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How should greenhouse gas emissions be taken into account in the decision making of municipal solid waste management procurements? A case study of the South Karelia region, Finland

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ABSTRACT

The ongoing trend in the public sector is to make more sustainable procurements by taking into account the impacts throughout the entire life cycle of the procurement. Despite the trend, the only deciding factor can still be the total costs. This article answers the question of how greenhouse gas (GHG) emissions should be taken into account in municipal solid waste (MSW) management when selecting an incineration plant for source separated mixed MSW. The aim is to guide the decision making of MSW management towards more environmentally friendly procurements.

The study was carried out by calculating the global warming potentials (GWPs) and costs of mixed MSW management by using the waste composition from a case area in Finland. Scenarios of landfilling and combustion in three actual waste incineration plants were used to recognise the main processes that affect the results. GWP results show that the combustion of mixed MSW is a better alternative than landfilling the waste. The GHG results from combustion are greatly affected by emissions from the combustion and substituted energy production. The significance of collection and transportation is higher from the costs' perspective than from the point of view of GHG emissions. The main costs, in addition to collection and transportation costs, result from the energy utilization or landfilling of mixed MSW.

When tenders are invited for the incineration location of mixed MSW, the main focus should be: What are the annual electricity and heat recovery efficiencies and which are the substituted fuels in the area? In addition, in the case of a fluidized bed combustor it is crucial to know the combusted share of mixed MSW after preparing solid recovered fuel (SRF) and the treatment of rejects. The environmental criteria for the waste incineration plant procurements should be made in order to obtain clear instructions for the procurement units. The results can also be utilized more widely. The substituted fuels in the area and the effect of the plant location on the utilization of the produced energy can already be identified when planning an appropriate site for the waste incineration plant.

1. Introduction

More than 30% of municipal waste was landfilled in the European Union (EU-27) in the year 2012. Landfilling rates decreased from 63% to 34% between the years 1995 and 2012. At the same time in the Nordic Countries of Sweden, Denmark, and Norway landfilling rates have fallen below 5% and incineration rates now account for more than 50%. (Eurostat, 2014.) Landfill bans on combustible/biodegradable waste have been introduced in these countries (Fischer et al., 2012). According to the landfill directive of the EU, by 2016 the biodegradable municipal waste ending up in landfills must be reduced to 35% of the total amount of biodegradable municipal waste produced in 1994 (1999/31/EC). The EU is also committed to reducing greenhouse gases (GHGs) by at least 20% by 2020 (Ministry of the Environment, 2011) and at least 40% by 2030 (European Commission, 2014) compared to the 1990 level.

In 2012, in Finland the landfilling rate of municipal solid waste (MSW) was 33% (0.90 Mt) and the energy utilization rate of MSW was 34% (0.93 Mt) (Statistics Finland, 2013b). The waste management sector produced approximately 3% (2.1 Mt CO_2-eq) of the GHG emissions in Finland in 2012. Emissions from landfills contribute over 84% of the total GHG emissions from the waste management sector. The total GHG emissions have decreased 48% since 1990. The main part of this reduction results from the decrease in the landfilling of waste in Finland. At the same time,

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incineration of MSW has become more common in past few years. However, the GHG emissions from waste incineration, collection, and transportation are allocated to the emissions of the energy sector. (Statistics Finland, 2014.) In 2014, eight incineration plants used only waste as a fuel, and more waste incineration plants are under construction (Finnish Solid Waste Association, 2014).

Behind the changes in the Finnish waste management sector are e.g. the forthcoming landfill ban and different targets. The Government of Finland (2013a) has accepted a new landfill decree where the maximum allowed proportion of total organic carbon (TOC) or loss on ignition (LOI) for the landfilled non-hazardous waste will be 10% at MSW landfills in 2016. It is believed that this will reduce emissions from the landfills even more. The ban is estimated to affect approximately 2 Mt of waste which is still landfilled. One of the fractions with a share of about 50% is the mixed MSW which exceed the limit. An alternative treatment is going to be waste incineration, and consequently, e.g. less CH_4 is produced from the landfills. (Wahlström et al., 2012.) Finland's obligation for those sectors not covered by the emissions trading scheme (non-ETS sectors such as waste) is to reduce by 2020 the GHG emissions by 16% from the 2005 level. In addition, the Government of Finland adopted, in 2009, a target of reducing by 2050 Finland's GHG emissions by at least 80% from the 1990 level. (Ministry of the Environment, 2011.)

The EU directive on public procurement (2014/24/EU) includes an option to take account of environmental factors and also the life-cycle costs. The public sector is constantly being encouraged to make more sustainable procurements, where the whole impact of the procurement's life cycle is taken into account. The Government of Finland (2013b) has decreed a decision, in principle, where the procurement unit of the state is obligated to take environment aspects into account when planning procurements by 2015, at the latest. This principle is still a recommendation for other procurement units such as waste management companies owned by municipalities. Waste management companies send out invitations to tender and buy the main proportion of services from private companies by using public procurement procedures. (The Government of Finland, 2013b.) Nowadays, the waste management companies in Finland are much more accustomed to taking into account waste collection and transportation emissions when invited to tender. The EU has already made binding criteria for road transport vehicles and services (2009/33/EC), and e.g. the EU and Sweden have also made their own voluntary criteria for transportation (European Commission, 2012; The Swedish Environmental Management Council, 2009). Despite the greener transportations, the only deciding factor can still be the total costs when e.g. inviting tenders for the incineration location of mixed MSW.

A comparison of landfilling and incineration of MSW from the point of view of GHG emissions has been done in many studies (e.g. Kaazke et al., 2013; Monni, 2010; Ragoßnig et al., 2009; Wittmaier et al., 2009). Landfilling has been the prevailing waste management solution or the way to handle waste before, and therefore, it has been modelled for comparative purposes. All of these studies are in favour of incineration. Moreover, significant factors when calculating total global warming potentials (GWPs) are mentioned, like energy recovery efficiency of the incineration plant and substituted fuels (e.g. Myllymaa et al., 2008b; Vainikka et al., 2012). Myllymaa et al. (2008b) has also mentioned that the location of an incineration plant affects the annual energy efficiency and substituted heat is calculated based on the heat production in the area. Thus, the composition of fuels used to produce the substituted heat energy ranges widely between different studies (e.g. Astrup et al., 2009; Monni, 2010; Myllymaa et al., 2008b; Wittmaier et al., 2009). These details show that there are significant factors that affect the GWP results. At the same time, waste incineration plants have an equal right to give an offer for the combustion of mixed MSW.

The aim of the study is to calculate the GWPs and the costs of mixed MSW management by using the waste composition from a rural area in the South Karelia region in Finland. The mixed waste is source separated which means that inhabitants are instructed to separately sort fractions of biowaste, glass, metals, cardboard, and paper so that the mixed MSW is the leftover fraction that is directed to the landfill or incineration. Still in 2012, landfilling was the way to handle the mixed MSW, and thus both landfilling and incineration of mixed MSW in the different locations were studied. The case study included the actual locations in Finland and the case is based on an actual invitation to tender situation in 2012; with the exception of one of the incineration plants which was still under construction in 2014. One of the incineration plants is the same as studied by Monni (2010). It is noteworthy that Monni (2010) did not compare the GWP results to other plants, the costs were not included in the study and the used waste composition was from a different area. Horttanainen et al. (2013) has noted that the composition of mixed MSW also varies in different areas inside Finland. This indicates the need to conduct regional GHG emission studies where the specific waste composition is taken into account.

The aim of this study is to recognise the main processes that affect the results and to find out how the GHG emissions should be taken into account in the decision making of MSW management procurements. The goal is to guide the decision making of MSW management towards more environmentally friendly procurements. Transport costs have traditionally been considered as one of the most deciding factors when making waste management procurements. Therefore, an investigation was also conducted to find out what is the contribution of waste transport emissions to the total GHG emissions, and should the waste transportation also be in focus in procurements from the environmental point of view.

2. Materials and methods

Life cycle assessment (LCA) is a tool to evaluate the potential environmental impacts related to waste management options throughout a life cycle (Ekvall et al., 2007; SFS-EN ISO 14044, 2006). LCA enables taking into account the environmental benefits that can be obtained through waste management processes, e.g. waste incineration where energy recovery reduces the need for other energy sources, and material from recycling processes replaces the production of virgin material. The LCA tool can be used to compare different options in waste management. (Ekvall et al., 2007.) This makes it possible to use the information developed in an LCA study as a part of a decision-making process (SFS-EN ISO 14044, 2006).

The life cycle of the mixed MSW begins from the moment the waste is delivered to the regional collection point and continues until the waste is utilized or landfilled. The unit processes from the mixed MSW collection to the utilization or landfilling of the waste were taken into account, including the production of auxiliary substances, the treatment of the end products of combustion, the recycling of metals, and substitutions. The functional unit used was the amount of mixed MSW in one year from the study area. The functional unit is used in an LCA study as a reference unit (SFS-EN ISO 14044, 2006). The GHG emissions investigated in this study were CO_2, CH_4 and N_2O. The GWP was evaluated through a 100-year time span. The GWP of the system was assessed in compliance with the ISO standards 14040 (SFS-EN ISO 14040, 2006) and 14044 (SFS-EN ISO 14044, 2006). The GaBi 6.0 life cycle modelling software and a methodology CML 2001 – November 2010 for impact assessment were used in the study (GaBi).