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INVESTMENT MEMO

ABOWE PILOT A FINLAND

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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. The purpose of this report is to gather together information from many aspects of the Finnoflag biorefinery technology which was piloted with Pilot A 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 or implementers of full scale plants. This means that ABOWE provides with profound information and a step forward regarding the technology. After ABOWE, the technology will need development for full-scale, and the feasibility will need further analysis. An implementer and investor is welcomed to conduct development further towards full-scale demo plant. Figure 1 illustrates this idea and positions ABOWE project in this development path.

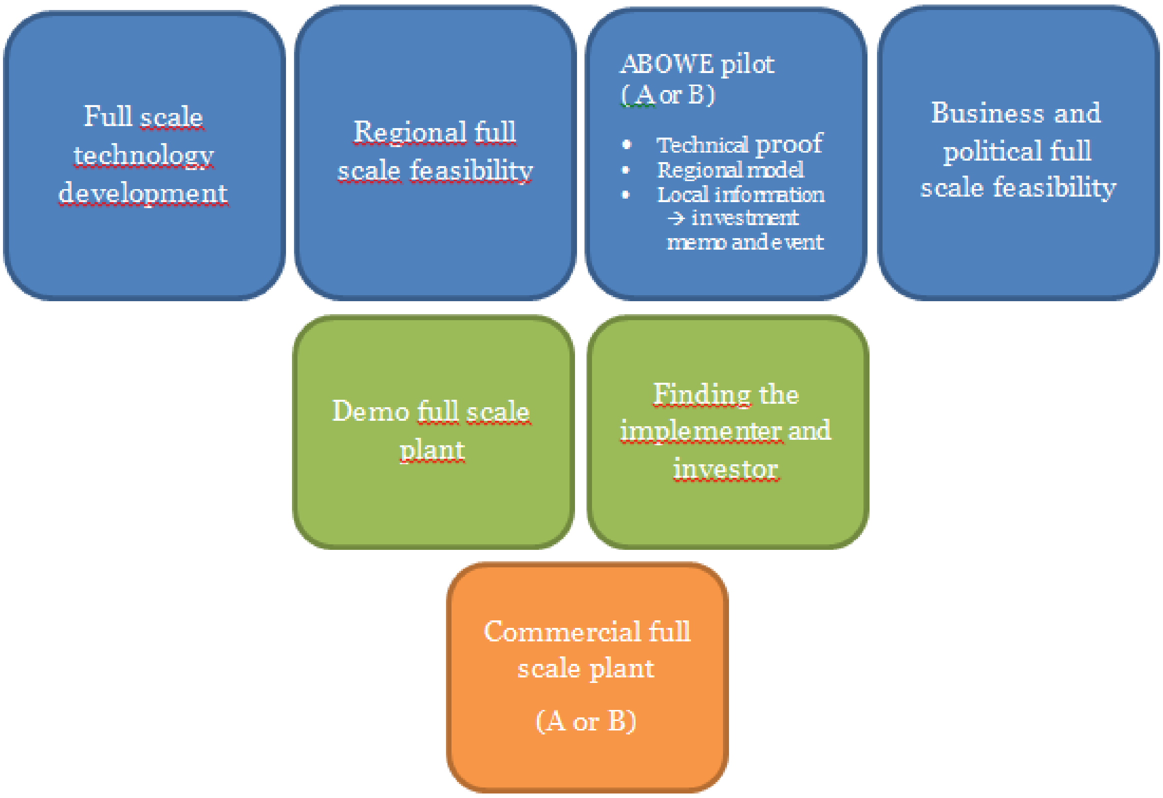

Figure 1. ABOWE in the path towards full scale plants.

Figure 2, on the other hand, illustrates the process of Investment Memo and Investor Event in ABOWE project.

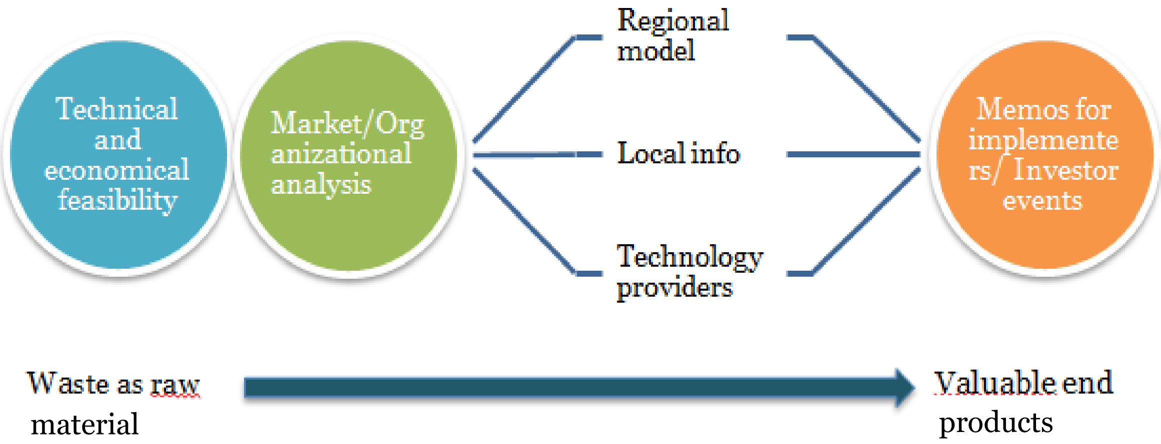

Figure 2. The process of Investment Memo and Investor Event.

2. Executive Summary

ABOWE Pilot A Finland Investment memo is a document that gives view of operating environment, energy and chemical market in Finland, biorefinery pilot and tests, regional model, business model and strategy to full scale business.

Research and development and innovations are increasing in finding sustainable solutions for waste management and reducing overall environmental load. They are part of EU's long-term climate and energy targets.

Novel biorefinery concept has been developed by Adjunct Professor Elias Hakalehto, Finnoflag Oy. Upstream bioprocess that was piloted is based on bacterial metabolism in the 2,3-butanediol fermentation. Other valuable products are also formed of this fermentation. Technology for actual downstream process has been developed in Ostfalia University of Applied Sciences in Germany.

Piloting period in Finland presented that the concept works and concentrations of 2,3-butanediol, butanol and hydrogen have been formed. Raw materials used in piloting are considered to represent an annual cost of about one million euro for the testing site.

In order to move forward for looking the investors for the full scale plant all the scheduled piloting were needed in Poland and Sweden with different kinds of raw materials. Downstream process is also substantive part of the whole process. Hence follow-up projects will be needed to attract the possible investors providing opportunity for combined pilot plant scale testing with both upstream and downstream processing and with longer testing time.

It is important to pay attention to the preliminary nature of the experiments. Nevertheless, a Proof-of-Concept actualized in all three countries with three different biowaste mixtures. This gives a sound basis for future developmental work on the basis of the novel biorefinery technology concept using the undefined microbes together with some known strains for the production of chemical goods in a low cost non-aseptic environment. Such arrangement underlines the sustainable values combined with reasonable investment and operation costs.

3. Operating environment

Political views of handling the waste are changing due to the policy of the European Union. EU has made objectives on decreasing GHG-emissions by the year 2020 for the Member States. (1) EU uses guiding methods to achieve 20% decrease on GHG-emissions. Finland has made even greater objectives on GHG emission reductions by the year 2020. (2) New waste act has objectives to increase recycling and reuse of waste by 2016 and 2020. By the year 2016 half of the municipal waste should be recycled for material recovery and by the year 2020 70 per cent of construction and demolition waste should be recycled or reused. Also all biodegradable waste consisting over 10 per cent total organic carbon (TOC), cannot be put to landfill.

Political and legal environment guides economical aspects by fares and different kind of tax-reliefs and bursaries from EU and government. Finland has set higher objectives on emission reductions by the year 2020. This means that there are also more financial endorsements from the government. EU is funding European research and development projects between 2014-2020 for total amount of 70,2 billion euros. (3) This biobased economy has and will be stepping on new levels. According some estimates biobased economy in 2040 will have market value around 90 billion euros.

Sustainability is one of the most important criteria when new kind of technology is applied to use. One of the bases for the EU's climate and energy targets is to make a sustainable way to use world's resources. This project follows the same principle. (4)

When looking things at technological point of view, situation at the moment is mainly focused in producing bioethanol or bio-oil from side streams in Finland. Waste is used as raw material and this can bring certain amount of competition, particularly waste from forest industry is highly desired raw material. Waste management has been increasing expense to the forest industry in the past years.

In this project there is goal to utilize new kind of technology to produce waste to energy and also to get commodities from the process e.g. liquid biofuels and other useful chemicals. Pilot has been proven to work after first pilot period has ended in Savon Sellu. Demand for the waste utilization will be increasing and technological innovations are researched.

4. Bioenergy and biochemical markets in testing region

Bioenergy and biochemical markets in Finland are potential in foreseeable future. Especially bioethanol production will rise towards the year 2020. Chemicals that can be made with the process are considered as platform-chemicals. Following is more detailed information about the products and their price levels.

4.1 Products

Among other the following products can be made with the process depending on raw material: 2,3-butanediol, ethanol, acetone, butanol, hydrogen and methane. Some are products due fermentation and other are by-products. It is noticeable that some of the chemical products can be also used as an energy source.

4.1.1 Chemical products

Most attractive of all them is 2,3-butanediol which is a substance that is used as raw material in making of materials like synthetic rubber, plastic monomers, anti-icing chemical, textiles, cosmetics and many other substances. (5)

Ethanol is alcohol which can be used as motor fuel, mainly as a biofuel additive for gasoline. In Finland the ethanol concentration of 95 octane petrol was raised in January 2011. Highest possible bioethanol concentration for E10 petrol is 10 per cent v/v. (6) Finland has also set biofuel blending mandate at 6 per cent. (7) Domestic bioethanol production will be crucial in future.

Acetone is chemical that is one of the most widely used industrial solvents. It is also used increasingly as chemical intermediate. About 75 per cent of the available acetone is used to produce other chemicals. Use of acetone applications range from surface coatings to pharmaceutical applications. (8)

Butanol is an alcohol that can be also used as transport fuel. It is also used to produce other chemicals, like in an ingredient in formulated products like cosmetics and solvents such as paints, coatings, resins, alkaloids and rubbers. (9)

4.1.2 Energy products

Hydrogen is a gas which has the highest combustion energy release per unit of weight of any commonly occurring material. It is considered as the fuel of the future due its non-polluting combustion products. (10) Hydrogen is most commonly produced via either steam reformation of methane or electrolysis. Hydrogen is also a common by-product in chemical industry. Hydrogen as biofuel for transportation is still considered quite expensive due to the cost of the fuel cell system needed to combust the hydrogen. Fuel cell technology will become more common and cheaper in the future but the growth will happen in certain areas in the world. To Finland the use of hydrogen as biofuel of transport will happen periodically. (11)

Methane is a gas and it is the main component of natural gas. It is mainly used as a fuel in energy and transport sector. In Finland methane is mainly used in combined heat and power (CHP) production and partly as biofuel for transportation. (12)

4.1.3 Fertilizers

Biorefinery process will leave some amount of residue. Depending on raw material this residue can be used as fertilizer. Due to high concentration of some substances in residue the most applicable use would be the use as forest fertilizer. It has been proven that one-time fertilization adds the growing stock in eight years by 13-25 m^3/hectare. (13)

Fertilizers can be also used in households if the high concentrations of some substances are removed.

4.2 Price levels of products

Price levels of the products are separated and they all are estimates.

4.2.1 Gate fees

Gate fees are paid by waste producers to the company that is responsible for managing the waste. This makes waste management economically worthwhile. Gate fees are depending on the contents of the waste. Gate fees are also in correlation with the total investment costs of the bio refinery and the profit of the outputs. That way the competitive gate fee amount can be solved. Savon Sellu produces 34 000 tons of sludge waste annually. That makes expense in class of million euros per year. For example gate fee of the CHP biogas plant in Oulu in Northern Finland, is for the municipal waste as high as 87 euros per ton without VAT. (14) That way roughly estimate can be given that gate fees vary between 30-90 euros depending on waste concentrations and the waste handler.

4.2.2 Energy products

Hydrogen in liquid fuel form costs at the moment approximately 10 euros per kilo. If hydrogen fuel cell technology takes off in larger scale, estimate is that costs are going down. 5 kilos of hydrogen fuel gives effective range of about 600 kilometers. At the moment there is only few pumping stations for hydrogen in Finland. (15)

Methane Biogas on Gasum pumping stations costs at the moment 1,45 €/kg. (16)

Estimates are that depending on the blend rate of 200-400 million liters of bioethanol would be consumed in Finland in 2020. This would translate into value of 50-100 million euros for Finnish ethanol market. (17). At the moment Finland has biofuel blending mandate of 6 per cent. So effectively Finland have committed that 6 per cent of the energy used in transport sector by gasoline comes from biofuels. (7)

4.2.3 Chemicals

Trends for the market prices of chemicals indicate steady rise. According to the publicly available sources the prices are for example:

- 2,3-butanediol - average price 12 200 EUR/ton;
- Butanol – average price 1200 EUR/ton
- Ethanol average price 1050 EUR/ton
- Hydrogen – average price 700 EUR/ton

2,3-butanediol can be seen as the main high level product (besides other alcohols and acids) due to its multiple uses. It is evaluated that the global market of 2,3-butanediol is around 32 million tons per annum, valued at approximately $43 billion in sales. (18) Because of the unique structure and costly chemical synthesis, 2,3-butanediol has not been produced on a large scale and has a high market price (7 700 – 16 700 EUR/ton). (19)

4.2.4 Fertilizers

Price levels of forest fertilizers ranges depending on the type of the used fertilizer. Yara Finland price levels for forest fertilizers range from 400-529 euros per ton without VAT. These are 2012 price levels. Fertilizer price level depends on the nutrient ratio. (20)

4.3 Competitors

Bio refinery technology is relatively new form of business in Finland. Therefore competition is at the moment minimal although big energy companies are using a lot of R&D in the field.

Bioethanol production will be increasing greatly in the next years to meet the government's climate and energy targets by the year 2020 and forward. Finnish energy solution company St1 has currently 7 bioethanol plants in Finland. (21) Their plants are using various waste and residues as inputs to produce the bioethanol. That brings competition on gate fees.

Finnish Green Fuel Nordic is a biorefining company. They have aims to build several bio refineries in Finland in upcoming years. Their plants will utilize commercially proven RTP™ technology. Their first plant is being built in Iisalmi in Northern Savo and second plant is on planning stage. Their goal is to produce second-generation bio-oil. Their main raw material will be renewable wood biomass. Their target market is industrial and municipal electricity and heat production alongside the use of bio-oil to power marine diesel engines. (22)

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Implementing Advanced Concepts for Biological Utilization of Waste

5. Feedstock potentials for fermentation processes

Biodegradable feedstock mass potentials and their distribution were assessed from Finland due to utilize them in sustainable waste-to-energy systems (Figures 3, 4 and 5.). Selected feedstocks were forest industry sludge, spoilt grass silage and household biowaste. Forest industry sludge from pulp, paper and board production is annually about 470 kt DM when under of landfilling legislation there is about 41 kt DM of sludge per year with average DM concentration of 34 % of FM. Spoilt grass silage potential is about 70 kt DM per year with average DM concentration of 33 %. Maximum house hold biowaste potential is about 270 kt DM per year, but in current status about 52 kt DM is separately collected with average DM of 33 %.

There is urgent need to find out sustainable waste-to-energy solutions for household biowaste and forest industry sludge, because they cannot be landfilled after 2016. Spoilt grass silage could act as additional feedstock, because it is not under landfilling regulation.
It is worth of try to aim towards sustainable biofuel production systems, because European commission favors them by inventive mechanisms. With forest industry sludges it is reasonable to concentrate on mill scale waste-to-energy solutions, because sludge properties are case specific, their properties have significant variation and sludge potential at one single origin is huge. In one mill sludge mass potential can be even twice more than separately collected household biowaste potential from North Savo province. Instead, household biowaste and spoilt grass silage have more homogenous properties and their origins are dispersedly located which makes them energy utilization possible by using effective waste collection in large scale waste management systems.

Collection area for household biowaste and spoilt grass silage should be at least in a scale of one province to achieve same mass availability as forest industry sludge has. In energy balance point of view it is reasonable to transport household biowaste up to 2000 kilometer from its origin in a biogas electricity production system. When thinking about end product sustainability properties, most of the desired end product is 2,3-butanediol, because it has potential to cut down GHG emissions twice more than European commission fossil fuel reference has.

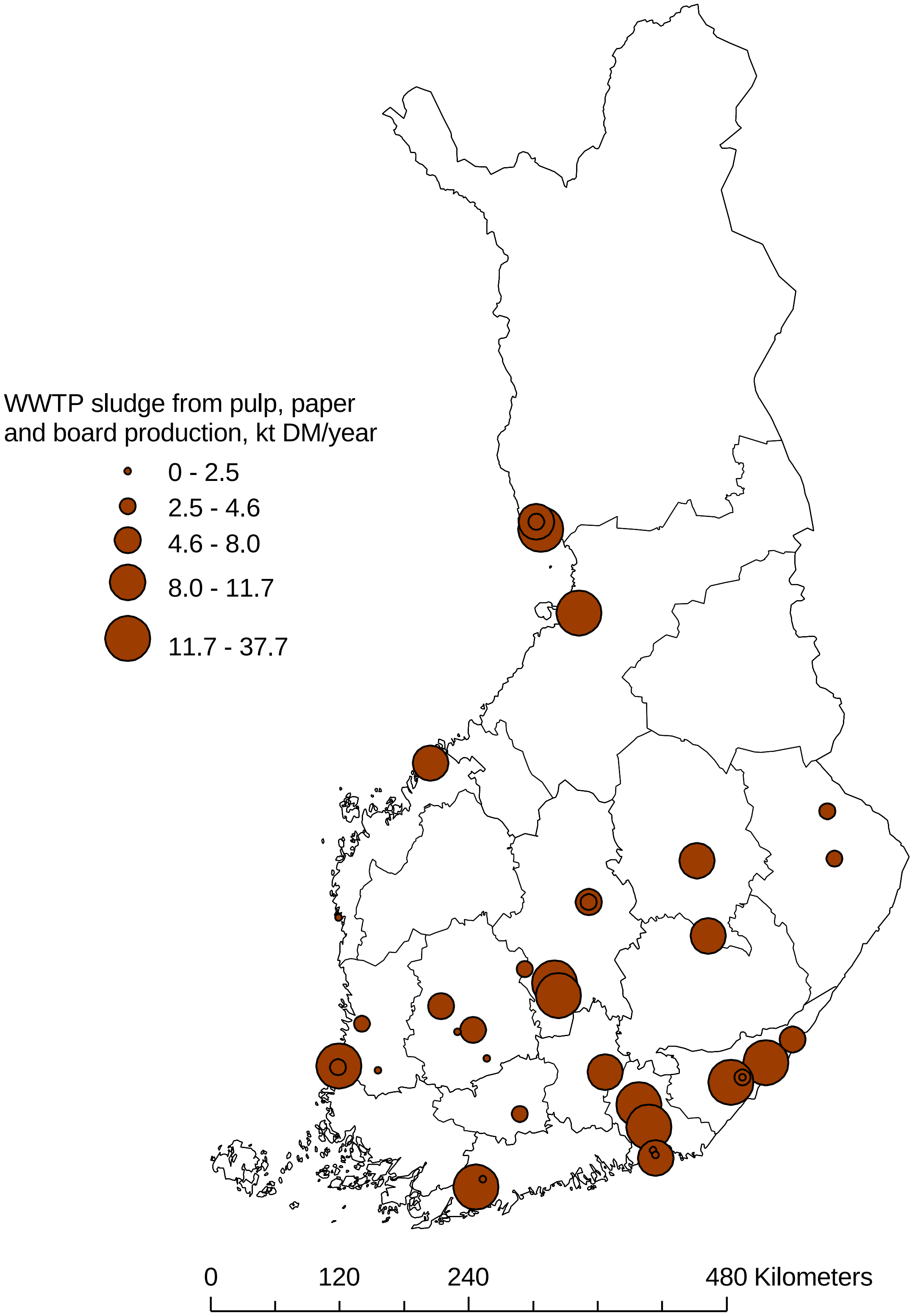

Figure 3. Sludge production was estimated according to pulp, paper and board production in 2012.

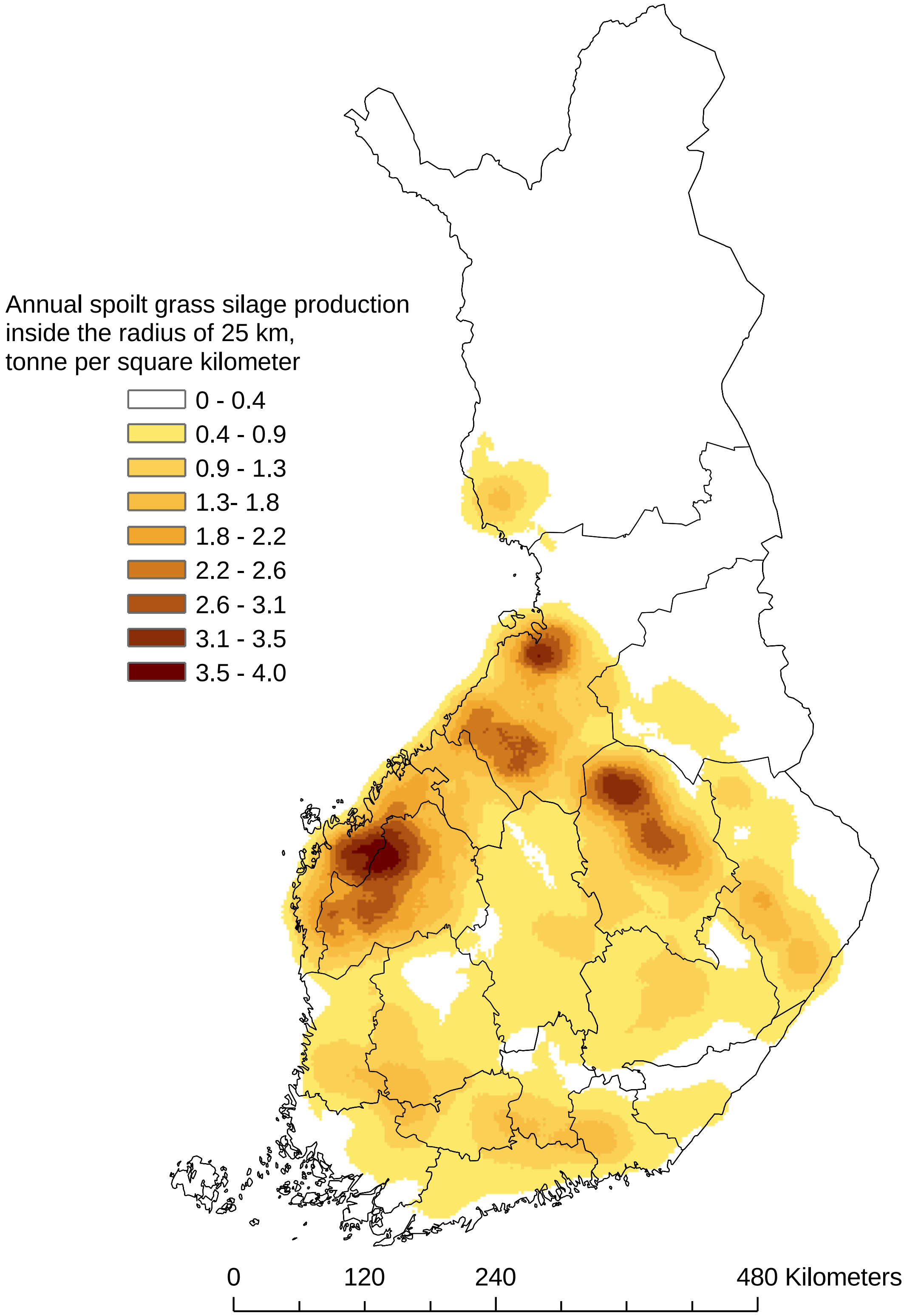

Figure 4. Spoilt grass silage production in terms of fresh mass units was estimated according to data from Ministry of Agriculture and Forestry.

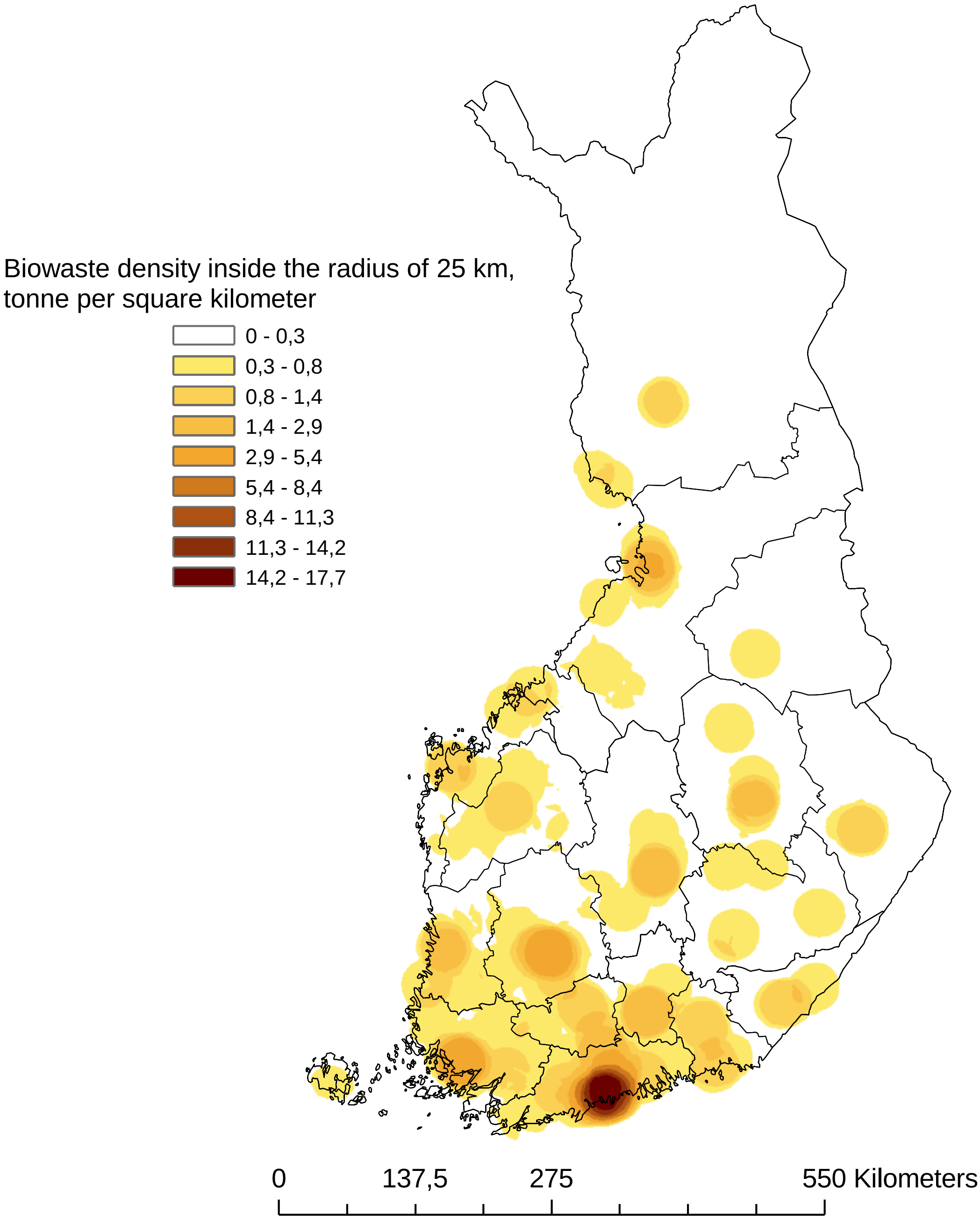

Figure 5. Household biowaste distribution in terms of fresh mass units was calculated from Finnish socio economic data base.

6. Pilot tests at Powerflute Oy Savon Sellu cartonboard plant in Kuopio

Finnoflag biorefinery technology test runs with Pilot A at Savon Sellu cartonboard factory's waste water treatment plant in Kuopio were performed during February-March 2014. The main purpose has been to test the equipment functions of the pilot plant which was designed and realized in the project and then transferred to the factory waste treatment site on 18.1. 2014 (Figure 6).

Figure 6. Pilot A in its first testing site at Savon Sellu Oy in January 2014.

From the bioprocess view, all six test runs in this two-month testing period were preliminary ones. Their main purpose was to get tested and fixed the various technical details and features of the Pilot A experimental station. Consequently, the focus was not in optimizing the bioprocess but, besides the technical runs, different characteristics of biomass waste as raw material and the use of mixed microbial cultures were experimented. Also, basics of the biochemical processes were charted. These first experimentations were thus producing:

1. Technical validation, reparation data and further technical preparation of the engineered pilot plant
2. Introduction of the process principles

3. Education of the users
4. Preliminary testing with the cellulosic waste material with proof of concept on using the Pilot A type of solution in the treatment of forest industry wastes

This evaluation period could have continued as actual optimization and improvement of the process, but the pilot was to be delivered to Poland according to ABOWE schedules. However, some encouraging first results were obtained. For example, the constant hydrogen containing gas flow observed earlier in the laboratory of Finnoflag Oy was detected also during the ABOWE piloting. The generation of molecular hydrogen was combined with the production of liquid chemicals. The diminishment in the environmental load was already comparable to the biogas process, and actually the biorefining for chemical commodities could be combined with subsequent biogas production for the highest decrease in the climatological effects in the waste treatment.

As a summary, products from these test runs were:

- Ethanol;
- Butanol;
- 2,3-butanediol;
- Organic acids;
- Hydrogen;
- Fertilizer biomass;
- Biogas;
- Purified water;
- Decreased waste treatment expenses; and
- Lesser environmental and climate load.

In principle, as the main focus was directed to learn to run the Pilot A experimental station, the production rates were secondary in the beginning. These levels are possible to get improved in long run, during actual optimization of the process. In fact, the basic principles for steering the pilot were being learnt, and their implementation gave promises for the potential for quick optimization of the results in future bioprocess development. In the start-up phase any result from the biological multi-variable process is giving valuable information for future trials. It was also possible to outline the potentials for future bioprocessing, as well as to get an idea on the process improvement. Also, the national and international teams learned well to cooperate in this milieu, where biological components (biomass, microbes and enzymes) meet with metal hardware, sensors and the computerized control.

The current test was the promising start for the future implementation of the bioprocess technologies into the waste treatment. During the short two-month period of time available for the Finnish testing, it was possible to demonstrate the potential for development of the microbial processing of the dried activated sludge from the forest industry waste treatment unit. The activated sludge is as such a product from a kind of biotechnological and microbiological process, which was then further processed in the Pilot A to comprise raw material for energy and chemical production. If combined with biogas formation from the residues, the positive climatological effect and sustainability of the whole chain of treatments could be enhanced. (23)

7. Business model creation

Business model is introduced here by using an Extended Business Model Canvas template (Figure 8). Items for the business model blocks were collected in two steps with a survey, and interviews with specialists. Questions for the business model survey were created by using the business model template and the answers were analyzed by using decision making tools. (24)

7.1 Business model survey and analysis

Survey for the business model was made in two steps. First survey was targeted to Finnish experts, and it was made in Finnish by using a web-based survey maker, Webropol. The questionnaire was applied in interviews to five experts, who had expertise in waste management, biowaste research, and business. Also a waste producer was interviewed.

The second step to collect ideas for the business model in a workshop during the Investor Event held in Kuopio in February 2014. The workshop had participants from all the Baltic Sea region partner countries and the brainstorming was realized in English. The interviews and workshop resulted into about 250 ideas for 12 business model blocks.

In the analysis of the ideas, duplicate ideas were deleted, and some of the ideas were integrated to each other. Evaluation of the ideas was done by using InTo evaluation tool from Savonia UAS. Five evaluators evaluated the ideas by giving them values from 1 (not good idea) to 7 (very good idea). Evaluation criteria were productivity and feasibility. An individual evaluation could be partial (not necessary to evaluate all ideas).

Decision making analysis (DCM) was used to select the best ideas. The methodology has been described in Kajanus et al. (2014). Constraint index was calculated. The best ideas against chosen evaluation criteria get best constraint index. A sensitivity value (percentage) was used to limit the number of selected ideas in the core business model. By changing the percentage, the core business model is, firstly, formed with a small number of key business items, and in the next steps, can be expanded.

Figure 7. illustrates the process for business model design. Phases 2-4 are in relation to business model analysis.

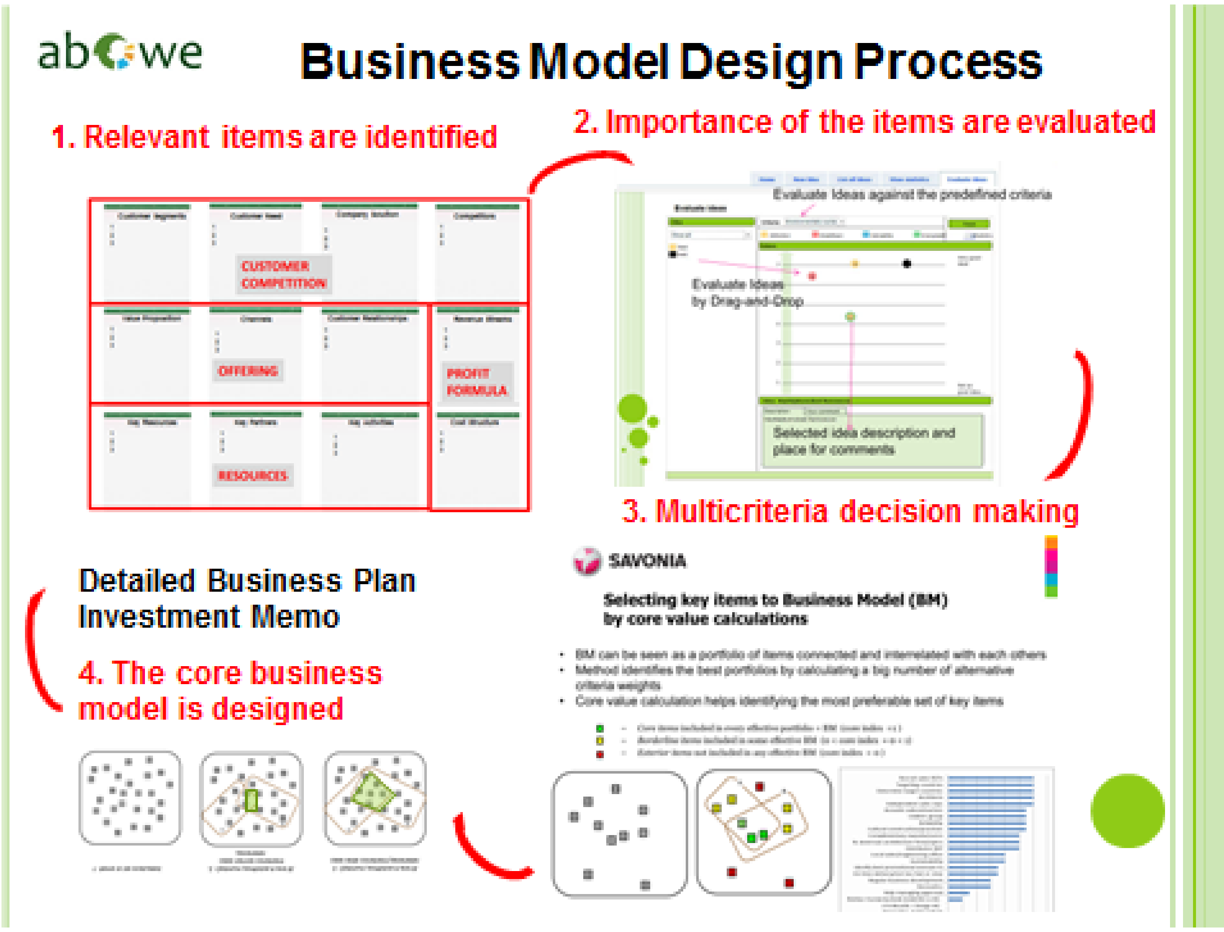

Figure 7. Business Model Design Process. (25) (26)

7.2 Results of the business model analysis

Results of this survey and analysis are shown in the Business Model Canvas (Figure 8). As it can be seen there are 12 blocks on four different colors. These colors helps reader to see quickly emphasized themes of business. The first, here light blue, theme is for customers and competition with customer segments, customer (end user) need, company´s solution and competitive solution. The second, light green, theme is for offering value propositions with channels and customer relation. The third, light red, theme focused on company´s resources like key resources, key partners and key activities. The fourth, pink, theme is important whenever there is business. The profit formula consists of revenue streams and costs structure.

46 business model items were selected to the core business model. Selection was made by using constraint index values calculated from evaluations against productivity and feasibility. Based on the constraint index, eight business items form the tightest core for the business model (red color in the table). In addition, value proposition of the business model was completed with an expert interview.

Customer/competition	Customer segments 1. Stora Enso 2. UPM Kymmene 3. Metsä Board 4. Biogas plants 5. Fertilizer distributors (for example Kekkilä)	End user, customer need 1. Solution for a waste treatment challenge 2. Modeling and measurement services in microbiological processes 3. Sustainable solution for waste treatment	Company solution 1. Customer oriented approach 2. Profesionally prosessed technical results 3. Can be taylored into use between several companies 4. Linsences of a plant 5. Expertised consulting	Competitive solution 1. Co-operation with competitors 2. More profitable and simplier solutions 3. Cheaper solutions
Offering	Value proposition* 1. Diversity for using waste as capital locally 2. Independent way to produce energy and chemicals locally 3. Emission reductions 4. Natural microbial strains used	Channels 1. Distribution chain of fuel 2. Appointments	Customer relation 1. Customer events 2. Providing continuously value to a customer	Profit Formula Revenue streams 1. Gate fees 2. Measuring and modeling services 3. Consulting 4. Waste treatment fees
Resources	Key recources 1. Sales expertise 2. Marketing espertise 3. Direct contacts 4. Customers of final products 5. Money from private and public sectors	Key partners 1. Neste 2. Pioneer orientated customers 3. ST1 4. Expert sellers 5. Finnoflag Oy	Key activities 1. Protecting the technology 2. Business Planning 3. Piloting 4. Marketing 5. Convinsing technical results and calculations	Cost structure 1. Charging customers by benefits 2. Service developement 3. Preliminary study phase

Figure 8. The most preferred ideas collected into the Extended Business Model Canvas. (24)

**Value Proposition is completed afterwards by an interview with Anssi Suhonen (Savonia University of Applied Sciences)*

7.3 Analysis of the business model

7.3.1 Customers and competition

The first, here light blue, theme is for customers and competition with customer segments, customer (end user) need, company solution and competitive solution. In the survey popped up as customers Stora Enso, UPM Kymmene and Metsä Board which are biodegradable wastes from forest industry. In addition to that biogas plants and fertilizer distributors are customer segments, too. These distributors need certain kind of biomasses to manufacture their products. These customers need new solutions for waste treatment due to tightening legislation. Customers need services to solve their waste treatment challenges in a sustainable way. Services can be turnkey-services or for one specific part of process. The company solution here is a customer orientated approach because every customer has different kind of bio waste and motivation to utilize it. Professionally processed technical result can help customers to make their investment decisions. One possibility to make business is to consult companies to get licenses for plants. In all of those solutions can expert consulting be part of business. Competitive solution providers are seen as co-operative partners which is reasonable at the early stage to getting markets. Because new business operator has to gain reputation and references to convince customers, co-operation with a well-known operator in this field of business can fasten the entry to market. However, it is possible, that the customers prefer cheaper solutions instead of a sustainable and new one. It is also crucial to constantly monitor competitors' offerings and position the own one in the right way.

7.3.2 Offering

The second, light green, theme is for offering including the most important block, value propositions with channels and customer relationships. Value proposition gives reasons to the customers to make their decision to buy the product or service. The customers may prefer to use their own biowaste locally. The technological solution gives possibility to increase independence in energy markets, and besides that gives opportunity of producing chemicals. To get rid of emissions is one great value for customers as well as making all this with natural microbiological way. Existing energy distribution chains of other fuels can be used as the channel to reach the end users of products. B2B sales are needed to make contracts to obtain biomasses and sell products. Customer relations are sustained by events and by providing continuously value to a customer by a personal key account manager.

7.3.3 Resources

The third, light red, theme focused on company´s resources like key resources, key partners and key activities. Key resources are in sales and marketing expertise; because new type of business needs to be convinced to customer and their interest can be obtained with personal direct contacts. All this is expensive to make functional, so funding is needed from both private and public sectors. For example partners like Neste and ST1 which are fuel providers and distributors, could be partnered for distribution and R&D. As a basic customer segment, self-motivated pioneer-orientated customers are identified. They importance is in advertising new technology. Also, the selling expertise and core technology knowledge of Finnoflag Oy are noted. As key activities are identified protection of the new technology, preparing of efficient business plans and marketing strategy. There is plenty of piloting to do to develop the technology. Of ultimate importance are convincing technical results and calculations in forms of reports.

7.3.4 Costs and revenue streams

The fourth, pink, is the profit formula consisting of revenue streams and cost structure. Revenue streams can be formed with gate fees when customers pay for the collection of their biowaste. Providing services such as testing and modeling and consulting is a quite obvious way to charge customer. Costs structure needs much considering but in this survey there were pointed out charging customer by benefits when part of costs are not covered elsewhere. Service based on new technology needs to be developed continuously and technical R&D needs funding. In the end, it is fully possible for this technology to make business out of it.

8. Business opportunities

ABOWE Pilot A, novel biorefinery, brings a lot of different kind of business opportunities. The pilot plant itself can be used as a testing station and there can be created business around that. The ultimate intention is to build a full scale plant and there are various business opportunities from supplier of technology to operative plant management. Full scale plants can produce energy, chemicals and fertilizers and they can be built for single or multiple customers, depending on the customer needs. Potential implementers and investors are among others:

- food and forest industry
- waste management companies
- farms
- sewage treatment plants

At first it is reasonable to start these businesses in Finland where key resources are available to create right kind of concepts and getting references. After these business models and concepts are proved and introduced to the market, new business models can be developed to other markets.

Here is focused on two options of service business. The first option is based on renting of the piloting unit to customers who have biodegradable waste in hands to test novel biorefinery solution to find a technological and economical solution. The second option is an all-inclusive testing and piloting service. The achieved knowhow so far gives an opportunity to establish a consulting business.

The following business model (Figure 9.) is made from the service business perspective. This business model is designed to integrate Pilot A related service capabilities and the economic viability and feasibility.

Customer/competition	**Customer segments** 1. Social waste water treatment plants 2. Pulp, carton and paper industry 3. Food Industry 4. Society waste handlers 5. Pharmaceutical manufacturers	**End user, customer need**	**Company solution** 1. Customized test periods 2. Movable test drive for the customer's individual needs 3. Investment calculations	**Competitive solution** 1. Ethanol producers 2. Biogas producers 3. Gasification 4. Landfill 5. Combustion technology
Offering	**Value proposition*** 1. Know-how networks	**Channels** 1. Consulting firm 2. Fairs 3. Agencies 4. Research institutes	**Customer relation** 1. Education 2. Social media 3. Networks 4. Membership	**Profit Formula** **Revenue streams** 1. Biomass examination 2. Analysis services 3. Expert services 4. Education services 5. Courses
Resources	**Key recources** 1. Professionals 2. Special expertise	**Key partners** 1. Transport firms 2. Device development 3. Workshops 4. Engineering offices	**Key activities** 1. Continuous service development 2. Sales 3. Specialists training	**Cost structure** 1. Preliminary experiments 2. Technical preparations 3. Transportation 4. Planning work 5. Analysis costs

Figure 9. Business model for the service business.

8.1 Expert services - Valuable way to develop your business

Figure 10 Expert services content scenario

Value proposition of expert services is to help customers to make revenue out of waste in a valuable way. The business model needs to address values such as transparency, sustainable and green technology. Customer gets the best waste utilization recommendations for the market. Output reports help making investment decisions.

Expert services include research on the possibilities for biomasses utilization. The customers need is reliable data to base their business decisions, for example whether to use their waste as their own energy source and invest to an energy plant of their own, or to sell biomasses as merchandise and make some profit instead of consuming money to waste treatments.

Mobile testing unit, known in ABOWE project as Pilot A, is essential to this business. Mobile testing premises can be transferred to customers´ premises and it is easy to be installed and it can refine diversified biomasses according to customers´ specified needs. Professional personnel have been involved in the ABOWE project from the very beginning and they can do highly qualified research with reliable results.

Results of this kind of researching business give a great deal of value to a customer, like data to make investment and business decisions. Also important is global knowledge on the utilization of biomasses as a renewable energy source. Cost structure in profitability calculation is based on data from Pilot A and two month's test period at Savon Sellu. Revenue streams come from selling the service which is charged by weeks.

After getting more data from several test periods with different kind of biomasses will the calculation (Table 1.) become more exact and service can be more tailored, for example in terms of time and price for testing periods.

A full economic analysis has been done in the Estonian Investment Memo (27).

Table 1. Service business profitability calculations are based on testing period of Savon Sellu with Pilot A with assumption of turn-key service solution for 36 testing weeks in a year.

Cost		**cost/year**	
Fixed costs			
Maintenance incl. spare parts		18 000 €	
Installation and packing of Pilot A		2 400 €	
Administration incl. coordination, accounting		35 000 €	
Data handling, reporting		25 000 €	
Total fixed costs			**80 400 €**
Variable costs	**cost/week**	**cost/year**	
Testing personnel	7 800 €	280 800 €	
Consumables	470 €	16 920 €	
Other variable costs	200 €	7 200 €	
Total variable costs			**304 920 €**
Total costs			**385 320 €**
Incomes			
Sold weeks	36		
Service price / week	12 000 €		
Total incomes			**432 000 €**
Total Profit			**46 680 €**

In Table 1. the contributions from Savonia University of Applied Sciences and Finnoflag Oy have been combined without specification. In actual cases the tender will be calculated in more detail and case specifically.
Consumables include process gases, additional chemicals, electricity, water and supplies (e.g. syringes, glucose measurement sheets).
Testing personnel and hence the service price can be far cheaper if

- Process Operator students from Savo Vocational College, Kuopio were participating as trainees and/or
- Environmental Engineering students from Savonia University of Applied Sciences were participating as bachelor thesis workers or trainees.

If testing took place in Finland then there is no need for additional insurance payment. In other countries a special insurance is needed. Transportation of Pilot A will be added to the costs.

8.2 Strategy to full scale plant

Full scale plant could be integrated to a large industrial facility, or function as an independent biorefinery by also collecting gate fees. Also use as a research facility has to be considered.

Transportation costs can be reduced significant to minimum, by building the full scale plant beside the factory where the raw materials are coming from. However, the amount of waste produced in the factory can be limited. In the case of Savon Sellu, the first piloting location in ABOWE, processing the sludge waste costs over 1 million euros per year for Savon Sellu. That amount is going to increase in the near future when restrictions on processing the biodegradable waste will become tighter. To locate the plant in this way means also that the plant can be built to match the customers need perfectly by the volume of the waste. (28)

Biofuels from the process have to be refined so they can be pumped straight to the pumping stations. Particularly hydrogen could have vast potential since it's the most potent biofuel formed so far. One scenario could be that pumping stations would be built near to the biorefineries. That way pumping stations would have endless supply of fuel coming from the refinery. Piloting has proven this far that Savon Sellu waste sludge is highly potential regarding hydrogen with daily potential high as 10 000 vehicle kilometers. Currently there is only one hydrogen pumping station in Finland by Woikoski and there is no short term targets for the hydrogen as biofuel for the transport sector although its potential is well known. (28)

A business model can also be made entirely around a full scale biorefinery. The plant would then be independent and all the needed inputs would be received from companies producing the waste. The revenues would be based on gate fees received from the companies delivering the waste, and on the value of substances made in the biorefinery process. Funding from EU and the government would be essential to build the plant. Private companies such as waste management companies (e.g. Ekokem), and public or private landfill operators could be interested in looking their role as investor or operator of a full scale biorefinery plant.

The full scale plant can also be used as a research facility. Research activities can be with either academic or related to business. Currently there is a medium scale biorefinery in Ghent, Belgium. It is run by the company called Bio Base Europe. The biorefinery is part of the open innovation and education center and is used for research purposes. It is a flexible and multipurpose plant. (29)

Lot of things has to be considered when planning the implementation of full scale biorefinery. Successful piloting, follow-up projects and investors are essential to get the database to build the first full scale plant. Also the economic viability and payback time of the investment will be proven in follow-up projects.

9. Pre-Engineering of a full scale plant for treatment of a pulp and paper mill's waste water sludge

Pre-Engineering work of an industrial scale biorefinery was done based on Savon Sellu's annual waste water sludge amount, 30 000 t/a (25 % Total Solids). The biomass which was used during the pilot tests was the dried sludge from the waste water treatment plant which consists of:

- Surplus of pulp factory's circulating water
- Hard wood pulp reject
- Flue gas scrubber's washing waters
- Surface waters of the sludge field
- Factory's sanitary waters

The aeration process of the active sludge treatment plant reduces the amount of valuable chemicals that can be recovered; therefore this study will concentrate on a solution where the biomass will be collected from the vertical clarifier surplus, before the active sludge treatment. In the calculations, it is assumed that we can collect equal amount of dried sludge compared to collected sludge from the present waste water treatment plant.

Investment cost for an industrial scale biorefinery based on ABOWE Pilot A technology (Table 2.) was calculated by M.Sc. Jyri Pelkonen from Pöyry Finland Oy (Table 1). Technical initial values and the process description was given by M.Sc. Anssi Suhonen of Savonia UAS. The microbiological process is invented and patented by Adjunct Professor Elias Hakalehto, Finnoflag Oy.

Table 2. Overall estimate of the investment requirement of the whole plant (30 000 t/a)

Construction work	2 340 000 €
Machinery and equipment	1 410 000 €
Electric, automation and instrumentation	550 000 €
Overhead costs (app. 15 %) including engineering and erection work	650 000 €
Cost booking (app. 15 %)	660 000 €
Indirect costs	1 300 000 €
Biorefinery total	**5 600 000 € (not including vat.)**

The pre-engineering was done based on the results of the pilot runs performed between February and March, 2014. The technology is new and the dimensioning of the plant is based on the data received from Savon Sellu, Finnoflag Oy and Savonia UAS. Pöyry's expertise and design experience of different bioprocesses and sludge fermentation was used in the dimensioning principles.

The crucial factors in plant operation that have risen up during the pre-engineering phase were:

- handling and pumping of sludge at 10 … 15 % TS higher dry mass content
- energy consumption and recovery in sludge heating and cooling
- bioreactor design with internal chambers in pool shape reactors -> higher TS%
- air lift principle in fermentation works when dry mass concentration is at levels of 4…6% TS
- the operational costs of liquid nitrogen and carbon dioxide will be approx. 50 … 60 000 € / a
- bioreactors' mixing using only nitrogen in large reactors
- handling of sludge residue left over after the bioprocess
- collection of biogas for energy use in post treatment of sludge
- scaling up pilot A's technology and technical solutions for a full scale plant

The result of the pre-engineering has still some assumptions in technological solutions and cannot therefore be precise in all aspects. The investment calculations have approximately a 30 % deviation on accuracy. The downstreaming process for chemical recovery has not been included in these calculations. (30)

10. Contents of a Management plan for a full scale plant

Management plan is meant to be a local implementation guide, covering practical aspects of establishing and managing the full scale plant. Management plan focuses on organizational aspects and assumes that all needed feasibility studies, technical development and institutional framework are already done and available and the start-up project is turning into preparation and implementation phases. The following list has been published in (31) and it covers the general aspects to be taken into consideration. Other aspects are national and regional aspects regarding the plant in question.

10.1 Establishment of the Implementer Organization

- Establishment of an official organization and an institutional support and framework. There should be an implementer organization, which is capable to accomplish the endeavor.
- Ownership and Top Management
    - Implementing organization can typically be owned by one of the following:
        - Private investors or a private investment association
        - Suppliers, often in BOO or BOOT (build, own, operate, transfer) arrangements
        - Private or public energy companies (for example, power or district heating companies)
        - The municipality/local government or a group of municipalities/local governments
    - For the owners, the most important issues are to ensure continued supply of the planned quality and quantity of waste; revenues from energy sale and fulfilment of instalments on loans; and maintenance of the plant in good operating conditions under qualified management.
    - The owners will normally be represented by a board that makes all crucial decisions based on sound recommendations of the plant management. The board hires a managing director, who will ultimately be responsible for operating and maintaining the economy of the plant.

10.2 Plant siting: Identification of siting alternatives selection of plant location

Tender and Financial Engineering

- Detailed financial engineering, negotiation of loans or other means of financing, and selection of consultants

Preparation of Tender Documents

- Reassessment of project, specifications, prequalification of contractors and tendering of documents

Award of Contract and Negotiations

- Prequalification of contractors. Tendering of documents. Selection of most competitive bid. Contract negotiations.

Construction and Supervision

- Construction by selected contractor and supervision by independent consultant

Commissioning and Startup

- Testing of all performance specifications, settlements, commissioning, training of staff, and startup by constructor

Operation and Maintenance

- Continuous operation and maintenance of plant. Continuous procurement of spare parts and supplies.

Environmental Impact and Occupational Health

- Noise
- Odors
- Air Emissions
- Waste Generation and Access to Landfill
- Water Supply
- Waste Water Discharge
- Occupational Safety and Health
- Airborne Pollution

- Heat
- Vibrations
- Chemicals
- Physiology
- Risk of Accidents

10.3 Training of Workers, Codes of Practice, and Occupational Safety and Health

The personnel or human resource development departments should be responsible for training workers. The skills and training courses in table 6.1 may be required. Codes of practices or documented work procedures should be prepared for all key plant activities and facilities. Furthermore, there should be contingency plans in case of accidents or equipment failure. The documentation should instruct the workers how to operate the equipment, and what to do if it fails or in case of accidents. Such documents can be used in new employee orientation, as well as a reference source for employees throughout the year. Equipment suppliers should be required to submit work procedures as part of the contract. Ideally, these should be used for preparing an integrated work procedure for the entire plant. The integrated procedures should be available in the operator’s room and with shift supervisors and other key personnel. Relevant excerpts should be placed at each machine or equipment.

11. SWOT Analysis

As a conclusion a SWOT analysis is presented in Figure 11. to summarize various perspectives for Finnoflag Biorefinery concept, based on ABOWE activities, towards full scale plant implementation.

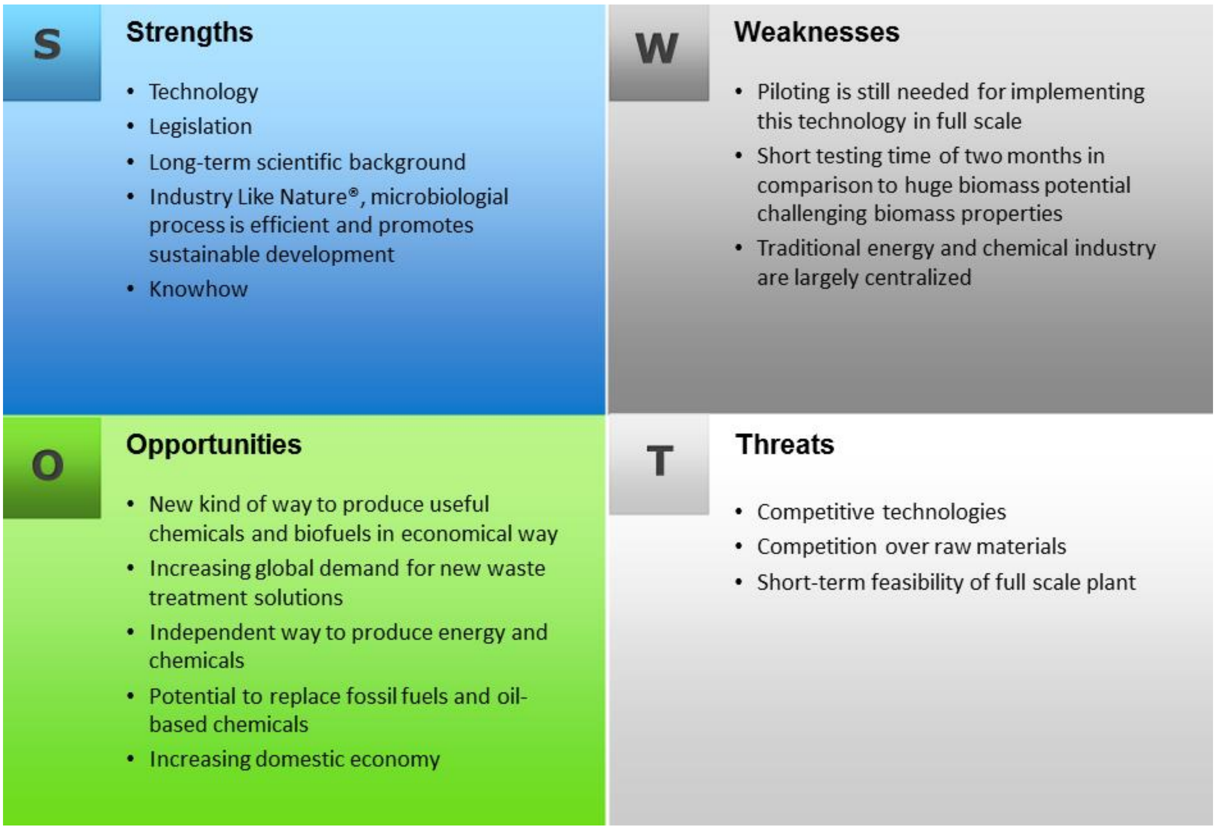

Figure 11 SWOT Analysis

As strengths are sustainability trends in legislation and interests of financing authorities. These things are giving right kind of atmosphere to use as assets knowhow based on long-term scientific background and industry executed Like Nature®. This registered expression points out that solution to make efficient and sustainable microbiological processes comes from nature itself.

As a weakness could be seen that the promising novel biorefinery technology will need more testing. In principle, the main focus in the Finnish tests was directed to learn to run the Pilot A experimental station in which the production rates were secondary in the beginning. These levels are possible to get improved in long run, during actual optimization of the process. In fact, the basic principles for steering the pilot were being learnt, and their implementation gave promises for the potential for quick optimization of the results in future bioprocess development. In addition to that traditional energy and chemical industry are largely centralized and as a new provider it is a longer process to enter to markets.

As threats are competitive technologies responding to demand of biofuels and waste treatment services. At the same time competition over biodegradable waste materials is increasing. To build a full scale plant needs to make long-term contracts with waste producers.

Opportunities that can be reached with this new technology can be emphasized a lot. The solution offers a new kind of way to produce chemicals and biofuels in an economical way, at the same time increasing independence to produce those. The new technology and business models supports increasing global demand for waste treatment solutions and will give a possibility to replace fossil fuels and oil-based chemicals. Domestically produced energy and chemicals increase GDP of economies.

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