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Memo SUSTAINABLE INNOVATION

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English summary of the report:
Klimaregnskap for avfallshåndtering, Fase I og II

Climate accounts of waste management systems in Norway

Phase I: Glass packaging, metal packaging, paper, cardboard, plastic packaging an food waste
Phase II: Residual waste and wood waste

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Rapport SUSTAINABLE INNOVATION

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Klimaregnskap for avfallshåndtering, Fase I og II

Fase 1: Glassemballasje, metallemballasje, papir, papp, plastemballasje og våtorganisk avfall
Fase 2: Treavfall og restavfall fra husholdninger

Introduction

This study has been commissioned by Waste Management Norway (Avfall Norge) and 18 municipalities/waste management companies in Norway due to increased attention to greenhouse gas emissions and climate change. The goal of the project was to develop a model for calculating Global Warming Potential (GWP) for different treatment options for the different waste types: glass packaging, metal packaging, paper, cardboard, plastic packaging, food waste, wood waste and residual waste.

The model is based on Life Cycle Assessment methodology (LCA) and has been employed to calculate the Global Warming Potential (GWP) per kilogram waste for the different treatment options and waste types. Based on the model, the GWP from waste handled within Norway in 2006 has been calculated.

The model has two main areas of use:

- Comparison of total GWP for different waste treatment options of different waste types. This may be used for evaluating waste management options and may form a basis for decision making.
- Development of climate accounts for waste handling in specific municipalities/regions/cities. The climate accounts for waste may contribute to a regions total climate accounts.

The model

The following waste management options are included in the model for the waste types glass packaging, metal packaging, paper, cardboard and plastic packaging (Phase I):

- Landfill
- Energy recovery
- Recycling (includes biological treatment (biogas and composting) for food waste)

The analysed systems are summarised for the different waste types: glass packaging, metal packaging, paper, cardboard and plastic packaging (Phase I) in Figure a below.

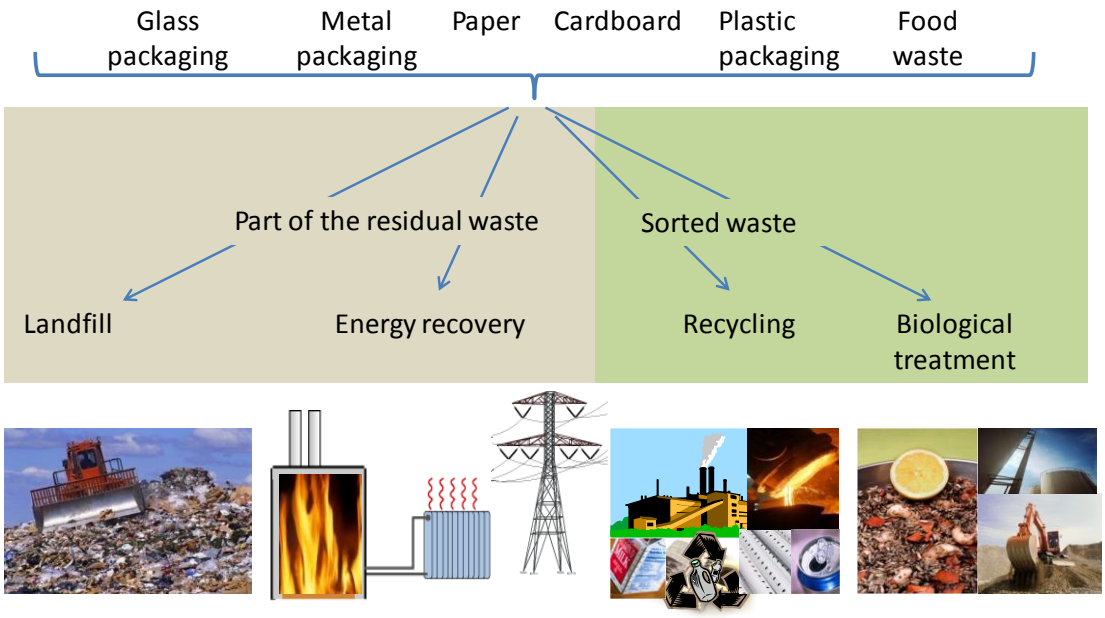

Figure a: The analysed systems for the waste types glass packaging, metal packaging, paper, cardboard and plastic packaging (Phase I)

Further the waste management options landfill and energy recovery are analysed for wood waste and residual waste (Phase II). The model also includes wood waste spread within compost, but this is not analysed separately as it is included in the analysis of composting of food waste. The analysed systems for wood waste and residual waste (Phase II) are summarised in Figure b below.

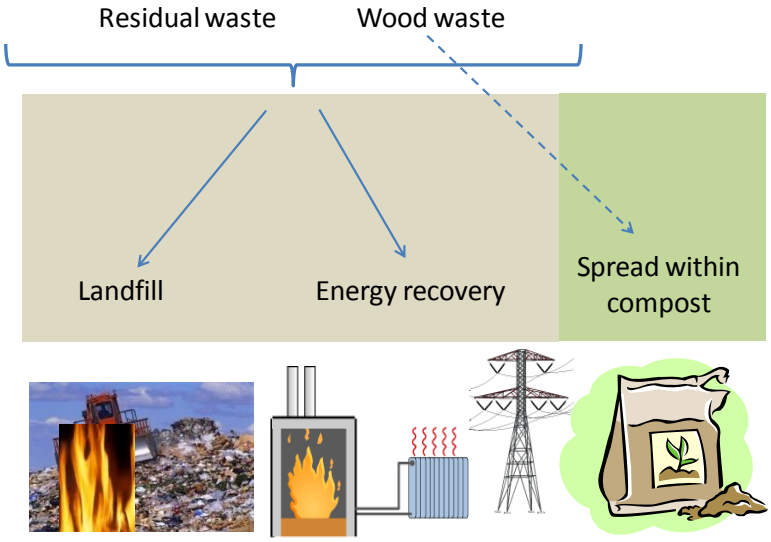

Figure b: The analysed systems for wood waste and residual waste (Phase II)

The model includes a number of general and specific parameters. Some of the parameters depend strongly on local conditions and can easily be changed using the model (called basic parameters), while others are fixed.

The chosen basic parameters presented in the results in the report represent average values of Norwegian waste types and management options for the year 2006. Examples of basic parameters are transport distances and means of utilisation of energy from incineration plants. These parameters can easily be changed or supplemented in the model when calculating global warming potential for one specific municipality or region. The choice of basic parameter values is important because the decision may have a large impact on the result of the analysis. Both the geographical/local conditions and the goal/scope of the study are important when considering values for the basic parameters and main assumptions used in the utilisation of the model.

In addition to the defined basic parameters, the model includes several fixed parameters and processes, for example emission data for CO_2 for transport, recycling and incineration processes, landfill emissions etc.

Main assumptions

The characterisation method for calculating the Global Warming Potential (GWP) is based on IPCC 2001 GWP 100a[1] v.1.04, adjusted for updated methane data for 2005 (IPCC). Emissions of CO_2 from the combustion of biomass are defined as zero, based on the assumption that biomasses absorb as much carbon from the atmosphere when growing as they release when biodegraded or burned.

The results of the analysis have shown that the most critical assumptions for GWP calculations of waste management systems are:

[1] The Global Warming Potential is based on a time horizon of 100 years

- How the energy generated from incineration plants (heat and electricity) is exploited and what kind of energy carrier the generated energy is assumed to replace.
- How the produced biogas is exploited and what kind of energy carriers the energy produced from biogas is assumed to replace.
- What kind of raw materials the recycled materials are assumed to replaced.

The decision of what kind of energy carriers the energy generated from waste is assumed to replace depends both on the goal/scope of the study (attributional/historical perspective or a consequential perspective), as well as local conditions.

In this study it is assumed that the heat energy generated from waste replaces the Norwegian mix of energy carriers used for district heat purposes in 2006 (attributional/historical perspective). A scenario for the replacement of other energy carriers (a mix of oil and electricity) is also calculated, to indicate the importance of the decision of these assumptions.

Should the model be used to describe a future situation, calculations for several scenarios for the replacement of energy carriers for both electricity and heat production should be performed, to show the importance of these assumptions and evaluate the results related to this.

Conclusions for an 'overall' system (e.g. waste management in Norway) may not be representative for the ones for a 'smaller' system (e.g. waste management in a specific municipality). The reason is that the overall system is based on average assumptions concerning for example the replacement of energy carriers, while a smaller system may use specific data for the use and replacement of energy carriers.

Global warming potential (GWP) per kg of waste

The results for the GWP for the different waste management options and waste types are summarized in the figure below.

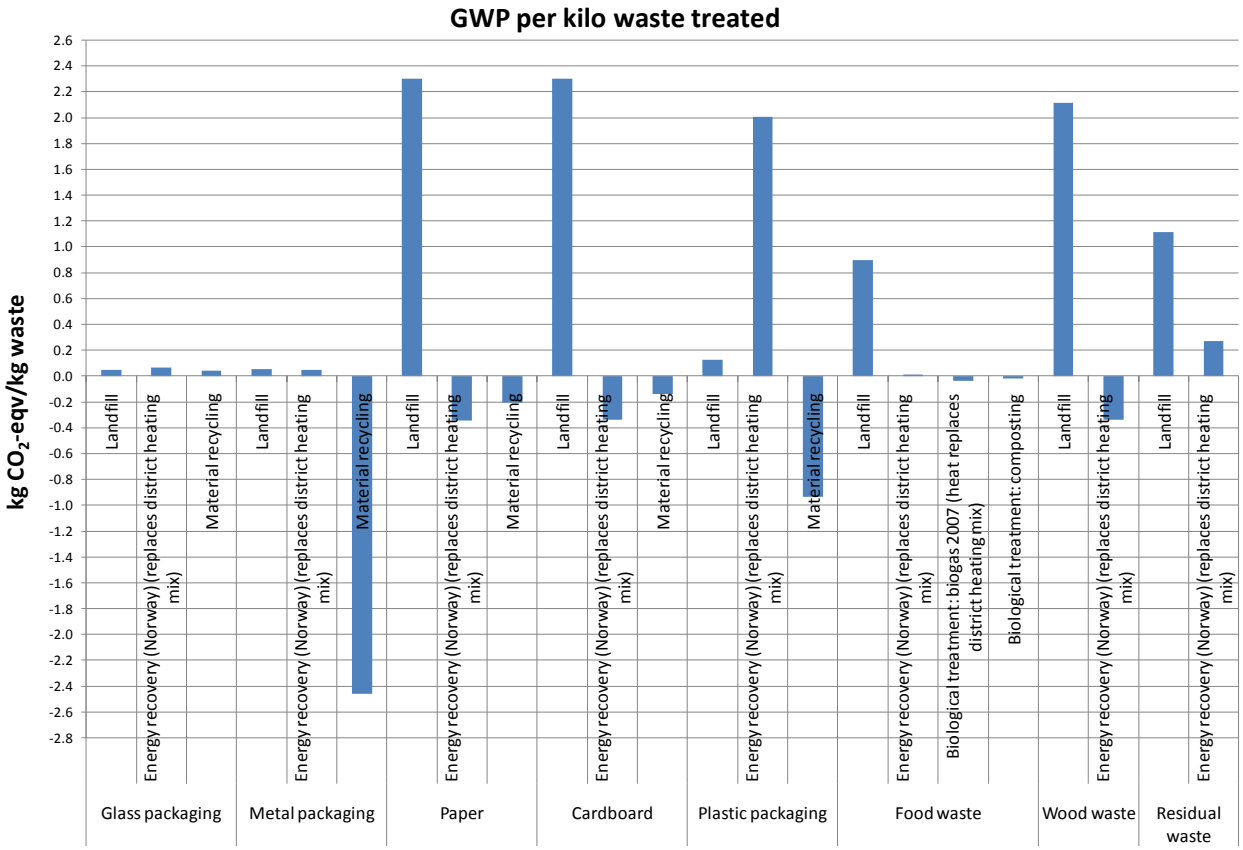

Figure c: Global Warming Potential for waste management of all the analysed waste types and options (emissions per kg).

The figure shows that the results vary considerably and are dependent on both the waste type and the waste management option. Land filling of all degradable waste types (paper, cardboard, food waste and wood waste), as well as incineration of plastic packaging result in the highest greenhouse gas emissions per kg waste. These results clearly emphasises the importance of the Norwegian legislations against landfill for degradable waste. The greatest GWP benefits per kg waste are achieved from recycling of metal and plastic packaging.

The results from the main analysis give the following ranking of the treatment options for the different waste types in relation to the Global Warming Potential:

- Recycling is the most beneficial treatment option for glass, metal and plastic packaging.
- Biological treatment (biogas production) is the most beneficial treatment option for food waste
- Energy recovery (incineration) is the most beneficial treatment option for paper and cardboard.
- Landfill result in the largest global warming potential for all the analysed waste types, except plastic and glass packaging.
- Energy recovery (incineration) is the most beneficial treatment option for treatment of 1 kg residual waste with ‘average composition for 2006’ in Norway. The composition of the residual waste has a large impact on the greenhouse gas emissions. Analysis of 1 kg of residual waste must not be used as a basis for decisions alone and must

always be seen in the context of the total amount of waste treated, and the amount of waste sorted and sent to recycling.

Other studies

Relevant international literature has been reviewed (WRAP, 2006, European Topic Centre on Waste and Material Flows, 2004, Frees et. al., 2005, Björklund et al., 2005) to compare the results achieved in this study to previous studies. The review has shown that the results for the global warming potential are robust for the waste types glass packaging, metal packaging, plastic packaging and food waste. For these waste types, recycling is the most beneficial treatment option. Further, the studied literature states that recycling is also the most beneficial treatment option for all other analysed environmental impact categories (e.g. energy use, acidification, eutrophication, land use, toxicity etc).

For the fibre waste types paper and cardboard, the conclusions for the calculated GWP are equal to the conclusions from the review; saying that the greenhouse gas emissions from the waste management options strongly depends on the assessments concerning the use and replacement of fossil fuel in the systems that are compared (recycling and energy recovery). The review also shows that the results for almost all other environmental impact categories, except GWP (e.g. energy use, acidification, eutrophication, land use, toxicity etc), conclude that recycling is the most beneficial treatment option for paper and cardboard. This is exemplified, for this study, for the category Energy use, see Figure d below.

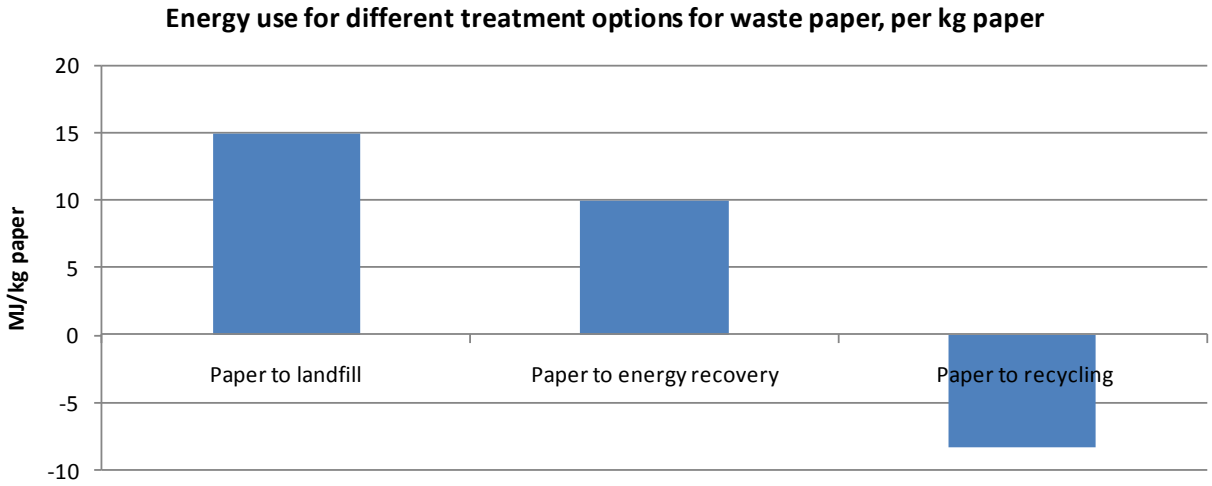

Figure d: Energy use for different waste management options of paper.

These results show that considering only one environmental impact category give a too narrow perspective for decision-making in waste management systems.

Global warming potential for waste management in Norway in 2006

The model has been applied to calculate that the total GWP for waste treatment of the included waste types from the waste sources households, industry, construction and building sector and service sector in 2006 (a total of 4.1 million tonnes) is 851,000 tonnes CO_2-equivalents. This is presented in the figures e and f below, distributed on GWP from sorted waste types (Figure e) an total GWP from wood waste, residual waste from households and residual waste from other sources (Figure f).

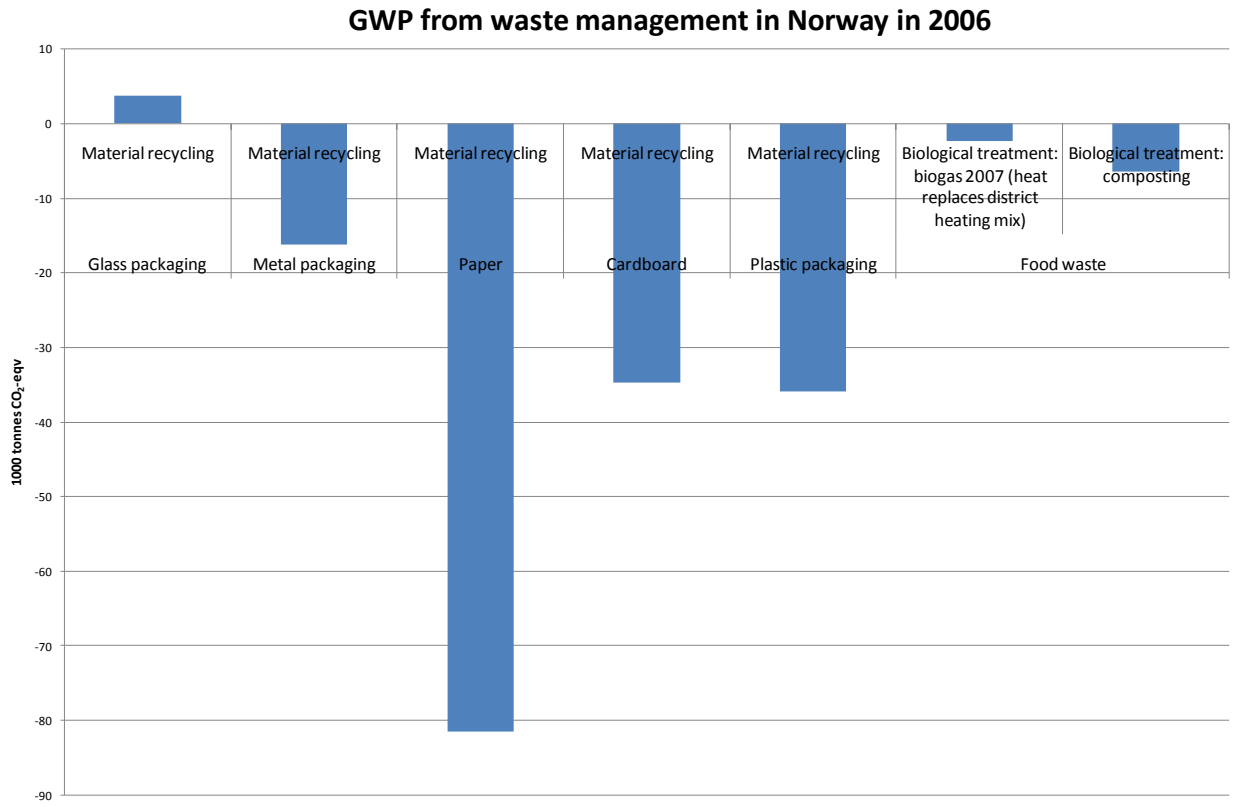

Figure e: Total GWP from treatment of recycled waste types in Norway in 2006.

The total GWP saved due to waste treatment of the sorted waste types in 2006 (a total of 1.3 million tonnes) is calculated to be 173,000 tonnes CO_2-equivalents.

The figure below shows GWP from landfill and energy recovery of the different waste types in 2006. Note that the scale in Figure e is not the same as Figure f.

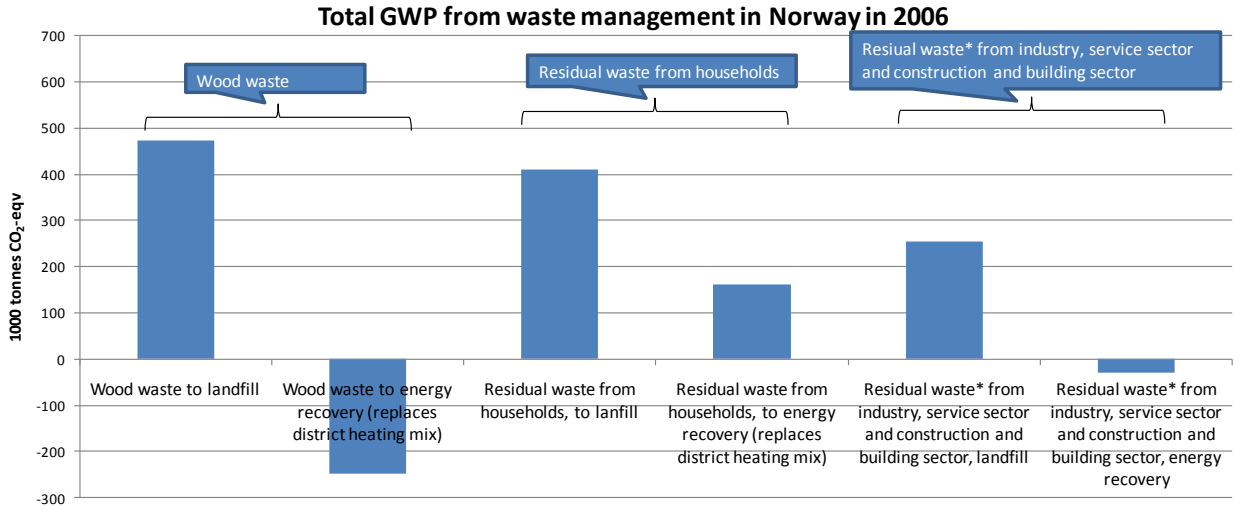

Figure f: Total GWP from waste treatment of wood waste, residual waste from households and residual waste from other sources in Norway in 2006.

* For residual waste from industry, service sector and construction and building sector, only the waste types paper, cardboard, glass packaging, metal packaging, plastic packaging and food waste are included.

The total GWP from waste treatment of wood waste, residual waste from households and residual waste* from other sources in Norway in 2006 (a total of 2.8 million tonnes) is calculated to be 1 million tonnes CO_2-equivalents.

The total GWP from waste treatment of all analysed types of waste included in the model from the waste sources household, industry, construction and building sector and service sector in Norway in 2006 (a total of 4.1 million tonnes) is calculated to be 851.000 million tonnes CO_2-equivalents. This equals annual GWP from about 243,000 cars.

In addition the total GWP from a created 'realistic optimal scenario' is analysed. This scenario only includes waste from households and assumes that the percentages of sorted waste for food waste and plastic packaging in the households are increased to 75% and 44% respectively, and that all paper that today is sent to landfill is sent to energy recovery. This results in a 'new' residual waste composition and an assumption that 95% of the residual waste is sent to energy recovery and that 5% is sent to landfill. For wood waste a 95%/5% distribution of energy recovery and landfill is assumed. The total of GWP in 2006 for treatment of household waste with a realistic optimal scenario is reduced from 689,000 tonnes CO_2-equivalents to 2,000 tonnes CO_2 equivalents, resulting in a nearly climate neutral waste management system for household waste in Norway.

Conclusions

The main conclusions from the project are summarised below:

1. Considering only one environmental impact category gives a too narrow perspective for decision-making for waste management systems.
2. The Global Warming Potential (GWP) for waste management systems vary to a great degree both between the considered waste types and management options. The results from the main analyses (with the considered assumptions) show that:
   - Recycling is the most beneficial treatment method for glass packaging, metal packaging and plastics packaging.
   - Biogas production is the most beneficial treatment method for food waste.
   - Energy recovery is the most beneficial treatment method for paper, cardboard and wood waste.
   - Landfill gives the largest global warming potential for all the analysed waste types, except plastics and glass packaging.
   - For residual waste the composition has a large impact on the GWP for landfill and energy recovery of the waste. The composition varies both with what types of waste that are disposed and the recycling systems offered in the different regions. This may vary with density of the population and the motivation of the population to recycle. Energy recovery results in the lowest greenhouse gas emission for an "average composition" of residual waste in Norway.
   - Analysis of residual waste must always be considered in context with the total amount of waste and treatment of the sorted waste types, as well as total amounts and composition of residual waste. This is important to avoid a system that is sub optimised.
   - Transport related emissions have generally a small impact on the results compared to the environmental benefit gained by material recycling or energy recovery.
3. The model has been applied to calculate that the total GWP from waste management of approximately 4.1 tonnes of Norwegian waste handled in 2006 resulted in emissions of 851,000 tonnes CO_2-equivalents. This amount equals the annual CO_2-emissions from approximately 243,000 cars.
4. An optimal handling (related to GWP) of all the analysed waste, will contribute to making the waste management of household waste in Norway nearly climate neutral.
5. The decision and choice of values for the basic parameters are important for the analysis results and depends both on the goal/scope of the study as well as local conditions.
6. Relevant international literature has been reviewed to justify the results achieved from this study. This can be summarised as follows:
   a. The results for global warming potential are very robust for the waste types glass packaging, metal packaging, plastics packaging and food waste, which shows, for all these waste types, that recycling is the most beneficial treatment option. According to the review, recycling is also the most beneficial treatment option for almost all other analysed environmental impact categories.

   b. For the fibre waste types paper and cardboard, the conclusions for the calculated GWP are equal to the conclusions from the review; saying that the

GWP impact from the waste management options strongly depends on the assessments concerning the use and replacement of fossil fuel in the systems that are compared (recycling and energy recovery). This is presented by calculating two sensibility analyses for treatment of paper, showing that the ranking between recycling and incineration is sensitive for these assumptions.

c. The results for almost all other impact categories (except GWP), e.g. energy use, acidification, eutrophication, land use, toxicity etc., show that recycling is the most beneficial treatment option for paper and cardboard. This is exemplified, for this study, for the impact category Energy use, showing that recycling gives the greatest energy savings.

7. The work carried out in the project has shown that waste management represents complex systems.

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