more new income opportunities to waste managers and energy producers. (Lietuvos Zemes Ukio, 2010)

Biogas can be used for many purposes such as electric energy production, heating cooling and car fuel. It can also be supplied to natural gas networks. European Parliament highlights

the advantages of using biogas to decrease gas emissions that leads to climate warming and to strengthening EU energy independency. (Lietuvos Zemes Ukio, 2010)

The biogas-technology has become a significant part of the biomass-to-energy chain. Installing systems that generate both power and heat increases efficiency significantly. Increased efficiency reduces greenhouse gas emissions and fuel input compared to power and heat systems that are separated. Producing electricity and heating from biogas is less costly compared to power generation using natural gas and other fuels. Figure 1 illustrates the process of producing biogas from agricultural waste with co-substrates. (Van Staden and Musco, 2010)

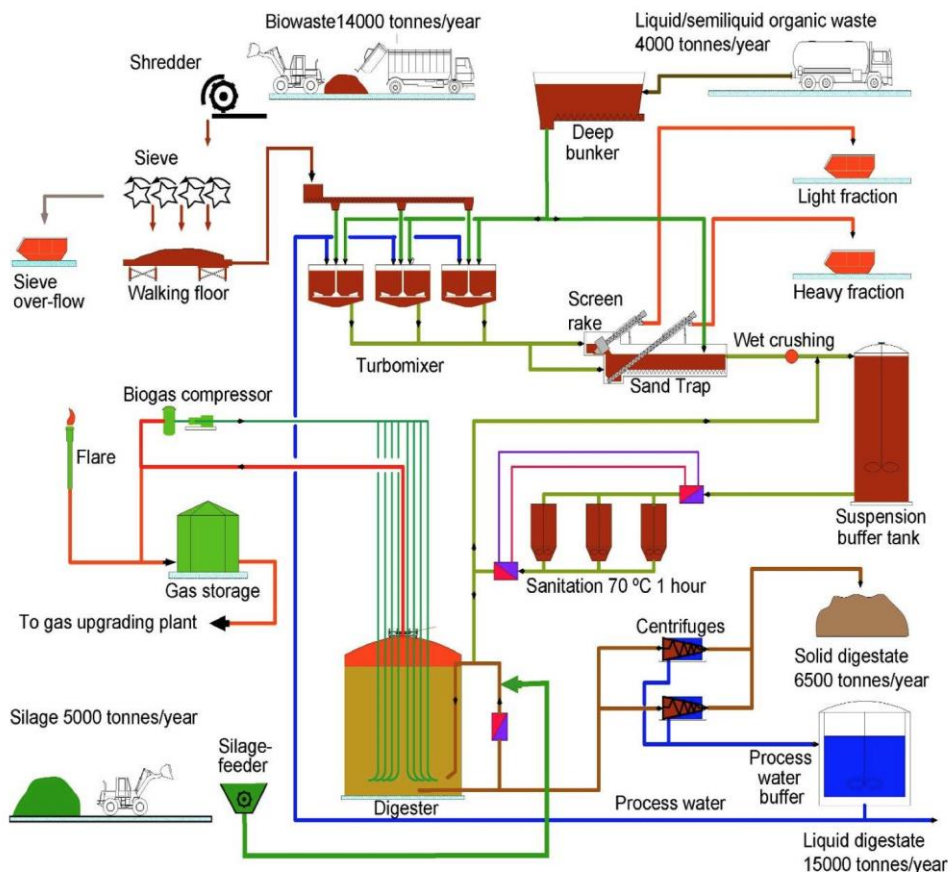


Figure 1. Process of producing biogas from bio waste and silage at Växtkraft, Västerås (Växtkraft, 2006).

3.1.2 Renewable energy policy

According to Regeringskansliet (2014) is more than half of the energy used in Sweden from renewable energy sources. Bioenergy and hydropower dominate, but wind energy is increasing rapidly. Since 2009 there is a EU directive that promotes the use of renewable energy sources (2009/28/EG). In this directive Sweden is committed to produce at least 49% of all energy used from renewable energy sources before 2020. Based on this directive, Sweden has set the following targets:

- At least 50% of the total energy use should come from renewable energy, and

- At least 10% of the energy used in the transport sector should come from renewable energy, in 2020.

Since 2003 Sweden has implemented a market based instrument, the electricity certificate system, to enable increased production of electricity from renewable energy sources. The goal is to increase production of electricity from renewable energy sources with 25 TWh until 2020, compared with the production in 2002. The Government also provides support to increase the use of wind energy to an annual production of 30TWh in 2020, of which 20 TWh on land and 10 TWh at sea. Apart from this there are a number of complementing instruments, including support to enable installation of photovoltaic systems as well as support to innovative production, distribution and use of biogas and other renewable gases. (Regeringskansliet, 2014)

The Swedish parliament has defined sixteen goals towards improved quality of the environment. All goals should be achieved by 2020. Biogas can have a positive contribution to four of these goals, i.e. decreased acidification, limited climatic effects, no eutrophication, and sustainable built environments. For instance, one part of the goal towards sustainable built environments is that at least 35% of the food waste from households, restaurants, industrial kitchens and shops should be reused through biological treatment latest 2010. This goal was not reached but as much as 25% of the food waste was recycled through biological treatment in 2010. New goals have been set, aiming to recycle as much as 50% of the food waste, producing energy and biological fertilizer. The latter contributes to the goal of at least 60% of phosphor compounds in sewers shall be returned to the soil of which half should be agricultural lands. This goal should be fulfilled already in 2015. (Biogasportalen, 2014)

3.1.3 Biogas plants in Sweden

The total amount of biogas that was produced in Sweden in 2013 was 1 589 GWh. The largest amount of biogas, approximately 42% (660 GWh) was produced by water treatment plants, 32 % from co-digestion plans, 16% (254 GWh) from landfills and 8% (121 GWh) from industrial plants. Small scale biogas productions, on farm level, contributed with 3% (47 GWh) (Biogasportalen, 2014). Most of the gas is upgraded and then used as vehicle gas, currently using 53% of all produced biogas. This is an increase of 15% from 2012. The second largest consumption of biogas is for heat production.

In 2012 biogas was produced at 242 biogas plants in Sweden. Of these plants, 135 are waste water treatment plants, 55 landfills, 26 smaller plants on farms, 21 co-digestion plants, and 5 industrial plants. The total digester volume was almost 560 000 m³. The water treatment plans have the largest total digester volume, while the industrial plants have the largest digesters. The smallest digesters have a volume of about 100 m³ while the largest have a volume of as much as 30 000 m³. There are about 50 plants for upgrading of biogas to vehicle gas in the country. There are a total of 154 public filling stations for gas driven vehicles in Sweden (Gasbilien, 2014).

A comparison of the gas production per county is presented in Figure 2. The illustration shows that Skåne county in southernmost Sweden has the highest biogas production (19% of the total production). More than 50% of the total amount of biogas produced comes from the counties of Skåne, Stockholm and Västra Götaland. (Biogasportalen, 2014)

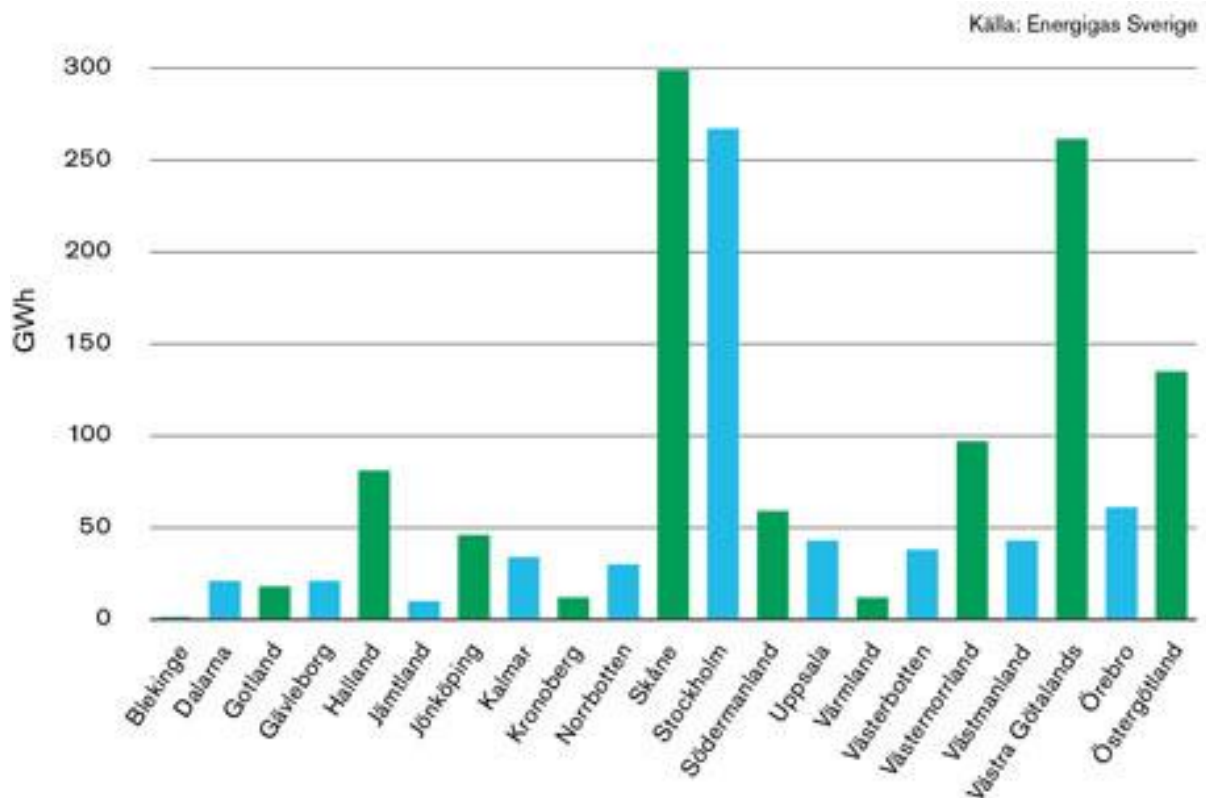


Figure 2. Biogas production per county (Biogasportalen, 2014)

In Västmanland county there is currently eight biogas plants, of which one is a landfill plant. In 2012 the total biogas production in the county was 43,5 GWh, which is the same as was recorded in 2011. The total digester volume is 14 710 m³. (Biogasportalen, 2014)

In Västerås there is currently two larger biogas plants, both situated at VAFAB Miljö's premises. Växtkraft is the most established plant that is producing biogas from Municipal bio-waste mixed with ensilage from surrounding farms. The biogas is upgraded to vehicle gas and used to power the municipal and regional buses and other transport vehicles in the region. The amount of substrate that is handled by the plant and the production of biogas per year at the Växtkraft plant in 2006 are presented in Table 2.

Table 2. Incoming substrate and production per year at the Växtkraft biogas plant (Växtkraft 2006)

Incoming substrates to the biogas plant per year	
• Source-separated organic waste from households and institutional kitchens with a dry matter content of 30 %	14 000 tonnes
• Liquid waste (grease trap removal sludge), with a dry matter content of 4 %	4 000 tonnes
• Ley crop from a contracted acreage of 300 hectares with a dry matter contents of 35 %	5 000 tonnes
Production per year	
• Biogas from the biogas plant	15 000 MWh
• Biogas from the sewage treatment plant	8 000 MWh
• Up-graded biogas to fuel quality Energy Equivalent to petrol	23 000 MWh 2.3 Million litres
• Digestion residuals	
Solid part with dry matter content of 25 – 30 %	6500 tonnes
Liquid part with dry matter content of 2 – 3 %	15 000 tonnes

The production of biogas is predicted to increase rapidly in Sweden. Figure 3 presents the prognosis for 2015 to be almost 2,5 TWh/år. This is due to the current construction of about 30 new biogas plants throughout the country. The goal for biogas production, set by Energigas Sveriges biogas section, is 3 TWh for 2015, including biogas from both digestion and thermic gasification (Biogasportalen, 2014).

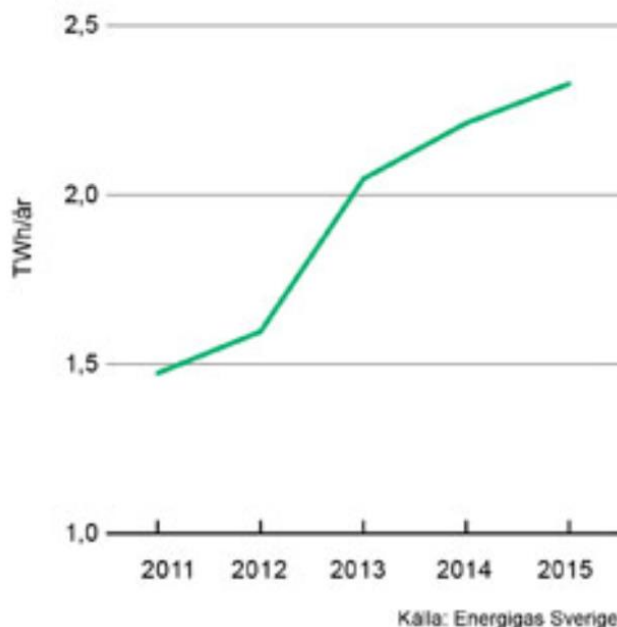


Figure 3. Predicted biogas production 2015 (Biogasportalen, 2014)

4. Pilot plant and tests

ABOWE Pilot B is a horizontal plug flow digester with process automation, gas measurement, four horizontal stirrer units and a volume of overall approximately 800 litres. Substrate is fed into the digester on a daily basis, which requires the operator to prepare daily feeding rates for the pilot plant on-site. The whole system is mounted in a 20-foot standard container, which keeps demands for space and costs for transportation low. The substrate is fed into the digester by a conveyor screw and the outtake of digestate works automatically. Digestate have to be collected on-site and treated afterwards. Therefore we would need a transportable tank or something else on-site. The substrate management should be prepared in detail according to the individual on-site operating conditions.

Daily feeding amount is approximately 10-20 kg, and expected daily gas production (depending on substrate) approximately 2 m³ of biogas, daily residue amount is approximately 15 kg. The pilot plant has a fully automated process control unit that allows manual as well as automated operations. Gas quality, power consumption and several other parameters (e.g. working hours of stirrers, screws, etc.) are collected separately. The container is equipped with heating, gas measurement and safety instrumentation to ensure a safe working area.

Additionally the system has a gas storage. The daily gas production is collected in a gasbag on top of the container and is drained once a day by using a 50 mbar gas blower and an enclosed gas burner. Pilot B has been described in detail in ABOWE Report O4.2 User guideline for Pilot B operation.

The substrate used in the Pilot B runs in Sweden was the residual fraction of municipal solid waste (MSW) after source sorting of biowaste. The plant was run under thermophilic conditions (55°C). Batch tests in both mesophilic and thermophilic conditions were done. The duplicate batch tests showed a big difference in biogas production, one giving higher methane production than the pilot plant and the other giving lower biogas production than the pilot plant. This might be a result of large variations in the substrate composition. In parallel also a garage fermentation pilot plant was tested with the same substrate, though with the difference that no sorting of the substrate was done. In the plug flow pilot plant about 10-25 % of the waste material was removed before feeding the pilot. The garage fermentation plant showed a biogas production per fed material that was about 70 % of the production in the plug flow pilot. The Swedish tests with Pilot B have been thoroughly reported in ABOWE Report O4.5 Technical Report of Swedish Pilot B tests.

5. Regional model

Climate impacts were considered for dry digestion system since it has strong impact on European waste and energy policy. Biomethane as vehicle fuel would be favored if it is proved to be sustainable. Thus, GHG emissions were calculated through mass- and energy balance in a dry digestion system that produces biomethane for vehicles. System considered biomethane production from well prepared fine MSW fraction that is sieved from residual municipal solid waste (MSW). Most important input values for calculations were adopted from dry digestion piloting at VafabMiljö Ab, but literature values were used to assess missing information. Dry digestion system and its parameters are described more detail in ABOWE report O.2.12. Biomethane production from fine MSW fraction in Västerås.

5.1 Mass and energy balance

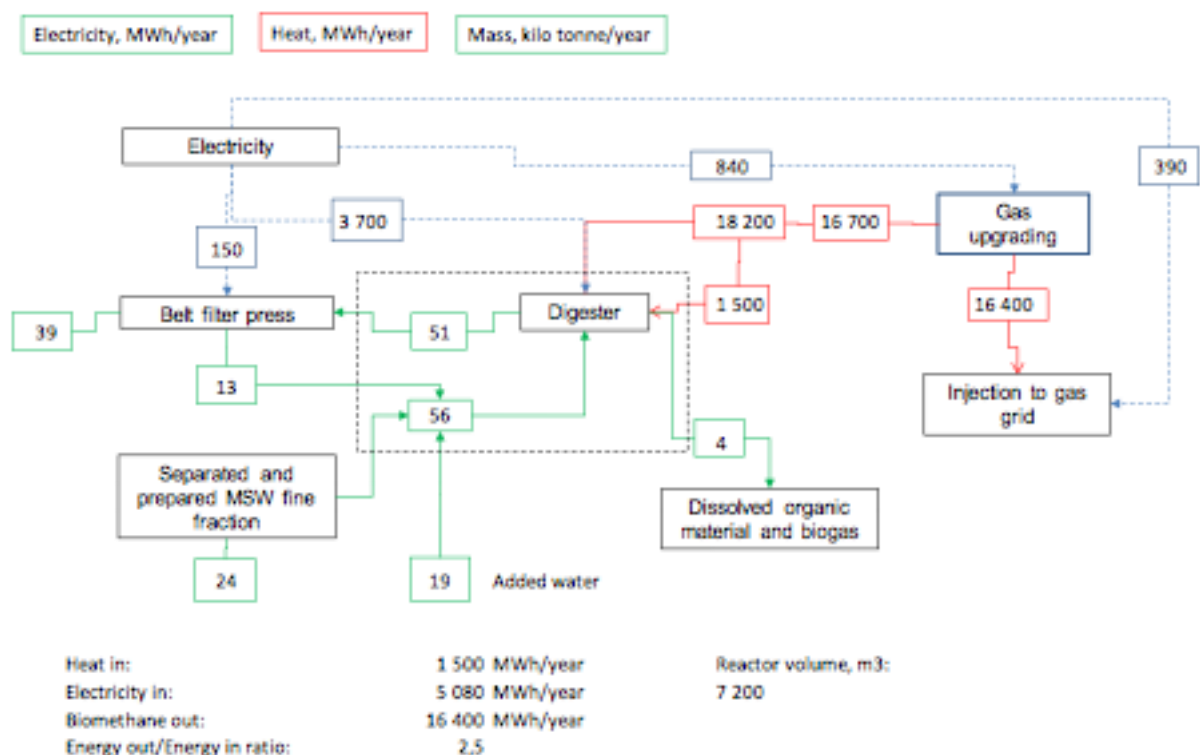


Figure 1. Mass and energy balance in a dry digestion system is based on input values of this report.

Digestate dewatering plays important role in dry digestion material balance. If 24 000 ton of fine MSW fraction have total solid concentration of 58 % of fresh mass as assumed, there would be need to add 19 000 ton of water and recirculated water of 13 000 ton to adjust feedstock total solid concentration to 25 % of fresh mass. In total, 56 000 ton of feedstock would be processed in the dry digestion system while 4 000 ton of volatile solids would be converted into dissolved organic compounds and biogas. When maximum TS concentration of 25 % of fresh mass in a typical belt filter press is assumed, there would be 39 000 ton of digestate for further end treatment.

One energy unit to the biomethane production system would give 2.5 unit of energy as

upgraded biomethane. After adding water and reject water from dewatering step to incoming feedstock its methane productivity per fresh mass decreases. When feedstock with methane productivity of 217 m³/(t VS) have adjusted total solid concentration of 25 % of fresh mass and VS concentrations of 60 % of TS its methane productivity is 33 m³/(t fresh mass). Still, compared to dairy cows methane productivity of 10 m³/(t fresh mass), methane productivity of fine MSW fraction fresh mass would be at its moisture content three time more (1). From produced methane of 16.4 GWh/year there is extracted 1.5 GWh/year of methane for dry digestion heating considering temperature increase of feedstock from 5 °C to 55 °C and total heat exchanger effectiveness of 50 %. In gas upgrading it was assumed that 2 % of the produced biogas is lost which contribute to overall GHG emissions. Electricity consumption in the system is based on the description in ABOWE Report O.2.12 Biomethane production from fine MSW fraction in Västerås.

5.2 GHG emissions

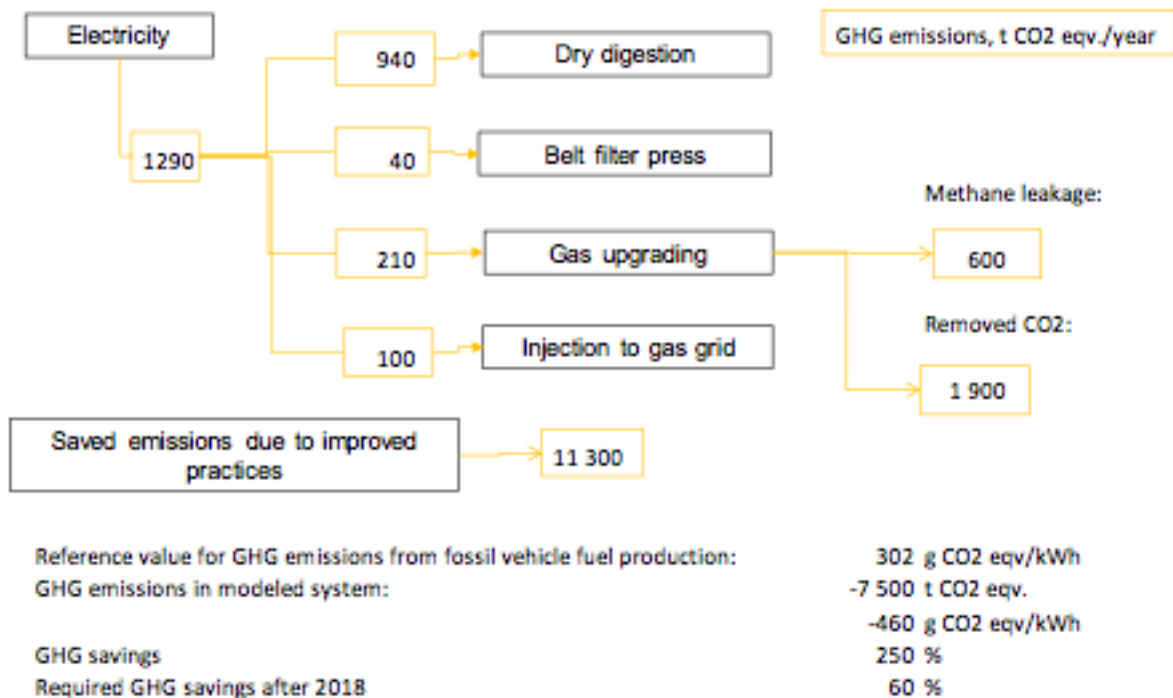


Figure 2. Greenhouse gas calculations are based on mass- and energy balance of dry digestion system.

GHG emission balance follows the results from mass and energy balance. Most of the savings are shown when biogas production from fine MSW fraction produces less GHG emissions than in its incineration. It was assumed that fine MSW fraction would contribute 52 % of the total emissions in a typical European MSW incineration resulting GHG emissions of 469 g CO₂ equivalents per fresh mass kilogram of fine MSW. If incineration of fine MSW fraction is replaced by dry digestion, GHG emissions would be decreased by 11 300 ton of CO₂ equivalent. Because Renewable energy directive does not count GHG emissions from biomethane use as vehicle fuel, GHG emissions occur only in biomethane production system (2009/28/EC). Net GHG emissions in the system are 7 500 ton of CO₂ equivalent. When compared to fossil fuel reference value of 302 g CO₂ per kWh actual reductions of 250 %

could be achieved.

Even result from GHG balance is very promising there should be paid attention into digestate end use. Probably most of the organic material is degraded in biogas process, but there can be still some amounts of organic and volatile compounds that can cause GHG emissions. In this study these emissions were neglected, but in the future it would be important to know how much GHG emissions occur when fine MSW fraction is used in covering landfills. Still, GHG reductions seem to be quite promising, even if GHG emissions would be counted from biomethane use. It would result GHG emissions of 3 200 t of CO₂ equivalent which could still result GHG reductions more than 60 %.

5.3 Conclusions

Material-, energy and GHG balances in biomethane production system look promising. The most important variables in these balances are methane productivity, total solid and volatile solid concentration of fine MSW fraction and dewatering properties of digestate. So far assessments about digestate dewatering properties are estimated and thus needs to be defined in further studies. In ABOWE project it is shown that piloting of dry digester would work and sufficient methane productivities can be achieved. Further information is needed about possible GHG emissions from digestate use as landfill covering material. Possible changes of fine MSW fraction properties due to waste producer's behavior are also important. So far assessments from material, energy and GHG point of view looks promising to continue applying dry digestion system for fine MSW fraction.

6. Business model

The business model analysis carried out for the up-scaling of the dry digestion technology piloted in Pilot B in Västerås, Sweden was based on the Extended Business Model Canvas. This tool is based on the original business model canvas developed by Osterwalder and Pigneur (2010). The original canvas is made up of nine building blocks (Table 1).

Table 1. Building blocks of the business model canvas of Osterwalder and Pigneur (2010)

Building block	Definition
Customer/Competition	
Customer segments	For which customer groups are we offering solutions?
Offering	
Value propositions	Which one of our customer's problems are we helping to solve?
Channels	Through which channels do our customer segments want to be reached?
Customer relationships	What type of relationship does each of our customer segments expect us to establish and maintain with them?
Profit formula	
Revenue streams	For what value are our customers really willing to pay?
Cost structure	What are the most important costs inherent in our business model?
Resources	
Key resources	What key resources do our value propositions require?
Key activities	What key activities do our value propositions require?
Key partners	Who are our key partners required to build the business?

The expanded business model canvas used for developing the business model for Pilot B in Sweden used three more building blocks (Table 2).

Table 2. Additional building blocks (expanded business model canvas) used by ABOWE project.

Building block	Definition
Customer/competition	
Customer needs	Which problem will be solved for the end user or customer?
Company solution	What is the practical offer from the company?
Competitors	Existing or foreseen competition?

The information that guided the development of the business model was gathered from key stakeholders during the investors' event and from an on-line questionnaire. Stakeholders that contributed to the survey represent municipalities, waste and energy sectors and academia.

6.1 Extended Business Model Canvas

The Extended Business Model Canvas was developed based on inputs from five key stakeholders representing academia, municipalities and/or the waste to energy sector. The project team carried out the assessment of the responses using the on-line tool 'Savonia Innovation Platform', developed by Savonia University of Applied Sciences in Kuopio, Finland. The resulting business model canvas is presented in Table 3.

6.1.1 Customer/Competition

The assessment of responses from key stakeholders suggests that the main customers, interested in implementing the piloted technology are municipalities and waste handling companies. This is likely a reflection of the kind of substrate that was tested, i.e. residue waste from an established waste management facility, where biogas production is already taking place, but with a less challenging substrate. Large scale waste handling and energy production is commonly carried out by municipalities in collaboration with either a public or private waste management company.

The customer needs scoring highest amongst the respondents were improved solid waste handling and the need to produce products of higher value from the collected waste. This reflects a general situation in Sweden where there is a growing demand to move more of the waste operations upwards in the waste hierarchy as well as the high costs associated to waste handling. It is essential to generate products of high value in order to make waste handling financially viable.

Regarding the proposed company solutions the majority of respondents emphasised the need for improved technology that can increase the value of products produced from bio-waste. For instance it was suggested that bio-waste currently not used for biogas production due to its complexity, i.e. poorly sorted residue waste, should also be used for biogas production. This leads to a number of complications as for instance the quality of residue from more homogenous non-toxic waste can be guaranteed, making it possible to use it as a fertilizer or other value adding products, which is less likely when using residue waste.

According to the respondents there are several competitors in the waste to energy sector in Sweden, not least in Västmanland. There are several energy plants that use bio-waste to produce energy. In Västerås an interesting collaboration has been initiated between Väckkraft, the biogas plant, and Mälarenergi, the municipal power company. Mälarenergi is incinerating waste, but cannot use the wetter waste, which instead is taken to Väckkraft for biogas production. Waste that Väckkraft can't use for biogas production is taken the other way, to Mälarenergi to be incinerated. This collaboration results in an improved waste handling in the region and a win-win situation for the companies involved.

6.1.2 Offering

The most common value proposition suggested by the respondents related to the piloted technology was the need to enable a more efficient energy production from a more diverse composition of waste. This is a response to a steadily increasing demand for biogas, which mainly is used as a vehicle fuel, and an increasing competition for waste amongst the energy producing companies.

All respondents stated that their main channels for communication with their clients/customers would be through face-to-face interactions, i.e. meetings. Some respondents stated that the municipality, in the role of project owner, would facilitate meetings.

6.1.3 Resources

The most important resources required for a successful business were a reliable and sufficient supply of waste and finances allowing for investment, operations and maintenance of the technology. The key partners identified were the municipalities and larger waste management companies. Again, this is a result of the pilot plant being operated at a large waste handling facility where biogas already is being produced. The stakeholders participating in investor events and contributing to the development of the business plan were mainly representatives from these sectors.

The activities that were given highest priority were to conduct extended technical and economic feasibility assessments, before any actual investment into a full scale plant based on the piloted technology would be realised. This suggests that it is difficult to do a direct up-scaling of the results from the pilot plant to a full scale implementation, which is understandable, taking the large costs involved in such an investment. Before a large scale investment can be done, not only economic viability calculations, but also environmental, social and well-being aspects have to be done. Respondents suggested that the economical feasibility is the most challenging as this depends on a number of factors that are beyond the control of the project team, e.g. increasing competition for waste and new, more demanding environmental regulations, as well as future demand for the produced energy.

6.1.4 Profit formula

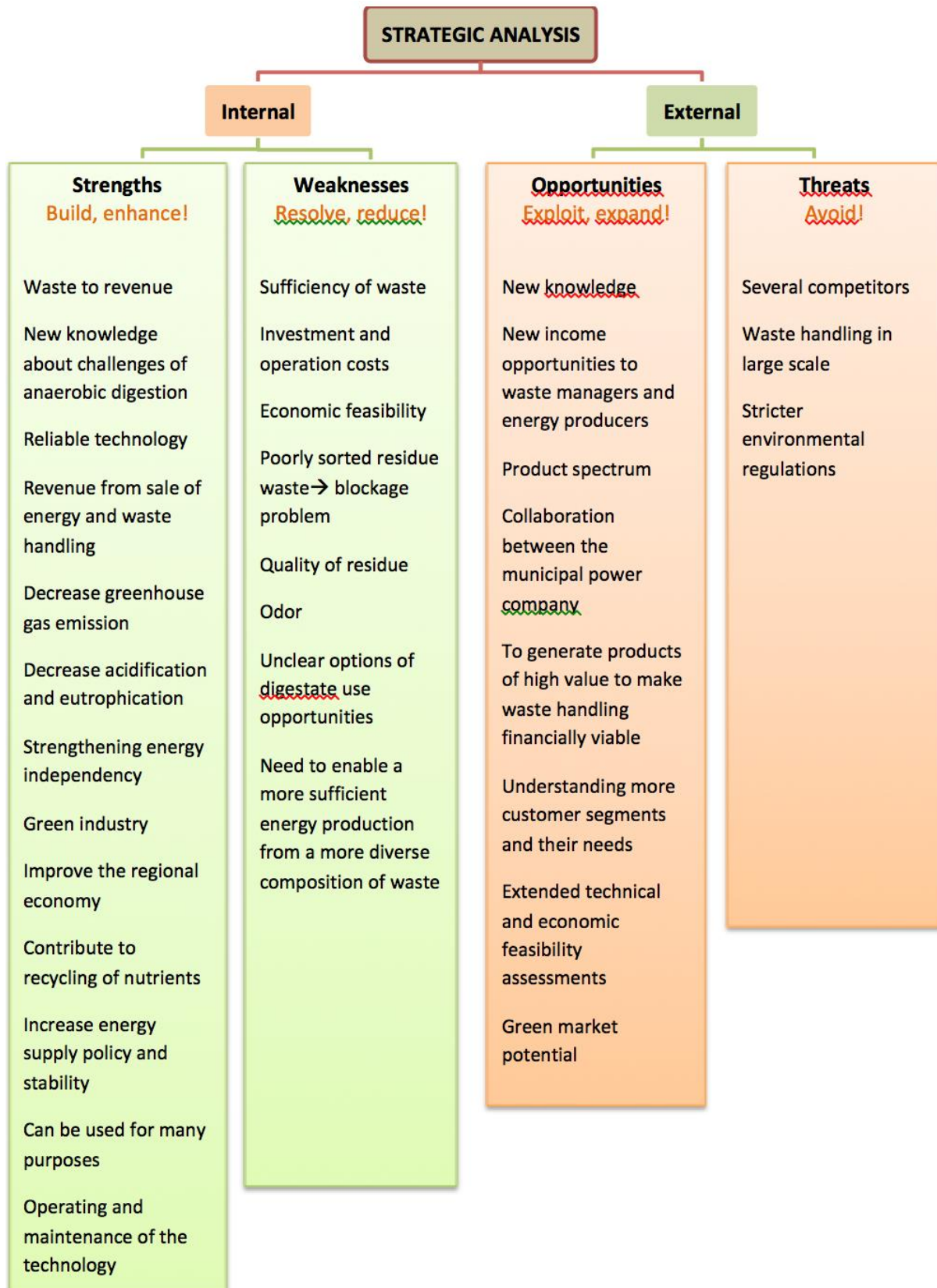
The most important revenue streams were said to be waste handling fees collected from households and sales of produced energy, mainly to municipalities and companies with large vehicle fleets, e.g. bus and transport companies.

Finally, related to the cost structure it can be concluded that all respondents consider that the construction of a biogas plant based on the technology piloted is a massive investment. Apart from the investment costs related to the construction the costs of administration, operations and maintenance in relation to the amount of waste treated and amount of gas produced have to be considered.

Table 3. Extended business model canvas for Pilot B: Dry digester, Swedish case.

Customer/competition	Customer segments 1. Biogas producer with waste demand 2. Waste handling companies 3. Municipalities 4. Big farmers 5. Supermarkets 6. Industry producing solid bio-waste	End user, customer need 1. Improved waste handling 2. Need to move operations upward in waste hierarchy 3. Produce more value added products from waste	Company solution 1. Improved technology to add value to waste	Competitive solution 1. Existing solutions 2. Other waste to energy solutions being introduced
	Offering	Value proposition 1. Improved waste treatment 2. More efficient energy production from waste 3. Higher value (fuel) production from waste	Channels 1. Face to face meetings 2. Seminars 3. Workshops	Customer relationship 1. Face to face meetings 2. Seminars 3. Workshops
Resources		Key resources 1. Waste 2. Market for produced biogas 3. Residue from biogas process 4. Reliable technology	Key partners 1. Municipality with waste issue 2. Biogas producer with waste demand 3. Municipal waste handler 4. Farmers 5. Regional council 6. Engineering and construction companies	Key activities 1. Technical and economic feasibility studies 2. Energy and mass balance of process 3. Waste resource analysis 4. Dimensioning of plant 5. Finance plan, including cost and cost reductions

7. SWOT Analysis



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