

SUSTAINABLE BIO-WASTE STRATEGY IN FINLAND: CASE STUDY OF OULU IN NORTHERN FINLAND

S. PIIPPO AND E. PONGRÁCZ

*Thule Institute, Centre of Northern Environmental Technology (NorTech Oulu),
P.O.Box 7300, FIN-90014 University of Oulu, Finland*

SUMMARY: In this paper, the prevalent bio-waste management system in Finland is presented, highlighting the example of the city of Oulu in Northern Finland. Separate collection of bio-waste in Finland has started about 20 years ago. Very different national and regional policies are applied to bio-waste management. Because Finland is a rather large country with sparse population, long transportation distances and quite challenging conditions, there is no single bio-waste management strategy that would be suitable for the entire country. The best solution depends on the number of the citizens to be served, population density, infrastructure and climate. The prevalent bio-waste treatment currently is composting, however, bio-waste is increasingly been seen as a source of energy, in both large-scale or small-scale facilities.

1. INTRODUCTION

In 2004, the Finnish Government approved a bio-waste strategy i.e. national strategy to reduce the amounts of biodegradable waste going to landfill by 2016. The strategy aims at reducing greenhouse gas emissions from bio-waste. This should be achieved by more recycling, the wider use of biological waste treatment methods (e.g. composting), and the increased use of wastes in energy production. (Ministry of the Environment, 2004)

The Finnish strategy was introduced as a response to the Landfill Directive (1999/31/EC), which stipulates a 35% reduction of biodegradable wastes of 1995 levels going to landfill by 2016. Also the new Waste Act requires more alternatives to the utilization of biodegradable wastes. Despite regulatory pressures, the amounts of MSW are still growing in Europe. Directive 2008/98/EC, the Waste Framework Directive (WFD), presents the basic concepts and definitions related to waste management. Waste legislation and waste policy in Finland is based on WFD and follows the EU waste hierarchy. The updated Finnish Waste Act (641/2011) came in force on May 1st 2012. Key reason for renewal was that waste amounts have not been reduced as hoped and waste recycling has not progressed as expected. According to the National Waste Plan in Finland, the primary aim is to stabilize the amounts of waste and then to reduce the amounts by 2016. Moreover, 50 % of MSW is to be recovered as material, and 30 % as energy and only 20% will be taken to landfills. (European Commission, 2014) End-of-waste criteria is a criteria which specify when certain waste ceases to be waste and obtains a status of a product, or a status of secondary raw material. End-of-waste criteria was introduced to provide a high level of environmental protection and an environmental and

economic benefit and, moreover, to further encourage recycling in the EU (Europa, 2014)

Bio-waste consists of biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises, and comparable waste from food processing plants. (European Commission, 2014) The estimation of the total annual amount of bio-waste in the EU is about 76.5-102 million tonnes of food and garden waste included in MSW and 37 million tonnes of waste from the food and drink industry. Generally bio-waste is wet waste which is putrescible. Green waste from parks and gardens includes usually 50-60% water and more wood, whereas kitchen waste contains up to 80% water but no wood. (Commission of the European Communities, 2008) The amount of garden waste affects the properties and quality of the bio-waste as it increases the dry matter content and lowers nitrogen content and methane production potential. Service sector bio-waste (grocery stores and restaurants) has the greatest methane production potential. (HSY, 2011) Bio-waste which is biologically treated can be recycled back as nutrients (Holm et al., 2011) as it is more reasonable to use bio-waste as material instead of landfilling or incineration since bio-waste is not only a source of energy but also of nutrients. (Chen and Chen, 2013).

There are differences in MSW and bio-waste management between EU countries. Some countries rely on incineration with high level of material recovery and biological treatment of waste whereas some countries have high material recovery rates and low incineration rates. Some EU countries rely mostly on landfills. Landfilling is considered as the worst waste management option for bio-waste. Landfills generate contaminants to soil and groundwater, produce methane, bio-aerosols and odours. Moreover, they need significant land areas and are a visual disturbance. When bio-waste is incinerated as part of MSW, it is regarded as energy recovery or as disposal. Composting and anaerobic digestion may be classified as recycling when the end product is used e.g. on land or for the production of growing media. Composting is the most common biological treatment option and especially suitable e.g. for green waste whereas anaerobic digestion is more applicable for treating wet bio-waste. (Commission of the European Communities, 2008) For instance, Austria and Denmark are relying on anaerobic digestion whereas composting is more used in Germany. (EEA, 2013a)

2. BIO-WASTE MANAGEMENT IN FINLAND

Finland is the most sparsely populated country in the European Union with less than 18 inhabitants per square kilometer (Figure 1). The length of Finland is 1 160 km from North to South and the land area of Finland is 338 424 km². Especially the Northernmost part of Finland is very sparsely populated since the majority of the 5,4 million inhabitants lives in the Southern regions of which 1.25 million inhabitants in the metropolitan area. There are also great contrasts in the climate, since there are cold winters and fairly warm summers. In 2013, the coldest day in was in Sodankylä, Northern Finland -39.7 °C and the warmest day in Liperi 32.4 °C (This is Finland, 2014).

The recovery of municipal waste in Finland is, in general, well-organized. Also a well-functioning bio-waste collection and treatment network is moderately easy to establish in the large cities with good infrastructure and large-scale composting or anaerobic digester (AD) plants in more populous cities especially in the Southern Finland. The challenges, however, are more severe in Northern, sparsely populated areas, characterized by long transportation distances, small amounts of waste, lack of proper recipient facilities, high establishment costs of well-functioning network and severe climate especially in winter times. These conditions are causing differences in bio-waste management between different regions. It has been determined that, in specific cases, bio-waste management may be justified to depart from the waste management hierarchy. National strategies for the management of bio-waste should be based on a comprehensive approach (e.g. collection

systems, waste composition and quality, climatic conditions, the potential of use of various waste-derived products). (European Commission, 2014)

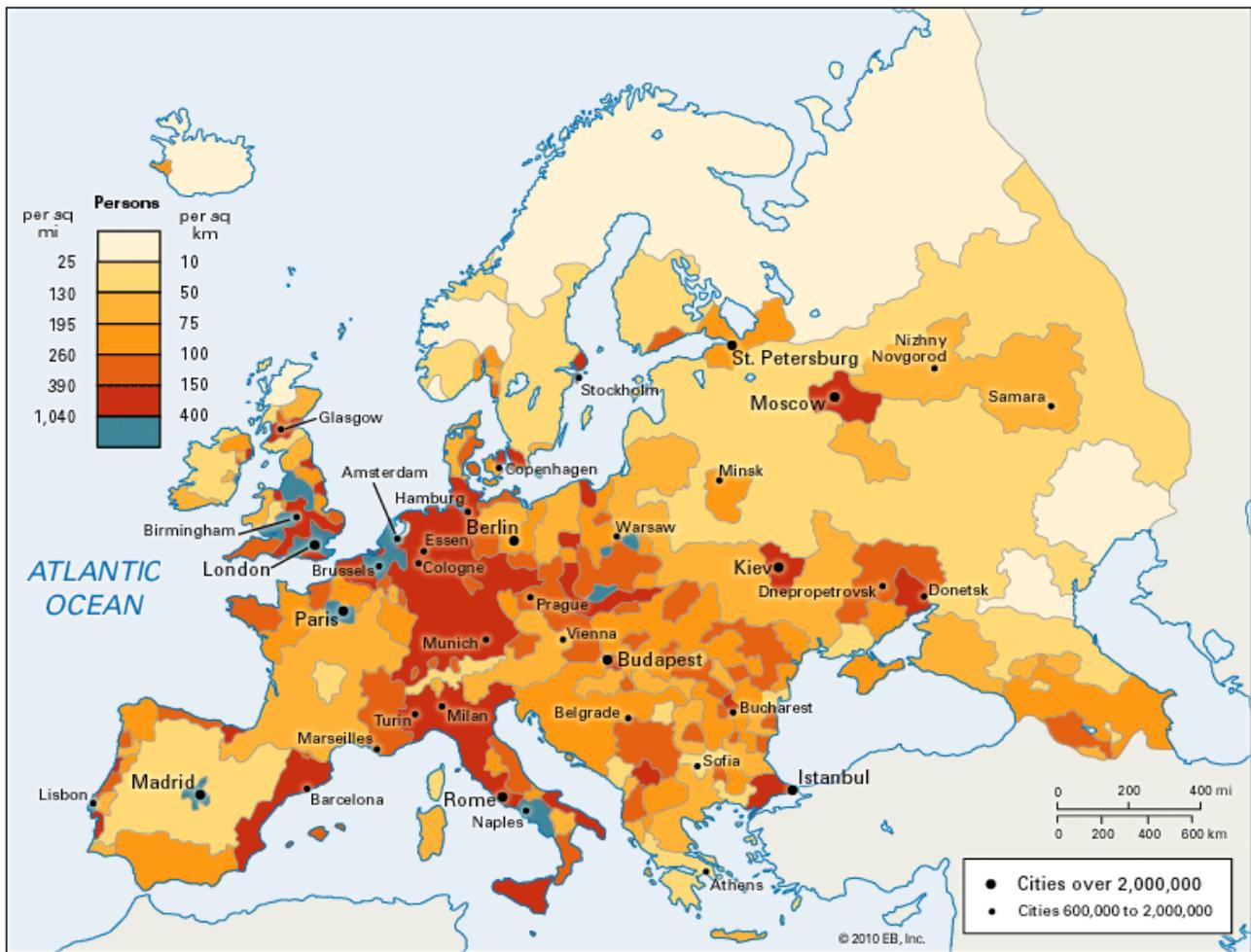


Figure 1. Population density of Europe. (Europe, 2014).

The challenges in Northern Finland are that the transportation distances are long. If possible, transportation of MSW is arranged as back haul. Moreover, if transportation distances are long, transfer stations are used in which the MSW is moved from smaller garbage trucks to larger ones and transported to their final destination. MSW is packed tightly to the containers or trucks so that the amount of the waste per vehicle is as big as possible. In Lapland, the amount of MSW produced is rather low so there is no need for so many transportations. Moreover, it is not reasonable to build facilities for very low amounts of waste since the establishment and operation costs of modern landfills built according to EU directives are high. Usually, wastes sorted already in households and properties are cleaner than those sorted in plants after the waste transportation. Finns sort their wastes very conscientiously according to the regulations, therefore, the sorted waste fractions are rather clean and there is no problem with emptying the containers. However, in the high North, sorted bio-waste may freeze in the container in winter times, causing emptying problems. (Lapin ELY, 2011, Illikainen, 2014)

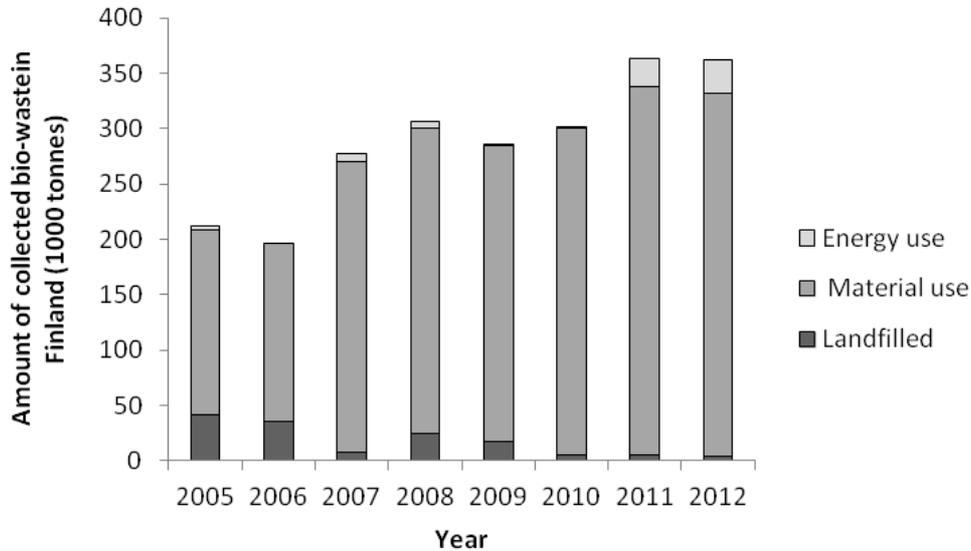


Figure 2. Amounts and treatment of collected bio-waste 2005-2012 (Statistics Finland, 2013)

2.1 History of the separate bio-waste collection

The pioneering in separate collection of bio-waste is the Helsinki Metropolitan Area council (YTV) by starting the collection experiments in the 1980s (Hänninen, 2009). The first bio-waste collection and composting experiments in Finland were in 1988 in Helsinki, in 1982 in Joensuu, in 1990-1991 in Espoo and in 1993 in Tampere and the results of these experiments were positive. (Lettenmeier, 1994). YTV launched the actual separate collection of bio-waste in 1993, after which the other municipalities started separate collection due to legislation. (Hänninen, 2009).

Although the main waste disposal method was landfilling until the 1990s, there were a few serious attempts on both incineration and composting (Tommila, 1984) such as the building of a new incineration plant in Helsinki in 1962. Already at the beginning of the 20th century there were several trials to separate and compost bio-waste, but without success. In 1959, a composting plant for waste was established in Helsinki and later on in Turku. In 1965, it was obvious that the costs of composting were too high and the product of the composting plant was not clean enough and the composting plant in Helsinki was closed. The incineration plant was also closed due to environmental reasons (Turpeinen, 1995). In the 1990s, sorting of bio-waste was more effective and a new composting plant was established. (Nygård, 2000) Currently, composting of bio-waste is the most common way to treat the bio-waste (Figure 2). However, the number of AD plants is increasing (Illikainen, 2009). According to Tuovinen (2002), anaerobic digestion is more environmentally friendly and economically feasible than composting. The amount of collected bio-waste and its mechanical treatment has increased steadily in Finland but, in recent years, energy use had a slight increase, and very few bio-waste is landfilled (Statistics Finland, 2013)

2.2 Bio-waste management as a part of the municipal solid waste management

Municipal solid waste management (MSWM) is a part of the infrastructure of the Finnish municipalities and it is organized by municipalities, companies and producer responsibility organizations (Figure 3). The waste fractions that are collected from properties differ by municipalities, depending on the Waste Management Regulations of the municipality. Most

commonly, mixed waste, bio-waste and cardboard is collected from properties (Jätelaitosyhdistys, 2011)

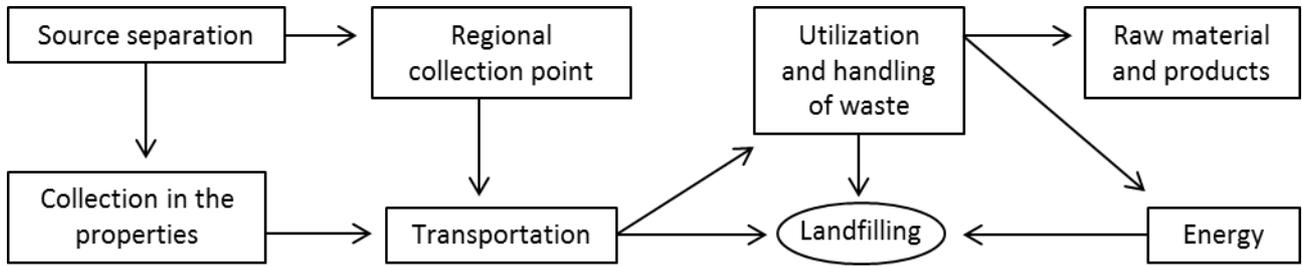


Figure 3. MSWM system in Finland. Landfilling is the last option after material and energy recovery. (Modified from Piippo et al., 2014a)

The amounts of MSW have increased for decades (Sokka et al., 2007), and material recovery rose steadily as well, but the amounts of landfilled MSW have started to decline only during the past years (Figure 4, Statistics Finland, 2013). Also energy recovery has increased steadily in the last few years, and, in 2012, only 33 % was landfilled. As it is estimated that up to 40 % of MSW is bio-waste (Tanskanen 2008), some amount of bio-waste is still landfilled among MSW.

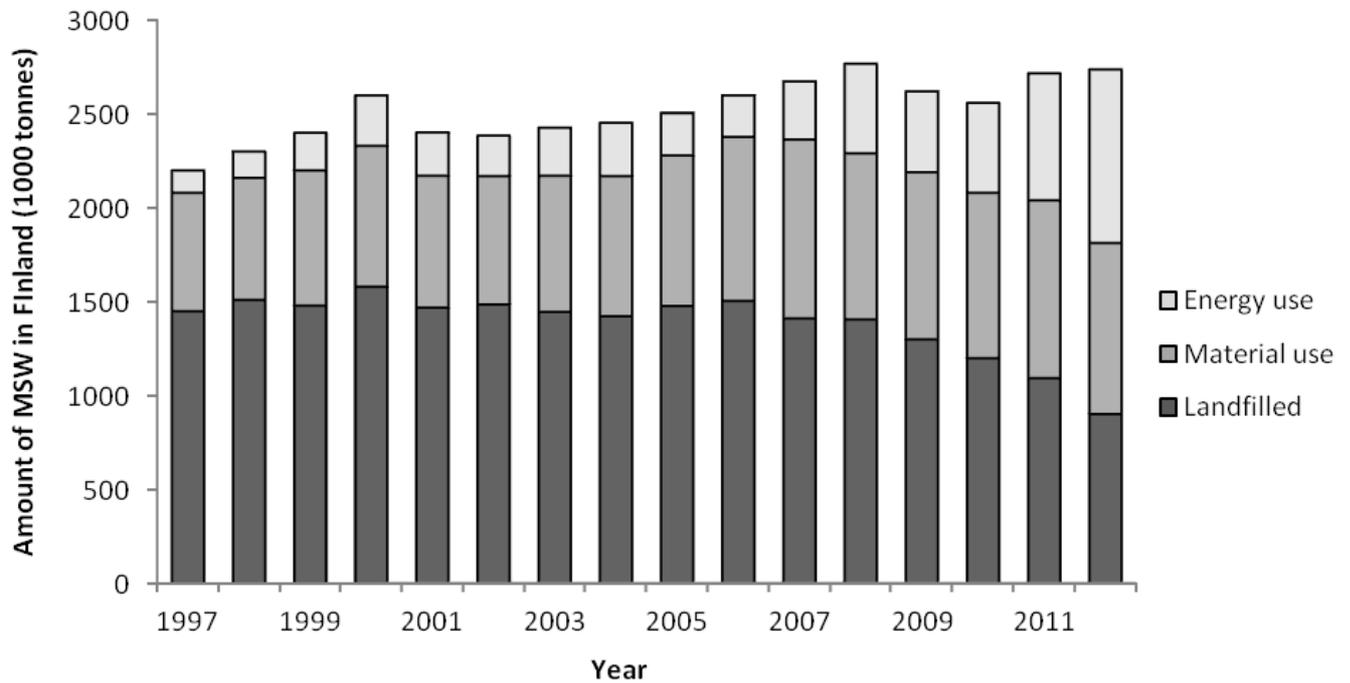


Figure 4. Amounts and treatment of municipal waste during 1997-2012. (Statistics Finland, 2013)

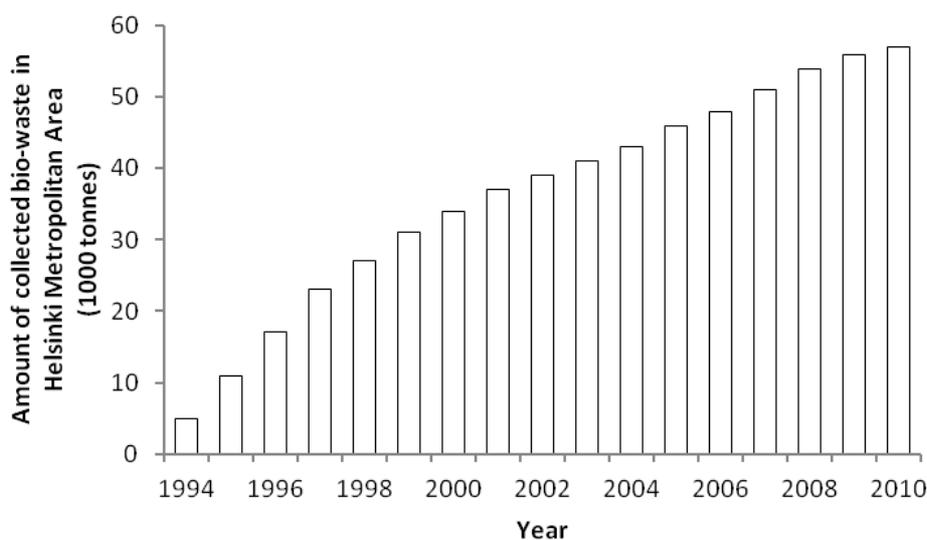


Figure 5. Amounts of bio-waste in Helsinki Metropolitan Area (HSY, 2011).

2.3 Bio-waste management strategies in different regions of Finland

2.3.1 Helsinki Metropolitan Area

The Helsinki Region Environmental Services Authority, HSY (Helsingin seudun ympäristöpalvelut), organizes the waste management for households and administration in the areas of Helsinki, Espoo, Kauniainen, Vantaa and Kirkkonummi. HSY started separate collection of bio-waste in the Helsinki Metropolitan Area in 1993 and, as the operational area is large with dense population, the collected amounts are large and growing steadily (Figure 5). (HSY 2011, 2014)

Most of the bio-waste comes to HSY from households, the public service sector and grocery stores. A single HSY household produce about 34 kg/person of sorted bio-waste annually and it is treated by composting. The annual composting capacity is about 49 000 tonnes of bio-waste (HSY, 2011) and the compost is used as topsoil in landscaping. In the near future, a facility based on digestion technique will supplement bio-waste treatment in HSY. (HSY 2014) The share of bio-waste in MSW in HSY area is about 40 % which is 69 kg per person annually (Tanskanen, 2008, HSY, 2013)

2.3.2 The Finnish Lapland

The surface area of Lapland is over 25% of the total surface area of Finland but hosts only 3.4% of population and the population density is less than two inhabitants per km² (Lapin ELY, 2011). Municipalities are small and far apart, the main road infrastructure is scarce in places, whilst tourist attractions abound. The estimation of Lapland's direct incomes achieved by tourism was about 595 million euro in 2010 making the tourism extremely important source of incomes. For instance, although the local population of the small municipality of Kolari is only 3 800, the Ylläs tourist centre in Kolari is the third most visited tourist centre of Lapland. (Lapland's Tourism Strategy, 2011-2014). Tourism is also the source of considerable amounts of wastes. The prevalent waste treatment method in Lapland is landfilling.

It was recently announced by the waste company of Lapland (Lapin Jätehuolto kuntayhtymä, Lapeco) that they will not organize the separate bio-waste collection at all for the citizens of small municipalities in the Lapland. The reasons are the challenges of large transportation distances and the weather conditions, as the bio-waste may freeze during the transportation in winter seasons.

Lapeco advocates home-composting, and offers a lower fee for the removal of mixed waste for customers who are composting. (Lapin Kansa, 2014) It has been suggested that a more sustainable solution would also be local treatment of bio-waste with sewage sludge and offal in an anaerobic digester and utilization of digestate to revegetate worn land (Piippo et al., 2014b). Multiple use of bio-waste would also add to the economic profitability and benefits of bio-waste management.

2.3.3 Use of bio-waste for biofuel manufacture

The Southern part of Finland is characterized by agricultural activities that also generate considerable amounts of bio-waste. In these areas, bio-waste and food waste are utilized to manufacture biofuel. St1 Nordic focuses on fuel marketing activities in Finland, Sweden and Norway and on renewable energy solutions such as waste-based ethanol fuel. In Finland, the st1 company produces ethanol in a decentralized model from bio-waste collected from separate waste collection bio-waste and from food companies. The intermediate product is produced near the large waste sources and they are transported to a dehydration facility to Hamina. In Hamina, they are upgraded to 99.8% and later on, the ethanol is mixed in RE85 biofuel, which contains 80-85% ethanol. (St1, 2010, Pongrácz et al., 2014)

3. CASE OULU

3.1 Waste management in Oulu area

Oulu is a Northern city of 191 000 inhabitants. It is the fourth largest city in Finland and the most populous city in Northern Finland. According to the waste management regulations of the Oulu area, all the properties are obliged to have collection containers for combustible waste. In addition, residential buildings with a minimum of four apartments must have separate collection containers for waste paper, metal, glass, cardboard and liquid packages as well as for bio-waste. Bio-waste needs to be transported to a licensed composting plant or composting area via organized waste transportation, or it needs to be composted in the property. All separately collected waste fractions need to be recycled. Small residential buildings are obliged to transport their recyclables to the regional waste collection points and to compost their bio-waste if possible. Recyclables need to be collected separately also on public events. (Waste management regulations, 2013)

3.2 The Oulu Waste Management Company

The Oulu Waste Management Company (Oulun Jätehuolto) is a public-service company of the city of Oulu which is responsible for the treatment of waste, the coordination of waste transportation, waste education and supplementary services. The operational area of the Oulu Waste Management Company consists of 12 municipalities and serves nearly 290 000 customers (Figure 6). In 2012, the amount of received MSW was 113 146 tonnes, of which 51% was incinerated, 16.7% was recycled as material and the rest was landfilled. (Oulu Waste Management Company, 2014)



Figure 6. Operation area of the Oulu Waste Management Company (Oulu Waste Management Company, 2014)

3.3 Bio-waste management in the Oulu Waste Management Company

The separate collection of bio-waste in Oulu area started in 1995 as the fourth municipality in Finland (Figure 7). At first, the bio-waste was treated in open stack compost on the field but after year 2000, the collected bio-waste was treated in a composting plant. Nowadays, about 10 000 tonnes of bio-waste is treated in Rusko Waste Centre in three composting drums. The composted bio-waste is used for landscaping and construction work at the waste centre. (Illikainen, 2009).

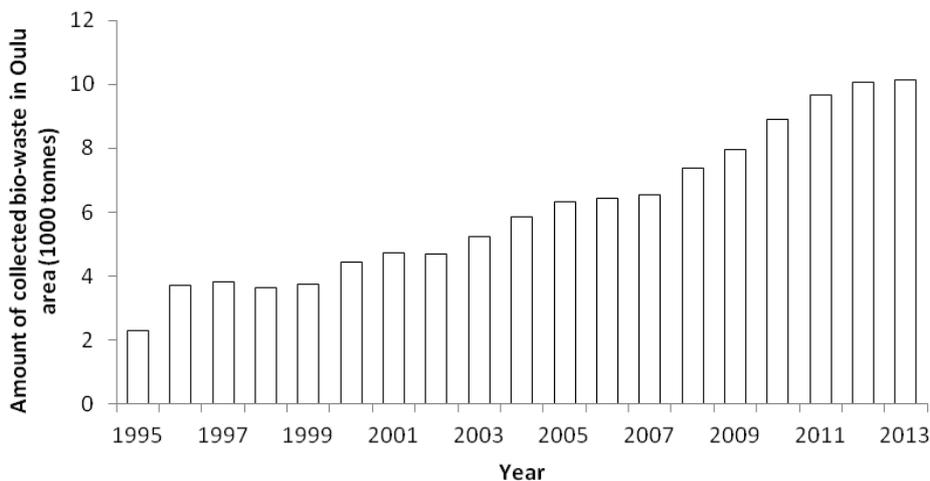


Figure 7. Amount of collected bio-waste of the Oulu Waste Management during the years 1995-2013. (Illikainen 2009, Oulu Waste Management Company, 2014)

As the composting plant in Oulu has been operating since 2000, there is an urgent need to rebuild it or build a new plant for the treatment of the collected bio-waste. Although there is a waste incineration plant in Oulu, incineration of bio-waste is not considered as an option for the management of bio-waste. The bio-waste management strategy in Oulu is according to the waste legislation and regulations and EU:s waste hierarchy since the bio-waste is mainly used as material, not as energy. As there will be shortage of some essential resources, it is more reasonable to use bio-waste as material than for incineration. Moreover, the end product, digestate, of the AD plant is easier to utilize than the ash from the incineration. (Illikainen, 2014) In addition, when comparing AD and composting, AD is more economically feasible and environmentally friendly than composting (Tuovinen, 2002).

Starting from 2015, bio-waste in the Oulu area will be treated in a new AD plant which can receive up to 19 000 tonnes of feedstock. The AD plant will provide services regionally and can receive also waste water sludge and waste fat from the food industry. The plant will produce about 15 000 MWh of energy as biogas annually, which would provide heating for 1 500 detached houses annually. The amount of energy is not remarkable but the AD plant is seen as a sustainable way to treat bio-waste. The amount of digestate to be generated in the AD plant will be enough for 2000-3000 hectares area as fertilizer. (Oulu Waste Management Company, 2014) The new AD plant will be built and operated by the private company who will buy the bio-waste from the Oulu Waste Management Company, treat it and take care of the end product. The private company will sell out the biogas produced in the AD plant. In the new AD plant, the liquids will be recycled and nothing will be going to the waste water treatment plant. Both the solid and liquid end products can be stored during the winter and utilized in the summer. The biogas to be produced by the AD plant will be sold, according to the plans, half of it will be bought by the Oulu Waste Management Company. (Illikainen, 2014)

The increase in the amount of collected bio-waste, as seen in Figure 7, is caused by strict waste management regulations of the Oulu area, increased population and improved awareness of citizens. Recently, the amount of bio-waste received from the grocery stores has increased, as also the packed foods are accepted for composting. The packages are shredded and removed from the bio-waste mass. There is no need to incinerate bio-waste as the prevalent amount of MSW is sufficient for the incineration plant as the combustible MSW is brought to Oulu even from the larger area than the Oulu Waste Management Company's operational area. Moreover, the incineration of waste is more expensive than composting. For bio-waste producers, the anaerobic digestion will be cheaper than the incineration as the fee for the bio-waste will remain at a lower level than the fee for combustible waste which increases the willingness to sort the bio-waste more efficiently. In 2014, the fee for bio-waste (including VAT) is 48,42 euro and for mixed waste 132,80 euro. Fee for combustible waste transported from properties with garbage truck is 114,07 euro. (Oulu Waste management Company, 2014) However, as the portion of bio-waste in MSW is estimated to be about 40 %, all the unsorted bio-waste is incinerated in Laanila Power plant. (Illikainen, 2014)

4. CONCLUSIONS

Amounts of MSW and bio-waste are still increasing in Europe and Finland. As Finland is a rather large country with sparse population, long transportation distances and quite challenging conditions, there is no single sustainable bio-waste management strategy that would be suitable for the whole country. The best solution depends e.g. on the number of the citizens, population density, infrastructure and climate. In future, bio-waste can be seen as a source of energy, produced either by large-scale or small-scale solutions.

The best solution for the densely populated Southern Helsinki Metropolitan Area with population of 1,25 million people and large and steady amount of bio-waste, would be the effective

collection network and large-scale bio-waste management plant, either composting or AD plant. The present method for the bio-waste management is composting but, in the near future, there will be a new AD plant which would produce energy as biogas. For a city such as Oulu, surrounded by the rather sparsely populated areas, AD plant which can utilize also waste water sludge and food-waste from the industry is reasonable, as the amounts of bio-waste may not be sufficient otherwise. Energy can be generated also by using the biomass for the production of ethanol in small-scale plants.

Situation is different in the most sparsely populated area of Finland, Lapland. As the number of inhabitants is low and transportation distances long, there is no environmental or economical justification to establish large-scale bio-waste management solutions. In tourist areas with seasonal peaks of bio-waste production, the solution could be a small-scale AD plant, which could treat the bio-waste of local citizens and from the tourist enterprises. During the low peak of tourism, the AD plant could utilize e.g. waste water sludge and offal. In the most sparsely populated areas with very low amount of bio-waste and no tourism, home-composting would be recommended. It can be expected, that with more efficient sorting, the amount of bio-waste landfilled or incinerated with MSW will be even lower in the future.

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