Greenhouse gas emission factors for Helsinki regions waste management

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Abstract Preventing waste and reducing green house gas emissions in municipal solid waste management is one of the goals in the Helsinki Metropolitan Climate Strategy. Julia 2030 -project aims among others at producing information and developing tools for citizens, companies and waste management professionals for calculating GHG emissions of waste recovery and treatment. For this purpose, 14 different waste component specific GHG emission factors were produced using the LCA methodology. The inventory data was collected from the current municipal waste management in Helsinki metropolitan area. Avoided processes in energy production and in raw material use were determined on the basis of the local situation.

1 Introduction

About three percent of Finland's greenhouse gas emissions (GHG) are caused by waste management. This amount contains emissions from landfills, sewage sludge treatment and biowaste composting. In addition waste transportation and incineration are reported in the energy sectors GHG emissions. Preventing waste and reducing GHG emissions in municipal solid waste management is a part of the EU Life+ funded project Julia 2030 "Mitigation of and adaptation to the Climate Change in the Helsinki Metropolitan Area – From Strategy to Implementation". The project is aiming at major GHG emission reductions by the year 2030 and it is based on the Helsinki Metropolitan Climate Strategy [1]. Julia 2030 project aims among others at producing information and developing tools for cities, citizens, companies and waste management professionals for calculating GHG emissions of waste recovery and treatment.

2 Materials and methods

One of the project´s goals is to develop calculators for the assessment of the GHG emissions of waste management. For this purpose, waste components specific GHG emission factors were produced using the LCA methodology. For the different waste components, the GHG emissions caused by waste management (including collection, transportation, treatment and utilization of waste) were calculated. The potential savings of GHG emissions due to the reuse of source separated waste components either as a raw material instead of primary natural resources or as energy instead of fossil fuels, were calculated as avoided GHG emissions. LCA based GHG emission factors were determined for: mixed municipal solid waste, biowaste, paper, cardboard, glass, metal, energy waste (including plastics, unrecyclable paper and cartons), recycled plastics, waste electrical and electronic equipment (WEEE), wood, hazardous waste, construction and demolition waste and sewage sludge.

2.1 Waste management and recovery options assessed for different waste fractions

The calculation of GHG emissions for all waste components was based on current information from the municipal waste management of the Helsinki Metropolitan Area (HMA). Also the avoided processes in energy production or in raw material use were determined on the basis of the local situation. In the following the waste treatment and recovery chains are described in general. The data were gathered from literature and other public documents, but to some extent also from not published planning documents or personal communications from e.g. Helsinki Region Environmental Services Authority experts.

2.1.1 Mixed municipal solid waste

Mixed municipal solid waste is currently disposed of at landfill. The GHG emissions of waste disposed off at landfills depend on the conditions in the landfill and the composition of waste. In conditions modelled for the HMA landfill the emissions can be estimated at approx. 25 kg CH4 per tonne of mixed waste. The most significant factor is the share of degradable carbon, which is here estimated at 21%. When the methane concentration of landfill gas is estimated at 47%, the energy content of LFG is approx. 12 MJ/kg. At the LFG recovery rate of 71% one tonne of mixed waste provides an amount of energy equivalent to 1.6 GJ in the form of recaptured LFG. This LFG is utilized to produce electricity in a gas power plant, and this electricity is assumed to replace electricity purchased by the Helsinki Region Environmental Services Authority (emission factor 94 kg CO2-eqv./GJ). [2]

In the future, the mixed municipal solid waste will be incinerated. The energy content of mixed waste is estimated at 10 GJ/t, the emission factor for mixed waste incineration 40 kg CO2-eqv./GJ [3] and the energy yield 8.1 GJ/t. According to the current plans, mixed waste will substitute for using coal as fuel (emission factor 117 kg CO2-eqv./GJ).

2.1.2 Biowaste

Biowastes (including food and other organic waste from households, and garden wastes) are composted at a composting plant. Garden waste acts as a drying agent in the composting process, hence no additional stabilizing material is needed. Of the degradable carbon (65% of weight) some 3% is estimated to end up as methane. The end product is used in landscaping as a surface material either for landfill sites or outside landfill sites. The substrate commonly used in landscaping is a mixture of sand, nutrients and organic material, which may be either biowaste compost or peat. Biowaste is hence assumed to replace peat in this landscaping substrate. Collection of peat from peatlands generates greenhouse gas emissions through emissions to air from the peat exploiting areas and the exploiting machinery. Transportation of 80 km for the peat was assumed [4].

2.1.3 Paper

Separately collected paper is baled and delivered to a paper mill for de-inking and reuse in newsprint manufacturing thus decreasing the need for forestry operations and thermo-mechanical pulp (TMP) production. On one hand, TMP production is very electricity-intensive, but on the other hand, the process produces heat as a by-product. As TMP production decreases, the need for purchased electricity decreases. Simultaneously, however, the need for additional heat (from the power plant of the mill) increases, and also the fuel mixture used at the power plant changes. When less virgin wood materials are used, less biofuels are produced at the paper mill and thus the need for fossil fuels for the power generation at the paper mill increases. [5]. The emission factor for purchased electricity used for the calculation was 288 kg CO2-eqv./MWh. This represents the average for Finnish grid electricity in 2006-2008.

2.1.4 Cardboard

Recovered cardboard is baled, transported to fibre separation [6], and used in the manufacturing of core board at a core board mill. Core board is used for the manufacture of various rolls for e.g., paper, thread and plastic film. At the factory considered here, core board is manufactured from chemi-mechanical pulp (CMP), which consists of roughly 75% recovered fibre and 25% virgin fibre (birch). CMP is an intermediate form of mechanical pulp and chemical pulp that is not bleached. In the calculation, recovered cardboard was assumed to replace birch.

2.1.5 Glass

Separately collected glass is crushed, cleaned, sorted and utilized in the manufacturing of glass wool, glass containers (e.g. jars and bottles) and in earth works. According to the data from year 2007 the reuse in glass wool manufacturing accounted for 38% of the recovery, reuse in packaging 53% and use in earth works 9%. The avoided emissions of the recovery of glass were based on comparing the emissions from a process using 100% virgin material against using 72% recycled glass in glass wool production and 38% recycled glass in containers production [7]. In earth works one tonne of recycled glass was estimated to replace 0.64 tonne of gravel.

2.1.6 Metals

Separately collected metals are transported to sorting facility, where aluminium, steel and copper are separated and delivered to use in metals manufacturing. The separately collected metal fraction consists commonly of 53% tin-coated steel, 24% aluminium, 15% stainless steel and 9% others. Metal recycling avoids emissions from the ore based production. [8]

2.1.7 Energy waste

Energy waste consists primarily of wood, paper, cardboard, carton packaging and plastics collected from groceries, hospitals, restaurants and offices. It may also include small amounts of separated energy waste from households. The average energy content of energy waste was estimated at 20 GJ/t and the content of bio-based materials such as wood, paper fibre or other at 80%. The energy waste is utilized at an industrial combined heat and power (CHP) plant, where it replaces natural gas.

2.1.8 Plastics

Plastics from households is either collected as energy waste or mixed waste. Separate collection of plastics for recycling thus includes plastics from groceries, companies, offices and alike producing large amounts of homogenous plastics. To some extent plastics is reused e.g. in plastic bag and pipe manufacturing, but data on the proportions of different uses is lacking. Hence it was assumed that all separately collected plastics is reused in plastic profile manufacturing replacing impregnated wood. One tonne of plastics was assumed to replace 0.83 tonne of wood [9].

2.1.9 Waste electrical and electronic equipment

The collection and recovery of waste electrical and electronic equipment (WEEE) are the responsibility of the producers. In Finland some 9 kg of WEEE are collected per person per year [10]. Large appliances make up about half the mass of scrap collected. Other large WEEE components by mass are computer and telecommunications devices, and consumer electronics, which both make up about 21 % of the collected WEEE. Cathode ray tubes (CRT) from old TV-sets and computer monitors are included in these waste components. Based on the collected masses the smallest device groups are small appliances, lighting, electric and electronic tools, toys, leisure and sports equipment, medical devices, control and surveillance devices, and automats. These components make up about 7 % of the collected scrap. The composition of the devices varies very much, both in and between different groups of devices. Pre-treatment of WEEE is done manually. Further processing is usually mechanical, including reduction of the size of the components and classification and separation of materials to ensure a better recovery. Additional options are X-ray separation, chemical immersion-floating, and whirlpool separation.

Data on different processes in the WEEE-dismantling chain were not available, but the energy consumption of the mechanical pre-treatment was estimated to vary between 0.2–0.7 GJ/t WEEE. The share of different materials in WEEE was estimated based on statistics and literature [10]. Approximately 25% of the weight of WEEE is plastics, some of which is recycled into plastics production, some is incinerated and some is landfilled. No data was available on the share of different treatment or recovery options for plastics. Hence, in estimating the emissions avoided due to recycling of WEEE, only recovery of metals (approximately 62% of the weight of WEEE; iron, copper, aluminium) and glass (approximately 6% of the weight of WEEE) was considered. From the calculated total amount of emissions avoided, the share of metals recycling is almost 98%.

2.1.10 Wood

Separately collected wood is chipped [6] and delivered to small district heat plants for energy recovery. The energy yield in such small plants is generally high, here 90% yield was assumed. Wood was assumed to replace oil as fuel.

2.1.11 Hazardous waste

Due to lack of data, all hazardous waste were assumed to be treated by burning. The emission factor for hazardous waste incineration was derived from the largest operator, Oy Ekokem Ltd. No avoided emissions were included. This overestimates the emissions from hazardous waste treatment, due to the fact that some of the energy produced compensates for other energy production. Data on the share was, however, not available.

2.1.12 Construction and demolition waste

The composition of construction and demolition (C&D) waste was estimated on the basis of information gathered from different operators. 67% of the C&D waste was estimated to be mineral waste (concrete), 13% wood, 14% mixed waste and

2% metals. The shares of other waste fractions were less than 2%. The concrete is crushed, iron is separated and delivered to metals manufacturing. The concrete crush is utilized in earth works instead of gravel. For the other fractions of C&D, the treatment and recovery processes described above were assumed.

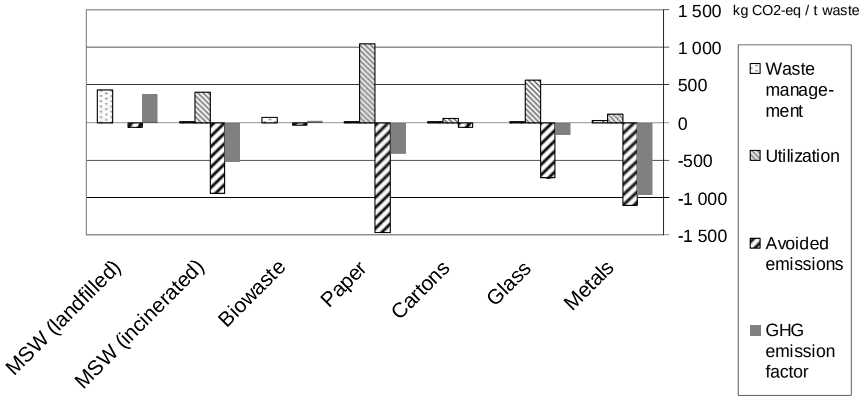
2.1.13 Sewage sludge

Sewage sludge from the municipal waste water treatment plant is digested and composted [6]. The anaerobic digestion process produces 694 MJ energy/ t of sewage sludge. 260 MJ of this energy is electricity, which replaces the use of grid electricity purchased by the Helsinki Region Environmental Services Authority. The solid reject of digestion is composted and this compost product is assumed to replace peat in landscaping substrate similarly to biowaste compost.

3 Results and discussion

3.1 Greenhouse gas emission factors

Studies and calculations show that GHG emissions of the waste management are generated mainly in the processes connected to waste utilization (Figure 1), where the main contributor is the energy consumption of the processes. The main sources of emissions from the waste treatment processes are landfilling or composting of biodegradable waste, which both produce methane emissions. Avoided emissions clearly dominate the overall GHG emissions and therefore the selection of especially the avoided fuels in energy production should be based on the most realistic local situation.



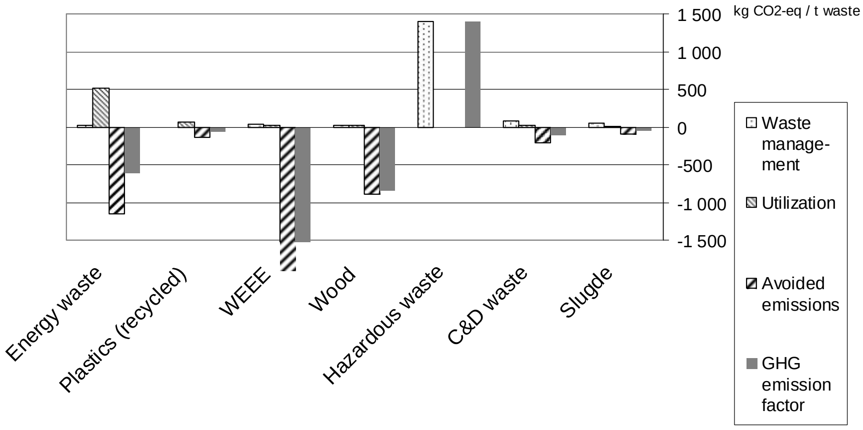


Figure 1: GHG emissions of the different waste components in Helsinki Region. Waste management includes collection, transportation, pre-treatment and treatment of waste. Utilization includes the processes needed for the recycling of the material or recovery of the energy. Avoided emissions include emissions from the processes potentially not needed due to the recycling or recovery of waste.

3.2 Greenhouse gas calculators

The GHG emission factors produced in the Julia 2030 project will be used for the development of waste management GHG emissions calculators for households, for the organizers of waste management in practice and for enterprises. The calculator for household wastes (KONSTA) is a web-based waste amount calculator, which shows households the climate impact of their wastes and compares the results to other households. The Material Flow Accounting system calculator (MARTTI) incorporates data on nearly all wastes generated in the Helsinki Region and on the ways in which waste is processed. The GHG calculator will be added to the system and the information will be used by the HSY in planning the waste management and assessing the climate impacts of it. The waste benchmarking system (PETRA) for companies and organisations in the Helsinki region enables enterprises to compare the waste volumes generated at their places of business with other enterprises operating in the same industry. The system helps organisations to improve the efficiency of solid waste management and reduce the amount and impacts of waste generated.

4 Conclusions

In the EU Life+ funded Julia 2030 project GHG emission factors in Helsinki region's waste management were calculated using the LCA methodology. The GHG emission factors of all the significant waste components will be used in three waste calculators in order to disseminate the information of climate impacts and reduction potentials from waste management and to prevent wastes in different target groups. The GHG reduction potential of waste prevention was not assessed in the project and one of the challenges in using the new GHG calculators and communications with public is thus to point out the limited role of the waste management in comparison to waste prevention. By taking into account for example the production and delivery of consumer goods the positive climate impact of waste prevention would appear in a totally different scale. GHG emission factors are time and area specific, so it means that the calculations must be updated regularly and especially when major changes in the waste management system are introduced.

5 References

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