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Areas on which to focus when seeking to reduce the greenhouse gas emissions of commercial waste management. A case study of a hypermarket, Finland

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ABSTRACT

This study focuses on commercial waste, which has received less attention than household waste in regards to greenhouse gas emission research. First, the global warming potential (GWP) of commercial waste management was calculated. Second, the impacts of different waste fractions and the processes of waste management were recognised. Third, the key areas on which to focus when aiming to reduce the greenhouse gas emissions of commercial waste management were determined.

This study was conducted on the waste generated by a real hypermarket in South-East Finland and included eight different waste fractions. The waste treatment plants were selected based on the actual situation. Three different scenarios were employed to evaluate the environmental impact of managing mixed waste: landfilling, combustion and more accurate source separation. The GaBi software and impact assessment methodology CML 2001 were used to perform a life cycle assessment of the environmental impacts associated with the waste management.

The results indicated that the total GWP of commercial waste management could be reduced by 93% by directing the mixed waste to combustion instead of landfill. A further 5% GWP reduction could be achieved by more accurate source separation of the mixed waste. Utilisation of energy waste had the most significant influence (41–52%) on the total GWP (−880 to −860 $kgCO_2$-eq./t), followed by landfilling of mixed waste (influence 15–23% on the total GWP, 430 $kgCO_2$-eq./t), recycling polyethylene (PE) plastic (influence 18–21% on the total GWP, −1800 $kgCO_2$-eq./t) and recycling cardboard (influence 11–13% on the total GWP, 51 $kgCO_2$-eq./t). A key focus should be placed on treatment processes and substitutions, especially in terms of substitutions of energy waste and PE plastic. This study also clarified the importance of sorting PE plastic, even though the share of this waste fraction was not substantial.

The results of this paper were compared to those of previous studies. The output of this analysis indicated that the total GWP can be significantly reduced by identifying an alternative recycling or incineration location for cardboard where it is used to substitute virgin material or replace fossil fuels respectively. In conclusion, it is essential to note that waste management companies have a notable influence on the emissions of commercial waste management because they choose the places at which the waste fractions are treated and utilised.

1. Introduction

While municipal waste is defined as waste from households, it also includes the similar waste generated by additional sources (1999/31/EC), such as commercial enterprises, offices and public institutions (Eurostat). According to the Waste Framework Directive (2008/98/EC), waste should be recycled before it is used to generate energy or placed in a landfill. Elevating municipal solid waste (MSW) management up the waste hierarchy offers one method by which it may be possible to reduce greenhouse gas (GHG) emissions. Methane emissions from landfills have decreased considerably in the past decade. At the same time, an increase in the amount of waste that is recycled has allowed recycled materials to replace virgin materials, and this has reduced the GHG generated during primary production (European Environment, 2013). Furthermore, member states of the European Union (EU) have been encouraged to promote the waste management practices that offer the best overall environmental outcome. This may entail that some waste streams depart from the traditional waste hierarchy;

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however, the overall life-cycle impact of the waste can justify this change (2008/98/EC).

The EU and Finland have set targets for the treatment of waste that are designed to steer municipal waste management in the desired direction. In 2014, the European Commission adopted a circular economy package that included proposals on waste management that were targeted for implementation by 2030. For example, member states are expected to recycle 65% of municipal waste and reduce landfill to a maximum of 10% of municipal waste (European Commission, 2015). Finland had its own targets for 2016; e.g., 50% of municipal waste to be recycled as material, 30% to be used as energy and no more than 20% of municipal waste to be landfilled (Ministry of the Environment, 2009). In 2015, the share of municipal waste that was recycled was 41%, while 48% was used for energy recovery and 11% was landfilled (Statistics Finland, 2016). This means that the recycling target has not yet been achieved. New targets that stretch to the year 2023 are currently being prepared; e.g., 55% of municipal waste is to be recycled, and it is anticipated that these targets will be formally accepted by autumn 2017 (Ministry of the Environment, 2017). A ban that prevents landfilling of organic waste that contains more than 10% of organic substances was implemented in Finland at the beginning of 2016 (The Government of Finland, 2013).

Targets that specifically aim to reduce GHG emissions are also steering waste management in the desired direction. In 2009, the Government of Finland adopted a target to reduce Finland's GHG emissions by at least 80% of the 1990 level by 2050 (Ministry of the Environment, 2011). The share of GHG emissions from the waste sector was 4% in Finland in 2015. A significant proportion of the emissions is produced in landfills. It is noteworthy that the GHG emissions from waste combustion and transportation are allocated to the emissions from the energy sector, which is the largest source of GHG emissions in Finland (Statistics Finland, 2017).

This study focused on commercial waste, which has some differences to household waste. First, the composition of commercial waste is different to that of household waste. Commercial waste includes a lot of packages. The products sold by commercial enterprises are delivered in secondary or tertiary packages, e.g., in cardboard boxes that may also have plastic wrappings. These packages must be emptied and recycled or disposed of. Paper and cardboard represented 19% of municipal waste in 2015 (Statistics Finland, 2016). In the case evaluated in this study, cardboard represented 49% of the total waste generated (Borisov, 2012; Hautamäki, 2012). It is also worth noting that, for example, the energy waste produced by shops is typically more homogeneous than that produced by households (Salmenperä et al., 2015).

Second, a large amount of commercial waste is produced in a small area. A total of 149 hypermarkets are located in Finland including 80 Citymarkets, 64 Prismas and 5 Minimanis (Finnish Grocery Trade Association, 2017). In Finland, hypermarkets are the largest type of shop, and they each cover an area of more than 2 500 m^2 (Finnish Food Information, 1996). Usually, the biggest cities in Finland have both a Citymarket and a Prisma. The number of products ordered and the sales volumes affect the amount of waste produced. The seller typically attempts to predict future sales as accurately as possible; however, losses are inevitable and occur when products are not sold; for example, out of date food. The total amount of avoidable food waste that is produced by Finnish wholesale and retail trade is estimated to be 65–75 million kilograms per year. At the same time, it is estimated that Finnish households generate 120–160 million kilograms per year of avoidable food waste (Silvennoinen et al., 2012). Statistics related to the amount of municipal waste produced by Finnish hypermarkets is not currently available. In 2015, municipal waste was generated at a rate of 500 kg/capita in Finland (Eurostat, 2017). The study described in this paper was based on the case of a hypermarket that generated the equivalent waste amount (603 t/a) of more than 1200 people. Based on population densities (Eurostat, 2016) and total areas (European Union), the same amount of municipal household waste would be collected from an area of 74 km^2 in Finland in 2016. A further issue that is related to the amount of commercial waste concerns the need for larger waste bins or compactors.

Third, the source separation of commercial waste can easily be improved. Separation is handled by a limited number of employees who can be instructed to separate waste into different fractions. This means that a single employer can have a direct impact on the accuracy of sorting procedures and changes in the source separation of commercial waste can be readily implemented. Household waste is source separated according to sorting guidelines, and this process is heavily influenced by free will. This is an issue because people's skills and willingness to source separation can vary considerable.

In Finland, commercial waste producers can choose which waste management company takes care of their waste. This differs from household waste management, which, in most cases, is managed by the municipal authorities in collaboration with producer associations. Commercial waste is often managed by private companies, and these companies compete with one another. The traditional way by which a waste contractor can stand out from the competition is by prices. Another manner by which a waste contractor can stand out from the competition is by developing the ability to estimate the environmental impact of the produced commercial waste, which waste fractions and processes have the biggest impact on the environment, and how the impact can be reduced. To this end, there is a need to develop a more comprehensive understanding of these matters.

The GHG emissions of different waste management scenarios have been calculated in many studies that have assessed different waste fractions. Kaazke et al. (2013) and Tulokhonova and Ulanova (2013) noticed that landfill demonstrate the greatest environmental burden. Bernstad et al. (2011), Buttol et al. (2007) and Corsten et al. (2013) all found out environmental benefits of recycling. Bernstad et al. (2011) showed that recycling of household waste provides substantial environmental benefits compared to a non-recycling alternative. Buttol et al. (2007) mentioned about the environmental beneficial effects of increasing recycling and incineration with energy recovery. At the same time, results of Corsten et al. (2013) showed that aiming for more and high-quality recycling can result in larger CO_2 emission reductions than focusing on incineration. Bernstad et al. (2011) explained that benefits varies greatly between recyclable fractions. Also, the type of energy substituted by incineration and used in different processes is relevance for the attained results (Bernstad et al., 2011).

Ripa et al. (2017) confirmed that one of the main responsible of the environmental burdens of MSW management is the low rate of separate collection. Same way, De Feo and Malvano (2009) had the highest avoided impact of GHG emissions in a scenario with the highest percentage of separate collection. Christensen et al. (2009) found that most waste management scenarios in Europe provided overall savings in GHG emissions. Savings were depending on waste composition, the crediting of the produced energy, the amount of paper recycled and binding of the biogenic carbon in landfills. Gentil et al. (2009) showed significant benefits due to the high level of energy and material recovery substituting fossil energy and raw materials production. They also showed that there are major differences in European member states in waste composition, availability of waste management technologies and the performance of these technologies (Gentil et al., 2009). However, some studies have not distinguished the impacts of different waste fractions (e.g., Buttol et al., 2007; De Feo and Malvano, 2009; Kaazke et al., 2013; Tulokhonova and Ulanova, 2013). As such, it

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