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UNIVERSITY of OULU
OULUN YLIOPISTO

Proposal for municipal solid waste management for the city of Kostomuksha

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INTRODUCTION

To achieve a reasonable and well-functioning MSW management system, the principles of sustainable development, integrated solid waste management and the waste management hierarchy must be included and practice at all the possible levels (e.g. national, regional and municipal levels). Strategic planning is necessary so that MSWM services meet the demand, are suitable to needs, and are cost-effective. (Worldbank 2001; European commission 2003)

The MSWM planning process itself consists of six phases: general considerations, status part, planning part, consultation process, implementation and plan revision (Worldbank 2001; European commission 2003). When starting to plan the MSWM system it is essential to consider the waste management principles, e.g. waste hierarchy. In the next stage, the present situation is studied very carefully before the actual planning and implementation is started. An important part of the planning process is the consultation of the experts. In implementation phase its orientations are put into practice by legislation, regulation, negotiations with the industry, and/or information to the public. Plan revision is needed before the expiry of the planning period. (European commission 2003)

This work was done as a part of the "Green cities and settlements" (GREENSETTLE) ENPI CBC project financed by the European Union, the Russian Federation and the Republic of Finland. This report proposes how to develop a municipal solid waste management strategy for the city of Kostomuksha in the Republic of Karelia, Russian Federation.

BACKGROUND PART

At the moment, landfilling is the only option for treating the MSW in Kostomuksha, so the planning needs to start from the very basic level, by establishing the collection point system for recoverables. (For the description of the city of Kostomuksha, see Chamilos 2011)

STATUS PHASE

EXISTING SITUATION

The population of the city of Kostomuksha is estimated to be 30 000 persons. The number of inhabitants has been quite stable during the 30 years the city has existed. The amount of MSW produced in Kostomuksha is 10 960 tonnes annually, which makes 365 kg per person. (Potapova 2012) The amount of municipal solid waste produced in the Russian Federation is estimated to be 440 kg per person annually so the amount of waste produced in Kostomuksha is less than the average in Russia (OECD 2011).

There is no recycling or recovery of MSW in Kostomuksha at the moment and the composition of waste has not been studied. According to Chamilos (2011), private entrepreneurs take care of waste collection and separating some of the paper and other valuables. Chamilos proposed the separation of bio-waste from MSW in Kostomuksha, since it would help the recovery of 'dry' recyclables. After successful bio-waste separation and data collection about waste composition, it is easier to find the recipient facility and to establish collection system for other recoverables as well. Since there is no data about the composition yet, only estimations can be used.

ESTIMATING MSW AMOUNTS IN THE FUTURE

The composition of the Russian MSW is a bit different than in Europe and it was estimated according to the statistics found in the literature. The most reliable estimate was found from the presentation of Loseva (2007) since it is based on the studied MSW in the waste center of St. Petersburg. Composition and daily amount of different waste fractions were calculated using the estimated 365 kg per person waste amount and the waste percentages of Loseva (2007) (table 1).

TABLE 1 ESTIMATES OF THE AMOUNTS OF DIFFERENT FRACTIONS OF MSW IN KOSTOMUKSHA. (PERCENTAGES ARE FROM LOSEVA 2007, MSW AMOUNT FROM POTAPOVA 2012)

Amount of MSW per inhabitant	Percentage	kg/year
Paper and cardboard	20 %	73
Bio-waste (food)	18 %	65,7
Plastic	12 %	43,8
Ferrous metals	4 %	14,6
Non-ferrous metals	1 %	3,65
Glass	10 %	36,5
Stones, bones, ceramics	9 %	32,85
Leather, rubber	1 %	3,65
Wood	4 %	14,6
Textile	5 %	18,25
Garden waste	1 %	3,65
Waste from treatment	10 %	36,5
Other	5 %	18,25
Total	100 %	365

Future amounts of wastes after five, ten and twenty years were calculated (table 2) based on the information about Kostomuksha from Potapova (2012) and by using the equation from the MSWM guide from Worldbank (2001). The population was estimated to be 30 000 both from 2012 to 2032, since the number of inhabitants is not fluctuating strongly. The current amount of MSW is 10 960 tonnes/year. It is estimated to be increasing since the economy, which is one factor affecting the amount of goods and waste produced, of the Karelian area is not regressing as the GRB is not declining but rather rising or at least staying quite stable (figure 1). It is estimated that the amount of waste is increasing 2 % per year for the whole twenty year period. The present service coverage in Kostomuksha is not known but it is estimated to be 70 % in 2012 and increasing to 90 % in 2032.

TABLE 2 AMOUNT OF WASTE PRODUCED IN 2012 AND ESTIMATE OF WASTE AMOUNT IN 2017 (POTAPOVA 2012, WORLDBANK 2001).

Kostomuksha	
2012	
Population	30 000
Amount of MSW	10 960 tonnes/year
Service coverage	70 %
Amount of MSW	365 kg/capita/year = 1 kg/capita/day
Total amount	(30 000 * 0,7 * 1000g/10^6) = 21 tonnes/day
2017	
Population (no change)	30 000
Service coverage	80 %
Amount of MSW	1000 * $1,02^5$ = 1104g
(2% annual increase)	
Total amount	(30 000 * 0,8 * 1104g/10^6) = 26,5 tonnes/day
2022	
Population (no change)	30 000
Service coverage	80 %
Amount of MSW	1000 * $1,02^{10}$ = 1219g
(2% annual increase)	
Total amount	(30 000 * 0,8 * 1219g/10^6) = 29,3 tonnes/day
2032	
Population (no change)	30 000
Service coverage	90 %
Amount of MSW	1000 * $1,02^{20}$ = 1486g
(2% annual increase)	
Total amount	(30 000 * 0,9 * 1486g/10^6) = 40,1 tonnes/day

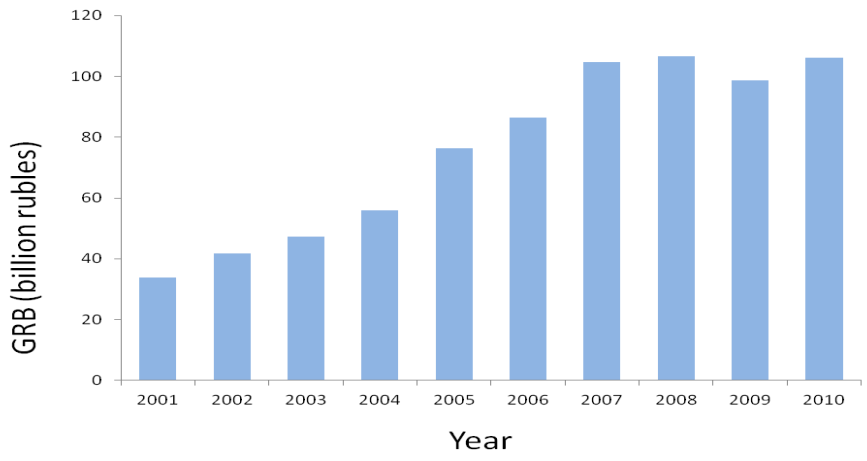

FIGURE 1 GROSS REGIONAL PRODUCT OF KARELIA (BILLION RUBLES). (ARCTICSTAT 2012, OFFICIAL KARELIA 2012)

If the service coverage percentage of MSW management were 70 % in 2012 (estimate), the amount of MSW collected would be 21 tonnes per day which is 7 665 tonnes annually. In 2017, with increased amount of waste and service coverage of 80%, the amount of collected waste would be 26,5 tonnes per day (9 673 tonnes annually) and 29,3 tonnes/day (10 695 tonnes annually). After 20 years and with 90% service coverage the MSW amount would be 40,1 tonnes per day (14 636 tonnes annually). The annual amounts of waste for 2012, 2017, 2022 and 2032 (table 3) show the estimated increasing trend in waste production.

TABLE 3 THE AMOUNTS OF MSW FRACTIONS PRODUCED IN 2012, 2017, 2022 AND 2032.

Waste fraction (kilos/day)	Percentage	2012	2017	2022	2032
Paper and cardboard	20 %	4200	5300	5860	8020
Bio-waste (food)	18 %	3780	4770	5274	7218
Plastic	12 %	2520	3180	3516	4812
Ferrous metals	4 %	840	1060	1172	1604
Non-ferrous metals	1 %	210	265	293	401
Glass	10 %	2100	2650	2930	4010
Stones, bones, ceramics	9 %	1890	2385	2637	3609
Leather, rubber	1 %	210	265	293	401
Wood	4 %	840	1060	1172	1604
Textile	5 %	1050	1325	1465	2005
Garden waste	1 %	210	265	293	401
Waste from treatment	10 %	2100	2650	2930	4010
Other	5 %	1050	1325	1465	2005
Total (tonnes/day)	100 %	21	26,5	29,3	40,1
Total (tonnes/year)		7665	9672,5	10694,5	14636,5

To consider the organization on the collection network and the amounts of collection bins, the weekly amount of recoverables and waste need to be estimated (table 4). The calculation of the weekly amounts is based on the numbers estimated in table 3 for year 2012 (30 000 inhabitants, 70% service coverage, MSW amount 1kg/week/person).

TABLE 4 THE WEEKLY AMOUNTS (TONNES) OF DIFFERENT MSW FRACTIONS FOR RECOVERY.

Amount of MSW per week (tonnes)	Percentage	2012	2017	2022	2032
Paper and cardboard	20 %	29,4	37,1	41,0	56,1
Bio-waste (food)	18 %	26,5	33,4	36,9	50,5
Plastic	12 %	17,6	22,3	24,6	33,7
Ferrous metals	4 %	5,9	7,4	8,2	11,2
Non-ferrous metals	1 %	1,5	1,9	2,1	2,8

Glass	10 %	14,7	18,6	20,5	28,1
Stones, bones, ceramics	9 %	13,2	16,7	18,5	25,3
Leather, rubber	1 %	1,5	1,9	2,1	2,8
Wood	4 %	5,9	7,4	8,2	11,2
Textile	5 %	7,4	9,3	10,3	14,0
Garden waste	1 %	1,5	1,9	2,1	2,8
Waste from treatment	10 %	14,7	18,6	20,5	28,1
Other	5 %	7,4	9,3	10,3	14,0
Total (tonnes)	100 %	147	185,5	205,1	280,7

The estimates of the needed regional collection waste management network can be based on the calculations presented in the reports of Ministry of Environment (Ympäristöministeriö 2010a, b). The suitable year for the consideration would be 2017 since it is quite suitable time for the establishment for such network and the waste amounts seem to be quite realistic.

In 2017, the largest produced MSW fraction is paper and cardboard (37,1 tonnes) and the amount of bio-waste is almost the same (33,4 tonnes). Other large fractions that would be suitable for recovering are plastic (22,3 tonnes), glass (18,6 tonnes) and metals (ferrous (7,4 tonnes) and non-ferrous metals (1,9 tonnes)). Other waste groups are not easily recovered and it would be hard to find reasonable use for some of them. Stones, bones and ceramics and waste from treatment are probably not recoverable.

To be able to plan the collection network, there is a need to estimate the produced amounts of recoverable waste fractions in volumes (table 5, conversion factor from Ympäristöministeriö 2010b) to be able to estimate the number of containers needed.

TABLE 5 THE WEEKLY VOLUMES (M^3) OF DIFFERENT MSW FRACTIONS FOR RECOVERY.

Amount of MSW per week (m^3)	2012	2017	2022	2032
Paper and cardboard	735,0	927,5	1025,5	1403,5
Plastic	504,0	636,0	703,2	962,4
Ferrous metals	29,4	37,1	41,0	56,1
Non-ferrous metals	7,4	9,3	10,3	14,0
Glass	49,0	61,8	68,4	93,6

PLANNING PART

ESTABLISHMENT OF AN MSW MANAGEMENT SYSTEM

The planning of MSW management system in Kostomuksha is based purely on data and prices found in the literature and internet and may not be perfectly suitable for the situation in Kostomuksha. Most of the data is collected from Finnish experiences since there are no functioning MSW systems with functioning recovery of waste materials in the Russian Federation.

At the moment, there are no collection points for recoverables in Kostomuksha. The collection for recoverables can be organized in regional collection points or as a kerbside collection. The central area of Kostomuksha is quite centralized, so also the regional collection points may serve very effectively if their location is suitable. Another option is to establish more numerous but smaller kerbside collection points because there are a lots of apartment buildings in the area. Usually kerbside collection is estimated to be more expensive but, on the other hand, it may be more effective in waste recovery.

Most commonly recovered MSW factions in Finland are paper and cardboard, bio-waste, glass and metal, so recovering of those waste sectors is very reasonable also in Kostomuksha as they are major waste fractions. The calculations of the establishment of regional collection point are based on collection of four waste fractions, which usually are paperboard, plastic, glass and metal (figure 2). As those waste fractions are the largest in Kostomuksha, it is justified to base the calculations to those fractions.

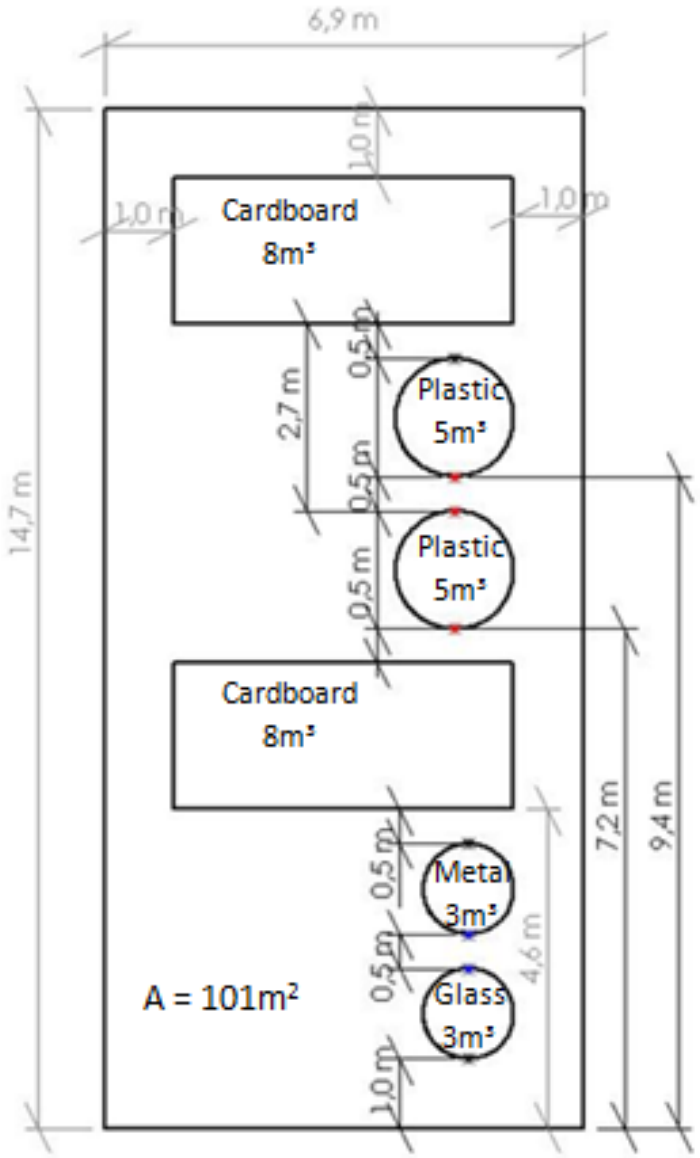

FIGURE 2 LAYOUT OF THE REGIONAL COLLECTION POINT (YMPÄRISTÖMINISTERIÖ 2010B, 8)

It is not very realistic to assume that people would take the bio-waste to centralized collection points because of its moist texture and odor problems, therefore, bio-waste collection is best establish as a kerbside collection. The number of the needed containers depends on the number of emptying times and also the number of collection points that is possible to establish in Kostomuksha. If the containers are surface containers, the collection points are quite easy to establish and move, if necessary. In addition, purchasing surface containers is more economical than the buying deep collection containers not to mentioned the special collection vehicle needed for their emptying. The volume of the surface containers usually is smaller than in deep collection containers so they need to be emptied more often.

After the recoverables have been collected from regional collection points or from kerbside collection, they need to be taken to the transfer stations if there are no utilization possibilities near the city of Kostomuksha. It would be reasonable to establish some kind of aerobic composter or anaerobic digester near Kostomuksha, since the weekly amounts of collected bio-waste is 33,4 tonnes in 2017. Paper, cardboard and plastic are valuable materials for recycling but if that is not possible in the area, it would be reasonable to use it for energy recovery. If that is not possible either, the recycling should be centralized to a more densely populated area. In this plan, it is suggested that the utilization of recoverables is considers in the industries of the city of Petrozavodsk. Also building of a transfer station near Segezha, would be sensible considering transport logistics (see map in figure 3, appendix 1).

SCENARIOS FOR THE ESTABLISHMENT OF MSWM SYSTEM IN KOSTOMUKSHA

There are five different Scenarios considered with different presumptions (table 6). Scenario 1 is based on the idea that all the possible recoverables presented in table 3 (Loseva 2007) will be collected and utilized as material or as energy. The amount of landfilled MSW is then quite small. Scenario 2 is based on the assumption that the collection is not very effective right from the beginning and the amount of collected recoverables is only half of the possible amount presented in Scenario 1. Hence, the number of collection points are smaller and the amount of landfilled MSW bigger. Scenario 3 is based on figures presented in the report of Ympäristöministeriö (2010b) which was used in Finland when calculating the amount of recoverables when establishing collection points. As the amounts of collected recoverables are quite small, the amount of landfilled MSW is high. Scenario 4 is based on the experiences in Arkhangelsk where there was the separate waste collection experiment in 2005 (Koivisto 2006). These values may be comparable to the situation in Kostomuksha when the differences in population are taken into account. Scenario 5 considers that all waste is landfilled in 2017, which is the situation of the baseline. The calculations in the Scenarios based on the data from Kostomuksha, found in literature and gathered from other sources are presented in appendix 2 (tables 7 and 8).

TABLE 6 SCENARIOS FOR KOSTOMUKSHA.

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Based on	Maximum recover (table 3, Loseva 2007)	Half of maximum recover (table 3, Loseva 2007)	Finnish experiences (Ympäristö-ministeriö 2010b)	Russian experiences (Koivisto 2006)	No recovering, (existing system in 2012)
Amount of collected recoverables	High	Moderate	Low	Low	None
Amount of landfilled waste	Low	Moderate	High	High	All

THE CURRENT SITUATION

The current situation of MSW management system in Kostomuksha is that nothing is recovered. The prices of the mixed waste containers are not estimated since there already are containers for mixed waste. The amount of generated MSW is 10 960 tonnes (132kg/m^3, Lahdelma 2002, 20) which is 83 030 cubic meters. The treating of landfilled waste in the existing system is estimated to cost about 317 840 euros annually and, similarly, transportation costs make up to 657 600 euros annually. The estimation of existing amounts of containers is 2 661. The costs of maintaining the containers would be 26 610 euros altogether/year. The estimates of annual costs are then 1 002 050 euros for the existing system.

SCENARIO 1 (MAXIMUM RECOVERY)

Scenario 1 is based on the maximum waste amounts that were calculated in table 3 for the year 2017. In that case there will be 30 000 inhabitants, 80% service coverage and generated MSW amount 1104g/week/person and all the inhabitants would recover all the possible waste fractions. The weekly volumes of recoverables are then paper and cardboard 927,5 m^3, plastic 636 m^3, metals (both ferrous and non-ferrous) 46,4 m^3 and glass 61,8 m^3 (based on data from Loseva 2007 and Potapova 2012).

Regional collection points of the recoverables

Establishment costs would be about 254 000 euros for 20 collection points. The annual costs for the emptying and transportation are 327 600 euros and maintaining costs would then be 7 200 euros per year. The annual costs would then be 334 800 euros altogether.

Kerbside collection of the recoverables

As the paper and cardboard are the largest fraction and it would be emptied once per day, the number of containers needed would be 133. Other containers would be emptied more rarely. The final sum of the establishing of the system would be 150 450 euros. The pure emptying costs would be 606 879 euros and annual maintaining cost is 5 320 euros which makes annual costs to be 612 199 euros.

Transfer costs of the recoverables

If all the recoverables were used as material, the total annual costs of transfer of recoverables would be 222 021 euros. If all the combustible recoverables were used for the energy production and only metal and glass for material use, the price would be different. Transportation costs of combustible materials would be 185 280 euros annually. The metal and glass would be used as material with transfer price for metal 28 384 euros and for glass 56 768 euros.

Bio-waste collection

The number of the bio-waste containers would be reasonable to be the same than of containers for other recoverables (133) and they could be emptied four times per week. The total costs of purchasing bio-waste containers could be 9 031 euros. The total cost of collection and transportation of the bio-waste would be 104 220 euros and the treatment of one tonne of bio-waste in the small-scale composting plant makes 173 700 euros annually. Annual costs of the maintaining the system and collecting, transporting and treating the bio-waste are 279 250 euros. The profit from the selling of compost is 5 790 euros.

If the produced biomass will be treated anaerobically for the production of biogas, the cost for the treatment of one tonne of bio-waste in small-scale anaerobic digester would be 26 055 euros annually. The amount of biogas would be 451 620 KWh and the value of produced electricity is 15 355 euros and the selling price of the produced compost makes 5 790 euros.

The selling price of the recoverables

The total selling price for all the collected recoverables for material use would be 731 962 euros. The selling price of metal would be 158 752 euro and of glass 46 416 euros in energy use option.

The price of the landfilling

If all the recoverables were collected separately, the amount of landfilled waste would decrease drastically. The only landfilled waste sectors would be wood, textile, garden waste, waste from treatment, leather, rubber, stones, bones and ceramics. The amount of landfilled waste would be 4 450 tonnes (33 712 m^3) annually instead of prevailing 10 960 tonnes. Annual costs of the landfilling of the mixed waste would be 406 850 euros altogether.

As the service coverage in this Scenario is 80 %, 20% of MSW is not collected by this system. It should be collected as other mixed waste costing 145 080 and treat as landfilled waste which would cost 70 122 euros. Annual maintaining costs would be 5 870, which makes the total annual costs 221 072 (table 9).

TABLE 9 CONCLUSIONS OF THE SCENARIO 9.

Establishment costs of the 20 regional collection points for recoverables	254 000 euros
or	
Establishment costs of the 133 kerbside collection points for recoverables	150 450 euros
Establishment costs of bio-waste collection system	9 031 euros
Establishment costs of mixed waste collection system	Already existing
Annual costs of the 20 regional collection points	334 800 euros
or	
Annual costs of the 133 kerbside collection points for recoverables	612 199 euros
Annual costs of the bio-waste management system (aerobic)	279 250 euros
or	
Annual costs of the bio-waste management system (anaerobic)	131 605 euros
Annual costs of the mixed waste collection system	627 922 euros
Transfer costs of the recoverables in the material use option	222 021 euros
or	
Transfer costs of the combustible recoverables to the energy use locally	185 280 euros
and	
Transfer costs of the metal and glass to be used as material	85 152 euros
The selling price of the recoverables in the material use option	731 962 euros
The selling price of the compost (in biomass composting)	5 790 euros
or	
The selling price of the electricity and compost from anaerobic digestion	21 145 euros

SCENARIO 2 (PARTIAL RECOVERY)

Scenario 2 is based on the partial collection of all the recoverables. The justification for this Scenario is, that it can be easily seen from the history of Finland that the recovering system cannot be established

overnight. It would be good achievement to be able to collect half of the recoverables based on the same assumptions than in Scenario 1 (year 2017, 30 000 inhabitants, 80% service coverage and generated MSW amount 1104g/week/person) but all the inhabitants would recover half of the possible waste fractions. The weekly amount of recovered paper and cardboard would be 18,6 tonnes (464 m^3), the amount of bio-waste 16,7 tonnes (56 m^3), plastic 11,2 tonnes (318 m^3), glass 9,3 tonnes (30,9 m^3) and metals 4,7 tonnes (23,2 m^3). The regional collection point for this Scenario would be the same than in figure 2. Almost all the costs and benefits would be half of those in Scenario 1.

The biggest difference between the Scenario 1 and 2 would be that if only the half of all the recoverables were collected separately, the amount of landfilled waste would decrease, but not so much than in Scenario 1. The landfilled waste sectors would be half of all the recoverable and also wood, textile, garden waste, waste from treatment, leather, rubber, stones, bones and ceramics. The amount of landfilled waste would be 7 705 tonnes (58 371 m^3) annually compared to the 4 450 tonnes in Scenario 1 and 10 960 tonnes in the prevailing situation.

In the Scenario 2, the costs of landfilling would be higher than half of the costs in the Scenario one. In that case there is need for 1 870 mixed waste containers emptied once a week. The maintaining costs 18 700 euros and collection and transportation costs 462 300 are euros annually. The price for the landfilled MSW tonne makes 223 445 euros altogether. Hence the annual price for landfilled MSW would be 704 445 euros.

In addition, as the service coverage in this Scenario is also 80 %, 20% of MSW is not collected by this system. It should be collected as other mixed waste costing 145 080 and treat as landfilled waste which would cost 70 122 euros. Annual maintaining costs would be 5 870 which makes 221 072 altogether (table 10).

TABLE 10 CONCLUSIONS OF THE SCENARIO 2.

Establishment costs of the 10 regional collection points for recoverables	127 000 euros
or	
Establishment costs of the 67 kerbside collection points for recoverables	75 225 euros
Establishment costs of bio-waste collection system	4 515 euros
Establishment costs of mixed waste collection system	Already existing
Annual costs of the 10 regional collection points	167 400 euros
or	
Annual costs of the 67 kerbside collection points for recoverables	306 100 euros
Annual costs of the bio-waste management system (aerobic)	139 625 euros
or	
Annual costs of the bio-waste management system (anaerobic)	65 803 euros
Annual costs of the mixed waste collection system	925 517 euros
Transfer costs of the recoverables in the material use option	111 011 euros
or	
Transfer costs of the combustible recoverables to the energy use locally	92 640 euros
and	
Transfer costs of the metal and glass to be used as material	42 576 euros

The selling price of the recoverables in the material use option	365 981 euros
The selling price of the compost (in biomass composting)	2 895 euros
or	
The selling price of the electricity and compost from anaerobic digestion	10 573 euros

SCENARIO 3 (EXPERIENCES IN FINLAND)

The Scenario 3 is based on figures in the report of the Ministry of Environment (2010b) and the population of Kostomuksha (30 000 inhabitants). In that report the data from various waste management companies are used when the new collection point system is planned so that data may be useful for Kostomuksha as well. The annual amounts of collected recoverables in that report were 5,6 kg/person/year for cardboard, 0,35 kg/person/year for plastic, 0,23 kg/person/year for metal and 1,8 kg/person/year for glass. The annual amounts of these waste sectors for 30 000 inhabitants would then be 168 tonnes of cardboard and paper, 10,5 tonnes of plastic, 6,9 tonnes of metal and 54 tonnes of glass. The weekly amounts would be about 3,2 tonnes of cardboard, 0,2 tonnes of plastic, 0,13 tonnes of metal and one tonne of glass. In volumes they would be 80 m^3 of cardboard, 5,7 m^3 of plastic, 0,65 m^3 of metal and 3,3 m^3 of glass.

Regional collection points of the recoverables

As the volumes are remarkably lower than in Scenarios 1 and 2, the number of regional collection points and emptying times needed are much lower than in the earlier Scenarios. The establishment and annual costs of the two regional collection points would be one tenth of the costs in Scenario 1 but the emptying costs would be different, 14 600 euros. The annual costs of maintaining would be 720 euros. The annual costs of two collection points would be 15 320 euros.

Kerbside collection points of the recoverables

The establishment of the kerbside collection system could be based on 10 kerbside collection points and establishment costs would be 11 312 euros. The emptying of the containers would cost 27 430 euros and maintaining costs would be 400 euros. Total annual costs of the kerbside collection would then be 27 830 euros.

Transfer costs of recoverables

As the amounts of the recoverable are low, there won't be many annual transfer trips. The annual transportation costs to Segezha and back would then be about and from there to Petrozavodsk and back 14 032 euros. These costs most probably would be lower since it is not reasonable to drive without full loads but combine the recoverables from other cities to the same vehicle. If all the combustible material will be incinerated, the transfer costs of glass and metal to material use is 6 239 euros and the transportation costs of combustible material to be incinerated locally 10 710 euros annually.

The selling price of the recoverables

The annual selling price of the recoverables would be 25 655,7 euros altogether in material use option. The annual selling price of the recoverables would in energy use option would be 2263,2 for metal and 2 592 euros for glass.

Bio-waste collection

The amount of collected bio-waste in Scenario 3 is not based on any Finnish experiments but is set in scale with the amount of other collected recoverables this Scenario being about one tenth of the bio-waste in Scenario 1 and the number of collection points about 13. All the costs and benefits of collecting, managing and treating of the bio-waste would be about one tenth of the Scenario 1.

The price of the landfilling

The amount of mixed waste is high in this Scenario being 11 678 tonnes (88 469m^3). The transportation costs would be 700 674 euros and the treating of the mixed waste 338 659 euros. The maintaining costs would be 28 360 euros. The total annual costs of the mixed waste is then 1 067 693 euros (table 11).

TABLE 11 CONCLUSIONS OF THE SCENARIO 3.

Establishment costs of the 2 regional collection points for recoverables	25 400 euros
or	
Establishment costs of the 10 kerbside collection points for recoverables	11 312 euros
Establishment costs of bio-waste collection system	903 euros
Establishment costs of mixed waste collection system	Already existing
Annual costs of the 2 regional collection points	15 320 euros
or	
Annual costs of the 10 kerbside collection points for recoverables	27 830 euros
Annual costs of the bio-waste management system (aerobic)	27 925 euros
or	
Annual costs of the bio-waste management system (anaerobic)	13 161 euros
Annual costs of the mixed waste collection system	1 067 693 euros
Transfer costs of the recoverables in the material use option	14 032 euros
or	
Transfer costs of the combustible recoverables to the energy use locally	10 710 euros
and	
Transfer costs of the metal and glass to be used as material	6 239 euros
The selling price of the recoverables in the material use option	25 656 euros
The selling price of the compost (in biomass composting)	579 euros
or	
The selling price of the electricity and compost from anaerobic digestion	2 115 euros

SCENARIO 4 (EXPERIENCES IN ARKHANGELSK)

Scenario 4 is based on the experiences of the pilot source separation and collection experiments carried out in Arkhangelsk in 2005 (Koivisto 2006). In the experiment, the collection points for paper and cardboard and for plastic and glass bottles and metal cans were established for the trial time of two months. The collection area was the area of Varavino with about 11 000 inhabitants. There were 18 containers for paper and cardboard and 13 containers for bottles and cans near the existing waste collection points. The containers for paper and cardboard were emptied every other day and the containers for bottles and cans every tenth day. (Koivisto 2006)

The collected amount of paper and cardboard in this experiment was 0,0197 m^3 per inhabitant in two months which makes 0,1182 m^3 annually. If the whole Kostomuksha (30 000 inhabitants) would collect the same amount of paper and cardboard, it would make 3 546 m^3 (142 tonnes) annually and 68 m^3 (2,72 tonnes) weekly. The amount of paper in that fraction was only 40 %, which is 27,3 m^3 weekly. The collected amount of bottles and cans were 0,53 kg/inhabitant in two month. The volume of collected plastic bottles were 28 m^3, of glass bottles 11,9 m^3 and of aluminum cans 7,6 m^3 in two months which makes 168 m^3 of plastic, 71, 4 m^3 of glass and 45, 6 m^3 metal in one year for 11 000 inhabitants. When calculated for 30 000 inhabitants in Kostomuksha, the annual amounts would be 458 m^3 (16 tonnes) plastic, 195 m^3 (58,5 tonnes) glass and 124 m^3 (24,8 tonnes) metal which are 8,81 m^3 (0,31 tonnes) plastic, 3,75 m^3 (1,13 tonnes) glass and 2,38 m^3 (0,476 tonnes) metal per week. The amounts of recoverables are then quite similar than in Scenario 3 but much lower than in two first Scenarios.

Regional collection points of the recoverables

When thinking of regional collection points, the volumes of recoverables are not big in the Scenario 4. Two regional collection points would be enough but the emptying times would be different than in the Scenario 3. The emptying and transporting costs would be 16 380 euros and the annual costs of maintaining would be 720 euros. The annual costs of two regional collection points would be 17 100 euros.

Kerbside collection points of the recoverables

The establishment of the kerbside collection system could be based on 10 kerbside collection points. The establishment costs of the containers would be 11 312 euros. The emptying of the containers would be 32 110 euros. The maintaining costs would be 400 euros. Total annual costs of the kerbside collection would then be 32 510 euros.

Transfer costs of recoverables

The amounts of the recoverables and transfers are low and almost similar than in Scenario 3. The annual transportation costs to Segezha and back would then be about 13 175 euros. By combining the transportations, these costs most probably would be lower. If all the combustible material will be incinerated, the transfer costs of glass and metal to material use is 6 239 euros and the transportation costs of combustible material to be incinerated locally 9 480 euros annually.

The selling price of the recoverables

The annual selling price of the recoverables for material use would be 23 440 euros altogether. The annual selling price of the recoverables in energy use option would be 8 134 euros for metal and 2 808 euros for glass.

Bio-waste collection

As there was no collection of bio-waste in Arkhangelsk there are no estimates for bio-waste collection. The collectable amount on bio-waste is set in scale with the amount of other collected recoverable in this Scenario as well, being same than in Scenario 3.

The price of the landfilling

The amount of mixed waste is high in this Scenario being 11 676 tonnes (88 455 m^3). The transportation costs would be 700 560 euros and the treating of the mixed waste 338 604 euros. The maintaining costs are 28 350 euros. The total annual costs of the mixed waste in Scenario 4 is then 1 067 514 euros (table 12).

TABLE 12 CONCLUSIONS OF THE SCENARIO 4.

Establishment costs of the 2 regional collection points for recoverables	25 400 euros
or	
Establishment costs of the 10 kerbside collection points for recoverables	11 312 euros
Establishment costs of bio-waste collection system	903 euros
Establishment costs of mixed waste collection system	Already existing
Annual costs of the 2 regional collection points	17 100 euros
or	
Annual costs of the kerbside collection points for recoverables	32 510 euros
Annual costs of the bio-waste management system (aerobic)	27 925 euros
or	
Annual costs of the bio-waste management system (anaerobic)	13 161 euros
Annual costs of the mixed waste collection system	1 067 514 euros
Transfer costs of the recoverables in the material use option	13 175 euros
or	
Transfer costs of the combustible recoverables to the energy use locally	9 480 euros
and	
Transfer costs of the metal and glass to be used as material	6 224 euros
The selling price of the recoverables in the material use option	23 440 euros
The selling price of the compost (in biomass composting)	579 euros
or	
The selling price of the electricity and compost from anaerobic digestion	2 115 euros

SCENARIO 5 (NO RECOVERY AT ALL)

In Scenario 5, the situation would be the same than in 2012 without any recovery. As there would be no establishment costs, all the waste management costs would be from the emptying of the containers, transportation and treating of waste. In addition there would be the maintenance costs of containers. The annual costs of landfilling 12 091 tonnes of wastes would then be 1 105 459 euros (table 13).

TABLE 13 CONCLUSIONS OF THE SCENARIO 5.

Establishment costs of mixed waste collection system	Already existing
Annual costs of the mixed waste collection system	1 105 459 euros

SUMMARY OF THE SCENARIOS

Establishment and annual costs of the collection systems

The establishment costs of collection system for recoverables naturally differ depending on the amount of recoverable waste, number of collection points and containers needed for the system varying from zero to 20 in different Scenarios. The establishment of the regional collection point seems to be more expensive option (on average double the price) compared to the kerbside collection point. The reason for that may be the fact that it needs bigger and more expensive containers with good foundation and better

planning of the location of the space-demanding point. The kerbside collection point can be easily established by using smaller containers next to existing mixed waste containers. The price for mixed waste containers was not estimated since they already exist.

The annual costs of regional collection points are lower than in kerbside collection points, since the emptying times are lower. In Scenarios 3 and 4, the number of regional points was only two which is not ideal when thinking of the rational use (location, distance from households) of the collection points. Therefore the location of collection points needs to be considered carefully. There is possibility to establish several regional collection points and empty them more rarely, only when needed. This situation is not analyzed in any Scenarios. The bio-waste collection is always kerbside collection due to the moist content of the bio-waste. Bio-waste containers are usually emptied four times per week.

The annual costs of different waste fractions vary markedly depending on the type and the amount of waste. When considering the treatment of the bio-waste, the price of the anaerobic digestion is remarkably lower that the composting of the same amount of the bio-waste, even without the selling of the produced biogas. Annual costs of transfer to the transfer station or utilization facilities does not seem to cause huge costs, since it is done with larger vehicles, it lowers the landfilling costs and also the local transportation to the landfill. In annual costs in can be clearly seen, that the local transportation costs are strongly affecting the price of waste management. It is really hard to estimate the real transportation costs of recoverables from collection points to e.g. local storage, since there are no any estimates but the price of the collection of mixed waste for that use. The transfer costs are more easily calculated but they are based on Finnish experiences, not on Russian ones.

Total annual costs of MSW system

The estimated total annual costs of waste management systems with cheapest management options (regional collection system for dry recoverables, kerbside bio-waste collection and treatment by using anaerobic digestion and material use of other recoverables) are seen in table 14. Incomes consist of selling the recoverables and compost and biogas from the digester.

TABLE 14 ANNUAL COSTS OF EXISTING SYSTEM AND IN DIFFERENT SCENARIOS (KERBSIDE BIO-WASTE COLLECTION AND ANAEROBIC TREATMENT; REGIONAL COLLECTION AND MATERIAL USE FOR OTHER RECOVERABLES)

	Establishment costs of collection systems for all recoverables (euros)	Annual costs without incomes from all recoverables (euros)	Annual costs with incomes from all recoverables (euros)
Existing system		1 002 050	
Scenario 1	263 031	1 316 348	563 241
Scenario 2	131 515	1 269 731	893 177
Scenario 3	26 303	1 110 206	1 083 971
Scenario 4	26 303	1 110 950	1 086 931
Scenario 5		1 105 459	

When comparing the existing system with the Scenario 5 (no recovering at all in both systems) it can be seen that the waste management will be more expensive after five years due to the increased amount of MSW generated.

Selling price of the recoverables

The selling price of the recoverables is essential when considering the benefit of the establishment of the collection system for the recoverables. The weaknesses in the assumption of the utilization of the recoverables collected from Kostomuksha are, that there is no information if the factories in Kostomuksha, Segezha or Petrozavodsk are able or willing to receive the recovered material. It may then be that there won't be any incomes from the recovered material. If the waste materials in Kostomuksha had the same price than the waste material in Europe, the selling of it would give incomes and lower the waste management price in Kostomuksha. The amount of incomes clearly depends on the amount of sold material. The treating of biomass can also produce compost and biogas but the incomes are much lower than from the sales of other recoverables.

Establishment costs of small-scale treatment facilities.

In case of the collection of the biomass, there is need to establish a small-scale biomass composting plant or anaerobic digester to Kostomuksha so that the collected biomass can be utilized. If the size of the plant were of 6 000 tonnes, the establishment costs of composting plant would be about two million euros and the establishment of anaerobic digester 670 000 euros (table 15). In addition, the annual treating costs of the bio-waste are much lower in anaerobic digester than in composting plant, and the selling of the biogas would produce incomes. It needs to be noticed that amounts of collected bio-waste must be large enough to establish bio-waste treatment plant. If there is need to establish a new landfill to Kostomuksha, the estimate of the establishing of the landfill of suitable size would be about 1,3 million euros.

TABLE 15 ESTABLISHMENT COSTS OF SMALL-SCALE TREATMENT FACILITIES (LUOSTARINEN 2008, ILLIKAINEN 2007 AND VÄNSKÄ 2007 IN MYLLYMAA ET AL. 2008)

Establishment costs of the composting plant for 6 000 tonnes/a + total annual costs of treating the bio-waste (100 e/tonne)	2 000 000 euros
or	
Estab. costs of anaerobic digester for 6 000 tonnes/a+microturbine (90 kW) + total annual costs of treating the bio-waste (15 e/tonne)	670 000 euros
Estab.costs of new landfill for 11 000 tonnes/year (5,2 Milj.e/45 000 t/year) + total annual costs of treating the mixed waste (30 euro/tonne)	1 300 000 euros

CONCLUSIONS FROM THE SCENARIOS

These calculations are based on reliable data about waste amounts, population dynamics and existing waste management situation in Kostomuksha. The formulas and statistics are based on literature and recent research results and they are provided from many well-known institutions and organizations. The exact texture of the MSW is not known, and neither is the service coverage. The estimation of amount of MSW after 30 years may not be so accurate, since the amount of waste is almost double compared to the present situation. It is justified that the amount of MSW will increase (changes in consumption, better living standards, new packaging materials) but it would be realistic to assume, that the amount of produced waste would stabilize after two or three decades as in many industrial countries.

All the Scenarios are based on the guidelines found from the literatures and/or the experiments in Finland or Russian Federation. Hence, there was a justification of using them. Scenario 1 was based on the maximum yield where all the citizens would separate and take all their recoverables to the collection points right away when the points would have been established. This may not be very reasonable Scenario to start with because not even in Finland all the citizens are separating their wastes. Scenario 2

is based on the fact that half of the recoverables are recovered. This may well be the situation after few years or decades after the establishment of the collection system. Scenarios 3 and 4 are quite similar and are based on the experiences in Finland and Russian Federation. As they support each other, they would be very well argued with good possibilities to succeed and something to start with.

When considering the establishment and annual costs, the most reasonable combination for the establishment of the MSW collection system is to use regional collection points for all the dry recoverables and kerbside collection for bio-waste and mixed waste, to establish and use anaerobic bio-waste treatment plant and to transfer other recoverables than bio-waste to be recovered as material, especially if there will be any incomes from the selling of waste material to the industry. However, the price of the local energy use of combustible material seems to be unreasonable high since there was no proper examples how to calculate it. Therefore it needs to be noticed, that this planning of MSWM system for Kostomuksha is not ideally suited for local circumstances and official planning would demand more accurate information about the area. Also the participation of the local stakeholders and public would be essential.

CONCLUSIONS

The MSWM plan for the city of Kostomuksha is mainly theoretical. As a background information, it is known that there is interest towards the more sustainable waste management system in the city which is essential when starting to plan the establishment of such system. As a status phase, it is important to estimate the waste amounts now and in the future, before considering the collection network of recoverables. In the planning phase, it is good to make some scenarios about the collection networks for the planning area. It is not always environmentally wise to collect and transport small amounts of recoverables over long distances, as it may be in the case of Kostomuksha. Therefore, it is important in the implementation phase to consider larger regions as a whole, establish transfer stations and utilize the waste in a centralized manner.

Using the information on prevalent MSW amounts in Kostomuksha, present and future amounts of waste fractions were estimated and scenarios on the recovery and utilization of these waste fractions were presented. It was concluded that the best option would be to separately collect bio-waste at kerbside and treat in an anaerobic digester. Other major recoverable fractions (paper and cardboard, plastic, metal and glass) would be reasonable to collect in centralized collection points and transfer to utilization facilities through transfer stations. In order to implement this plan, it is essential to have recipient facilities in a reasonable distance and an infrastructure of transfer stations built in the Republic of Karelia. This will require regional level legislative control and political agreement in the Republic of Karelia. On the municipal level, also information and education campaigns will need to be planned in order for the public to get involved and participate in separate waste collection

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APPENDIX 1. MAP OF KARELIA AND FINLAND.

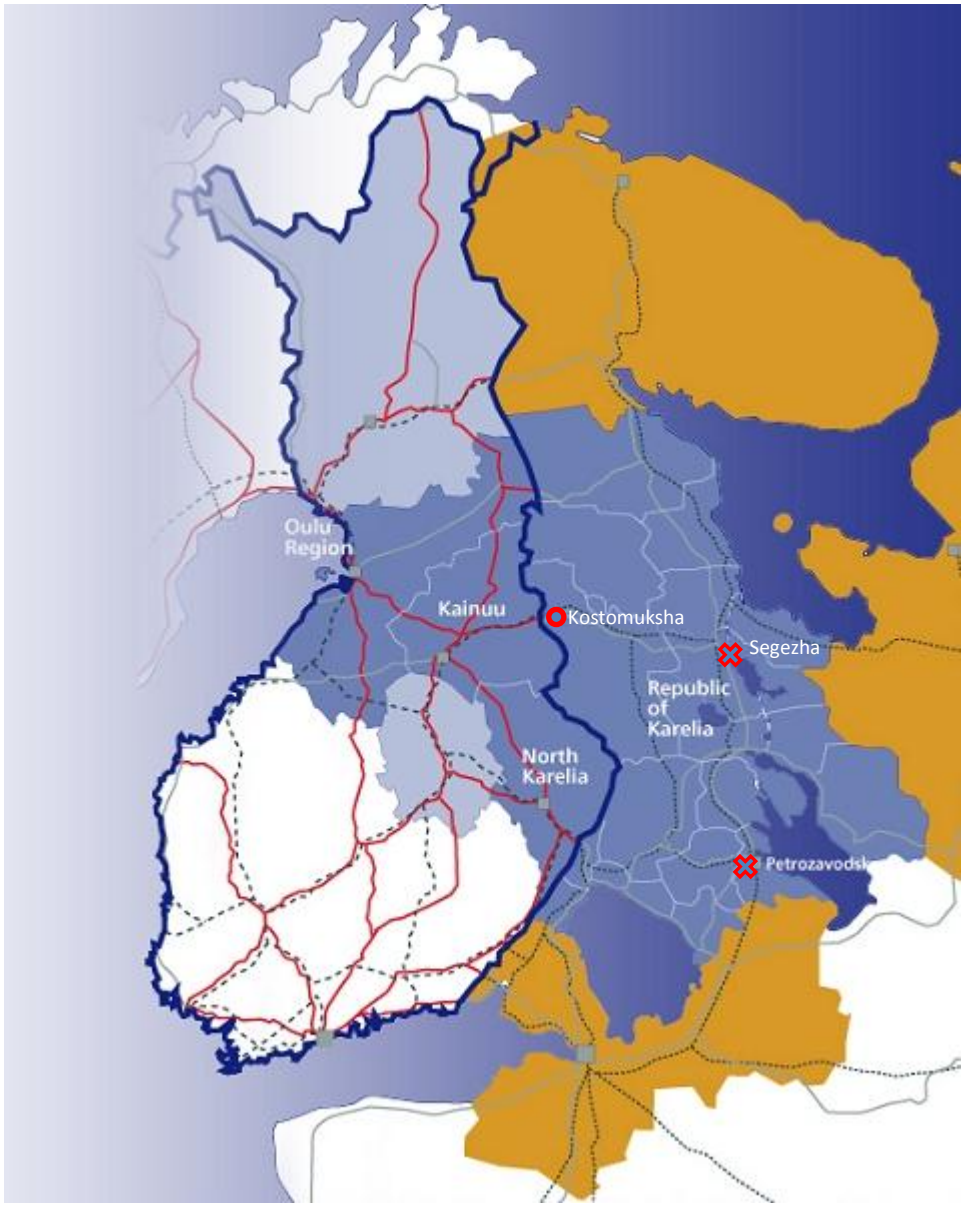

FIGURE 3. MAP OF KARELIA AND FINLAND. CIRCLE SHOWS THE LOCATION OF THE CITY OF KOSTOMUKSHA, CROSSES SHOW THE LOCATION OF THE TRANSFER STATION AND UTILIZATION FACILITIES, SEGEZHA AND PETROZAVODSK. (EUREGIO KARELIA 2010)

APPENDIX 2.

The calculations in the Scenarios for Kostomuksha

The number of collection points in all the Scenarios was usually based on the amount of the largest waste fraction i.e. paper and cardboard. The container of paper and cardboard was emptied daily or several times per week and the other containers less frequently. The volumes of the containers in one regional collection point are as in the figure 2 (2*8 m^3 for paper and cardboard; 2 * 5 m^3 for plastic; 3 m^3 for metal and 3 m^3 for glass) and the volumes in kerbside collection points are 1m^3 for paper and cardboard and plastic and 0,6 m^3 for metal and glass. The *number of containers* needed in every Scenario was calculated by using volumes of containers and the estimation of the future waste volumes (table 8) The *establishment costs* of collection points were calculated by using the information about purchasing price of containers (table 7). However, according to the report of the Ministry of Environment (2010b), by buying large amounts of containers and by using competitional bidding, the savings may be even 30% of the costs, which was used in calculation. The *annual maintenance costs* of collection points are caused by wearing, cleaning, repairing and administration of the collection points and were calculated by using the information about average maintaining costs (table 7).

As the emptying times varies in different Scenarios, *annual emptying costs* need to be calculated separately for every Scenario by using the emptying price for the container of recoverables in table 7 and emptying times in table 8. In the report of Myllymaa et al. (2008), it was assumed that the recoverables are emptied straight to the vehicles that transfer them to the transfer stations so there should not be local transportation costs in regional collection points. The annual emptying costs (including transportation) of mixed waste and bio-waste were calculated by using the weight based emptying costs (table 7). The *annual costs of treating* the waste material was calculated by using the average treating prices for bio-waste tonne and mixed waste tonne (table 7). The price for treating of bio-waste differs if the bio-waste is treated in composting plant or in the anaerobic digester (table 7).

The *annual transfer costs* of the recoverables from Kostomuksha to Segezha and Petrozavodsk were calculated by using the information of waste loads, transfer capacities and consumption of vehicles, driving distances, loading and unloading times, hourly costs of vehicles and coefficient for breaks and refilling (tables 7 and 8). The average speed of the vehicle for the whole trip would be 70 km/h, the loading and unloading of the vehicle would take one hour and because of the breaks and refilling the transportation time should be multiplied by 1,15.

The annual selling price of recoverables in material use option (paper and cardboard in Segezha and other dry recoverables in Petrozavodsk) was calculated by using the selling price of material/tonne and the amount of collected material (tables 7 and 8). The exact share of paper in the fraction of paper and cardboard is not known but it was estimated to be 75 %. As the prices of the waste materials fluctuate very rapidly according to the market situation, the latest EU prices are used (Eurostat 2012; Teknologiateollisuus ry 2012). In energy use option produced waste plastic and waste paper and cardboard could be used as a fuel in the industry producing district heat for the city of Kostomuksha. As the price for the REF is assumed to be negligible, there would not be any monetary benefit of providing the waste for the incineration but the using of recovered material as energy save the costs of landfilling. The selling price of the produced compost (about 1/3 of the original volume) and the production of electricity from the treating of the biomass was calculated by using the information of the original amount of bio-waste and production and price of the electricity (tables 7 and 8)

TABLE 7. THE GENERAL ASSUMPTIONS IN SCENARIOS

Year	2017
Population in Kostomuksha	30 000 (Potapova 2012)
Service coverage	80 % (used in Scenarios 1 and 2)
Utilization facilities	In material use Segezha for paper and cardboard; Petrozavodsk for plastic, metal and glass; Kostomuksha for bio-waste. In energy use Kostomuksha for paper, cardboard and plastic. Other fractions same than in material use
Transfer stations	In material use Segezha for plastic, metal and glass
Distances	Kostomuksha-Segezha 241 km Segezha-Petrozavodsk 256 km
Amount of generated MSW	1104g/day/person; 80% coverage 9672,5 tonnes annually (used in Scenarios 1 and 2)
Composition of MSW	Calculated using the statistics by in Loseva 2007 (table 3) (used in Scenarios 1 and 2)
Regional collection point	For four waste fraction, general layout in figure 2 (Ympäristöministeriö 2010b)
Volumes of containers in one regional collection point	2 * 8 m^3 for paper and cardboard; 2 * 5 m^3 for plastic; 3 m^3 for metal; 3 m^3 for glass (Ympäristöministeriö 2010b)
Size of bio-waste container in kerbside collection	240 liters
Emptying times of containers	Varies depending on the filling of containers
Price for emptying of the containers	For paper and cardboard 30 euros; for plastic 15 euros; for metal 25 euros; for glass 20 euros; for biomass 7 euros For mixed waste 6,5 euros (Ympäristöministeriö 2010b)
Establishment costs of one regional collection point	12 700 euros (average of the report of Ympäristöministeriö (2010b))
Annual costs of maintaining regional collection point	90 euros per material per regional collection point (Ympäristöministeriö 2010b)
Annual costs of maintaining one mixed waste/bio-waste container	10 euros/container
Purchasing price for one bio-waste container (240 liter)	97 euros (Lassila&Tikanoja 2012)
Purchasing price for one mixed waste container (600/1000 liter)	358 euros/450 euros (Lassila&Tikanoja 2012)
Transportation costs of bio-waste and mixed waste	60 euro/waste tonne (see Myllymaa et al. 2008)
Transportation costs of other recoverables to transfer stations	Hourly cost of the vehicle 83 euros; coefficient 1,15 for breaks and refilling; consumption of diesel 0,014kg/km/waste tonne for 24 tonnes/load and 0,011kg/km/waste tonne for 40 tonnes/load; time for loading and unloading 1 hour, price for diesel 0,77 euro/liter. Consumption of empty vehicle 20 liters/100km for smaller (24 tonnes) and

	25 liter/100km for bigger (40 tonnes) vehicle. (see Myllymaa et al. 2008)
The price for treating the bio-waste	100 euro/bio-waste tonne in small-scale composting plant; 15 euro/bio-waste tonne in small-scale anaerobic digester (see Myllymaa et al. 2008)
The price for treating the landfilled waste	29 euro/tonne (see Myllymaa et al. 2008)
The selling price for the compost	10 euro/tonne (see Myllymaa et al. 2008)
The selling price of waste material for material use	For paper 142 euro/tonne; plastic 277 euro/tonne; metal 328 euro/tonne; glass 48 euro/tonne (Eurostat 2012; Teknologiateollisuus ry 2012)
The selling price for waste material for energy use	The price for REF fuel is estimated to be 0 euro/tonne (Ympäristöministeriö 2010b)
The production of electricity from bio-waste	260 KWh/biomass tonne (Raimovaara 2004)
The price for electricity	34 euro/MWh (Nord Pool Spot 2012)

TABLE 8. FIGURES FOR SCENARIOS 1-5.

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Collected weekly amounts (m^3) of					
-paper and cardboard	927,5	464	80	68	
-plastic	636	318	5,7	8,81	
-metal	46,4	23,2	0,65	2,38	
-glass	61,8	30,9	3,3	3,75	
-bio-waste	111	55,5	11	11	
-mixed waste	648+352	1123+352	1 726	1 726	1 761
Number of regional collection points with containers for paper and cardboard (2*8m^3), plastic (2*5m^3), metal (3m^3) and glass (3m^3)	20	10	2	2	
Emptying times per week					
-paper and cardboard	3	3	2	2	
-plastic	3	3	0,25	0,5	
-metal	1	1	0,125	0,5	
-glass	1	1	0,5	0,5	
Establishment costs (euros)	254 000	127 000	15 320	15 320	
Emptying costs (euros)	327 600	163 800	14 600	16 380	
Maintaining costs (euros)	7 200	3 600	720	720	

Number of kerbside collection points with containers for paper and cardboard (1m^3), plastic (1m^3), metal (0,6m^3) and glass (0,6m^3)	133	67	10	10	
Emptying times per week					
-paper and cardboard	7	7	7	7	
-plastic	5	5	0,5	1	
-metal	0,5	0,5	0,111	0,5	
-glass	1	1	0,5	1	
Establishment costs (euros)	150 450	75 225	11 312	11 312	
Emptying costs (euros)	606 879	303 440	27 430	32 110	
Maintaining costs (euros)	5 320	2 660	400	400	
Transfer times per year (to Segezha/to Petrozavodsk)					
-paper and cardboard	80 / 0	40 / 0	7 / 0	6 / 0	
-plastic	48 / 29	24 / 15	1 / 1	1 / 1	
-metal	20 / 12	10 / 6	1 / 1	1 / 1	
-glass	40 / 24	20 / 12	3 / 2	3 / 2	
Costs of transfer in material use (euros)	222 021	111 011	14 032	13 175	
Costs of transfer in energy use					
-metal and glass	85 152	42 576	6 239	6 239	
-paper, cardboard and plastic	185 280	92 640	10 710	9 480	
Number of kerbside collection points (euros) with container for bio-waste (0,25m^3)	133	67	13	13	
Emptying times per week	4	4	4	4	
Establishment costs (euros)	9 031	4 515	903	903	
Emptying costs (euros)	104 220	52 110	10 422	10 422	
Maintaining costs (euros)	1 330	665	133	133	
Treating costs in composting plant (euros)	173 700	86 850	17 370	17 370	
Treating costs in anaerobic digester (euros)	26 055	13 028	2 606	2 606	
Number of containers for	1 080+587	1870+587	2 836	2 835	2 936

mixed waste (0,6m^3)					
Emptying times per week	1	1	1	1	1
Establishment costs (euros)	Existing	Existing	Existing	Existing	Existing
Emptying costs (euros)	267000+145080	462300+145080	700 674	700 560	725 460
Maintaining costs (euros)	10 800+5 870	18 700+5 870	28 360	28 350	29 360
Treatment costs (euros)	129050+70122	22345+70122	338 659	338 604	350 639
Selling price of recoverables (euros)					
-paper	205 474	102 737	17 892	8 066	
-plastic	321 320	160 660	2 909	4 432	
-metal	158 752	79 376	2 263	8 134	
-glass	46 416	23 208	2 592	2 808	
-bio-waste (compost)	5 790	2 895	579	579	
-bio-waste (compost and biogas)	21 145	10 573	2 115	2 115	