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AQUAREL CONCEPT Aquatic resources for green energy realization

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AQUAREL
AQUATIC RESOURCES FOR GREEN ENERGY REALIZATION

CONTENTS

ENPI CBC KARELIA

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1. BACKGROUND OF THE PROJECT

Fish-farming is a growing industry in the Republic of Karelia. Fish waste disposal is one of the most widely discussed topics related to the fish farming industry in Russia. Fish processing generates side streams that are currently unutilized due to different reasons, among them are the missing waste management processes and practices. However, the utilization of side streams generates profitable business opportunities in waste management. It would also create a potential solution for local energy production in remote rural areas, at the same time reducing the environmental impact that dumping the fish waste to landfills is causing.

Relatively low gas and energy tariffs, lack of a relevant waste management system and governmental support together with low environmental awareness of people and business are currently not boosting the utilization of organic waste in Russia. Yet, there are some upsides that would promote the utilization of organic waste and bio energy production in the future.

For “AQUAREL” - Aquatic Resources for Green Energy Realisation project, one of the original objectives was to develop and introduce an innovative and efficient concept for producing *green energy from* fish waste and other aquatic biomaterial in the Republic of Karelia. Additionally project studied alternative utilization methods due to current moderate energy price in Russia and possibility to get better price with other means. Another objective was to significantly reduce the environmental impact caused by bio waste disposal and to initiate an ideological change in the way bio-waste is perceived amongst local entrepreneurs i.e. to see the bio-waste as a profitable feedstock.

The AQUAREL project studied the availability and optional utilization methods for fish processing side streams and other aquatic biomaterial in the Republic of Karelia. The created AQUAREL concept introduces practical process and technology for managing fish processing side streams, including side stream collection, logistics and fish oil production. The concept covers also relevant funding sources that could support building needed financial environment for local fish farmers and other actors involved in the process. Optional biofuel and energy production processes and technologies studied during the project are presented in the document also in more extent.

“AQUAREL” - project was financed by the Karelia ENPI CBC Programme. The 24-month project started in October 2012 and was closed in October 2014. The project was implemented by companies, research and development organizations from Finland and the Republic of Karelia in Russia.

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2. SUMMARY OF THE CONCEPT

The AQUAREL project studied the availability and optional utilization methods for fish processing side streams and other aquatic biomaterial in the Republic of Karelia. Additionally processing aquatic biomaterial with manure and sewage sludge was studied. Based on the results, the most feasible option today is to process fish side streams to fish oil and dewatered oil-free residue and to use them for fish or animal feed production. However, it is necessary to highlight, that changes in e.g. economic environment, energy prices and demand may require re-evaluating the results and conclusions made in the project.

Producing fish oil from fish processing side streams is an easy and relatively simple production process generating a valuable end product. The functionality of the process was confirmed in a pilot conducted in the project. The oil and solids are separated from the heated fish waste based on gravity. The fish oil separating on top of the separator unit is removed. Fish oil can as such be utilized for heating purposes, fish meal or animal feed production, but it can also be further processed to biodiesel. However, due to currently moderate energy prices in Russia, biodiesel production is not economically profitable.

Even if the fish oil production process is not complicated, the operative management of small-scale fish oil production unit requires dedicated resources and separate facilities especially to meet hygiene requirements. Managing the side streams is not a core business for fish farmers. Efficient and economically profitable fish oil production requires a centralized production unit with bigger processing capacity. One fish processing unit needs to be designed to manage side streams collected from several fish farms.

The optimum location for the processing unit is in the middle of the fish farms. Based on the transportation cost analysis in the Republic of Karelia, it is not economically efficient to transport bio-wastes for more than 100 km since the transportation costs start increasing substantially. Another issue to be considered is that collection of side streams, including the dead fish, from the fish farms should be organized on a daily basis in order to eliminate the need for storing the side streams at the farms.

Based on AQUAREL project studies there are different public funding sources available for supporting and enabling profitable and environmentally sustainable utilization, research or development of fish processing side streams and other aquatic biomaterial. Different funding programmes can be utilized by companies, research organizations, authorities and non-governmental organizations.

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3. FISH WASTE

3.1. Quantity and Quality

At present, 53 fish farms are operating in the Republic of Karelia. Volumes of fish farming have almost doubled during the last 5 years. As of 2012, 99% of farmed fish was rainbow trout, and 1.2% were nelma, whitefish, peled and sturgeon. About 13 500 tons of fish were produced in 2012. According to the forecasts of the Ministry for Agriculture, Fishing and Hunting of the Republic of Karelia, commercial fish farming development implies the increase of production up to 16,5 thousand tons in 2013, and 20 thousand tons in 2015. Given that forecast, the number of enterprises will reach 60 with up to 900 employees (Kareliastat 2011, Bolgov & Mayorov 2012).

The largest input in the development of commercial fish farming in 2012 was made by the following enterprises:

- OOO «Ladozhskaya Forel» (together with OOO «Raiguba») - 2147 t,
- OOO «Kala ja Marjapojat» - 1932 t,
- OOO «Rokfor» - 1606 t,
- OOO «Segozerskoye» - 1321 t,
- ZAO «Kala-Ranta» - 1122 t.

The following nine (9) enterprises were engaged in fish processing:

1. ZAO «Kala-Ranta» (Lahdenpohja district). On January 22, 2013 a new fish processing plant was put into operation, and it will provide for drastic production increase in 2013. As of today the production is up to **1 000 t/a**,
2. OOO «RokFor» (Lahdenpohja district) – **up to 1500** t,
3. OOO « Ladozhskaya Forel» (Pitkaranta district)- **up to 1600** t,
4. OOO «Rainbow» (Olonets district) – **up to 1000 t**,
5. IE Fedorenko N.V. (Kondopoga district) – no data,
6. OOO «RAIGUBA» (Kondopoga district) - **up to 2000** t. in 2013
7. OOO «Nord-Ost Rybprom» (Medvezhjegorsk district) – **up to 3000** t,
8. OOO «Segozerskoye» (Segezha district) – **up to 5000 t** in 2013 t,
9. OOO «Kala ja Marjapojat» (Kostomuksha) – **up to 1900** t,

The processed fish amounts and resulting fish waste amounts from these nine enterprises are presented inTable 1. The data was obtained by making interviews in enterprises. Two farms (Kala ja Marjapojat and Fedorenko) are utilizing fish waste for oil separation. Fedorenko sells the oil for fish fodder production in Leningrad region. The fish oil separated in Kala ja Marjapojat enterprise is used in generating heat at the boiler house.

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Table 1. Fish waste in Karelian Region and present use

	Fish mass t/a	Fish waste t/a	Present use
LLC "Rayguba"	2000	560	Not mentioned
PE N.V. Fedorenko		150	Oil sold 25 RUB/l
Ltd. "Kala ja maryapoyat	1900	150	Fish oil, solid for compost
LLC "Segozerskoye	5000	300	Modern equipment
Ltd. "Nordost Rybprom	3000	500	Part for hunting entities rest disposed
LLC "Rainbow	1000	100	Waste not used
Ltd. "RokFor	1500	150	Waste not used
Kala Ranta	1000	170	Not mentioned
Ladozskaja Forel	1600	500	Not mentioned
Total	17000	2580	

Fish waste properties are presented in Table 2. Fish waste contains a lot of moisture but they can also hold significant amounts of oil for separation and subsequent utilization, especially intestines of fish. To date most of the processed fish is sold whole and frozen. In the processing only the intestines are removed which means that the fish waste from Karelian Region has high oil content.

Table 2. Fish waste properties.

Fish	Fish part	Moisture wt-%	Lipid/fat wt-%	Protein wt-%	Ash wt-%	Reference
Pink salmon	Liver	77	3.3	19	1.5	Bechtel & Oliveira 2006
Trout	Head	70 ± 2.8	12 ± 0.6	14 ± 0.4	4 ± 0.3	Kotzamanis et al. 2001
	Frame	71 ± 1.4	11 ± 1.1	15 ± 1.2	3 ± 0.4	Kotzamanis et al. 2001
	Tails	73 ± 1.5	7 ± 0.7	16 ± 1.1	5 ± 0.5	Kotzamanis et al. 2001
	Mean of waste [2]	70 ± 1.9	11 ± 3.1	15 ± 0.9	3 ± 0.9	Kotzamanis et al. 2001
	Intestines	56 ± 2.8	35 ± 2.7	8 ± 1.2	1 ± 0.2	Kotzamanis et al. 2001
Salmon	Head		16			Mbatia 2011
Salmon	Head	71	3.9	14	3.9	Jayasinghe & Hawboldt
	Viscera	78	1.8	17	1.8	2012
Salmon	Viscera	59	24			Sun et al. 2006

[2] Weighted mean of heads, frames and tails

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3.2. Potential utilization methods

3.2.1. Fish oil and biodiesel

Fish oil separated from fish waste can be used in biodiesel production and residual solid matter could be used as fodder or in biogas plants (Mukatova & Chan 2012).

Fish waste can be pre-treated with crushing and formic acid in order to preserve it up to 2-3 months before utilization. If the fish waste can be directly utilized from the fish processing plant, other pre-treatment than crushing is not needed. (Salminen 2013,Enerfish 2009).

Sustainable community enterprises (2007) state that the process steps included in separating the fish oil are: heating for enabling oil extraction in pressing, pressing, centrifuging of oil to remove solids and heating of oil to insure that the oil has no more than 0.5% water and solids by weight. The pressing removes approximately 70% of the raw material mass as water (stick water) and 10% as crude oil. The oil-free fish waste is usually used in feed production. The process is illustrated in Figure 1. The separated fish oil can also be sold for fish fodder production.

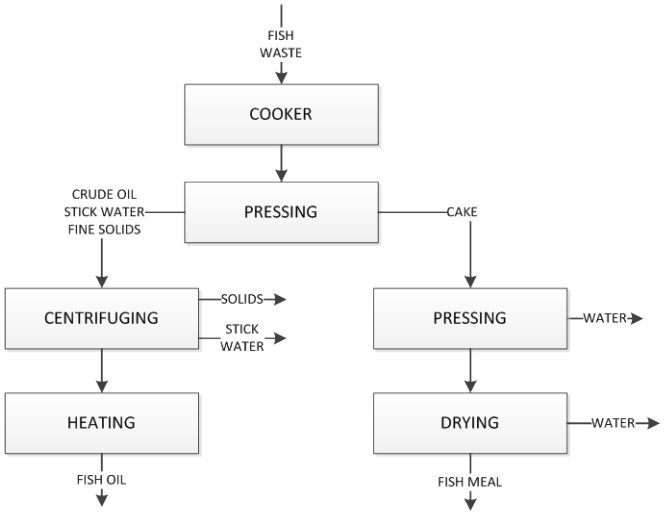

Figure 1. Preparing fish oil from fish waste (Sustainable community enterprises 2007, Flottweg 2012).

Fish oil could be used directly as a fuel for example in heat boiler or it can be further processed into biodiesel for example by transesterification.

Transesterification reaction can be achieved by three methods: short chain alcohol and base catalyst, methanol and acid catalyst or by conversion oil first to fatty acids and then to alkyl esters (biodiesel) with acid catalysis. The used short chain alcohol is most commonly ethanol or methanol. The base-catalyzed transesterification is the most used one (Shadid & Jamal 2011. The production of fish oil by transesterification is illustrated in Figure 2. According to Lin & Li (2009) the lower heating value (LHV) of biodiesel is 41 MJ/kg. The mass balance of fish biodiesel is presented in Table 3.

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Table 3. Raw materials and end products of biodiesel production.

Raw material	Amount	Reactants	Biodiesel	Glycerol	Reference
Fish oil	3.5 t fish oil	700 kg methanol, app. 70kg NaOH	3.5 t	700 kg	Uusikaupunki 3489/37/371/2006

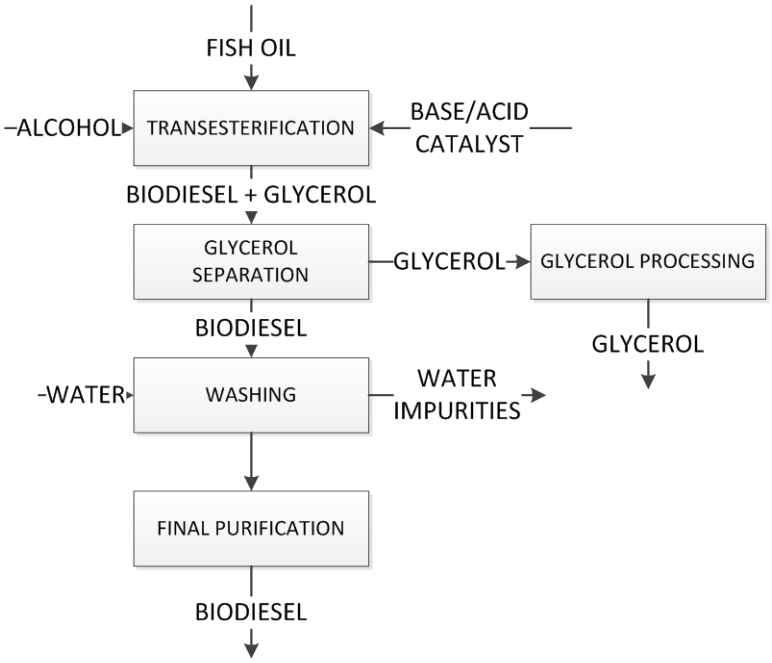

Figure 2. Production of biodiesel from fish oil by transesterification (modified from Flottweg 2011).

Glycerol, the main by product, can be utilized in cosmetics, chemical industry, in biogas production or it can be burned. The lower heating value of glycerol is 17.1 MJ/kg. (Bernesson 2004.) The glycerin share when using waste salmon oil is 20% of the volume of the oil (Sustainable community enterprises 2007).

The fish waste sludge (insoluble fraction after oil separation) has many applications. It could be used as microbiological media, biofertilizer or animal feed. In addition it could be utilized in energy production by anaerobic digestion. (Mbatia 2011.) According to Erämaavirta (2013), the oil free fraction containing the water and solid material of fish could be utilized for biogas production. According to Arnold (2009) the best economic benefits from this fraction can be achieved by using it as animal feed.

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3.2.2. Biogas

According to Mbatia (2011) fish waste and fish waste sludge are not suitable for digestion alone due to high content of proteins, lipids and light metals. Mbatia (2011) co-digested fish waste sludge with Jerusalem artichoke. Mshandete (2004) co-digested sisal pulp and fish waste. Regueiro et al. 2012 used fish waste as co-substrate in anaerobic digestion of pig manure. They found that biogas production and methane content were higher than in the only pig manure digestion. The co-digestion helps in balancing the carbon-nitrogen ratio (C:N) in the mixture as well as macro and micronutrients, pH and TS (Mbatia 2011). The optimum C:N is 20-30 for anaerobic digestion and for fish waste it is much lower, so it should be co-digested with materials having higher carbon content. Research conducted by Gebauer and Eikebrokk (2006) showed that biogas could be produced from salmon smolt hatchery sludge with methane yield of 0.14-0.15 l/g COD. Gebauer (2004) also investigated the use of sludge from saline fish farm effluent in biogas production. The methane yield was 114-184 l/g COD and 160-241 l/g VS added. The methane yields from anaerobic digestion of fish waste are presented in Table 4.

Table 4. Methane yields from anaerobic digestion of fish waste.

Waste	TS %	VS of TS %	Methane m^3n/t_{VS}	C:N	Reference
Fish waste	32	56	390	9	Mshandete et al. 2004
Fish waste	41	86	828		Mbatia 2011
Fish sludge	38	83	742		Mbatia 2011
Fish farming sludge	10-12	59-62	260-280		Gebauer & Eikebrokk 2006

3.2.3. Other utilization methods

Meal and fodder

Fishmeal and rendering plants process bones, heads, slaughterhouse wastes and trash fish into meat and bone meal and fishmeal by drying and grinding of processing wastes. Feed meal stands out among other protein foodstuffs for the high content of readily digestible proteins, mineral salts, vitamins, nearly all biologically essential micro nutrients, and essential amino acids.

Meat and bone meal and fishmeal are a foodstuff made. Meal has valuable nutritional properties. It's been found that protein from meal is assimilated by animals much more readily than protein from vegetative fodders.

The cost of the equipment to process fish wastes into meal and fodder ranges from one to six millions robles with feed capacity from 2 to 60 t/day. The equipment is designed to produce meat and bone meal or fishmeal (Bogeruk 2007).

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Fertilizers

Fish waste can be used to produce fertilizers, which is called fish emulsion. It has become quite popular among floriculturists. Sodium, phosphorus and potassium content in fish emulsion is variable, depending on the process. An advantage of this fertilizer is that it has high nitrogen content but without the risk of damaging the plant. The emulsion is applied once a month during the growing season. In addition to essential macro nutrients the soil will receive some micro nutrients the plants need for active growth. Using these fertilizers one can expect good yield. The cost price of these products is much lower than the cost price of fish meal of similar biological and energy value (Vorobyov & Vasilov 2005).

Industrial applications of fish oil

Fish oil is mostly utilized in tanning and dyeing to replace vegetable oils (flaxseed, etc.), for lighting of mines, and in soap making. The raw material for fish oil in the Kaliningrad Region is trash fish – stickleback (plant in Kaliningrad), whereas in other Russian regions it is chiefly fish viscera, offcuts and offal. Top quality oil, nearly colourless and odourless, can be derived from pike-perch viscera. It can be added to dry pressed caviar, or added when frying fish. However, rendering is no longer of industrial scope in Russian fisheries, whereas in the USSR herring and lamprey from the Astrakhan' region were used exclusively for rendering and oil production (Ryzhkov & Kuchko 2008, Vorobyov & Vasilov 2005).

Medical applications of fish oil

Two grades of fish oil are distinguished in medicine: purified light yellow oil, and non-purified brownish yellow oil. The former is factory-made, and owing to the absence of intense odour and flavour it is preferred to various grades of low-tech fish oil, since the latter, with their impurities and liver decay products, may often upset digestion processes and cannot therefore be used in long-term treatment.

The medicinal value of fish oil is nearly totally dependent on the lipid content, whereas the content of other component parts such as iodine, bromine, phosphorus, bile pigments and salts is so negligible that no therapeutic effect can be observed. That is why morrhuol extracted from the oils failed to make its way into medical practices. Compared to other fats, emulsified fish oil has a smaller particle size and is therefore more readily absorbed; experiments have proved also that the product passes cell membrane pores more easily than other oils, and is quicker to get oxidized. The capacity of vegetable oils to diffuse through cell membrane pores is much lower; e.g. olive oil diffusion through the pores is 7-8 lower than for fish oil. Compared to dairy butter, fish oil diffusion capacity is 6 times higher. The product can be consumed in quite high quantities, 15.0-30.0 ml several times a day, and over quite long time periods.

Fish oil is prescribed to enhance the nutrition value, because owing to easy oxidation the product can help save the nitrogenous material needed to build up tissues. Thus, fish oil is prescribed to patients with lung, bone or gland tuberculosis, rickets, anemia, emaciation upon serious diseases, night blindness (some physicians consider fish oil to be a specific cure for this disorder).

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3.3. Analysed scenarios for producing energy

The different possibilities for producing energy from fish waste produced in 9 fish processing plants in the Karelia region (Figure 3) are examined by forming different scenarios and calculating the mass and energy balances for them.

Scenario 1: Producing biodiesel in a fish farm that produces 200 t/a fish waste.

Scenario 2: Biodiesel and biogas production potential of two centralized facilities which are located in northern area (Segozerskoe) and southern area (Kalaranta) of the examined region.

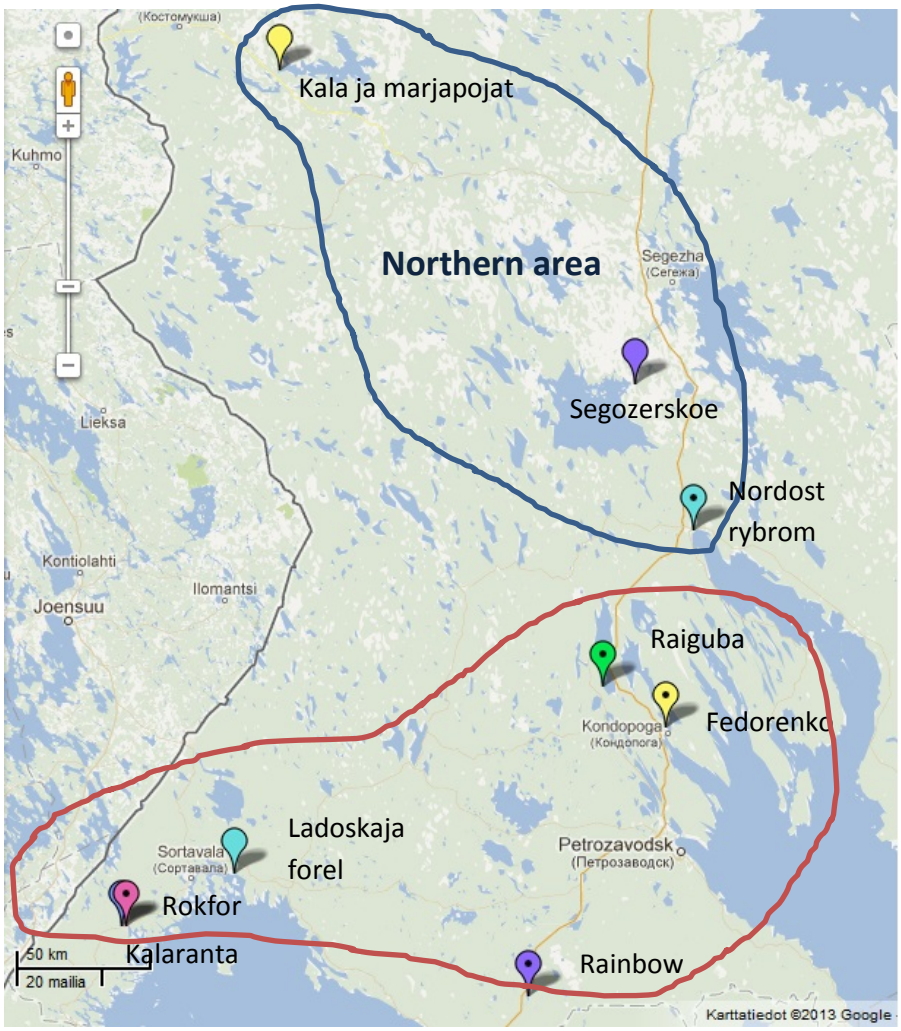

Figure 3. Fish processing plants examined in the AQUAREL project.

The initial values used in calculations for fish waste properties and combined heat and power (CHP) production efficiencies are presented in Table 5.

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Table 5. Initial values used in calculation (Kotzamanis et al. 2001, Mshandete et al. 2014, Mbatia 2011, Valovirta 2011, Uusitalo et al. 2013, Hupponen et al. 2011)

Variable	Unit	Value
VS	% TS	86
Protein + ash	%	9
Oil yield	% mass	35
Methane yield	m^3/t_{VS}	390
CHP efficiency	electricity %	40
	heat %	40

3.3.1 Small scale biodiesel production plant

The small scale plant in scenario 1 is assumed to be using small scale technology capable of producing 1000 l batch of biodiesel (Erämaavirta 2013). The only energy consumption is the electricity used for powering the equipment and heating up the fish waste mass. The separation of fish waste consumes electricity 56 kWh/t biodiesel and transesterification consumes 111 kWh/t biodiesel. In addition the plant requires 20% methanol and 3% potassium methylate in relation to the volume of biodiesel (Erämaavirta 2013.) The density of methanol is 790 kg/m^3 (Krook 2013) and the density of sodium methoxide is 990 kg/m^3 (Nissinen 2013). The biodiesel production from fish waste requires 1h work for oil separation and 3 hours work for transesterification (Erämaavirta 2013).

The mass and energy balance results from the Scenario 1 are presented in Table 6. The produced biodiesel would be enough to fuel around 30 passenger cars using 7 l / 100 km and driving 40 000 km annually. In addition the produced glycerol could be used in generating heat together with for example wood chips. The produced glycerol would be enough for space heating of approximately three single-family detached homes if heat need would be 15 MWh/a. The total input energy to process, including fish oil is 830 MWh/a and output is 850 MWh/a, which means that output-input ratio of biodiesel production is close to one. Oil free mass has to be directed to further utilization.

Table 6. Mass and energy balance of scenario 1.

	Mass t/a	Energy MWh/a
Feedstock	200	
Fish oil	70	740
Energy demand		
Electricity		12
Heat		-
Chemical demand		
Methanol	12	68
Potassium methylate	2.3	11
Produced		
Biodiesel	70	800
Glycerol	12	55
Oil free mass	130	

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3.3.2. Large scale biogas and biodiesel production plant

The larger scale biodiesel plants in scenario 2 are assumed to be using technology capable to utilize 3-5 t/h fish waste. The equipment used for fish oil separation is PoweRes 1, which crushes, heats and separates oil, water and protein rich side flow. The fish oil separation uses electricity 15 kWh/t fish waste and heat 100 kWh/t fish waste (Sybimar 2012). The transesterification consumes electricity 20 kWh/t biodiesel and heat 35 kWh/t biodiesel (Salminen 2013). The biogas production is assumed to be using mesophilic (35 ^{o}C) and wet (10% TS) anaerobic digestion. The electricity demand of digestion is assumed to be 55 MJ/t (10% TS) (Berglund & Börjessön 2006) and heat demand is calculated including the heating of the masses and heat losses from the reactor. The lower heating value of methane is 10 kWh/m3.

The results from scenario 2 are presented in Table 7 and Table 8. The amount of biogas potential is 611 MWh/a from the northern plant and 1 050 MWh/a from the southern plant. The energy potential of biodiesel is much greater (80%) than the biogas potential. The northern plant could provide space heating for 35 and southern plant for 60 single-family detached homes with heat demand of 15 MWh/a. On the other hand if fish waste would be used for biodiesel production the northern plant could provide fuel for 130 and southern plant 230 passenger cars using 7 l/100 km and driving 20 000 km/a.

Table 7. Scenario 2 northern plant biodiesel and biogas production potential.

		Transesterification	An-aerobic digestion
Feedstock	t/a	950	950
Fish oil	t/a	333	-
	MWh/a	3 510	-
Energy demand			
Transport fuel	MWh/a	20	20
Electricity	MWh/a	21	68
Heat	MWh/a	107	35
Chemical demand	t/a	73	-
	MWh/a	399	-
Produced			
Biodiesel	MWh/a	3 787	-
Glycerol	MWh/a	297	-
Net electricity	MWh/a	-	493
Net heat	MWh/a	-	526
Mass products		Oil free mass	Digestate
Mass	t/a	618	729
	TS %	14 %	4 %

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Table 8. Scenario 2 southern plant biodiesel and biogas production potential.

		Transesterification	An-aerobic digestion
Feedstock	t/a	1 630	1 630
Fish oil	t/a	571	-
	MWh/a	6 022	-
Energy demand			
Transport fuel	MWh/a	71	71
Electricity	MWh/a	36	116
Heat	MWh/a	183	55
Chemical demand	t/a	126	-
	MWh/a	685	-
Produced			
Biodiesel	MWh/a	6 497	-
Glycerol	MWh/a	510	-
Net electricity	MWh/a	-	846
Net heat	MWh/a	-	908
Mass products		Oil free mass	Digestate
Mass	t/a	1 060	1 250
	TS %	14 %	4 %

3.4. Economic aspects

A promising and potentially profitable activity for the Republic of Karelia is processing of fish wastes into fish meal and fodders. Fishmeal and fodder production can be regarded a profitable way to process fish wastes in the Republic of Karelia given that the amount of feedstock is sufficient for the process.

Fish waste processing into biogas in the Republic of Karelia is not cost-efficient mainly due to high cost of the purification equipment. The equipment investment makes small-scale biogas production economically inexpedient.

Currently also biodiesel production in the Republic of Karelia will not be profitable. A comparison of information from different vendors shows the equipment is rather expensive and requires large feedstock volumes.

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3.5. Conclusions

There are several companies producing fish waste in the region that was investigated in this study. The fish waste from these companies could be used in biodiesel production by separating the fish oil and further processing it. In addition to biofuel production, fish waste can be used to obtain valuable substances. Fish waste can be used in production of fish protein hydrolysate by enxymatic treatment. Fish waste can be used for extracting enzymes, gelatin and proteins. (Jayathilakan et al. 2012.)

At the moment one fish processing company already has equipment for fish oil separation from fish waste. This same company is also the only one interested in producing biodiesel from fish waste. Other companies are more interested in fish-oil, fish meal production or treating the fish waste with some other means. There seems to be a demand for waste fish oil and flour produced from fish waste. Therefore at present the interest for biofuel production is small.

The estimated scenarios included small scale biodiesel production in scenario 1 and comparison of anaerobic digestion and biodiesel production at larger scale in scenario 2. Small scale biodiesel plant utilizing fish waste from one fish processing plant would be sufficient to produce biodiesel for multiple cars. However it might not be economical to produce such small amounts and transport it to refuelling stations. It might also be hard to compete with the diesel prices. The produced biodiesel could be used as a fuel in the fish utilization farms as well and the separated fish oil could also be used as a poor quality fuel. The produced glycerol could be suitable fuel for heating purposes which could be utilized for example with wood chips. The larger scale utilization of fish waste as examined in scenario 2 would require obtaining fish waste from multiple fish processing plants. This might lead to more profitable utilization of fish waste depending on the transport costs. It would seem that biodiesel production would result in higher energy amounts than using fish for anaerobic digestion purposes. However, the anaerobic digestion could be useful in treating the residual solid material resulting from oil separation. In general it seems that energy use of fish waste is less economical than utilizing fish waste for producing fish meal.

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4. ALGAE

4.1. Quantity and Quality

The macrophyte flora (algae and higher plants) of the White Sea is quite rich. It comprises 183 species: green (Chlorophyta), brown (Phaeophyta) and red (Rhodophyta) algae, and two higher flowering plants (eelgrass Zostera marina and Eliocharis sp.). Just like in other temperate seas, brown algae prevail in the White Sea – they contribute some 60% to the total numbers of macrophytes (Miagkov 1975, Vinogradov & Strik 2005).

At present, only 2 collective farms do the harvesting, and algae supplies dropped sharply. E.g., the quota in 2007 being over 7,000 tons (wet weight), only 120 tons of kelp and nearly the same amount of fucoids were actually harvested, Ahnfeltia harvest was ca. 3.5 tons (dry weight). All in all, tradeable algae stocks along the Karelian and Pomor coasts are estimated at: kelp – 170,000 tons wet weight; fucoids – 110,000 tons wet weight; Ahnfeltia – 1,800 tons wet weight. Thus, algal resources are very much underexploited. (Bakhmet & Naumov 2014, Bakhmet I.N. & Tishkov 2014)

The algae can be harvested from the sea by manual or mechanical harvesting. The main reason for harvesting algae is human consumption and hydrocolloid production. (Bruton et al. 2009.) At present, the main technologies for utilizing macroalgae for energy is according to Bruton et al. (2009) biogas production by anaerobic digestion or ethanol fermentation. Ethanol fermentation of Saccharina latissima has been studied by Adams et al. (2009). Biogas production has been used for various biodegradable materials and it has been proven also with macroalgae (Bruton et al. 2009, Morand et al. 1999, Ertem 2011, Matsui et al. 2006).

Storm cast algae samples from White Sea were collected to determine algae properties. The algae were collected from the beach of Ostrov Sonostrov island. The algae species collected were: Fucus vesiculosus, Saccharina Latissima and Laminaria digitata. The algae species were analyzed in laboratory to find out total solid (TS) and volatile solid (VS) content. TS content was determined by drying the algae samples at 105 °C overnight. The dried algae were ground to smaller than 1 mm particle size. Approximately 200 mg of powder was combusted at 550 °C for 20 minutes to analyze the VS content. Three parallel samples were analyzed due to the heterogeneity of the algae. The results by of this study made by Puro (2013) are presented in Table 9. Algae properties found from literature are presented in

Table 9. TS and VS contents of examined algae species (Puro 2013).

	TS (%)			VS (%)		
	Min	Max	average	Min	Max	average
Fucus vesiculosus	24.9	28.8	26.7	82.2	83.2	83
Saccharina latissima	10.2	11	10.6	71.4	73.1	72
Laminaria digitata	13.1	14.7	13.9	73.4	74.8	74

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Table 10. Properties of different algae species.

	TS %	VS from TS %	Ash from TS %	LHV MJ/kg	Source
Fucus vesiculosus [a]	87	59	14		Ross et al. 2008
Fucus serratus [a]	88	52	21		Ross et al. 2008
Laminaria digitata [a]	89	60	11		Ross et al. 2008
Laminaria digitata [b]	94-97		14-35	10-14	Adams et al. 2011
Laminaria hyperborea [a]	86	62	13		Ross et al. 2009
Brown seaweed	10-25	62-78	22-37		Bruton et al. 2009
Enteromorpha clathrata [a]	87	42	37	8	Wang et al. 2009
Sargassum natans [a]	90	49	29	9	Wang et al. 2009
Gracilaria cacalia [a]	88	55	15	12	Yu et al. 2008
Enteromorpha clatharata [a]	87	42	37	8	Yu et al. 2008
Laminaria japonica [a]	87	39	3	7	Yu et al. 2008

[a] air dried, [b] dried at 70-80 ^{o}C

4.2. Potential utilization methods

4.2.1. Biodiesel

With modern technologies algae can be processed into crude oil within an hour. A suspension of wet algae is used for this purpose. This process in the nature takes several millions of years. The “black gold” resulting from the new process is of high quality, and can be used to produce kerosene, petrol or diesel fuel. In the process of making crude oil a suspension of wet algae is pumped into a chemical reactor, where the biological material is treated with a jet of hot water under high pressure. The output of this process, which takes around an hour, is liquid and gaseous fuel. In experiments, up to 50% of hydrocarbons contained in the plants were transformed into oil, and in some cases the effect reached 70%. The residual water, nitrogen, phosphorus and potassium can be used as fertilizers for growing new plants.

4.2.2. Biogas

Cecchi et al. (1996) examined co-digestion of algae from Venice lagoon (mainly Ulva rigida and Gracilaria confervoides) with sewage sludge. They reached a conclusion that co-digestion of this algae with sewage sludge is applicable with algae:sludge ratios up to 2:3. The biogas production was comparable to that of sewage sludge or even better. Møller et al. (2012) suggest that the co-digestion of algae with manure is beneficial, but the ratios are dependent on the algae species. They noticed that Laminaira had the best improvement in methane yield. According to Yen & Brune (2007), the C:N ratio of algae is not optimal for anaerobic digestion. The low C:N ratio can lead to high total ammonia nitrogen and high volatile fatty acid accumulation in reactor.

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The anaerobic digestion of algae can be divided into stages to improve methane yield. Matsui et al. (2006) divided the biogas production to pretreatment and fermentation stages. The biogas production from algae was examined in field test plant in large scale. They concluded that one ton of wet algae produces 22 m^3 methane. The methane content of biogas was 60%.

Vergara-Fernandez et al. (2008) also used two algae species (Macrocystis pyrifera and Durvillea Antarctica) in two-stage system to produce biogas. The biogas yield was for both species 180.4 +/1 15 m^3/t_{TS} and biogas methane content was around 65%. The methane yields of different algae species are presented in Table 11.

Table 11. Methane yields from different algae species.

	TS	VS of TS	Methane		C:N	Reference
	%	%	m^3n/t_{VS}	%		
Polysiphonia sp. red algae	24	80				Ertem 2011
* 90/10	4	62	100.1	61	11	Ertem 2011
* 80/20	5	55	94.9	61	10	Ertem 2011
* 70/30	6	58	109.5	65	10.3	Ertem 2011
Cladophora sp. green algae	23	41				Ertem 2011
* 90/10	5	60	237.9	64	9.8	Ertem 2011
* 80/20	3	47	139.6	64	9.6	Ertem 2011
* 70/30	4	44	125.3	64	9.2	Ertem 2011
Mix red & brown algae	40	58				Ertem 2011
* 90/10	3	56	84.5	61	9.7	Ertem 2011
* 80/20	3	50	45	59	9.3	Ertem 2011
* 70/30	4	40	68	53	8.5	Ertem 2011
Ulva sp. green algae	10	83.7	17.9			Matsui et al. 2006
Laminaria sp. brown algae	10	62.7	25.87	65		Matsui et al. 2006
Ulva sp. green algae	21	51			16.7	Morand et al. 1999
Ulva sp. Hydrolysis juice			321.5	82		Morand et al. 1999
Laminaria saccharina brown algae			245			Østgaard et al. 1993
Macrocystis brown algae			400			Chynoweth et al. 2001
Laminaria			257			Møller et al. 2012
Saccharina			206			Møller et al. 2012
Aschophyllum			119			Møller et al. 2012

* Algae/inoculum ratio, Inoculum is based on digested cow manure slurry, vegetable and fruit residues

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4.2.3. Other utilization methods

Industrial production of food, cosmetics and pharmaceuticals are the main applications for algae.

Food industry

Some sea algae are edible (kelp, porphyra, sea lettuce/ulva). In some countries algae are cultivated to gain large amounts of biomass to be fed to livestock and used in the food industry. Edible algae are rich in mineral nutrients, especially iodine, and are mainly used in East Asian cuisines (Ilyash et al 2012).

Algae for foods can be supplied to the Archangelsk Pilot Algae Processing Plant (APAPP).

Pharmaceutical industry

In the pharmaceutical industry algae are processed into gelling and mucinous substances – agar (Ahnfeltia, Gelidium), agaroids (Phyllophora, Gracilaria), carrageen (Chondrus, Gigartina, Furcellaria), alginates (kelp and fucoids), fodder meal with micro nutrients and iodine. Algae contribute to the formation of some therapeutic muds.

Algae for manufacturing pharmaceutical products can be supplied to the Archangelsk Pilot Algae Processing Plant (APAPP).

Cosmetics

Both in Karelia and elsewhere in the world two groups of algae are used in cosmetic production – kelp and brown algae (fucoids). Their commercially harvestable stocks are available in the White Sea. Cosmetic products are based on algal galenicals, where the active agents are natural polysaccharides, little-degraded protein-mineral complexes, and products of harsh hydrolysis to oligo- and monosaccharides and amino acids (Berger 2009).

Active substances of algae help to normalize blood circulation and burning excess body fat. As result of this, algae have become an indispensable component of the anti-cellulite cosmetics and correction. Medical cosmetics seaweed great heals scars, as well as effective in the treatment of dermatitis, acne, acne and other skin diseases.

The equipment needed for processing algae to cosmetics is not too sophisticated but expensive due to consumer safety requirements. A result of this, processing of algae can be carried out by specialized companies that can fulfil high demands on hygiene similar to pharmaceutical production.

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Chemical industry

Sea algae are used also in the chemical industry to produce iodine, alginic acid, agar, potash salts, cellulose, alcohol, acetic acid. To process, especially chemically, sea algae using most advanced technologies one must thoroughly study the chemical composition of the raw material. Although qualitatively the chemical composition of algae is quite stable, quantitatively is varies significantly among groups of genera, and among species within genera. Even within a species the chemical composition of plants depends on many factors: age, vitality, habitat, harvesting time, etc.

Pure (unbound) iodine is very rare – mainly occurring in Japan and Chile. It is mostly derived from sea algae (1 ton dry kelp yields 5 kg iodine). Algae for manufacturing chemical products can be supplied to the Archangelsk Pilot Algae Processing Plant (APAPP).

4.3. Economic aspects

Depending on the type of product, its quality and the situation in the world market the prices of algal products vary within 1.5-2 USD for 1 kg of raw product, 4-5 USD for 1 kg of low-grade alginate, up to 100 USD for 1 kg of very pure alginate, 250-300 USD for 1 kg of high quality carrageenan. The prices are quite steady, even with some upward trend due to constant demand for the products in the food, confectionery, perfumery, pharmaceutical, leather, paper, textile, paint and coatings industries, and many other spheres.

Preliminary estimates show the economic potential of artificial algae cultivation is quite high. Some of the constraints however are the high initial investment and harsh climatic conditions: low temperatures, short light duration from autumn to spring. In Karelia, artificial cultivation of algae makes sense at the facilities with plenty of excessive heat, since algae require constantly high temperature to breed (Bakhmet & Tishkov 2014).

According to conducted studies it currently makes no sense economically to use algae for energy. Current situation is mainly due to the economic and administrative problems of the harvesting companies. The leading factor that makes algae harvesting and processing unprofitable is the high specific share of production energy costs in the product cost price, and energy prices keep growing. In addition to that, the value of algal products and their health and fitness properties are not advertised enough.

Given the prices of algae (1 kg dry kelp costs 10-30 USD on average), the most profitable application of algae is in cosmetology.

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4.4. Conclusions

Biogas production from algae is possible and there is literature from biogas production in laboratory scale (Ertem 2011, Morand et al. 1999, Matsui et al. 2006, Møller et al. 2012) and full scale trial (Matsui et al. 2006). However, it seems that the main problems are related in making the algae cultivation and collection economical.

The TS and VS content of the algae species studied at the Lappeenranta University of Technology are similar to values reported by Bruton et al. (2009). With air drying the algae can be dried significantly from 10-20%TS to 87-90% TS (Ross et al. 2008, Wang et al. 2009). The air drying might be useful in case algae mass has to be transported long distances.

The algae C:N ratio may not be optimal for biogas production and co-digestion it with other carbon rich feedstock should be further investigated. However, the C:N ratio of Laminaria digitata was according to the research conducted by Adams et al. (2011) suitable for anaerobic digestion when collected between July and October. The varying properties of algae allows for making the collection then when the properties are suitable. However, the seasonality of algae properties will also make it difficult to run biogas plant whole year round.

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5. MANURE

5.1. Quantity and Quality

Data on twenty biggest agricultural enterprises of the Karelian Republic were analyzed within the study. The possibility of recycling biowastes by processing into biogas was considered. Most promising in this respect are poultry, pig and fur animal farms. These farms are OAO Korm, OAO Agrofirma Vidlitsa, ZAO Svinokomplex Kondopozhsky pig farm, ZAO Pryazhinskoe, and, potentially, OOO Rodina. Other companies grow cattle, and use simpler biowaste disposal methods.

Manure management in Karelian region mainly relies on spreading on fields. Manure is seen as a valuable fertilizer that is useful for the crop production. In addition to use as a fertilizer, manure could also be utilized for energy production via anaerobic digestion. The digestate which is remaining as a residue from anaerobic digestion can be used as a fertilizer. Biogas can then be used in combined heat and power production (CHP) to supply the nearby region with heat and electricity can be directed to the grid. The challenge with anaerobic digestion is that the farms are quite far from each other and it seems that the farmers are not willing to transport the manure more than 15 km on average.

The manure data from 20 largest farms in Republic of Karelia was gathered with interviews. The manure amounts are presented in

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Table 12 and the manure types in Figure 4. From the interviewed 20 farms 19 are operating and one is closed due to bankruptcy (Tishkov & Shcherbak 2014).

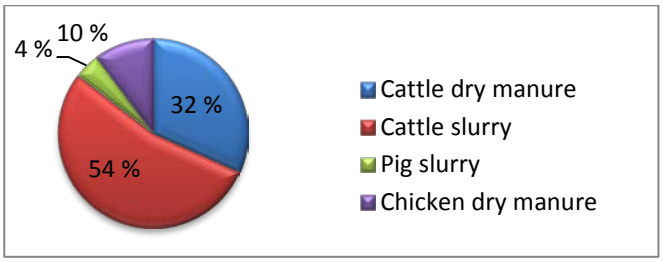

Figure 4. Manure types as mass percent from 19 operating farms**.**

Table 12. Manure amounts and treatment in interviewed farms in Republic of Karelia

Farm	Animals Number	Species	Manure t/a	Treatment
OAO Tolvujsky Collective Farm	1 388	cattle	10 000	Field
ZAO Medvezhjegorsky Molokozavod	1 900	cattle	45 000	Field
OAO Ilyinskoe breeding farm	2 000	cattle	50 000	Field
OAO Megrega breeding farm	3 270	cattle	90 000	Field
OAO Tuksa Agrofilm	Bankrupt			
OAO Agrarny collective farm	1 200	cattle	11 000	Field
OAO Vidlitsa Argofirm	640	cattle	9 000	Field
OOO Vozrozhdenie Salmi	450	cattle	5 000	Specialized plot
OOO Ladozhskoe	200	cattle	2 500	Fields, lagoons
ZAO Janishpole	506	cattle	5 000	Field
OOO Real	133	cattle	1 500	Field
ZAO Kondopozhsky pig farm	6 261	pig	15 000	Polygon in Voronovo
OOO Mayak	574	cattle	6 000	Field
OAO Zaitsev Agrokomplex	801	cattle	17 000	Field
OAO Karel'skoe breeding enterprise	7	cattle	20	Manure is for sale
OAO Korm	400 000	chickens	35 000	Field or sold
ZAO Essoila	1 600	cattle	20 000	Field
OAO Vedlozersky	1200	cattle	11 000	Field or sold
ZAO Pryazhinskoe	792	cattle	10 000	Field
OOO Rodina	72 + 200	cattle + sheep	1 000	Field
20	423 194		344 007	

The willingness to utilize manure in biogas production was not really widespread among the farmers in Karelian region. From the 19 operating farms, only 5 expressed interest in giving manure for biogas production. These farms and the produced manure amounts are presented in Table 13.

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Table 13. Farms willing to give manure for biogas plant.

Farm Name	Animals Amount	Spcecies	Manure Type	t/a	Treatment
OAO Tolvujsky Collective Farm	1 388	cattle	Dry manure	10 000	Field
OAO Ilyinskoe breeding farm	2 000	cattle	Slurry	50 000	Field
ZAO Kondopozhsky pig farm	6 261	pig	Slurry	15 000	Polygon
ZAO Essoila	1 600	cattle	Dry manure	20 000	Field
ZAO Pryazhinskoe	792	cattle	Dry manure	10 000	Field
Total	12 041			105 000	

Three of these farms (ZAO Kondopozhsky pig farm, ZAO Essoila and ZAO Pryazhinskoe) are located relatively close to each other and a city of Petrozavodsk (Figure 5). These farms could be seen viable to supply a common biogas plant located on road P-15 between Petrozavodsk and Kondpoga.

Figure 5. Farms close to Pedrozavodsk.

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5.2. Biogas production potential

5.2.1. Calculation method

The biogas potential is calculated for the total manure from all 19 farms, 5 farms showing interest in biogas production and for the assumed biogas plant utilizing manure from three farms located close to each other (Tishkov & Druzhinin 2013, Baader et al 1982, Vorobyov & Vasilov 2005, Vasilov 2008). The manure minimum, maximum and average values used in calculations are presented in Table 14. The biogas production is assumed to take place by mesophilic wet anaerobic digestion. The resultant biogas is assumed to be used in CHP. The values for parasitic energy use and CHP efficiencies are presented in Table 15.

The minimum, maximum and average values in Table 14 and Table 15 are used in calculating the range of total biogas potential in Karelian region. Average values are used for calculating the biogas potential from interested farms and also used in calculation of biogas potential for the assumed biogas plant.

Table 14. Manure properties (Berdino 2013, Deublein & Steinhauser 2008, Güngör-Demirci & Demirer 2004, Kumar & Bharti edit. 2012).

	TS			VS/TS			Methane	m3/tVS	
	Min	Max	Average	Min	Max	Average	Min	Max	Average
Cattle slurry	3	4	3.5	68	85	76.5	120	300	210
Cattle dry manure	15	25	20	68	85	76.5	126	264	195
Pig slurry	3	4	3.5	68	85	76.5	250	600	425
Chicken manure	32	74	53	63	88	75.5	210	360	285

Table 15. CHP efficiency and parasitic electricity and heat (Berglund & Börjesson 2006 Valovirta 2011, Uusitalo et al. 2013, Hupponen et al. 2011).

		Min	Max	Average	
Parasitic use WET	electricity	55	80	66	MJ/t 10%TS
Parasitic use DRY	electricity	88	113	99	MJ/t 10%TS
Parasitic use WET and DRY	heat	70	180	110	MJ/t 10%TS
CHP efficiency	electricity	35	50	40	%
	heat	35	43	41	%

5.2.2. Results

The total energy potential of biogas from all the manure produced in these 19 operating farms varies between 34 GWh/a and 165 GWh/a when using minimum and maximum values for manure properties. Using average values for manure properties gives biogas potential of 85 GWh/a. The

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manure properties had a much significant effect on the obtainable electricity and heat amounts than the used values for CHP efficiency and parasitic energy use as can be seen from Figure 6.

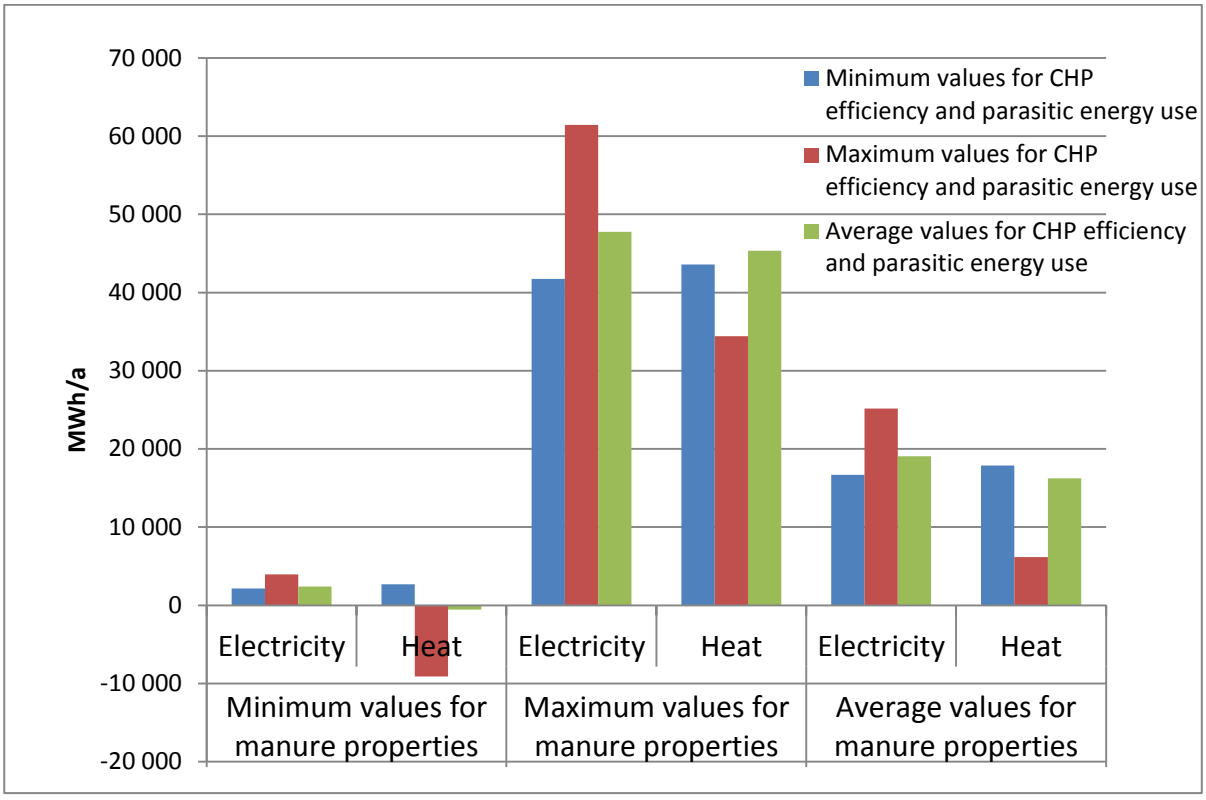

Figure 6. Total manure potential of Karelian region.

The manure amount from the five interested farms represents 31% from the total manure amounts from the 19 investigated farms and 34% from the calculated biogas energy amount. The calculated net electricity and heat amount can be seen from Table 16.

Table 16. Calculated biogas energy and obtainable electricity and heat energies from five farms interested in biogas production.

Farm	Biogas	Own use		Produced		Net energy	
		Electricity	Heat	Electricity	Heat	Electricity	Heat
Name	MWh/a	MWh/a	MWh/a	MWh/a	MWh/a	MWh/a	MWh/a
OAO Tolvujsky	2 984	550	611	1 193	1 223	643	612
OAO Ilyinskoe	14 918	917	1 528	5 967	6 116	5 050	4 588
ZAO Kondopozhsky	1 707	275	458	683	700	408	241
ZAO Essoila	5 967	1 100	1 222	2 387	2 446	1 287	1 224
ZAO Pryazhinskoe	2 984	550	611	1 193	1 223	643	612
Total	28 558	3 392	4 431	11 423	11 709	8 032	7 278

The assumed biogas plant where waste from three closest farms would be delivered would utilize 13% of the total manure from the investigated 19 farms and could produce same share from the

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total biogas energy amount. The capacity of the plant would be 45 000 t/a manure. In Finland this size of biogas plant would already require environmental impact assessment since the capacity is higher than 20 000 t/a (VnA 713/2006). This biogas plant could provide 2.3 GWh/a electricity and 2 GWh heat. One apartment building in St Petersburg with 214 apartments and 11 000 m^2 could consume 3.5 GWh/a, so the heat could be consumed in one apartment building. The same apartment building would consume 100 MWh/a electricity so the electricity from biogas plant would be enough for 23 apartment buildings.

Table 17. Calculated biogas energy and obtainable electricity and heat energies from the assumed biogas plants utilizing manure from three farms.

Farm	Biogas	Own use	MWh/a	Produced		Net energy	
		Electricity	Heat	Electricity	Heat	Electricity	Heat
	MWh/a	MWh/a	MWh/a	MWh/a	MWh/a	MWh/a	MWh/a
ZAO Kondopozhsky	1 707	275	458	683	700	408	241
ZAO Essoila	5 967	1 100	1 222	2 387	2 446	1 287	1 224
ZAO Pryazhinskoe	2 984	550	611	1 193	1 223	643	612
Total	10 657	1 925	2 292	4 263	4 370	2 338	2 078

5.3. Economic aspects

5.4. Conclusions

There seems to be a significant potential of manure for biogas production in Karelian region. The total biogas potential calculated in this study had a huge variation depending on the values used for manure properties. The total biogas energy content calculated using minimum values for manure properties was only 21 % from the energy content calculated by maximum values and 40% from the energy content calculated with average values for manure properties.

The challenges arise from the long distances between farms and lack of interest towards biogas production amongst farmers. Lindgren (2013) also found that the farmers do not possess financial means to invest in biogas equipment. The farmers were more interested in compressing or concentrating the manure to make it more economical and easier to transport the manure.

The farmers interested in biogas production were willing to transport the manure 10-15 km. Even if the biogas plant would be located in Petrozavodsk the closest farms are located within 40-50 km of the plant which is longer distance than the farms would be willing to transport the manure. However, if the farms are getting larger the need to utilize the manure could become more stressing and biogas production would become more interesting. Also the increasing prizes for energy might support the biogas production from manure.

To set up processing of biowaste from livestock farming in the Republic of Karelia the focus should be on pig-, poultry- and fur animal farms. Cattle manure is a valuable fertilizer utilized in fields.

Pig and poultry farms in Karelia are few. They have also established a disposal system using storage facilities. Yet, these enterprises have potential for growth, in which case they will have to

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look for solutions to dispose of the increased amounts of biowaste. The biogas option will then be considered.

6. SEWAGE SLUDGE

6.1. Quantity and Quality

Total wastewater discharge to surface water bodies in the Republic of Karelia is 225.4 million m^3, including 174.3 million m^3 classified as undertreated, and 20.1 million m^3 of untreated wastewater (Lotosh 2002, Shcherbak 2012). The use of digestate from anaerobic treatment of sewage sludge might be challenging since it might contain too much heavy metals for it to be suitable for spreading on field.

Based on the study of sewage and sludge treatment and disposal in the Republic of Karelia the potentially available excess activated sludge from the full treatment of all wastewater in the republic was estimated to be approximately 30 tons a day. Most of it is formed at large enterprises ("Kondopoga" JSC, "Segezhsky Pulp-and-Paper Mill" JSC, "Pitkaranta Pulp Plant" JSC) and municipal wastewater treatment works of cities (Program activities on the ecology of the Government of the Republic of Karelia. 2010). Excess of activated sludge available for biogas production from Petrozavodsk sewage treatment works is 3.8 – 5.3 tons a day. The yearly sewage sludge amount in is approximately 11 000 t/a and the amount of sludge from Petrozavodsk city 1 400 – 1 900 t/a and on average 1 700 t/a (Borisov 2013, Turkov 2013, Report of Petrozavodsk wastewater treatment plants 2013).

6.2. Biogas potential

The sewage sludge is dewatered by filter press and the resulting total solid content is assumed to be 20%. The biogas potential is assumed to be 142 m^3CH_4/t_{TS}. (Davidsson et al. 2008, Ferrer et al. 2008). The amount of sewage sludge from Republic of Karelia is 11 000 t/a and from Petrozavodsk city 1 700 t/a. The CHP efficiencies and biogas production electricity and heat use are assumed to be same as presented for manure anaerobic digestion. The biogas potential and produced net energy amounts are presented in Table 18.

Table 18. Biogas energy potential from sewage sludge in Republic of Karelia and Petrozavodsk city.

	Methane MWh/a	Own use Electricity MWh/a	MWh/a Heat MWh/a	Produced Electricity MWh/a	Heat MWh/a	Net energy Electricity MWh/a	Heat MWh/a
Republic of Karelia	3 100	600	670	1 200	1 300	640	610
Petrozavodsk	470	91	100	190	190	97	92

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6.3. Conclusions

The found sludge amount in Republic of Karelia is about the same as from the city of Lappeenranta 10 000 t/a even though in Republic of Karelia there are 640 000 inhabitants which is multiple times more than in Lappeenranta, which has 73 000 inhabitants. In Finland the total solid amount of sewage sludge varies 11-79 kgTS/a/person and for Republic of Karelia 3 kgTS/a/person and in Petrozavodsk 1 kgTS/a/person. In the Leningrad region the sewage sludge potential is calculate to be 31 kgTS/a/person (Värri et al. 2010). All this would indicate that part of the sewage is not treated in the Republic of Karelia or sewage treatment is not so efficient. The sewage sludge net electricity and heat anaerobic digestion plant for manure from the three farms close to Petrozavodsk mention in Chapter 5.3.2 would be 4% higher if the sewage sludge from Petrozavodsk city would also be directed to that plant. The increase in net electricity and heat is not so significant and the use of digestate from the plant might be jeopardized by the inclusion of sewage sludge as a feedstock if the sewage sludge contains a lot heavy metals (Värri et al. 2010).

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7. TRANSPORTATION COSTS

Bio-waste that en up to landfill or is otherwise not appropriately processed deteriorate the sanitary and epidemiological situation for people. Timely removal, processing and disinfection of bio-hazardous waste by properly qualified companies is becoming a key issue for the managers of organizations and enterprises interested in making their process environment friendly.

Data on three types of waste were analyzed within AQUAREL project: fish and other marine product waste, algal waste suitable for commercial utilization, and manure for biogas.

High fuel and oil prices notably reduce the companies' possibilities to haul out and further transport bio-wastes. Analysis of bio-wastes in Republic of Karelia revealed three major areas where they now accumulate: Pryazhinsky and Prionezhsky Districts in the south, Pitkärantsky and Olonetsky Districts in the south-west, and Segezhsky and Medvezhjegorsky Districts in the north.

Waste transportation costs are listed in Table 19 below (Katzman & Korolev 2003, Roads of Russia 2008, Yakunin 2005).

Table 19. Waste transportation cost (1 ton for 1 km, RUR).

transport cost / *waste type*			
fish and other marine product wastes	15-20	20	10
algal wastes suitable for commercial utilization	12-17	15	8.13
manure for biogas	2.23	3.3	2.50
source	*data from Federal Road Agency*	*data on Moscow and the Moscow Region*	*data from Federal Statistics Agency*

The cost of transporting wastes, for instance from Prionezhsky to Medvezhjegorsky district will be: RUR 3400 per 1 ton of fish and other marine product wastes, RUR 2550 per 1 ton of algal wastes suitable for commercial utilization, RUR 600 per 1 ton of manure for biogas.

The cost of transporting wastes, for instance from Olonetsky to Prionezhsky district will be: RUR 3000 per 1 ton of fish and other marine product wastes, RUR 2250 per 1 ton of algal wastes suitable for commercial utilization, RUR 495 per 1 ton of manure for biogas.

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The cost of transporting wastes, for instance from Segezhsky and Medvezhjegorsky to Olonetsky district will be: RUR 8000 per 1 ton of fish and other marine product wastes, RUR 6000 per 1 ton of algal wastes suitable for commercial utilization, RUR 1200 per 1 ton of manure for biogas.

Analysis of the transport costs in Republic of Karelia shows it is economically inexpedient to transport bio-wastes for more than 100 km since the transport costs would substantially raise the cost price of bioenergy generation.

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8. PILOTING

In the AQUAREL project pilot the fish oil was separated from the fish processing side streams. Produced fish oil can further be utilized in bio-diesel or animal feed production. The decision to produce fish oil as an end product was based on existing market demand and profitability calculations. The production of bio energy i.e. biodiesel currently is not economically profitable and there are lack of demand for biodiesel in Karelia. Additionally an essential aspect having an impact on the end product selection was the identified business associate with whom the project shared common interests.

The purpose of the pilot was to confirm the functionality of the transportation logistics and the fish oil production process.

8.1. Pilot process definition

The pilot included the following process steps (Figure 7):

1. Collection. Fish processing side streams are collected from the fish processing farm located in Kondopoga. The side streams are in transportation containers.
2. Transportation. Side stream containers are transported to pilot facility in Borovoi, around 500 km northwest from Kondopoga.
3. Pre-treatment. The side streams are treated to decrease the particle size.
4. Heating. Side streams are heated in target temperature for specified time.
5. Removing the oil phase. The fish oil on top of the heating unit is removed and collected to oil canister.
6. Separation. The oil phase is separated from protein and solid phase by gravity in an insulated separation unit.
7. Removing the oil phase. The fish oil on top of the separation unit is removed and collected to oil canister.
8. Removing the protein and solid phase. The protein and solids are stored to transportation containers for further utilization.

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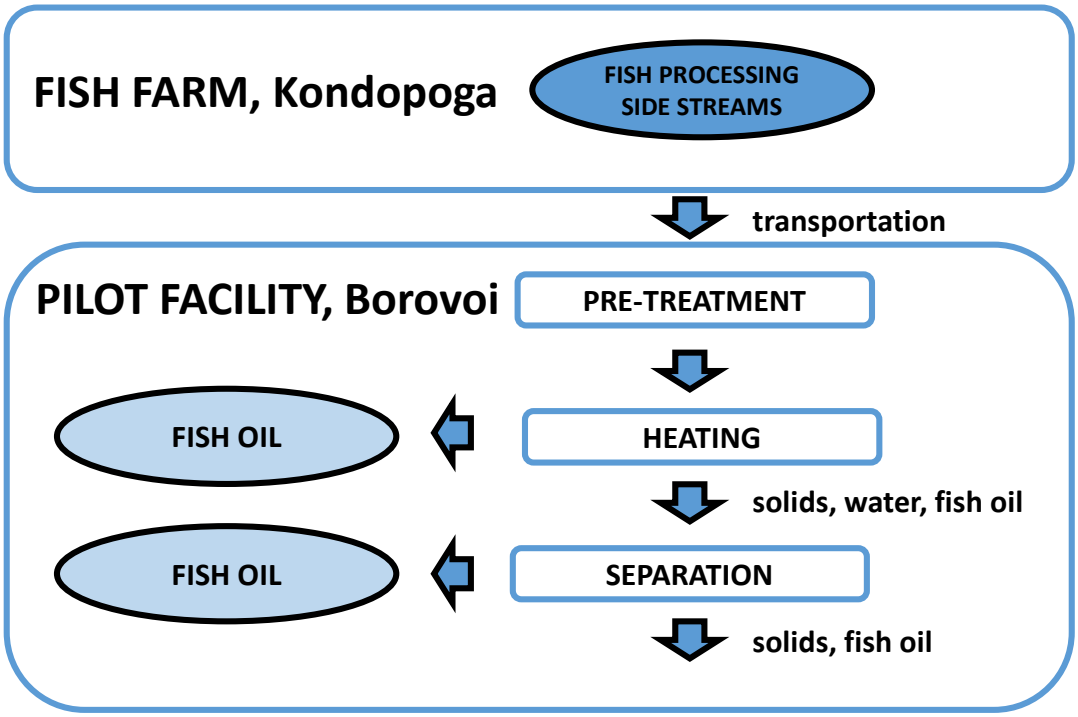

Figure 7. Pilot process steps.

In the pilot process the fish side streams are first heated in a heating unit. The oil phase on top of the heating unit is removed after which the rest of the mass is pumped to the fish oil separation unit. In separation unit the fish waste is separated into two (2) phases by gravity; fish oil and solids including the water and oil.

The process piloted was a batch process, designed to manage 250kg of side steam per batch. For each of the pilot run, the key process parameters were changed; heating temperature and time, with or without the pre-treatment and separation time.

8.2. Results

When the heating temperature increases beyond ~50^{o}C most of the side streams are smelt. That makes the crushing after the heating unnecessary. Instead crushing the side streams before the heating will speed up the heating decreasing the overall processing time.

Even if the production process itself is not complicated, the operative management of small-scale fish oil production unit requires dedicated resources and separate facilities. Process parameters need to be monitored. The transportation, storage and moving the side stream, solids and fish oil require specific equipment and containers to ensure smooth operations and to meet hygiene requirements. For the same purpose, also cleaning the process equipment and facilities require special focus.

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In the pilot, the side streams were transported for 500km distance to the pilot facility. The pilot was conducted during the summer time, so the road conditions did not cause any surprises. However, long transportation distance creates a risk outside the summer time. On the other hand, the pilot confirmed the location of the waste management unit do not need to be besides the fish farmers assuming the transportation equipment are appropriate.

The cold chain need to be robust during the whole side stream management process. That creates the basis for meeting the hygiene requirements.

8.3. Conclusions

Producing fish oil from fish processing side streams is an easy and relatively simple production process generating a valuable end product. For a small scale process, also the equipment investment stay moderate.

Even if the fish oil production process is not complicated, the operative management of small-scale fish oil production unit requires dedicated resources and separate facilities especially to meet hygiene requirements.

Managing the side streams is not a core business for fish farmers. There is clearly a business opportunity for an actor, who would manage the fish processing side streams in the Republic of Karelia. Efficient and economically profitable fish oil production requires centralized production unit which processing capacity would cover the side streams from the majority of the fish farmers in the Republic of Karelia. Managing the side streams should cove the dead fish as well, to create a comprehensive waste management solution. Even if the dead fish would require a separate management process.

The optimum location for the fish waste processing unit is in the middle of the fish farms or at least close to one of the main roads. Another issue to be considered when locating the processing unit is that side streams collection from the fish farms is reasonable to be organized on a daily basis to eliminate the need for storing them at the farms.

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9. CERTIFICATION OF PRODUCTS MADE OF FISH WASTE

Fish fats are divided into several categories:

a) Veterinary fat of fish, whales and sea animals, GOST (Russian Standard) 9393-82, National product classification code 928110, it is used for veterinary purposes and feeding of farm animals, fish and poultry. Veterinary fat is produced either natural (content of vitamins in 1 g. should be 500-1000 measured in international units) or fortified with vitamins.

b) Edible fat of fish and sea mammals, GOST (Russian Standard) 9393 8714-72, National product classification code 928113, it is used for production of solid hydrogenated fats and other food products.

c) Technical fat of fish and sea mammals, GOST (Russian Standard) 1304-76, National product classification code 928115, it is used for technical purposes and production of veterinary fat.

Veterinary fat of fish, whales and sea animals and edible fat of fish and sea mammals is subject to obligatory quality confirmation by a declaration of conformity. Technical fat is not subject to obligatory quality confirmation, veterinary expertise is enough.

All abovementioned products could be voluntary certified to get a voluntary certificate of compliance. The voluntary certificate of compliance does not substitute obligatory confirmation by a declaration of conformity.

A certificate of compliance for medical fat and sperm oil could be obtained in certification bodies specializing in this sphere.

In the Republic of Karelia declarations of conformity and (or) voluntary certificates of compliance are obtained in LLC “Karelsertifikatsiya” (Petrozavodsk). It is a body responsible for the certification of products including the ones made of fish. “Karelsertifikatsiya” certifies food products and issues appropriate certificates of compliance, prepares and registers declarations of conformity, holds consultations on issues related to obtaining declarations of conformity and certificates of compliance for products and products’ marking, completes shipping documentation and elaborates scientific and technical documentation.

Confirmations of compliance of all food products, except for the ones made of fish, are done in accordance with a technical regulation of Customs Union «On food safety». Safety of fish products is controlled by Sanitary Rules and Norms (SanPiN) No. 2.3.2.1078-01 and unified sanitary regulations.

At the moment the technology of production of biodiesel from fat need to comply with the requirements of Russian national standard. GOST R 53605:2009. Automotive fuels. Fatty acid methyl esters (FAME) for diesel engines. General technical requirements.

As regards the equipment for production of fat and biodiesel, the necessary certificates should be provided by the equipment producers.

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10. ENVIRONMENTAL IMPACT OF UTILIZING FISH WASTE FOR BIODIESEL OR FISH MEAL

Two different fish waste utilization methods were compared from their environmental impacts perspective. In one analysis fish waste was assumed to be utilized for biodiesel production and in the other for fish meal production. The greenhouse gas (GHG) emission balance was calculated and compared for both cases. The production processes were expected to take place in Karelia Region.

The GHG balance calculation aims to take into considerations the emissions from all the significant processes used in utilizing fish waste. The GHG emission calculation starts from fish waste utilization since waste for utilization is considered as burden-free. Therefore fish farming and fish processing impacts are excluded from the calculations since they are considered as impacts caused of the produced. Furthermore, the products produced from fish waste can be used to replace other products used for similar purposes. This means that these other products do not have to be produced which reduces emissions. The emission reductions caused by this displacement are included in the GHG balance. Then the calculation of GHG balance indicates whether there are net GHG emissions or net GHG reductions.

10.1. Life cycle inventory data for fish waste utilization

Life cycle assessment of utilizing fish waste for biodiesel production or fish meal production was conducted to calculate the greenhouse gas (GHG) balance of these utilization methods. The functional unit was the annual mass of fish waste for utilization in Karelian Republic (2580 t/a). Transportation of fish waste or products is not included in the calculation because it is assumed not to have significant impact on which utilization option is better.

Biodiesel production starts with oil separation from fish waste. The oil-free fish waste residue from oil separation is assumed to be composted in pile which is assumed to produce insignificant amount of GHG emissions. Fish oil is directed to transesterification where biodiesel and glycerin are produced using methanol and sodium hydroxide (NaOH) as processing chemicals. Both of these processes require electricity and heat. Glycerol is assumed to be used for heat production. Additional heat is needed for the processes and is assumed to be produced with light fuel oil (LFO). The used electricity is assumed to be average grid electricity in Russia. The emission factor of LFO heat and electricity are taken from GaBi 5.O database. The produced biodiesel is assumed to displace diesel use in average Finnish diesel car in 2011 consuming 2.3 MJ/km (Lipasto 2012). The properties of fish waste and lower heating value (LHV) of fuels are presented in table 20 and the energy and material use of biodiesel production in table 21.

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Table 20. Properties of fish waste and lower heating value (LHV) of fuels.

Properties				Reference
Fish waste	oil content	35	%	(Kotzamanis et al. 2001)
	moisture content	56	%	(Kotzamanis et al. 2001)
	VS from TS	55	%	(Mshandete et al. 2004)
	N from TS	8.4	%	(Laos et al., 2002, Mshandete et al. 2004).
Biodiesel	LHV	41	MJ/kg	(Lin & Li 2009)
Glycerol	LHV	17.1	MJ/kg	(Bernesson 2004)
Diesel	LHV	42.8	MJ/kg	(Tilastokeskus 2013)

Table 21. Biodiesel production energy and material use and glycerol combustion efficiency.

Biodiesel production				Reference
Oil separation	Electricity use	0.054	MJ/kg fish waste	(Sybimar 2012)
	Heat use	0.36	MJ/kg fish waste	(Sybimar 2012)
Biodiesel production	Electricity use	0.072	MJ/kg oil	(Salminen 2013)
	Heat use	0.13	MJ/kg oil	(Salminen 2013)
	Methanol	0.2	kg/kg oil	(Uusikaupunki 2006, National biodiesel board)
	NaOH	0.01	kg/kg oil	(Lin & Li 2009)
	Glycerol	0.2	kg/kg oil	(Enerfish 2009, Uusikaupunki 2006)
Glycerol combustion	Heat efficiency	83	%	(Cavalcante Junior et al. 2012)
Oil free fish waste composting	Static pile No turning VS degradion	82	%	(Haug 1993, Martin 1999, Tchobanoglous 1993)

The fish meal production includes separating the water and oil from the fish waste. The solid fraction is further processed to fish meal. The used electricity is assumed to be average grid electricity in Russia and the needed heat produced with LFO. The fish meal from dried oil free residue and separated fish oil are assumed to be mixed together. The produced mix of fish meal and fish oil is assumed to displace average salmon feed. The emission factors are presented in Table 23.

Table 22. Fish meal production energy use, fish meal dry content and LFO combustion efficiency

Fish meal production			Reference
Electricity use	0.12	MJ/kg raw material	(FAO 2012)
Heat use	1.2	MJ/kg raw material	(FAO 2012)
LFO heat efficiency	85	%	(GaBi 5.0)
Fish meal dry content	92	%	(Ingredients 101)

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Table 23. GHG emission factors used in the GHG balance calculation

Emission factors			Reference
NaOH	0.63	$kg_{CO2,eq}/kg$	(Thannimalay et al. 2013)
Methanol	0.53	kg_{CO2}/kg	(NREL 2013)
Salmon feed	1.6	$kg_{CO2,eq}/kg$	(Pelletier et al. 2009)
Diesel car	0.16	$kg_{CO2,eq}/km$	(Lipasto 2012)
Electricity and LFO heat	Gabi 5.0 database		(PE International)
Composting CH_4	0.126	kg_{CH4}/kg_{VS}	(Szanto et al. 2007)
Composting N_2O	9.9	% of tot N	(Szanto et al. 2007)

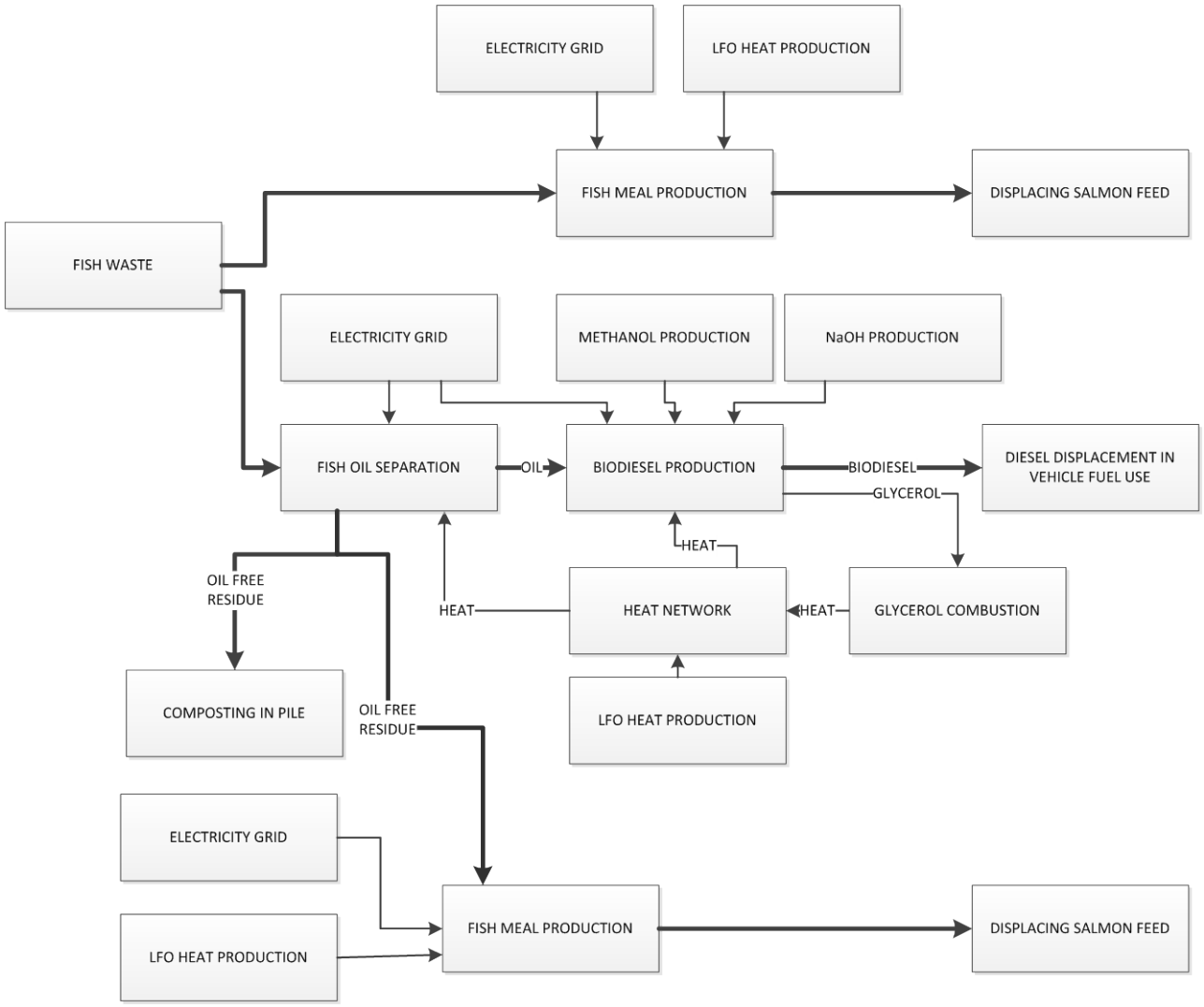

Figure 8. Simplified flowchart of fish waste utilization in fish meal or biodiesel production.

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10.2. The results of GHG emission comparison

The annual GHG balance of utilizing 2580 t/a fish waste in biodiesel production or fish meal production are presented in Figure 9. The biodiesel production chain causes more GHG emissions annually than the fish meal production due to large emissions from composting. However, the emission reductions from displacing fossil biodiesel are larger than from displacing salmon feed. The annual net reductions are therefore slightly higher from utilizing fish waste for biodiesel production. After it was recognized that composting of fish waste causes most GHG emissions in biodiesel production chain, it was thought that it could be useful to direct oil free fish waste to fish meal production. Ultimately this option resulted in highest net GHG emission reduction.

The GHG emission factor of producing fish meal from fish waste is 0.3 $kg_{CO2,eq}$/kg fish meal, which is much lower than emission factor of average salmon feed 1.6 $kg_{CO2,eq}$/kg and this result in emission reduction potential of -1.3 $kg_{CO2,eq}$/kg fish meal. The biodiesel emission factor is 36 $g_{CO2,eq}$/MJ, which can be compared to the average emission of fossil vehicle fuel 83.8 $g_{CO2,eq}$/MJ presented in Directive 2009/28/EC, hereafter RED directive. The RED directive has emission reduction demand for renewable vehicle fuels which is at present 35% and 65% after 2016. The emission reduction of biodiesel from fish waste calculated in this study is 60% which means that the biodiesel from fish waste clearly reaches these goals even when high emissions from composting oil free fish waste are accounted for.

In general it would seem that it is more reasonable, from GHG emission point of view, to utilize fish waste for fish biodiesel production and the oil free residue from fish oil separation in fish meal production.

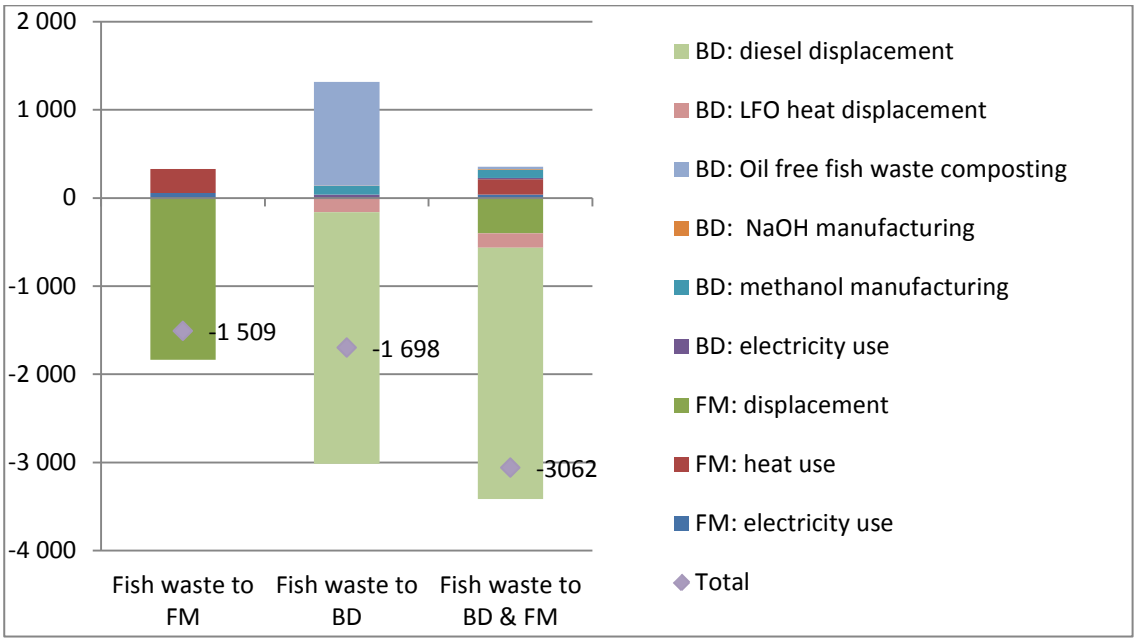

Figure 9. Annual GHG balance utilizing 200 t/a fish waste either in fish meal (FM) or biodiesel (BD) production.

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11. FUNDING OPTIONS FOR INVESTING IN BIO-WASTE PROCESSING

Based on AQUAREL project studies there are different public funding sources available for supporting and enabling profitable and environmentally sustainable utilization, research or development of fish processing side streams and other aquatic biomaterial. Different funding programmes can be utilised by companies, research organizations, authorities and non-governmental organizations.

Typical groups involved in organic waste management that are interested in public funding are fish farms and fish processing companies, companies developing equipment for fish processing and bioenergy production, other bioenergy focused companies, public administration that works with fish farming either from the business development or environmental perspective, and universities and institutes who carry out research activities that benefit the companies and public administration.

Appendix 1 covers the list of relevant public funding sources in more details.

12. FINAL CONCLUSIONS AND RECOMMENDATIONS

The final conclusions and recommendations how to utilize different kind of organic waste in the Republic or Karelia are time dependent. Changes in the quality, quantity and location of organic waste as well as changes in e.g. the economic environment, energy prizes and demand may require re-evaluating the results and conclusions made in the project.

The key aspects that have been considered here are the environmentally sustainable utilization of organic waste and economically profitable production process. The advantages and challenges of each waste processing technology are also considered. The parameters that have impact on the profitability of end products are as well expressed in the chapters below.

12.1. Biodiesel, fish oil

Producing fish oil and biodiesel from fish waste is an easy and simple production process generating a valuable end product. Fish oil can as such be utilized for heating purposes and fish meal or animal fodder production, but it can also be further processed to biodiesel. The use of biodiesel instead of fossil diesel is environmentally more sustainable, since combustion emissions are lower compared to fossil diesel. Glycerine is biodiesel production side product, which can further be processed to soap or other e.g. cosmetics products.

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The challenge of producing biodiesel is that there are valuable other end uses for fish oil. I.e. there are competitive other means of utilizing fish oil besides biodiesel production. Considering the biodiesel production from Karelia perspective, fish oil or biodiesel production is currently not centralized. Due to that the production units are small increasing the investment costs. Another obstacle for biodiesel production is getting needed chemical permissions to start a production where chemicals are used.

The side products from biodiesel and fish oil production process can be further utilized. The residue from oil separation can be used for animal feed and glycerine, that is a residue from biodiesel production, can be further utilized or processed to soap or e.g. other cosmetics products.

The equipment cost play a major role when making the profitability calculations for utilizing waste for biodiesel and fish oil production. Even if there are small scale processes available, which equipment costs are moderate.

The location of fish meal producers have impact on the logistics costs. Thus this is one of the key parameters when evaluating the profitability of further processing the fish oil for fish meal production.

In current economic environment in Russia biodiesel production will not be profitable since market price for fish oil in ~0,8-1€/ litre and for biodiesel only ~0,7€/litre.

As an outcome of studies conducted in AQUAREL project, the project recommendation and final conclusion is that fish oil and dewatered oil-free residue are feasible to be used for fish or animal feed production. From the waste management point of view, it is also essential to use the dewatered oil-free residue, which forms the major part of waste, for fish or animal meal production.

In the current economic environment in Russia biodiesel production from fish oil will not be profitable. There are more economical use for fish oil. However, using fish oil for individual companies' own heating purposes in fish farming company could be feasible.

12.2. Biogas

There are several advantages of producing biogas from bio-waste. Biogas provides an alternative fuel for traffic vehicle. It is also a realistic option for local heat and electricity production especially in remote rural areas that need independence from, or are lacking connection to, centralized energy production. Fish-waste alone is not feasible for biogas production, but can be utilized when combined with other material e.g. municipal bio-waste, sewage sludge and manure.

In many ways biogas production is sustainable and environmentally friendly method for processing the bio-waste. Bio-waste dumped in to landfills cause methane emission, which can be decreased by biogas production. Digestion residues can be further used for fertilizers, increasing their soluble nitrogen content. Biogas production also enable recycling the nutrients from bio-waste.

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The challenge of biogas production is the low energy production output compared to the cost of equipment investment. Utilizing biogas for traffic vehicle requires refining, which is an expensive process. From environment perspective, biogas production do not reduce total amount of waste significantly and a feasible recovery possibility as fertilizer (or other land use material) is needed for the digestion residue.

There are a number of parameters that have an impact on the biogas profitability. One of the parameters are the current waste treatment costs, i.e. gate/land fill fees and another is the current price of other energy sources like natural gas and hydro power. Russian government subsidy policy for energy producers have impact on the profitability. Bio-waste need to be collected and transported to production site, thus the cost of transportation and logistics need to be taken into account as well as the equipment investment for biogas production. Also the price of fertilizers are one of the profitability calculation parameters, since biogas digestion residues are used for fertilizers.

As an outcome of the studies conducted in AQUAREL project, project recommendation and final conclusion is that biogas could be *a local* solution when getting energy from the state network is a challenge. Another thing is that for processing fish waste to biogas requires also other biowaste material like manure, sewage sludge – fish waste alone is not enough.

12.3. Animal meal and fodder

Human perspective recovering material and using fish waste for producing animal feed and fodder is more reasonable than using the material for energy production. The value or profitability of animal feed is also higher than the value of the energy. Another advantage is that the use of fish waste reduces the use of small fish as a raw material for animal feed production. Instead the small fish can be used for human food.

However, the quality requirements for animal feed set quite demanding requirement for production and for the whole supply chain. The conditions for logistics, storage etc. have to be well organized. Combining fish waste from different sources increase the risk of spreading animal diseases. The hygiene need to be carefully taken into account.

How fox farming business is doing has an impact on the profitability of using bio waste for animal feed production. Also the price of fish meal and fish meal raw material needs to be taken into account.

As an outcome of the AQUAREL project studies, producing fish meal and animal feed in Karelia from local fish waste decrease the need for importing fish meal and raw material for fish meal at least up to 1000 ton per year. Moreover the Ministry of Agriculture of the Republic of Karelia is interested about feed production since it provides a sustainable way to utilize fish waste.

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12.4. Pharmaceutics, cosmetics

There are good examples in Karelia for utilizing algae for production of pharmaceutics and cosmetics.

The advantage of utilizing algae for production of pharmaceutics and cosmetics is its' unique composition and healing properties. Pharmaceutics and cosmetics goods based on algae are already worldwide popular.

Human can utilize almost 100% of active substances in algae. Additionally cosmetics produced from algae do not have side effects.

Algae harvesting is limited to short season during the autumn time and the harvesting is highly labour intensive work. The high hygiene requirements set challenges for the whole supply chain e.g. requiring logistics and storage to be well organized. Due to consumer safety requirements, also the production equipment are expensive.

At the present time algae using in cosmetics and pharmaceuticals is popular and profitable business. Cosmetic's products produced from algae have high consumer preference.

As an outcome of studies conducted in AQUAREL project, project recommendation and final conclusion is that pharmaceutics and cosmetics is the most reasonable solution for algae utilization. However, the processing requires specialized enterprises for example the Archangelsk Pilot Algae Processing Plant or other similar enterprises.

12.5. Combined solutions

In order to utilize bio-waste in Karelia as effectively as possible, co-operation of different actors and combination of solutions need to be considered. The investments needed for bio-waste utilization processes are high and require co-operation of different stakeholders.

One of the major fish processing company in Kondopoga, Karelia has invested on production unit and is currently working on to start the fish meal raw material production (fish oil, protein). That may become a major solution for the whole Karelia.

In areas located in longer distance from Kondopoga, additionally local solutions will be needed. One of the solutions may be to import fish waste from Sortavala area to Parikkala, Finland for further processing. Another solution may be that the residue from oil separation will be used for biogas production in Sortavala area. However, this requires enough other material like manure and sewage sludge (e.g. from waste water treatment plant in Sortavala).

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APPENDIX 1
DESCRIPTIONS OF FUNDING OPPORTUNITIES

1. State support for small and medium enterprises in the Republic of Karelia Regional Programme	
Description:	Regulatory framework of the Programme: 1. The Federal Law "On the development of small and medium enterprises in the Russian Federation» № 209-FZ of July 24, 2007. 2. Law of the Republic of Karelia "On some issues of small and medium enterprises in the Republic of Karelia" July 3, 2008 № 1215-SAM. 3. Decree of the Government of the Republic of Karelia 21.02.2009. Number 29-P "On approval of the Regional Programme Development of small and medium enterprises in the Republic of Karelia for the period up to 2014 " The main executor of the programme is the Ministry of Economic Development of the Republic of Karelia - namely, the Department of development entrepreneurship, innovation and support for investors.
What can be funded:	The Programme contains more than 20 priorities (actions) in all areas of support provided by the Federal Law of July 24 , 2007 № 209 -FZ " On the development of small and medium enterprises in the Russian Federation ", namely: • Information and consulting support of SMEs; • Support in the area of training, retraining and advanced training of SMEs ; • Property support of SMEs (through Business Incubator) ; • Support for small and medium enterprises engaged in foreign trade ; • Support in craft activities ; • Support for innovation and industrial production; • Support of SMEs producing and (or) selling goods (works, services) intended for export; • Financial support of SMEs
Eligible partners:	The main category of small and medium enterprises (SME) , eligible to receive support: • Medium-sized enterprises (average number of employees - 101-250 people, Revenue - limit to 1 billion roubles) • Small businesses (average number of employees - 100 people. , Revenue - limit to 400 million roubles); • Micro (average number of employees - up to 15 people, Revenue - limit to 60 million roubles)
Public funding rate	100%
Average project size:	Up to 500 000 RUB
Funding body:	The main curator of the program is the Ministry of Economic Development of the Republic of Karelia - namely, the Department of development entrepreneurship, innovation and support for investors.
Call Schedule:	n/a
Further info:	Additional information could be found on the following sites: http://msb.karelia.ru, http://smb10.ru, www.binrk.ru

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2. Nordic Environment Financial Corporation - NEFCO	
Description:	NEFCO is an international financial institution established by the five Nordic countries. NEFCO finances investments and projects primarily in Russia, Ukraine, Estonia, Latvia, Lithuania, Moldova and Belarus as well as climate projects across the world. NEFCO's main focus is to generate positive environmental effects of interest to the Nordic region. The project should be carried out in one of NEFCO's countries of operation in Eastern Europe. Namely, NW Russia, Estonia, Latvia, Lithuania, Ukraine and Belarus. The project must be feasible. The environmental, technical, institutional, economic and financial feasibility of the project should be demonstrated, normally through an adequate feasibility study. NEFCO requires projects to meet reasonable profitability criteria but, this having been established, focuses more on the environmental effects. In this NEFCO represents a green equity concept, unlike commercial investment funds. **The main criteria for NEFCO's participation in projects are:** • The project is located in one of NEFCO's countries of operation • The project has a relevant environmental effect. • The project is based on long-term cooperation through investments in enterprises, primarily though the formation of joint venture companies or corporate acquisitions. • The project has a Nordic company or institution as business partner. • The project is economically, financially, institutionally and technically viable. **NEFCO can participate in a project through:** • Subscriptions of equity and shares, facilitating mobilization of the necessary equity base for a project. NEFCO then participates as a partner in the project. • Medium and long-term loans and guarantees, which are usually provided on market terms. In some cases subordinated loans and loans with equity features may be provided. Often the loans are extended in addition to NEFCO's equity participation in the project. • Since 1996 NEFCO also administers a special Nordic facility for concessional financing of selected environmental projects within the neighbouring region.
What can be funded:	**NEFCO priorities (relevant to AQUAREL project).** **Energy Saving** **Modern technological solutions** create business opportunities within the energy sector. Combustion of fossil fuels causing emissions of carbon dioxide, contributing to the greenhouse effect as well as acidifying substances and heavy metals, can be significantly decreased by installing modern process technology. Technological solutions minimizing emissions and increasing energy efficiency constitute priority areas. NEFCO is financing projects in a variety of sectors wherein energy efficiency can be increased and/or renewable fuels substituted for fossil fuels. Such projects may include installation of modern technology at water/wastewater treatment plants, improved efficiency at power plants, insulation of buildings, and improved process technology at industrial enterprises. **Industry** **Within industrial projects**, the objectives are improved use of resources and by this reduce emissions to air, soil and water. The positive environmental effects may be obtained directly by the investment, but also indirectly through NEFCO financial support to companies

	producing environmental equipment e.g. water treatment chemicals or insulation material. In those cases the environmental effect is realized at the consumer level. NEFCO has financed a number of industrial projects with direct and indirect reductions of environmental emissions. Eligible projects have been for example, modernisation of cement production, modernisation of rockwool production, establishment of modern slaughterhouse, conversion of fossil fuelboiling to biofuel etc. **Waste Management** **The general objective** for NEFCO's participation in waste projects, is to minimize the amount of waste and improved treatment of waste by e.g. sorting, recycling and/or re-use. Projects may include both household waste and/or industrial waste that may contain paper, plastics, chemicals, heavy metals etc. **Waste from human activities creates a number of environmental problems:** • Toxic compounds leaking to soil, ground water and atmosphere from dumping grounds • Waste incineration creates hazardous atmospheric emissions • Waste collection demands extensive transportation • Non-recirculated waste consumes non-renewable resources By the establishment of modern waste handling systems more and more waste will end up as products instead of creating the problems mentioned. NEFCO has financed for example waste disposal sites in Russia. Projects aimed of the use of waste site methane have been implemented in Lithuania for instance. Waste management projects focused on treatment of medical and domestic waste are underway in the Barents region.
Eligible partners:	Any private of public entity
Public funding rate	The percentage of public of private co-funding is very different from project to project
Average project size:	n/a
Funding body:	**NEFCO Nordic Environment Finance Corporation** Fabianinkatu 34 - P.O. Box 249, FI-00171 - Helsinki, Finland Tel. +358 (0)10 618 003 | Fax +358 9 630 976, info@nefco.fi
Call Schedule:	Funds can be applied continuously, see programme's website for further details
Further info:	**NEFCO Nordic Environment Finance Corporation** http://www.nefco.org/ Fabianinkatu 34 - P.O. Box 249, FI-00171 - Helsinki, Finland Tel. +358 (0)10 618 003 | Fax +358 9 630 976, info@nefco.fi

3. EBRD (European Bank for Reconstruction and Development)	
Description:	The EBRD is the largest single investor in central and Eastern Europe and central Asia. There are several ways that companies and entrepreneurs can benefit from EBRD assistance, depending on their circumstances and business aims. Projects may be considered for EBRD assistance if they: • are located in an EBRD country of operations • have good prospects of being profitable • have significant equity contributions in cash or in kind from the project sponsor • would benefit the local economy • satisfy EBRD's environmental standards as well as those of the host country
What can be funded:	The Bank tailors solutions to client and project needs and to the specific situation of the country, region and sector. It assigns a dedicated team of specialists with expertise in project finance, the region and sector, law and environment. • The EBRD funds up to 35% of the total project cost for a greenfield project or 35% of the long-term capitalisation of an established company • Additional funding by sponsors and other co-financiers is required. The EBRD may identify additional resources through its syndications programme • Typical private sector projects are based on at least one-third equity investment • Significant equity contributions are required from the sponsors. Sponsors should have a majority shareholding or adequate operational control. In-kind equity contributions are accepted In addition, the Bank may not finance certain products or processes due to their environmentally harmful nature or if adverse impact cannot be adequately mitigated.
Eligible partners:	Any private entity
Public funding rate	75%
Average project size:	5-250 million € / average for private sector
Funding body:	**EBRD Moscow Office** Ducat Place III, Second floor, 6 Gasheka Street 125047 Moscow, Tel: +7495 787 1111 http://www.ebrd.com/pages/about/contacts.shtml#gen
Call Schedule:	Funding can be applied continuously.
Further info:	http://www.ebrd.com/pages/homepage.shtml ; http://www.ebrd.com/downloads/research/factsheets/guide.pdf

4. ELY Centre – funding for companies	
Description:	The Centres for Economic Development, Transport and the Environment (ELY Centres) are responsible for the regional implementation and development tasks of the central government. Finland has a total of 15 ELY Centres, which are tasked with promoting regional competitiveness, well-being and sustainable development and curbing climate change. ELY Centres have three areas of responsibility: • Business and industry, labour force, competence and cultural activities • Transport and infrastructure • Environment and natural resources ELY Centres are very important funding bodies for business development in Finland, the most important form of support being **Company development funding**. Funding is provided also for **Fisheries**, where funds came mostly from the European Fisheries fund.
What can be funded:	**Company funding:** ELY Centres provide funding for companies for • expanding business • technology • internationalisastion • improving productivity • enhancing skills The most important ELY Centre's funding instrument for companies is the Company development support, with which companies can e.g. enhance their business skills, internationalise business, develop products, services and production methods and prepare larger projects. Eligible costs in projects: Salaries, travel, subcontracting, equipment purchase, material and supplies **Funds for fisheries:** Funding can be provided for several different kinds of activities, e.g. • Investments in vessels • Investments in socio-economic activities • Investments in facilities and equipment • Promoting demand and entry to new markets • Pilot projects
Eligible partners:	Projects can be implemented by 1 or several Finnish partners that can be in company development projects only companies, and in fisheries fund projects either public or private organisations.
Public funding rate	Company development funding: Max. 50% Fisheries projects: 20-90 % depending on the type of applicant organization
Average project size:	Projects total 50.000 - 2 million €. Average duration: 6-36 months
Funding body:	ELY Centres
Call Schedule:	Company development funding: Applications can be submitted continuously Fisheries: Calls can be organized several times a year or applications can be submitted continuously, depending on the type and size of the project
Further info:	Company development funding: http://www.ely-keskus.fi/web/ely/rahoitus1#.U8ogSLGMKB4 Fisheries: http://www.ely-keskus.fi/web/ely/rahoitus4#.U8od0rGMKB4 http://www.mmm.fi/fi/index/ektr/tuen_hakeminen.html

This project is co-funded by the European Union,
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5. European Regional Development Fund (ERDF) in Northern and Eastern Finland	
Description:	The European Regional Development (ERDF) fund aims at increasing employment and regions' competitiveness and vitality. The programmes aim especially at improving employment rates in those Finnish regions where unemployment levels are high.
What can be funded:	In order to increase employment, the ERDF supports for instance: • Promoting innovation activities and networking • Development of new environmental technologies • Improving the accessibility of regions • New, creative projects on service sector • Growth and competitiveness of SMEs • Development of operational environments and services that promote the growth of employment
Eligible partners:	Projects can be implemented by 1 or several Finnish partners.
Public funding rate	Up to 80%
Average project size:	Projects total 50.000 - 2 million €. Average duration: 6-36 months
Funding body:	Funding is provided by ELY Centres, regional councils, Tekes and Regional State Administrative Agencies (AVI)
Call Schedule:	Calls can be organized several times a year or continuously, depending on the funding body
Further info:	http://www.rakennerahastot.fi/

This project is co-funded by the European Union,
the Russian Federation and the Republic of Finland.

6. Tekes – Finnish funding agency for innovation	
Description:	Tekes is the most important publicly funded expert organisation for financing research, development and innovation in Finland. Tekes promotes a broad-based view on innovation: besides funding technological breakthroughs, Tekes emphasises the significance of service-related, design, business, and social innovations. Research, development and innovation funding is targeted to projects that create in the long-term the greatest benefits for the economy and society.
What can be funded:	**Companies:** Tekes innovation funding helps companies to grow more quickly and renew their business operations. The funding can be used for R&D, business and organisational development, and in planning for global growth. **Research organisations:** Universities, educational institutes, and research units are eligible for Tekes research funding for high-quality research activities that generate new business opportunities for Finnish companies. **Public services:** Public service providers such as towns and cities, municipalities, and hospital districts can use Tekes funding to develop high-quality services, organisational management, and in the implementation of public sector projects. Projects can be connected to programmes; examples of the current Tekes programmes: Arctic Seas, BioIT, Groove – Growth from Renewables, Green Growth – Towards a Sustainable Future Eligible costs in Tekes projects: Salaries, travel, subcontracting, equipment purchase, material and supplies
Eligible partners:	Projects can be implemented by 1 or several Finnish partners (companies, research organisations, public organisations).
Public funding rate	Up to 70% depending on the type of applicant organization, also loans besides grants
Average project size:	Projects total 50.000 - 2 million €. Average duration: 6-36 months
Funding body:	Tekes – Finnish Funding Agency for Innovation
Call Schedule:	Calls can be organized several times a year or continuously, depending on the funding body
Further info:	http://www.tekes.fi

This project is co-funded by the European Union,
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7. Eurostars	
Description:	Eurostars supports research-performing small and medium enterprises, which develop innovative products, processes and services, to gain competitive advantage by providing funding for transnational innovation projects; the products of which are then rapidly commercialized. Eurostars aims to stimulate R&D performing SMEs (SMEs that dedicate at least 10% of their turnover or full-time equivalent (FTE) to research activities) to lead international collaborative research and innovation projects by easing access to support and funding. It is fine-tuned to focus on the needs of SMEs, and specifically targets the development of new products, processes and services and the access to transnational and international markets. The projects can address any technological domain for any market but must have a civilian purpose and be aimed at the development of a new product, process or service. Market introduction of the project outcomes should be foreseen within 2 years after project end. The project should have innovative elements and be strongly market-oriented. The R&D performing SMEs must undertake 50% of total project cost.
What can be funded:	Product / service / concept development activities, testing (not demonstrations), pre-commercialisation activities like light market studies etc.
Eligible partners:	At least 2 partners from 2 different Eurostars countries. The consortium leader of a Eurostars project must be an R&D performing SME in order to satisfy the Eurostars eligibility criteria. Usually consortia are set up with R&D SMEs, SMEs and Research Institutes and Universities. Also large companies can participate in the projects. Eurostars countries: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom. Important: All countries do not necessarily participate in all Eurostars calls; check the programme website for details. Max. 75% of the project budget can go to one country.
Public funding rate	Different rates in different countries; for SMEs 50-75%, large companies up to 50% in many countries and universities / research & development organisations up to 100%. Detailed info: http://www.eurostars-eureka.eu/home/what
Average project size:	Projects total 500.000 - 2 million € (average: 1,4 M €). *The R&D performing SMEs must undertake 50% of total project cost.* Consortium average: 3-4 partners from minimum 2 Eurostars countries
Funding body:	Decisions are made in Brussels by independent experts but projects are funded primarily through national funding schemes
Call Schedule:	Continuous call, evaluation in batches, next deadline for proposals: 11th Sept 2014
Further info:	Eurostars programme: http://www.eurostars-eureka.eu

8. Horizon 2020 Collaborative research & development projects	
Description:	Horizon 2020 is the biggest EU Research and Innovation programme ever with nearly €80 billion of funding available over 7 years (2014 to 2020). Horizon 2020 is the financial instrument implementing the Innovation Union, a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness. It will be complemented by further measures to

	complete and further develop the European Research Area. 1. Excellent Science • European Research Council (ERC) • Future and Emerging Technologies • Marie Skłodowska-Curie Actions • Research infrastructures 2. Industrial Leadership • Leadership in Enabling and Industrial Technologies: ICT, nanotechnology, advanced materials, biotechnology, advanced manufacturing and processing and space. • Access to Risk Finance • Innovation in SMEs 3. Societal Challenges • Health, demographic change and wellbeing; • Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bioeconomy; • Secure, clean and efficient energy; • Smart, green and integrated transport; • Climate action, environment, resource efficiency and raw materials; • Europe in a changing world - inclusive, innovative and reflective societies; • Secure societies - protecting freedom and security of Europe and its citizens.
What can be funded:	The pillars Industrial leadership (part Leadership in enabling and industrial technologies) and Societal challenges the projects are sought for specific topics, for example: • BG-02-2015: Forecasting and anticipating effects of climate change on fisheries and aquaculture • BBI.VC3.F1: Added value products from underutilised agricultural resources • SFS-11b-2015: Consolidating the environmental sustainability of European aquaculture Funding is provided for salaries, travel, equipment, external services and overheads.
Eligible partners:	At least 3 partners from 3 different EU member or associated countries. Other countries can be eligible with special conditions. Partners can represent companies, public administration, research and education organisations and NGOs.
Public funding rate	Private organisations: 70% + 25% for overheads, public organisations: 100% + 25% for overheads. In special cases other rates can be applied.
Average project size:	Projects total 2-20 million € Consortium average: 6-10 partners from minimum 4 countries
Funding body:	European Commisson
Call Schedule:	Calls are open according to specified schedules, more information: http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/index.html -> Calls
Further info:	http://ec.europa.eu/programmes/horizon2020/en/what-horizon-2020 http://www.tekes.eu/en/horizon-2020/

9. Horizon 2020 SME instrument	
Description:	Small and Medium-sized Enterprises that are EU-based or established in a country associated to Horizon 2020 can get EU funding and support for innovation projects that will help them grow and expand their activities into other countries – in Europe and beyond. The SME Instrument helps high-potential SMEs to develop groundbreaking innovative ideas for products, services or processes that are ready to face global market competition.
What can be funded:	SME instrument's supports close-to-market activities, with the aim to give a strong boost to breakthrough innovation. Highly innovative SMEs with a clear commercial ambition and a potential for high growth and internationalisation are the prime target. The SME Instrument offers small and medium-sized businesses the following: • Business innovation grants for feasibility assessment purposes (optional phase I): EUR 50,000 (lump sum) per project (70% of total cost of the project); • Business innovation grants for innovation development & demonstration purposes (possible phase II): an amount in the indicative range of EUR 500,000 and 2,5 million (70% of total cost of the project as a general rule); • Free-of-charge business coaching (optional in phases I and II), in order to support and enhance the firm's innovation capacity and help align the project to strategic business needs; • Access to a wide range of innovation support services and facilitated access to risk finance (mostly in optional phase III), to facilitate the commercial exploitation of the innovation. **Feasibility assessment (phase 1) - optional** Funding is available for: exploring and assessing the technical feasibility and commercial potential of a breakthrough innovation that a company wants to exploit and commercialize. Activities funded could be: risk assessment, design or market studies, intellectual property exploration; the ultimate goal is to put a new product, service or process in the market, possibly through an innovative application of existing technologies, methodologies, or business processes. The project should be aligned to the business strategy, helping internal growth or targeting a transnational business opportunity. *Amount of funding:* lump sum of €50,000 (per project, not per participating business). *Duration:* typically around 6 months *Outcome:* The outcome of a phase 1 project is a feasibility study (technical and commercial), including a business plan. Should the conclusion of the study be that the innovative concept has the potential to be developed to the level of investment readiness/market maturity, but requires additional funding in view of commercialisation, the SME can apply for Phase 2 support. **Innovation project (phase 2)** Funding is available for: innovation projects underpinned by a sound and strategic business plan (potentially elaborated and partially funded through phase 1 of the SME Instrument). Activities funded in phase 2 can be of several types: prototyping, miniaturisation, scaling-up, design, performance verification, testing, demonstration, development of pilot lines, validation for market replication, including other activities aimed at bringing innovation to investment readiness and maturity for market take-up. *Amount of funding:* in the indicative range of €500,000 – € 2.5 million or more (covering up to 70% of eligible costs, or in exceptional, specific cases up to 100%). *Duration:* typically around 1 to 2 years *Outcomes:* • a new product, process or service that is ready to face market competition; • a business innovation plan incorporating a detailed commercialisation strategy and a financing plan in view of market launch (e.g. on how to attract private investors, if

	applicable). **Commercialisation (phase 3)** With the view of facilitating the commercial exploitation of the innovation activities resulting from phase 1 or phase 2, specific activities will be proposed. These can include support for further developing investment readiness, linking with private investors and customers through brokerage activities, assistance in applying for further EU risk finance, and a range of other innovation support activities and services offered via the Enterprise Europe Network (EEN). Coaching Innovation and Business development coaching is proposed in parallel throughout phases 1 and 2 to help SMEs: • enhance the company's innovation capacity • align the project to the identified business development strategy • develop the commercial/economic impact and long term sustainability. Coaching will be provided by experienced business coaches, selected through the Entreprise Europe Network (EEN).
Eligible partners:	Min. 1 SME from an EU or associated country, partners can also be included in the projects
Public funding rate	See above in the Phase descriptions
Average project size:	See above in the Phase descriptions
Funding body:	European Commission
Call Schedule:	Continuous call, evaluation in batches for different phases
Further info:	http://ec.europa.eu/programmes/horizon2020/en/h2020-section/sme-instrument http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/calls/h2020-smeinst-1-2014.html

This project is co-funded by the European Union,
the Russian Federation and the Republic of Finland.

10. Life	
Description:	LIFE is the EU's financial instrument supporting environmental, nature conservation and climate action projects throughout the EU.
What can be funded:	**LIFE Nature & Biodiversity** (sub-programme for Environment) will co-finance action grants for best practice, pilot and demonstration projects that contribute to the implementation of the Birds and Habitats Directives Directives and the Union Biodiversity Strategy to 2020, and the development, implementation and management of the Natura 2000 network. **LIFE Environment and Resource Efficiency** will co-finance action grants for pilot and demonstration projects to develop, test and demonstrate policy or management approaches, best practices and solutions, including development and demonstration of innovative technologies, to environmental challenges, suitable for being replicated, transferred or mainstreamed, including with respect to the link between the environment and health, and in support of resource efficiency-related policy and legislation, including the Roadmap to a Resource Efficient Europe; and to improve the knowledge base for the development, implementation, assessment, monitoring and evaluation of Union environmental policy and legislation, and for the assessment and monitoring of the factors, pressures and responses that impact on the environment within and outside the Union. **LIFE Environmental Governance & Information** (sub-programme for Environment) will co-finance action grants for information, awareness and dissemination projects to promote awareness raising on environmental matters, including generating public and stakeholder support of Union policy-making in the field of the environment, and to promote knowledge on sustainable development and new patterns for sustainable consumption; to support communication, management, and dissemination of information in the field of the environment, and to facilitate knowledge sharing on successful environmental solutions and practice, including by developing cooperation platforms among stakeholders and training; and to promote and contribute to more effective compliance with and enforcement of Union environmental legislation, in particular by promoting the development and dissemination of best practices and policy approaches. **LIFE Climate Change Mitigation** (sub-programme for Climate Action) will co-finance action grants for best practice, pilot and demonstration projects that contribute to the reduction of greenhouse gas emissions; that contribute to the implementation and development of Union policy and legislation on climate change mitigation, including mainstreaming across policy areas, in particular by developing, testing and demonstrating policy or management approaches, best practices and solutions for climate change mitigation; that improve the knowledge base for the development, assessment, monitoring, evaluation and implementation of effective climate change mitigation actions and measures and that enhance the capacity to apply that knowledge in practice; that facilitate the development and implementation of integrated approaches, such as for climate change mitigation strategies and action plans, at local, regional or national level; and that contribute to the development and demonstration of innovative climate change mitigation technologies, systems, methods and instruments that are suitable for being replicated, transferred or mainstreamed. **LIFE Climate Change Adaptation** (sub-programme for Climate Action) will co-finance action grants for best practice, pilot and demonstration projects that contribute to supporting efforts leading to increased resilience to climate change; that contribute to the development and implementation of Union policy on climate change adaptation, including mainstreaming across policy areas, in particular by developing, testing and demonstrating policy or management approaches, best practices and solutions for climate change adaptation, including, where appropriate, ecosystem-based approaches; that improve the knowledge base for the development, assessment, monitoring, evaluation and implementation of effective climate change adaptation actions and measures, prioritising, where appropriate, those applying an ecosystem-based approach, and to enhance the capacity to apply that knowledge in practice; that facilitate the development and implementation of integrated approaches, such as for climate change adaptation strategies and action plans, at local, regional or national level, prioritising, where appropriate, ecosystem-based approaches; and that contribute to the development and demonstration of innovative climate change adaptation technologies, systems, methods and instruments that are suitable for being replicated, transferred or mainstreamed. **LIFE Climate Governance and Information** (sub-programme for Climate Action) will co-finance action grants for information, awareness and dissemination projects that promote

	awareness raising on climate matters, including generating public and stakeholder support of Union policy-making in the field of the climate, and to promote knowledge on sustainable development; that support communication, management, and dissemination of information in the field of the climate and to facilitate knowledge sharing on successful climate solutions and practice, including by developing cooperation platforms among stakeholders and training; and that promote and contribute to more effective compliance with and enforcement of Union climate legislation, in particular by promoting the development and dissemination of best practices and policy approaches.
Eligible partners:	Public or private bodies, actors or institutions registered in or, exceptionally, outside the European Union. Project proposals can either be submitted by a single applicant or by a partnership which includes a coordinating beneficiary (the applicant) and one or several associated beneficiaries.
Public funding rate	EU contribution: 60% of eligible costs
Average project size:	Projects total 600.000 - 3 million €
Funding body:	European Commission
Call Schedule:	One call / year, next deadline for proposals: 16th Oct 2014
Further info:	http://ec.europa.eu/environment/life/funding/life2014/index.htm

11. The Baltic Sea Region Programme 2014-2020	
Description:	The Programme will support cooperation projects working for a more innovative, more accessible and sustainable Baltic Sea region, where partners look for joint solutions to common issues. At least three partners from three countries in the region can form a project. Projects should demonstrate clear links to needs and assets in regional development. Successful projects have transferable results and high visibility - others should benefit from the achievements of a single project.
What can be funded:	In the period 2014-2020, the Baltic Sea Region Programme is offering funding in four thematic fields, the so called Priorities: • Priority 1, "Capacity for innovation", will offer support for e.g. development of innovation infrastructures, implementation of smart specialisation strategies and development of non-technological innovations. • Priority 2, "Efficient management of natural resources", highlights the need to manage natural resources more efficiently. Resource efficient blue growth, renewable energy sources, energy efficiency and clear waters are examples of the areas that will receive support. • Priority 3 will concentrate on "Sustainable transport". Here themes such as accessibility of remote areas, maritime safety, environmentally friendly shipping and urban mobility will attract project proposals. • Priority 4 offers support to the stakeholders of the EU Strategy for the Baltic Sea Region. The Programme will group thematically linked projects into clusters. Clustering will help to coordinate activities and increase the impact of the projects. Project clusters will run as and in parallel to the "regular" projects.
Eligible partners:	Public authorities from local, regional and national levels, research and training institutions, business development institutions and, new in this period, private (for-profit) organisations can also take part in projects and receive funds. Eligible countries: see http://eu.baltic.net/redaktion/download.php?id=2518&type=file
Public funding rate	75 – 85 % (for ERDF funds).
Average project size:	500.000 – 3,5 million EUR, 5-20 partners
Funding body:	Managing Authority: Investitionsbank Schleswig-Holstein (IB.SH), Grubenstrasse 20 18055 Rostock, Germany; E-mail: info@eu.baltic.net
Call Schedule:	The start of the new Programme will be announced at the Programme Conference on 26-27 November 2014. From September 2014, the Joint Technical Secretariat will start provide advisory services to interested applicants.
Further info:	http://eu.baltic.net/ ; http://eu.baltic.net/redaktion/download.php?id=2518&type=file

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the Russian Federation and the Republic of Finland.