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Energy from waste
Potential contribution to EU renewable energy and CO_2 reduction targets

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utveckling

Preface

This report shows the potential contribution to accomplish EU targets for renewable energy and greenhouse gas reduction targets to 2020. The Swedish waste sector has reduced the emission of greenhouse gases by 34 per cent during the years 1990-2006 and for the years 1990-2020, the estimated reduction will reach 76 per cent. Is it possible to do the same in EU?

The study examines the possible energy recovery from the renewable waste quantities that remain after material recycling and biological treatment. Thereby, it is stressed that energy recovery in this study does not undermine the possibilities to reach EU targets on material recycling.

Profu AB accomplished the project.

Malmö October 2009

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Summary and main conclusions:

The aim of this study is to examine the potential for energy recovery from renewable waste fractions regarding its possible contribution to accomplishing the European renewable energy- and climate goals to 2020. A secondary goal is to increase the knowledge of energy recovery from waste and raise the awareness of its potential as energy source.

The study examines the possible energy recovery from the renewable waste quantities that remain after material recycling and biological treatment. Thereby, it is stressed that energy recovery in this study does not undermine the possibilities to reach EU targets on material recycling. Thus, the contribution to the targets to reduce CO_2 emissions and increase the use of renewable energy from the renewable waste streams is calculated after material recycling and biological treatment on waste that else would have been landfilled.

Additionally, the study assumes the introduction of a target on biological treatment (composting and anaerobic digestion), based on an existing green paper of the topic. Thus, the alternative treatment method to energy recovery for the waste to energy recovery in this study is landfilling.

In this report the name renewable waste is used for the whole non-fossil part of the waste streams. The study covers the vast majority of the renewable waste generated within EU27 by including both municipal solid waste and industrial waste. The waste originates from non-fossil sources and constitutes thus renewable waste fractions. These waste fractions are sometimes also called biodegradable waste streams. A part of the renewable waste is easily biodegradable and thus possible to treat with biological treatment methods such as composting or anaerobic digestion. Most of the waste fractions are combustible. Agricultural waste and sludge are excluded.

The data on waste quantities of 2006 comes from the Eurostat database. Several scenarios for waste growth until 2020 are evaluated. The main scenarios are based on two extremes of the upcoming waste amounts: (1) an increase of waste quantities with economic growth and (2) an absolute decoupling between the two.

Results

The main result and conclusion from the study is that energy from waste has the potential of being an important energy source in Europe. Renewable waste fractions can significantly contribute to the common goals of increased use of renewable energy and also reducing the emissions of greenhouse gases. The study shows that the renewable parts of the waste streams, for the waste that remains after material recycling, can contribute with as much as **20% of the target to increase the use of renewable energy with 20% to 2020** and as much as **30% of the total reduction target for CO_2 to 2020**.

The large reduction of greenhouse gases that results from energy recovery from waste has two reasons: (1) the avoidance of landfilling the waste and thus avoiding methane emissions from the landfills; and (2) from replacing fossil fuels for heat and electricity production. 15% is gained from avoiding landfilling and 16% is gained from replacing fossil fuels. Thus, the avoided landfill emissions, which are often

forgotten, are in a greenhouse gas perspective of the same significance as the replacement of fossil fuels.

These very large contributions to the targets for renewable energy and greenhouse gas reduction demonstrate the potential for waste to energy options. They can be achieved but not easily. These changes require large investments in both incineration plants and district heating systems which are difficult to realize especially in such a short time period as until 2020. It would be easier and perhaps more realistic to assume that incineration can continue to expand in the same speed that have been experienced during the past 10 to 15 years. If so, waste to energy would contribute with **4% of the target to increase the use of renewable energy with 20% to 2020** and **14% of the total reduction target for CO_2 to 2020**. Even with this more conservative expansion rate, waste to energy can be an important option for reaching the targets.

The main conclusions from the study are listed below.

Conclusions regarding the target to achieve at least 20% reduction of green house gas emissions by 2020:

1. Based on the energy content of the renewable waste, **energy recovery from waste could contribute with 34% of the total reduction target for CO_2 to year 2020**. Approximately 14% is gained from avoiding landfilling and 20% is gained from replacing fossil fuels. There are uncertainties in data and assumptions that can change this conclusion. For instance if coal is assumed to be the alternative fuel instead of the modelling mix used here, the total reduction would be as much as 45%. There are also large differences in measurements for landfills which could alter the assumption for avoided emissions at landfills (both up and down).
   This is, as mentioned above, a calculated value that shows the maximum potential based on the energy contents of the renewable share of the waste, alone. No consideration is here taken to possible offset of the energy and technical limitations in building all these incinerations plants and district heating systems. However, it is possible for some of the studied EU27 countries to nearly reach this level in 2020.

2. If it instead is assumed that all new plants will be built with the same energy efficiencies that are seen in the EU27 countries today, **the contribution to the reduction target for CO_2 to year 2020 would be 26%.** This value reflects the differences in infrastructure between the countries that can be found today where some countries have small possibilities to utilize the heat in district heating systems or industries

3. The potential for energy recovery from waste would be somewhere between these two values, thus between 26% and 34%. An average value of 30% will be used in this report to illustrate a practical potential that can be achieved if large efforts are made by the EU27 countries. Thus, **the contribution from energy recovery from waste to the reduction target forCO_2 can be as high as 30% of the total target for 2020**.

4. The above contributions require a large expansion of new incineration plants. If it is assumed that waste incineration will continue to increase with the rate as seen historically, **renewable waste would contribute to 14% of the EU goal to reduce GHG emissions with 20% to 2020**. Of the result, 6% comes from replacing fossil fuels and 8% from avoiding landfilling. The alternative fuel mix consists of natural gas 9%; coal 82%; biofuels 5%; wind 5%, and is calculated by using the comprehensive energy model Markal.

All four calculated results, contributing to the target, are illustrated in figure A.

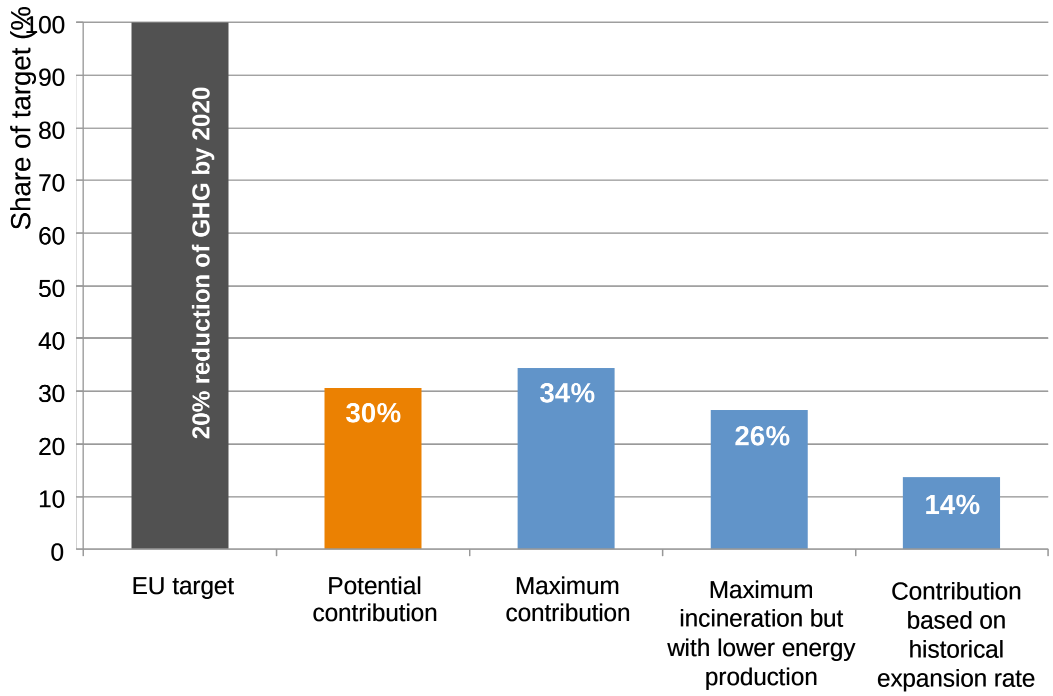

Figure A: Contribution from energy recovery from waste to the target to decrease the greenhouse gas emissions to 20% by 2020 within EU27.

Conclusions regarding the target to increase the share of renewable energy to 20% by 2020:

5. Based on the energy content of the renewable waste, **energy recovery from waste could contribute to 20% of the target of 20% renewable energy in year 2020**. Taking into account energy from biogas the contribution might be 22%. This is a calculated value that shows the maximum potential based on the energy contents of the renewable share of the waste, alone. No consideration is here taken to possible offset of the energy generated or to technical limitations in building the large amount of incinerations plants and district heating systems. However, it is possible for some of the studied EU27 countries to nearly reach this level in 2020.

6. If it is assumed instead that all new plants will be built with the same energy efficiencies that are seen in the EU27 countries today, **the contribution to the target to increase renewable energy could be up to 15%.** This value reflects the differences in infrastructure be-

tween the countries that can be found today where some countries have small possibilities to utilize the heat in district heating systems or industries

7. The potential for energy recovery from waste would be somewhere between these two values, thus between 15% and 20%. An average value of 17% will be used in this report to illustrate a practical potential that can be achieved if large efforts are made by the EU27 countries. Thus, **the contribution from energy recovery from waste to the target to increase renewable energy can be as high as 17% of the total target for 2020**.

8. The above contributions require a relatively large expansion of new incineration plants. If it is assumed that waste incineration will continue to increase in the same speed as was seen previously, **waste to energy could contribute with 4% of the target to increase the use of renewable energy with 20% to 2020**. The historical increase of waste incineration capacity was 13 Mtonne new capacity from 1995 to 2005.

All four calculated contributions to the target are illustrated in figure B.

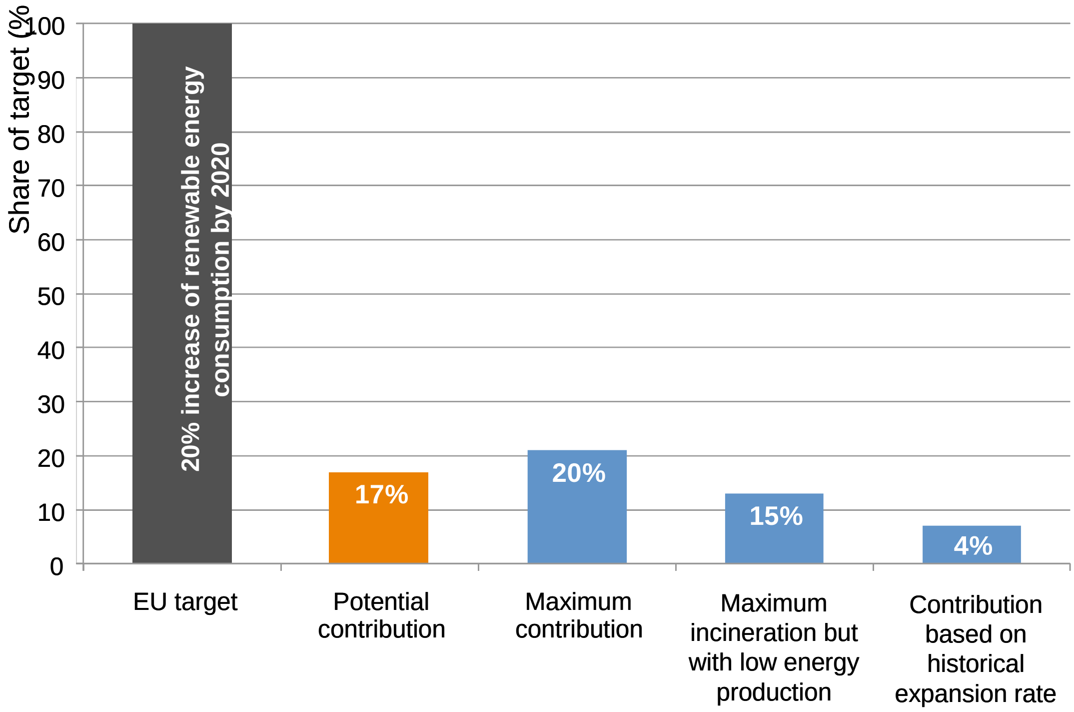

Figure B: Contribution from energy recovery from waste to the target to increase the share of renewable energy to 20% by 2020 within EU27.

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1. Introduction

The aim of this report is to examine the potential of energy recovery from renewable waste regarding its possible contribution to accomplishing the European energy- and climate goals to 2020. A secondary goal is to increase the knowledge of energy recovery from waste and raise the awareness of its potential as energy source.

The studied waste types originate from industries and households, and only renewable waste is considered in all scenarios. The main waste types are: waste wood, renewable waste from food preparation and products, renewable textiles, renewable waste in mixed waste from household and industrial and paper and cardboard.

Sludge from municipalities and industries, ashes from energy facilities as well as sorting residues from waste management are not included in the study.

Consideration is taken to targets for material recycling in all scenarios, for the waste fractions affected, so that energy from waste not is to diminish the possibilities of accomplishing these targets.

In 2008, Swedish Waste Management (Avfall Sverige) published the study *Energy from Waste - An international perspective*. This project is a separate follow up study.

2. Background

The Community has set four major energy and climate goals until 2020:

- 20 % greenhouse gas reduction
- 20 % decrease in energy consumption
- 20 % increase in the share of renewables in energy consumption
- 10 % share of biofuels in transport fuel consumption

The aim of this study is to investigate how a potential development for energy recovery from waste can contribute to the achievement of these goals.

There are several driving forces that facilitate or offset future energy recovery from waste. The Waste Framework Directive (2008/98/EC) and the Directive (1999/31/EC) on landfill of waste are two directives that currently to a large extent affect waste management in Europe.

The four community goals and, for this project, central parts of the Waste Framework and the Landfill Directive are presented in section 1.1 (Community Policy). Waste generation and treatment statistics are presented in section 1.2 (Waste generation and treatment).

20 % Greenhouse gas reduction

In order to transform Europe into a highly energy-efficient and low-green house gas emitting economy the Community has made a commitment to achieve at least 20 % reduction of green house gas emissions by 2020 compared to 1990 (Decision No 406/2009/EG). In order to fulfil the commitment, each member state shall by 2020 limit its greenhouse gas (GHG) emissions in relation to its GHG emissions in 2005. Each Member states reduction target is based on the principle of solidarity between Member States and the need for sustainable economic growth across the Community, taking into account the relative per capita GDP of Member States. Figure 2.1 shows that 15 of the Member States have to reduce their emission levels while the remaining 12 Member States have the possibility to increase their emission level compared to 2005.

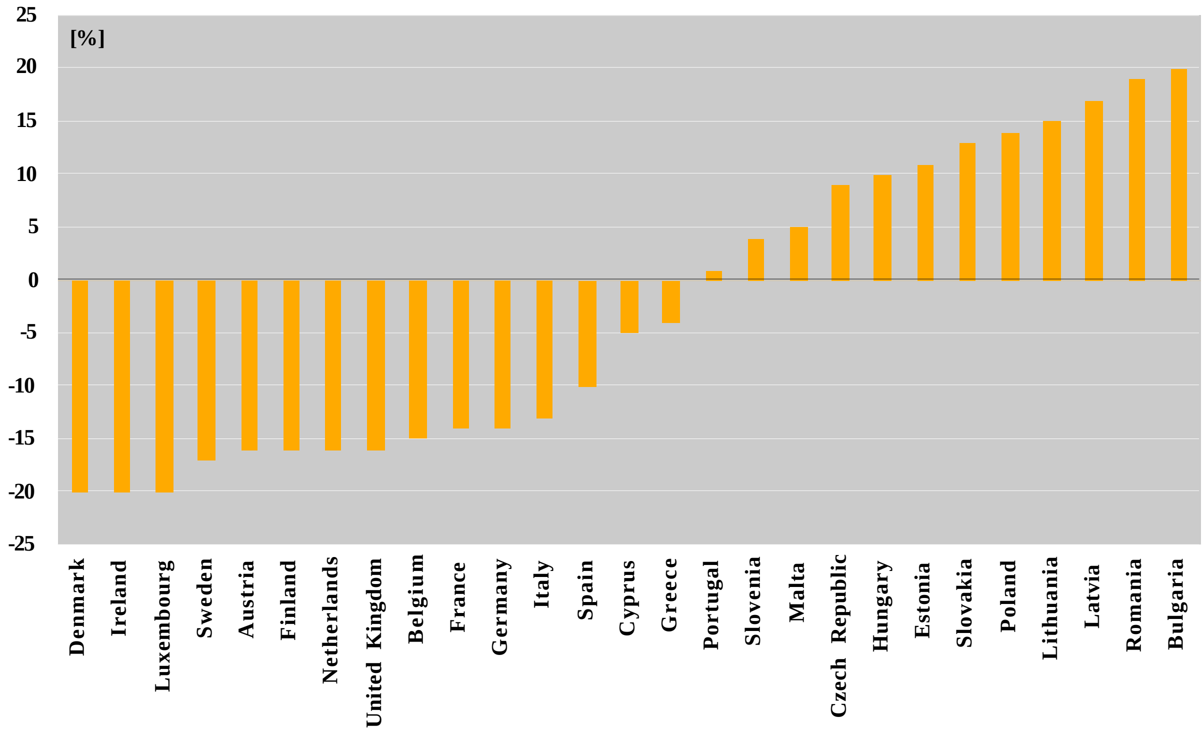


Figure 2.1 Member State greenhouse gas emission reduction until 2020. Negative values represent a minimum percentage of which the member state has to reduce its GHG emissions compared to its GHG emission level in 2005. Positive values represent the maximum allowed increase in GHG emission level for a member state compared to its level in 2005.

20 % decrease in energy consumption

Energy efficiency improvements are a crucial element for the Community and its Member States to reach the Community goals. By 2020 each Member State therefore has to decrease its energy consumption with 20 % compared to its projected energy consumption for 2020 (Decision No 406/2009/EG).

20 % increase in the share of renewable energy in energy consumption

Another Community target is to increase the share of renewable energy in final energy demand or consumption to 20 % by 2020. The target has been transformed into individual targets for each Member State based on factors such as: the starting point, renewable energy potential, existing level of energy from renewable sources, energy mix and GDP (Gross Domestic Product). Each member state’s level is given in Figure 2.2.

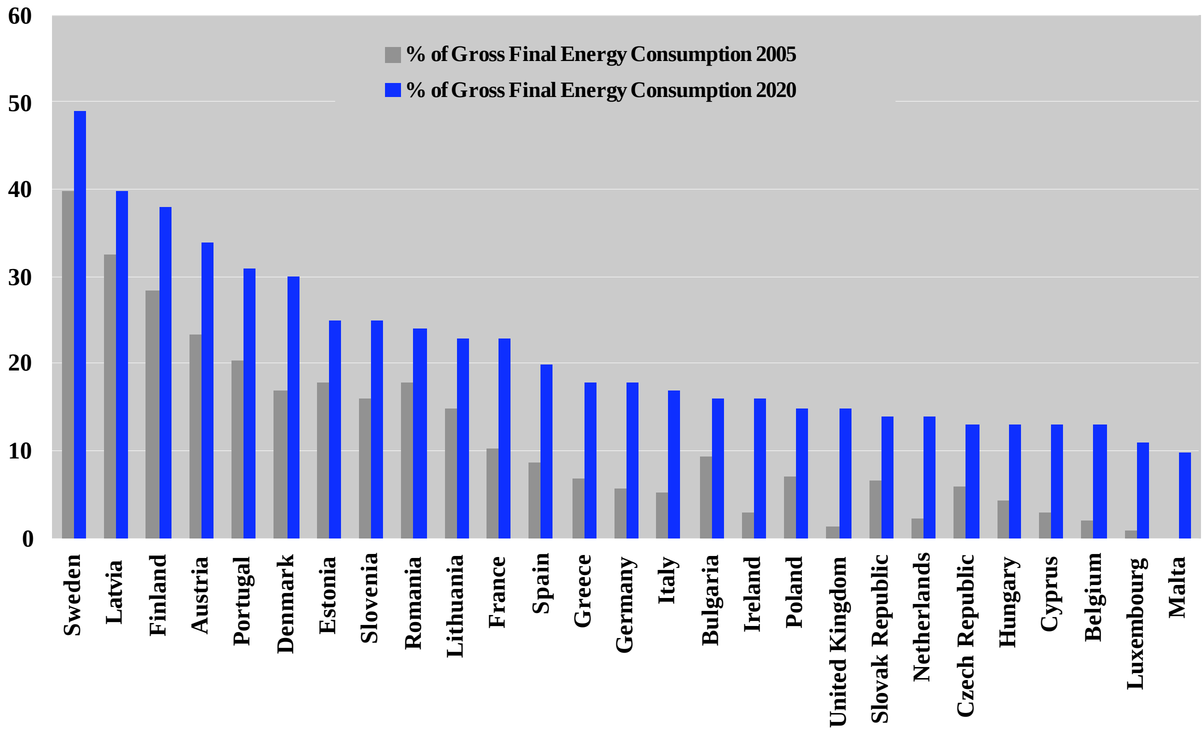


Figure 2.2 Share of renewables as percentage of Gross Final Energy Consumption 2005 and target shares of renewables as a percentage of Gross Final Energy Consumption 2020

10 % share of biofuels in transport fuel consumption

Each Member State shall ensure that the share of energy from renewable sources in fuels for all forms of transport in 2020 is at least 10 %. (Directive 2009/28/EC).

Waste Framework Directive

The Waste Framework Directive (2008/98/EC) is the central pillar in waste management. It defines the waste hierarchy as

1. prevention
2. preparing for re-use
3. recycling
4. other recovery, e.g. energy recovery
5. disposal.

The hierarchy shall be applied as a priority order in waste prevention and management legislation. However, Member States shall take measures to encourage the options that deliver the best overall environmental outcome. This may require specific waste streams departing from the hierarchy where this is justified by life-cycle thinking on the overall impacts of the generation and management of such waste.

The framework also sets recycling and re-use target rates for different waste streams. The most important targets for the outcome in this project are:

- At latest 2020 a minimum of 50 % by weight of paper, metal, plastic and glass from households (and possibly also from household similar waste generated in industrial sectors) shall be prepared for re-use and recycling
- At latest 2020 a minimum of 70 % by weight of construction and demolition waste shall be prepared for re-use, recycling and other material recovery

According to the directive Member States shall also take measures to encourage:

- Separate collection of bio-waste with a view to the composting and digestion of bio-waste
- Treatment of bio-waste in a way that fulfils a high level of environmental protection
- Use of environmentally safe materials produced from bio-waste

The Commission shall, according to the waste directive carry out an assessment on the management of biodegradable waste with a view to submitting a proposal if appropriate. The assessment shall examine the opportunity of setting minimum requirements for bio-waste management and quality criteria for compost and digest from bio-waste, in order to guarantee a high level of protection for human health and the environment.

The framework's call upon the Commission has so far resulted in a green paper *(Green paper on the management of bio-waste in the European Union)*. In late 2009 the Commission intends to present its analysis of the responses to the Green Paper and if appropriate its proposals and/or initiatives for an EU strategy on the management of bio-waste.

Decrease in landfilling

The purpose with the Directive 1999/31/EC on the landfill of waste is to decrease the negative environmental effects of landfilling. Compared to the produced amount of Municipal Solid Waste (MSW) 1995, the renewable fraction of MSW allowed to be landfilled corresponds to at most

- 75 % (by July 16th 2006)
- 50 % (by July 16th 2009)
- 35 % (by July 16th 2016)

Instead of landfilling, alternatives such as reuse, composting, biogas production, material- or energy recovery should be used. European member states landfilling more than 80 % of their MSW in 1995 have the option of postponing each goal four years.

3. Generation and treatment of waste

Municipal waste consists to a large extent of waste generated by households collected by or on behalf of municipal authorities and disposed of through the waste management system. It also includes waste which is similar to household waste generated by small businesses and offices and collected by the municipality.

There are many factors that affect municipal waste generation. During a previous project in 2008 the final consumption expenditure of the households was identified as the factor that best correlates to municipal waste generated in Gothenburg. Figure 3.1 shows the development during 1996-2007 for municipal waste generation per person and the final consumption expenditure of households per person. It can be concluded that there is a relatively good correlation for the last four years. Discrepancy for earlier years can be explained with uncertainties in the waste statistics.

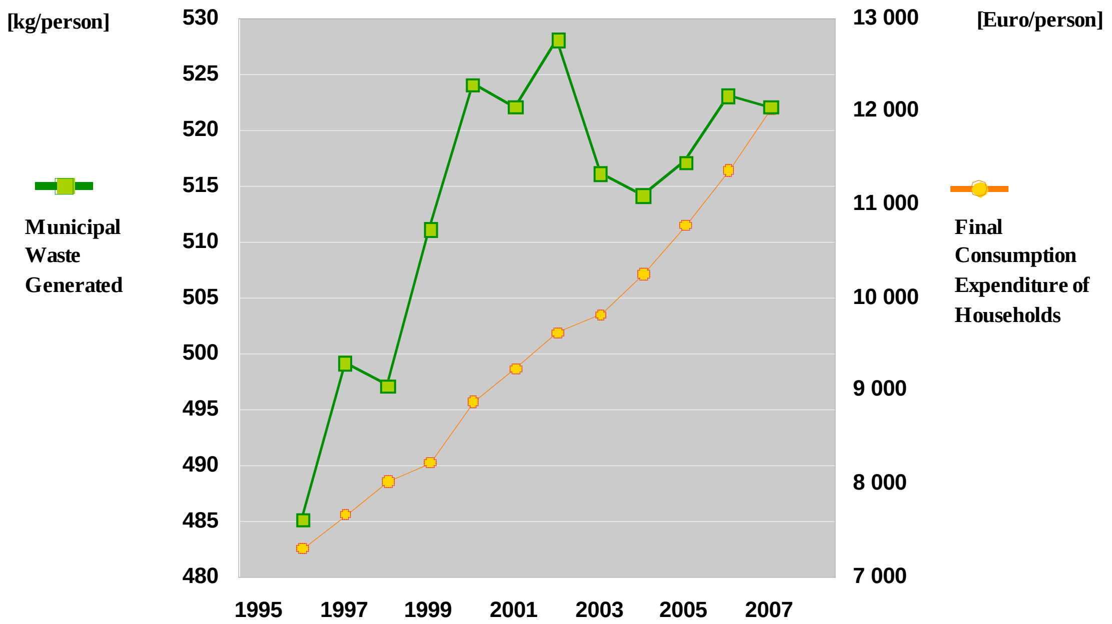


Figure 3.1 Generated Municipal Waste [kg/capita] and final consumption expenditure of households [Euro/person] 1996-2007. Source: Eurostat (2009, 2009a)

Figure 3.2 shows generated amounts of municipal waste per person in respectively Member State during 2007. Denmark, Ireland and Cyprus have the highest generation while Czech Republic, Slovakia and Poland have the lowest. The Community average is approximately 522 kg per person.

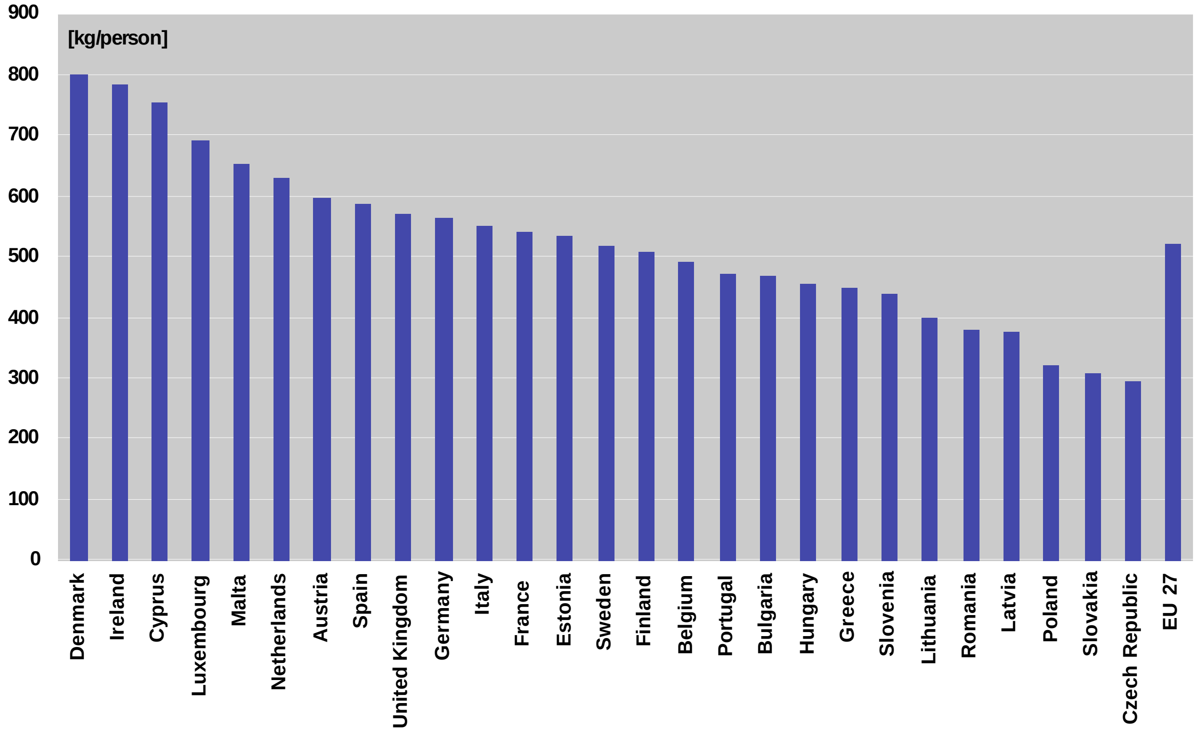


Figure 3.2 Generated municipal waste [kg/capita] in 2007. Source: Eurostat (2009b)

There are four different treatment options for waste reported to Eurostat: landfilling, incineration, recycling, and composting (including anaerobic digestion[1]). Figure 3.3 shows the treatment of municipal waste in 2007. The following definitions have been used by Eurostat, from which the statistics in

- Landfill: depositing of waste into or onto land, including specially engineered landfill and temporary storage of over one year.
- Incineration: thermal treatment of waste in an incineration plant.
- Recycling: any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes.
- Composting: treatment of biodegradable matter. The amount of municipal waste treated by anaerobic digestion is very low in the EU. In the study it is assumed that Eurostat has included these amount into the composting figures.

Data on treated municipal waste only refer to waste treated within the Member State, and does not take into account waste exported for treatment.

[1] Anaerobic digestion is the bacterial breakdown of organic materials in the absence of oxygen. The process produces a gas, called biogas, consisting of methane.

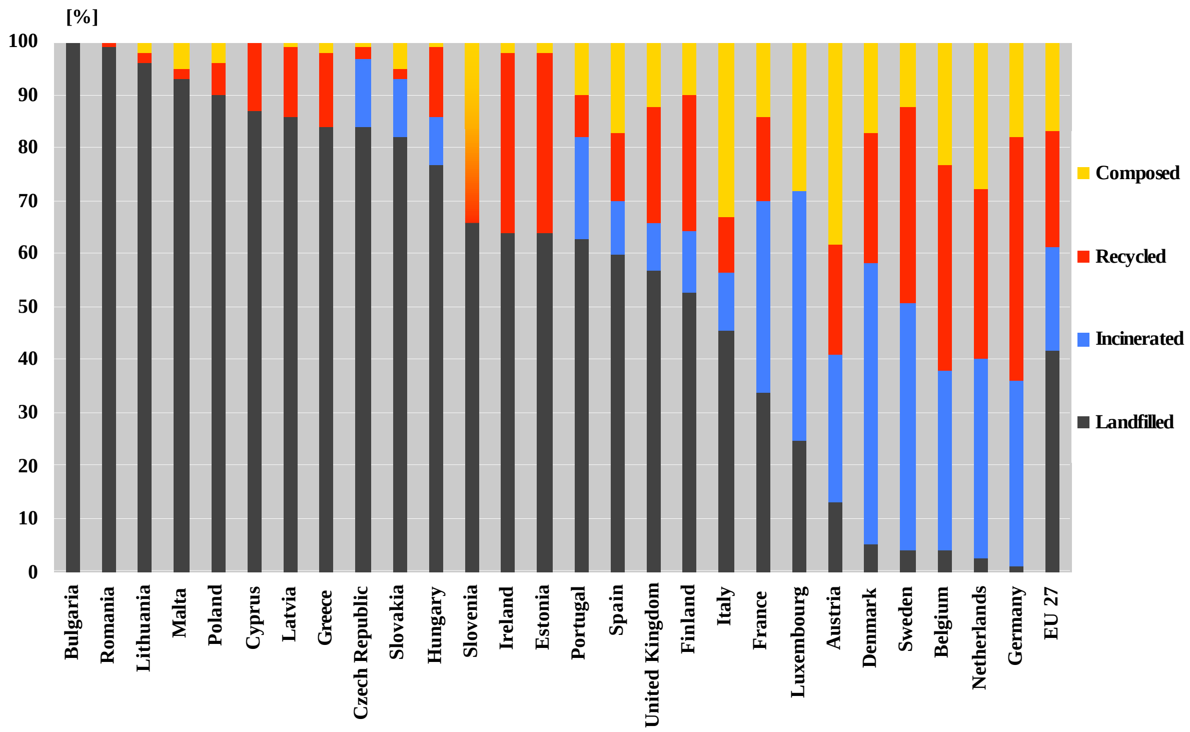


Figure 3.3 Treatment of Municipal Waste [%] in 2007. Source: Eurostat (2009b)

Figure 3.3 shows that landfilling is the dominate treatment method in 18 of the 27 Member States. The top five countries for the other treatment methods are:

- Incineration: Denmark, Luxembourg, Sweden, Netherlands and France
- Recycling: Germany, Belgium, Sweden, Slovenia and Ireland
- Composting: Austria, Italy, Luxembourg, Netherlands, Belgium

It should be noted that there are large differences in how efficient the waste treatment methods are in these countries. For instance, incineration can be with and without energy recovery. Both material recycling and biological treatment are efficient when the materials are replacing the right virgin materials, not else.

Generation of industrial and household waste

Figure 3.4 shows the generation of industrial and household waste in the Member States 2006. As seen, most of the waste is generated in the industrial sector. Out of the total waste generation, which almost reached 3 Gtonne in the EU, 93 % originated in the industrial sector while 7 % came from households. In the industrial sector the vast majority was mineral waste, not included in the study. France, Germany and United Kingdom were the three countries that generated most waste during 2006.

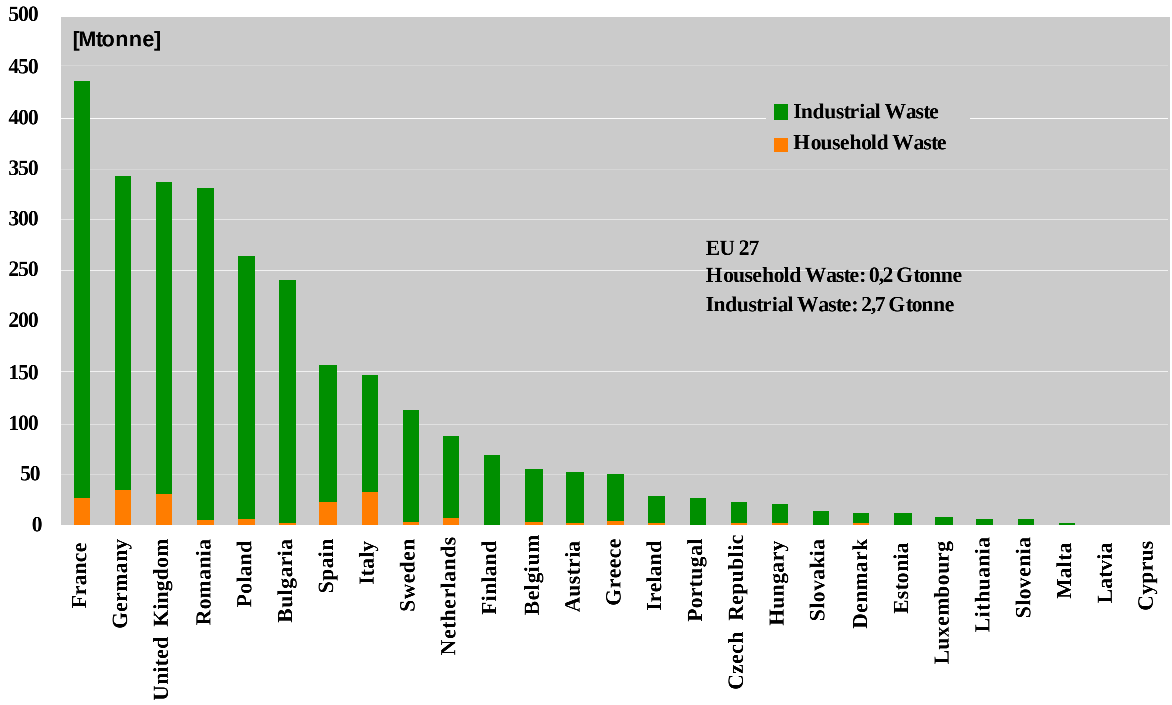


Figure 3.4Generated Waste [Mtonne] in 2006. Source: Eurostat (2009c)

4. Generation of biogas from landfills

Biogas is collected from landfills (also called landfill gas), from anaerobic digestion of sewage sludge, and from agricultural residues. The total amount of biogas recovered at these facilities amounted to 57 TWh in 2006 (Eurobserver 2008). Biogas that was flared is not included. Figure 4.1 shows the production divided into three groups, where biogas from landfills is the main source.

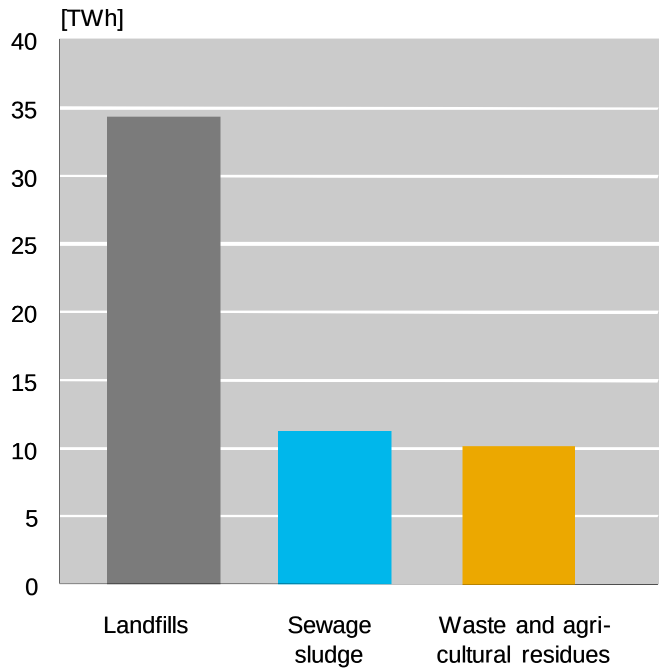


Figure 4.1 Recovered biogas from landfills and anaerobic digestion of sewage sludge, waste and agricultural residues in 2005. Source: (Eurobserver 2007)

During 2005, 13 TWh of gas were used for electricity production while 8 TWh and 0.1 TWh respectively were used in heat production and as vehicle fuel. It is important to point out that this energy amount is a result from many years of landfilling. Compared to incineration and anaerobic digestion a considerable larger amount of waste is therefore needed to recover this amount of energy. Figure 4.2 shows the energy form which biogas from landfills and other sources were transformed into in some countries.

It is not surprising that a large share of the gas is used for heat production in countries where district heating has a large share of the heating market. Gas is primarily used for electricity generation in countries with a small share of district heating, such as Portugal, Great Britain and Spain. Many countries have generous policy measures for electricity generated from biogas from landfills and other sources, which leads to an increased electricity production. An example of this is Germany where the producers are especially rewarded for using biogas from agricultural residues. The effect of this support can be observed in the substantial increase of biogas production that took place between 2005 and 2006. It is notable that in Sweden only, biogas was upgraded to vehicle fuel on a large scale.

One reason behind the upgrading of biogas into vehicle fuel in Sweden is the existence of governmental investment programs, In one program (KLIMP), 53.1 MEURO were used for biogas systems (production, distribution and biogas vehicles).

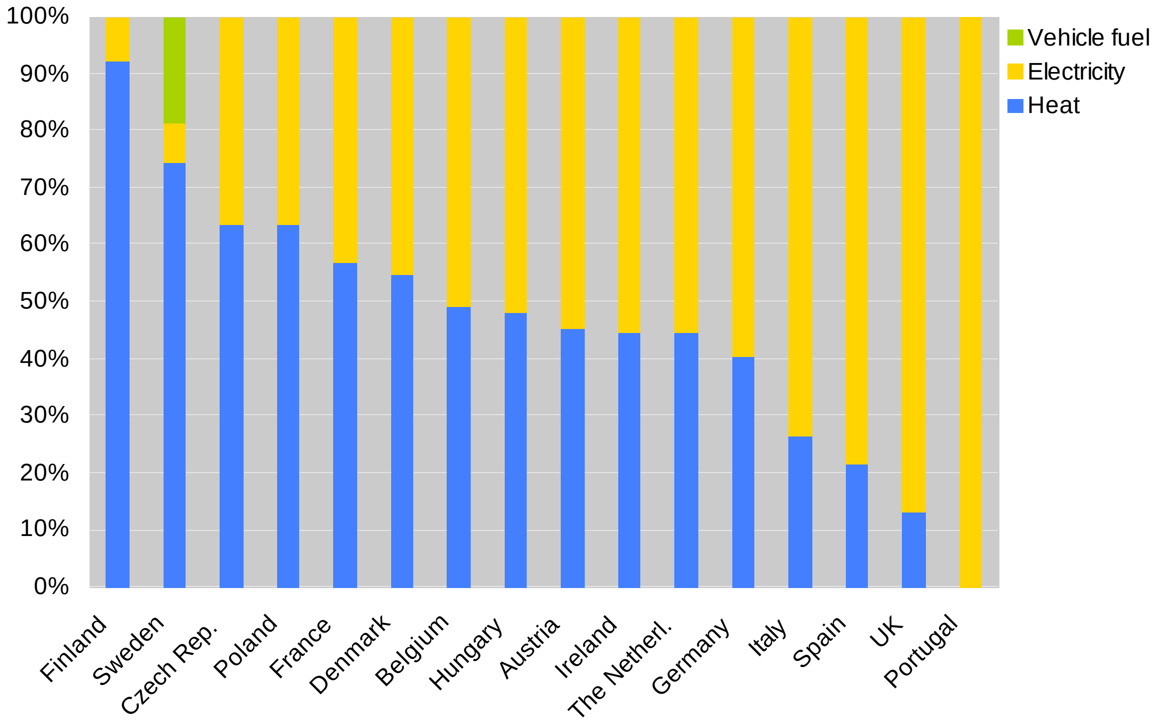


Figure 4.2 The use of biogas from landfills and other sources in 2005 in some countries, expressed as electricity, heat, and vehicle fuel production. Source: Sweden (Swedish Energy Agency 2007), the remaining countries (Eurobserver 2007)

5. Methodology

The starting point for the prognosis is the municipal and industrial waste quantities generated in the EU-27 countries 2006 as reported to Eurostat (2009c). Hazardous waste from both sources is not included.

For industrial and household waste two scenarios are assumed; high and low growth of waste quantities, in total four scenarios. Assumptions and methodology differ to some extent between industrial and household waste, and two different projection methods are used for the high scenarios. These are described in the forthcoming sections.

The low scenarios are assumed to be "Decoupling" scenarios. Decoupling between economic growth and waste quantities is set out as an environmental objective in the Sixth Environmental Action Programme (2002-2012). Additionally, decoupling objectives are to be set for 2020, according to the Waste Framework Directive (2008/98/EC).

There are examples of countries with a relative decoupling between municipal waste quantities and economic growth, meaning that waste quantities grow more slowly than the economy (EEA 2009). Especially some EU-12 countries have had a decrease or slow waste growth even with a fast economic development. One explanation given by EEA to the decline in waste quantities is that the introduction of weighting systems at landfills may have supplied more trustworthy data. The average municipal waste quantity per citizen has increased by 10% from 1995 and 2007.

For both industrial and household waste the estimate of the growth of renewable waste fractions are made separately.

Waste quantities - Industrial waste

Estimates on future quantities of industrial waste are based on projected economic growth of industrial sectors in Europe. The economic growth rates are taken from a previous study by CPB (2008), in which two scenarios for the future of manufacturing in Europe are presented. In the scenarios, trends for global trade barriers, technological progress and energy efficiency are altered in the modelling. It is concluded that manufacturing production sectors are likely to grow, but that the trend towards a typical service sector is expected to continue in Europe.

In this study, production volume growth rates are assumed to relate to waste generation quantities, and the resulting growth rate of the CPB study is used as input data for the waste quantity modelling. The average growth rate in the scenario with lowest increase in the CPB study is used. This is the "Industrial growth" scenario.

The renewable waste fractions, which are in focus in this study, are modelled, and accordingly based on projected economic growth of industrial sectors. For each renewable waste fraction, the major industrial sector from where the waste originates, is identified. This is made based on the Eurostat database, in which the origin of separate waste fractions can be determined. When the corresponding industrial sector is identified, its growth rate of the CPB study is set to represent the growth of all waste of that individual waste fraction. Thereby, the waste is assumed to increase proportionally with its corresponding industrial sector until 2020. This is a simplification, to assume all waste originate from one industrial sector. However, the growth rate between sectors giving rise to the same waste fraction does no differ much. Thereby the simplification is assumed not affect the result within the scope of the study. Table 5.1 shows the waste fractions studied its proportional origin from the largest source (industrial sector) and assumed growth rate until 2020.

Table 5.1 The renewable waste fractions considered in this study, assumption of industrial sectors they originate from, the proportion of the waste fraction originating from that sector and its respective growth rate until 2020.

Waste fraction	Main industrial sector, where the fraction originates	Proportion of total fraction originating from the sector	Growth rate/a until 2020
Waste wood	Forest industry	55%	1.6%
Waste of food preparation and products	Food preparation	64%	1.3%
Renewable textiles	Textile industry	78%	0.1%
Renewable waste in household waste from industries	Mixed waste in all industrial sectors	-	1.15%
Paper and cardboard	Service sectors/ pulp and paper	50%/23%	1.1%/1.2%

Table 5.2 Summary of scenario assumptions on growth (%) for municipal waste quantities: resulting average values for EU-27.

	2007	2008	2009	2010	2011-2020
Scenario high	2.9	0.9	-4	-0.1	2.1
Scenario low	2.9	0.9	-4	-0.1	0

Waste quantities - Municipal waste

The forecast of total municipal waste is based on modelling results in a study by ETC/RWM (2008). In their study, municipal waste growth is modelled and one of the modelling parameters is the private consumption expenditure. Also data of earlier waste prognosis studies from Sweden shows that historically generated municipal waste quantities follow the private consumption expenditure.

However, the study by ETC/RWM does not take into account the recent and ongoing recession in European and world economy. For that reason, the outcome is controlled by comparing the waste growth with the case it would follow recent and future GDP instead. Real GDP growth rate data for the years 2007-2010 is taken from the Eurostat database (Eurostat 2009b), where data for the years 2007-

2008 is resulted value, while from 2009 an onwards, data is estimations. From 2011-2020 data is taken from DG ECFIN (2006). Data is modelled for each country individually.

In the low scenario, an absolute decoupling is assumed, as described above. The starting point is the year 2006 with data from Eurostat.

The renewable municipal waste fractions are based on the average modelling results in the study by ETC/RWM (2008).

Waste to material recycling 2020

By 2020 50% of waste materials such as paper, glass, metals and plastics from households (and possibly also from waste similar to household waste generated in industrial sectors) is to be material recycled. This is set in the Waste Framework Directive (2008/98/EC). For this study this target is assumed to affect paper and paper board, and subsequently, that 50% of the generated quantity is not available for energy recovery but will go to material recycling. The available waste paper and cardboard amounts are thereby reduced by 50% in all scenarios.

Furthermore, it is assumed that until 2020 a target on biological treatment of waste from kitchens and food industry in place, and thereby reduced these waste types for energy purposes. A target level of 20% is assumed. The available quantity of waste from kitchens and food industry are reduced by with 20% in all scenarios. This is based on the green paper[2] mentioned in Chapter 2. Additionally there is a goal of 70% material recycling of construction waste. However, according to Eurostat data these waste types are mainly not renewable,[3] and the goal thereby has little effect on the results of this study.

Potential energy recovery

The potential energy recovery is calculated in two scenarios: “possible total energy recovery” scenario and “reasonable growth of waste-to-energy capacity in Europe” scenario. The starting point for both scenarios is the assumed energy recovery from renewable waste of 52 TWh in Europe in the year 2006. The input data for the assumed value is a calculated average of several sources (Table 5.3). The values of the sources are recalculated assuming that 50%(energy) of the incinerated waste is of renewable origin, and that 74%(weight)[4] incinerated waste origin from households.

[2] *Green paper on the management of bio-waste in the European Union*
[3] 91% of the waste from construction corresponds to the waste classification mineral and solidified wastes
[4] Swedish Waste management (2008)

Table 5.3 Input data for the assumption on current (2006) energy recovery from renewable waste in EU-27.

Source:	TWh (heat and electricit)	Waste types included
IEA (2009)	73	Industrial and municipal waste, all waste included
Swedish Waste Management (2008)	124	
CEWEP (2008)	133[5]	
Eurobserver (2008a)	33	Renewable MSW

Scenario Possible total energy recovery

The first scenario is based on the technically possible energy recovery from the renewable waste for energy purposes after material recycling. The starting point is the total, combustible waste fractions available for energy purposes, meaning after material recovery. Of these combustible fractions the renewable share stands for 20% in industrial waste and about 50% according to the results in this study. For the renewable waste fractions an average calorific value for each waste fraction is assumed. Thereafter, a possible total energy recovery is calculated.

The average calorific values assumed for the waste fractions considered in this study are presented below.

Table 5.4 The average calorific values assumed for the waste fractions considered in this study.

Waste fraction	[MWh/tonne]
Wood	3.9
Paper and cardboard	3.5
Biodegradable textiles	2.0
Biodegradable waste in mixed waste	2.0
Separated food waste	1.0

The energy is assumed to be recovered in combined heat and power plants (CHP), heat only plants and in condensing plants for electricity production only. The CHP plants are the most efficient plants with the largest contribution to the environmental goals that are studied in this report. The energy production varies a lot between the countries. In the study, each country is studied separately and the countries are also divided into two groups in order to get a detailed description of the present energy recovery from waste in EU27. The countries have been sorted after the main focus of the energy recovery from waste: heat or electricity. The countries with large heat production also have electricity production (CHP). The countries with high heat recovery are: the Czech Republic, Denmark, Latvia, Austria, Poland, Finland and Sweden (Swedish Waste Management, 2008). The remaining countries are countries with low heat recovery.

[5] Calculated with an assumed calorific value of 3 MWh/tonne and a total efficiency of 75%,

The assumed energy recovery of the facilities is dependent on the main focus of the energy recovery from waste, as well as the waste type incinerated. The assumed energy output is showed in Table 5.5, and fulfils the criteria for recovery units of the Waste Framework Directive (2008/98/EC). These assumed values are for an average mix of municipal and industrial waste in Europe. The waste incinerated is a mix of fossil and renewable origin, but only the part of the energy recovered from the renewable fractions of the waste (20% (industrial waste) and 50% (municipal waste), is considered, see above).

Table 5.5 The assumed energy output of the waste incineration plants. Source: WasteAtlas (2009)

Plants with low heat recovery				
Waste type incinerated	household waste		Industrial waste	
Output	electricity	heat	electricity	heat
[MWh/tonne incinerated]	0.8	1.0	0.9	1.2
Plants with high heat recovery				
Waste type incinerated	household waste		Industrial waste	
Output	electricity	heat	electricity	heat
[MWh/tonne incinerated]	0.5	2.7	0.6	3.2

Scenario Reasonable growth of waste-to-energy capacity

The scenario "reasonable growth of waste-to-energy capacity" is based on the historical increase of waste-to-energy capacity, an increase of 13 Mtonnes in total between the years 1995-2005. This gives an increase rate per year of 1.3 Mtonnes/a. The same growth rate is assumed to continue from 2006-2020.

The capacity of waste incineration was 59 Mtonnes in 2006 (CEWEP 2008). In 2013, the current capacity plus known plans of increased capacity gives a total waste incineration capacity of 76 Mtonnes/year (Swedish Waste Management, 2008). With the increase rate above, it instead is assumed a reasonable total waste incineration capacity of 85 Mtonnes/year in 2020.

6. Results: Waste quantities

Industrial waste

The results of the scenarios for future amounts of industrial waste is shown in Figure 6.1. The main results are the red (3100 Mtonne) and yellow (2700 Mtonne) lines, as well as the green line for renewable waste (200 Mtonne). The blue line is shown for comparison, if the waste quantities would increase along with the projected GDP. The 200 Mtonne renewable waste consist of the waste fractions of Figure 6.2. Waste wood dominates in industrial waste.

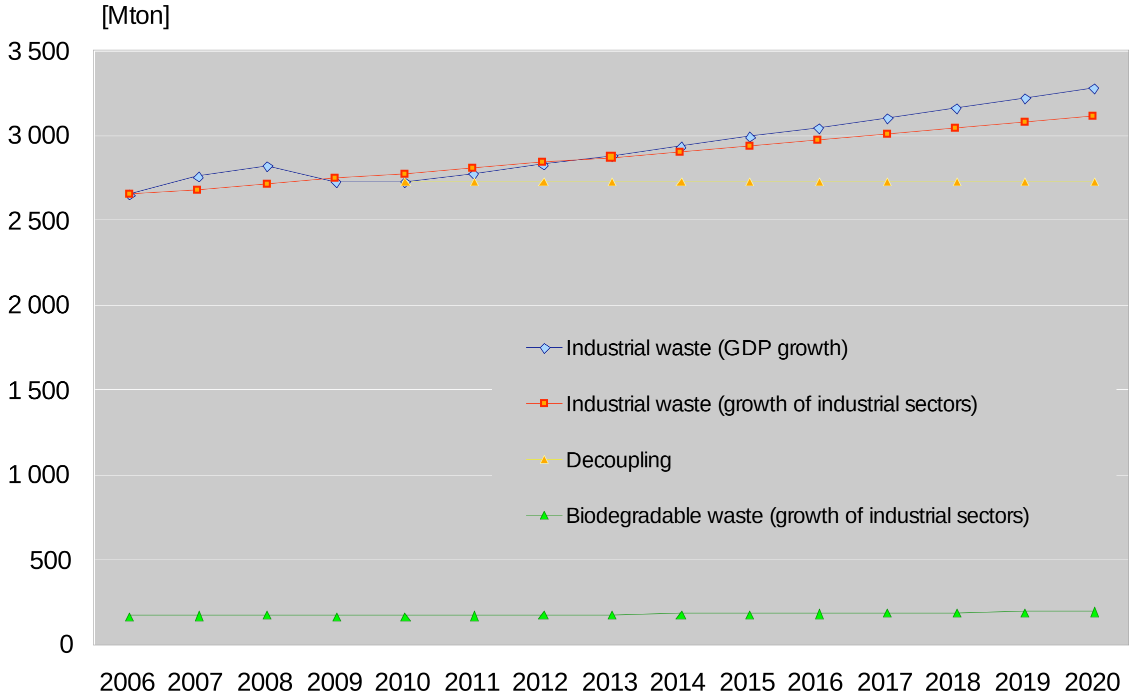


Figure 6.1 Scenarios for future amounts of industrial waste

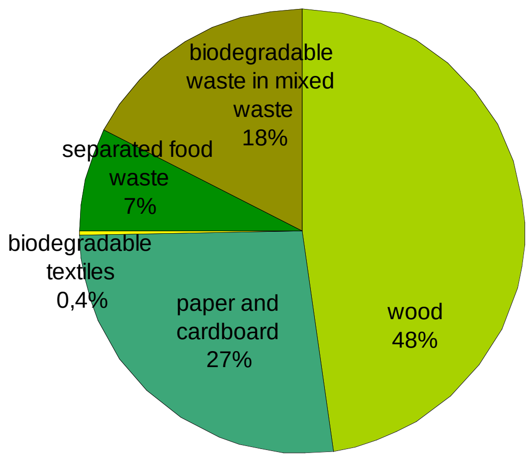


Figure 6.2 Renewable industrial waste fractions in the study.

Municipal waste

The results of the scenarios for future amounts of municipal waste is shown in Figure 6.3. The main results are the blue (250 Mtonne) and yellow (210 Mtonne) lines, as well as the green line for renewable waste (120 Mtonne). In the figure there is also an additional red line, for comparison. The line represents the case if waste amounts are not affected to the same extent as the blue line, of the current economic recession. The 120 Mtonne renewable waste consist of the waste fractions of Figure 6.4. Unsorted renewable waste in mixed municipal waste dominates.

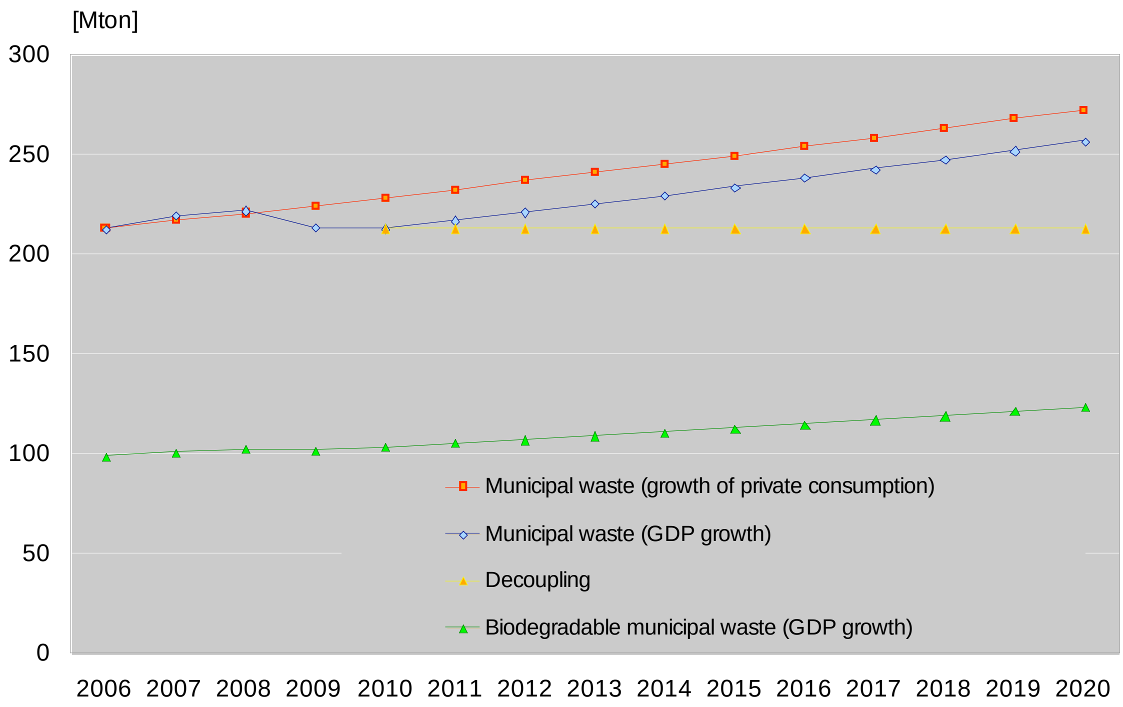


Figure 6.3 Assumed growth of municipal waste

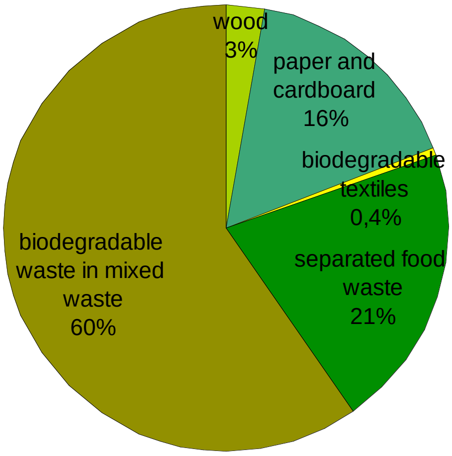


Figure 6.4 Renewable municipal waste fractions in the study.

7. Results: Energy recovery from renewable waste fractions

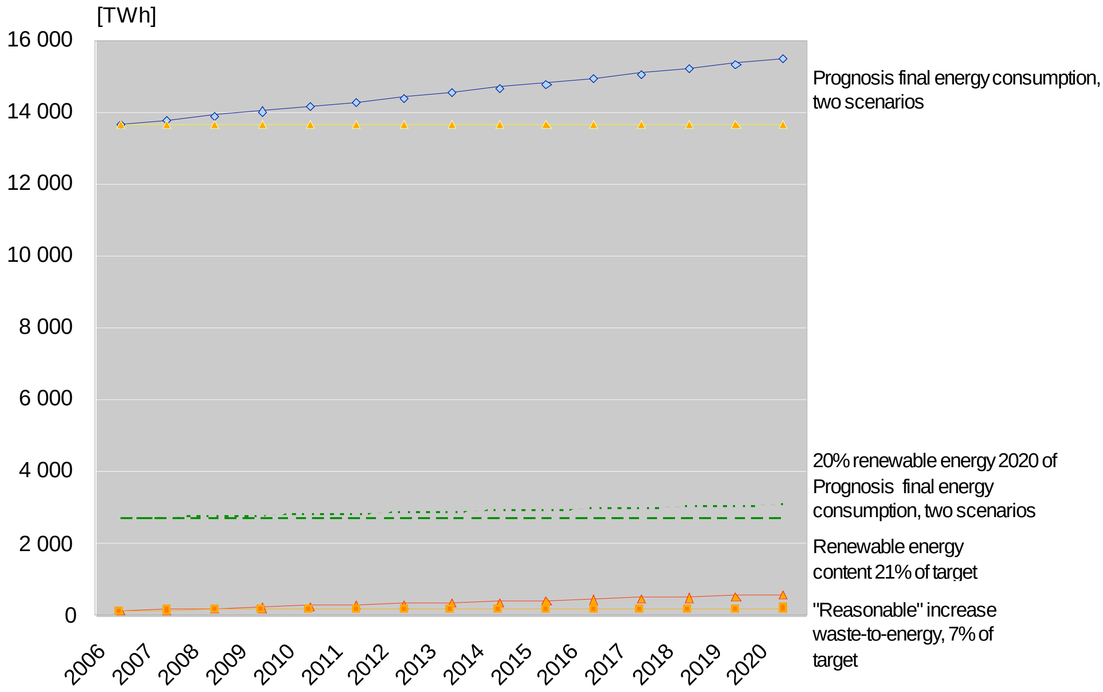


Figure 7.1 Renewable waste to energy contribution to target 20% renewable energy by 2020.

Figure 7.1 and Figure 7.2 show the potential for renewable waste-to-energy contribution to the target of 20% by 2020. In Figure 7.1, the blue and yellow lines show two scenarios for final energy demand by 2020. The green dotted lines show the targets of 20% renewable energy of the final energy demand by 2020, corresponding to the values of the blue and yellow lines, respectively.

The red and orange lines show the scenarios for contribution of waste-to-energy to the target of 20% by 2020. The starting point for both scenarios is the assumed (2006) energy recovery from renewable waste of 52 TWh in Europe.

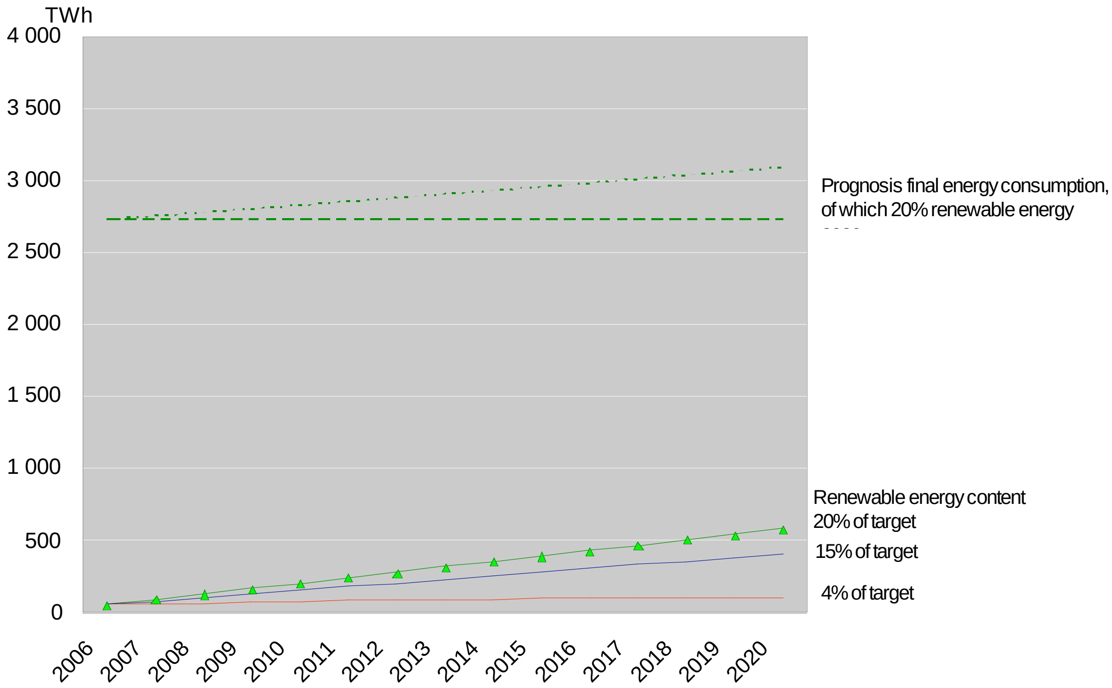


Figure 7.2 Renewable waste to energy contribution to target 20% renewable energy by 2020.

In Figure 7.2 the blue and yellow lines are remove, and the green dotted lines show the targets of 20% renewable energy of the final energy demand by 2020, as in Figure 7.1.

The results of the figures show that waste-to-energy could contribute with 20% (580 TWh) of the target of 20% (2700 TWh), considering the total renewable energy contents of the waste 2020, according to the assumptions of this study. This is a theoretically calculated value, where no consideration is taken to the possible offset of the energy, to new construction of incineration plants, efficiencies of facilities.

If considering possible energy efficiencies of waste incineration plants, the contribution to the target would be 15% (400 TWh) (Figure 7.2). Both values 20% and 15% are calculated compared to the lowest of the two scenarios for final energy consumption 2020.

Finally, if assuming the future increase rate of new waste incineration capacity being the same as between the years 1995-2005 in Europe, renewable waste to energy would contribute with 4% (100 TWh, red line) (Figure 7.2) to the target in 2020, according to the assumptions.

In the scenario of decoupling, meaning that waste quantities and energy recovery stabilise on current levels, renewable waste-to-energy would be 0.5% of the target 2020. However, the potential is currently higher than the current energy recovery from waste, depending on large quantities renewable waste being put on landfills. The quantities will however decrease depending on the target levels of the landfill directive.

In comparison E3MLab/NTUA (2008) calculates on a contribution of biomass including waste up to 65% of the target of 20% renewable energy in 2020 as well as wind power 12%; hydro power 11%, solar

8% and geothermal 3%. This is calculated on the scenario with the highest amount of primary energy from renewable sources[6] in the E3MLab/NTUA study.

These results differ from the results of a previous study by EEA (2006). With the assumptions of this study, the potential energy from waste in the highest scenario, is about 20% lower than theirs. The discrepancy depends on their study including sludge and agricultural waste which not is considered in this study. Other differences between the studies is that this study includes more wood waste which the EEA study put in another category, as well as paper and cardboard, which they do not consider for energy purposes.

Results: Future recovery of biogas from landfills

The amount of generated biogas from landfills both depends on the development of the total amount of landfilled waste and the share of renewable waste.

Both of these factors shall decrease according to the European Union's ambitions. Changes in land-filled amounts that are made today will not affect the amount of emitted gas immediately, since it takes a long time for the waste to decompose in landfills. Current amounts of generated biogas from landfills are collected from earlier landfilled amounts in varying decomposing stages.

Therefore, in the time perspective of this study (approximately 10 years), changes in the amount of recovered biogas from landfills is assumed to especially depend on the expansion rate of gas collecting systems.

ETC/RWM (2007) has estimated the amount of landfilled gas from MSW than can be collected and recovered in EU-25. The estimation is based on earlier landfilled amounts (1950-2004) as well as an estimation of the landfilled amounts during 2005-2020 and a collecting efficiency in each respective country, reaching 20 % of the generated amount. Additionally a 30% collecting efficiency was discussed and examined in a follow up study ETC/RWM (2008).

Based on these estimations, approximately 0.85 Mtonnes of methane from municipal solid waste will be collected and recovered in EU-25 around the year 2020. The amount of collected methane from landfilled MSW corresponds to an energy amount of just less than 12 TWh. Note that this collected amount is based on municipal waste alone.

As reported by (Eurobserver 2008b) primary production of energy from biogas was in total 24 TWh 2006, from all sources including landfills, agriculture and sewage sludge treatment. For the aim of this study it is assumed that in 2006 energy from biogas from landfills was the average of the above values (12 and 24 TWh) resulting in 18 TWh. For 2020 it is assumed an increase of 50%, based on an assumed expansion of gas collecting systems as well as higher collecting efficiencies. This would result in 27 TWh energy from biogas, a contribution of 1% to the target of 20% energy from renewable sources in 2020.

[6] The example is taken from the scenario "EC proposal with JI/CDM and RES trading".

8. Results: CO_2 emissions savings

This chapter presents how much waste to energy can contribute to the EU goal to reduce GHG emissions with 20 % to 2020[7]. When renewable waste incineration is increased and landfilling decreased, emissions of greenhouse gases are reduced from (i) landfilling, (ii) from alternative heat production and (iii) from alternative electricity production.

The largest reduction of greenhouse gases that is gained from using waste to energy options is gained from avoiding landfilling of waste and thus avoiding methane emissions from the landfills. This “triple reduction effect” makes incineration a very competitive alternative for reaching CO_2 reduction targets. The renewable waste fractions are not only a renewable energy source with zero GHG emissions, it actually has negative emissions since it avoids landfills emissions. Appendix 1 illustrates a typical example of CO_2 savings that can be gained from waste to energy.

The GHG level for the Community reached approximately 5.6 Gtonne in 1990 (EEA 2009a). This means that the maximum allowed level in GHG emissions in 2020 corresponds to approximately 4.5 Gtonne. In 2005 the Community level reached 5.1 Gtonne (EEA 2009a) which means that a 660 Mtonne reduction in GHG emissions is needed from 2005-2020.

The following text describes the assumptions and data used for calculating the CO_2 reductions that can be made for EU27 and how large share of the reductions targets to 2020 that incineration can contribute to.

Reductions from avoiding landfilling:

Landfill gas is generated during the decomposition of organic material contained in solid waste landfills. Some factors that affect the formation and emission of the gas are: materials earlier put in the landfill, the content of water, the depth of the landfill, the density of the material, and the temperature. The final emission of landfill gas also depends on the effectiveness of the gas collection system, if any. All these factors make calculations of emissions of landfill gas uncertain, also in this study. The estimation is done for the total amount of waste, household and industrial waste.

Applied to the previously presented waste quantifications this will result in following CO_2 eq reductions

[7] All figures and results are based on emission levels excluding land-use change and forestry (LULUCF).

Table 8.1 GHG reductions due to avoided methane emissions from landfills.

	Avoided landfilling in year 2020	Avoided CO_2 eq	Share of EU:s target for 2020
	(Mtonne)	(Mtonne)	(%)
Potential according to base case:	200*	90	14
Potential with low landfill emissions:	200	64	10
Potential with high landfill emissions:	200	144	22
Historic growth for future incineration:	100	45	7

* 38 Mtonnes household waste and 162 Mtonnes industrial waste

Reductions from avoiding alternative energy production:

The following assumptions on fuel usage of alternative sources have been made:

(A) Alternative energy source: coal: Heat and electricity produced from waste are assumed to replace heat and electricity produced by coal in HOB (heat only boiler) respectively in power plants. Only emissions of CO_2, CH_4 and N_2O are considered.

(B) Alternative energy source: a mix: Heat from waste is assumed to replace heat produced by natural gas in HOB. Electricity produced from waste is assumed to replace electricity produced from a mixture of both fossil and renewable sources. This mixture approximately consists of:

Natural gas: 9 %
Coal: 82 %
Biofuels: 5 %
Wind: 5 %

The mixture is derived from an analysis by Unger and Sköldberg (2008). The authors make a basic analysis of the long term effects of the electricity generation mix and CO_2 emissions due to changes in use and/or production. The system analysed is the north European electricity system[8]. It is concluded that the change itself affects not only the utilization of existing capacity but also the future development of new investments. The impact of new investments includes, generally, not only one generation technology but rather a mix of several technologies. The assumed mix has an emission factor corresponding to 630 kg CO_2 equivalents/$MWh_{electricity}$.

Compared to CO_2, CH_4 and N_2O the CO_2- -equivalent contributions from HFCs, PFCs and SF6 are negligible. The latter three are therefore not considered in any of the case studies.

In this study, the result was that 234 TWh heat and 137 TWh electricity in theory can be generated from waste in 2020. The level of CO_2 savings that this energy from waste can contribute to, depend on the assumed the production method of the energy substituted.

[8] The counties included are: Denmark, Finland, Germany, Norway, Poland and Sweden (Sköldberg and Unger 2008)

In this theoretical potential, where the total energy content of the waste is calculated, waste contributes with 30 % of the target when it is assumed that the alternative energy source is coal, thus alternative A above, and 20% of the target when it is assumed that the alternative energy sources is a mix according to alternative B above.

All of the results presented elsewhere in this report are based on alternative B. This assumption is believed to give a closer description of what energy sources that are actually replaced.

The contribution from heat and electricity from waste is almost the same (45 % respectively 55 %). This maximum value of the usage of the energy content of the waste and where it is assumed that an energy mix according to alternative B is avoided, are found under the headline "Maximum contribution" in figure 8.1 below. In this diagram it is illustrated that the total contribution from waste to energy, thus calculating both the avoided emissions from alternative energy production and from avoided landfill emissions.

As mentioned above the production of 234 TWh heat and 137 TWh electricity from waste is theoretical. If taking into consideration the historical expansion rate of waste incineration, this would result in an energy recovery of 102 TWh (64 TWh heat and 38 TWh electricity) from waste in 2020.

Total reductions:

Waste to energy plants can, if the results from all avoided emissions are summarised, contribute considerably to the target to achieve 20% reduction of green house gas emissions by 2020. The following four conclusions can be made from the calculations:

1. Based on the energy content of the renewable waste, **energy recovery from waste could contribute with 34% of the total reduction target for CO_2 to year 2020**. Approximately 14% is gained from avoiding landfilling and 20% is gained from replacing fossil fuels. There are uncertainties in data and assumptions that can change this conclusion. For instance if coal is assumed to be the alternative fuel instead of the modelling mix used here, the total reduction would be as much as 45%. There are also large differences in measurements for landfills which could alter the assumption for avoided emissions at landfills (both up and down).
   This is, as mentioned above, a calculated value that shows the maximum potential based on the energy contents of the renewable share of the waste, alone. No consideration is here taken to possible offset of the energy and technical limitations in building all these incinerations plants and district heating systems. However, it is possible for some of the studied EU27 countries to nearly reach this level in 2020.
2. If it instead is assumed that all new plants will be built with the same energy efficiencies that in the EU27 countries today, **the contribution to the reduction target for CO_2 to year 2020 would be 26%.** This value reflects the differences in infrastructure between the countries that can be found today where some countries have small possibilities to utilize the heat in district heating systems or industries

3. The potential for energy recovery from waste would be somewhere between these two values, thus between 26% and 34%. An average value of 30% will be used in this report to illustrate a practical potential that can be achieved if large efforts are made by the EU27 countries. Thus, **the contribution from energy recovery from waste to the reduction target for CO_2 can be as high as 30% of the total target for 2020**.
4. The above contributions require a large expansion of new incineration plants. If it instead is assumed that waste incineration will continue to increase with the rate as seen historically, **renewable waste would contribute to 14% of the EU goal to reduce GHG emissions with 20% to 2020**. Of the result, 6% comes from replacing fossil fuels and 8% from avoiding landfilling. The alternative fuel mix consists of natural gas 9%; coal 82%; biofuels 5%; wind 5%, and is calculated by using the comprehensive energy model Markal.

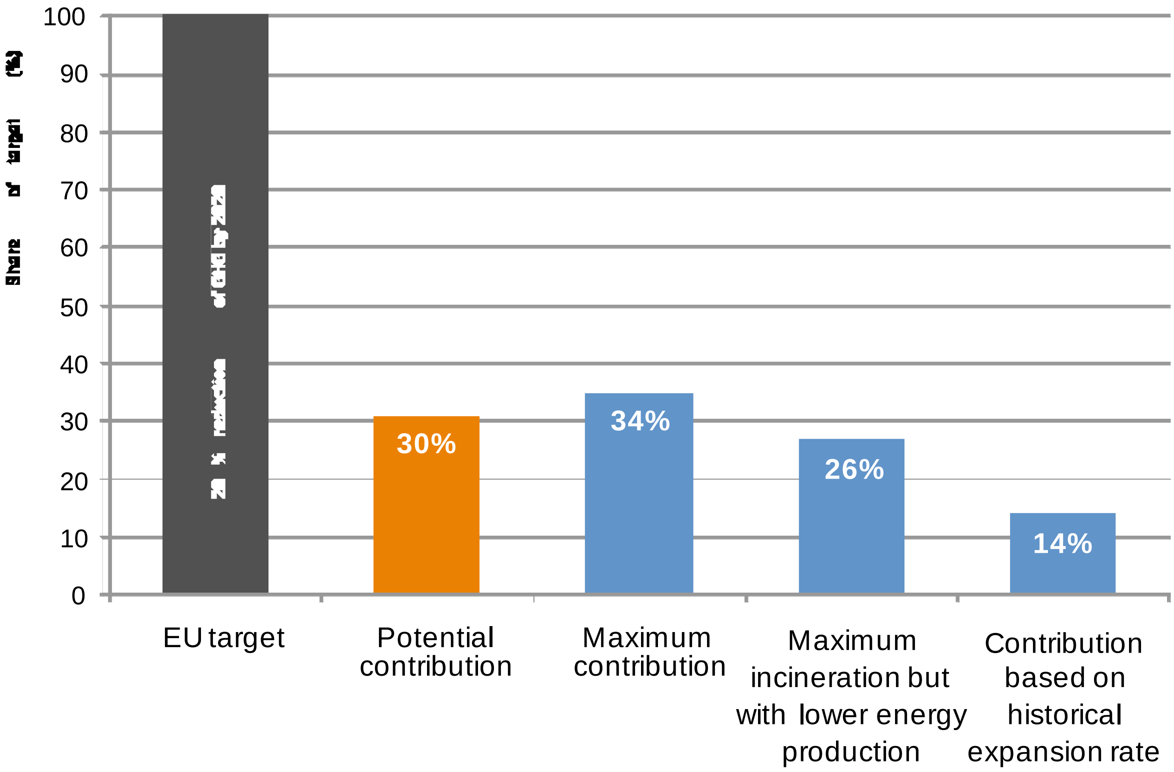


Figure 8.1: Contribution from energy recovery from waste to the target to decrease the greenhouse gas emissions to 20% by 2020 within EU27.

There are some uncertainties in the assumptions used for the calculations. The most important of these are the assumed emission of methane from the landfills. Several different assumptions and landfill emissions models have been studied in this project. From these findings a base case was selected and also a high and a low case, that covers most of the assumptions used by other research groups. The results are presented in diagram 8.2 below.

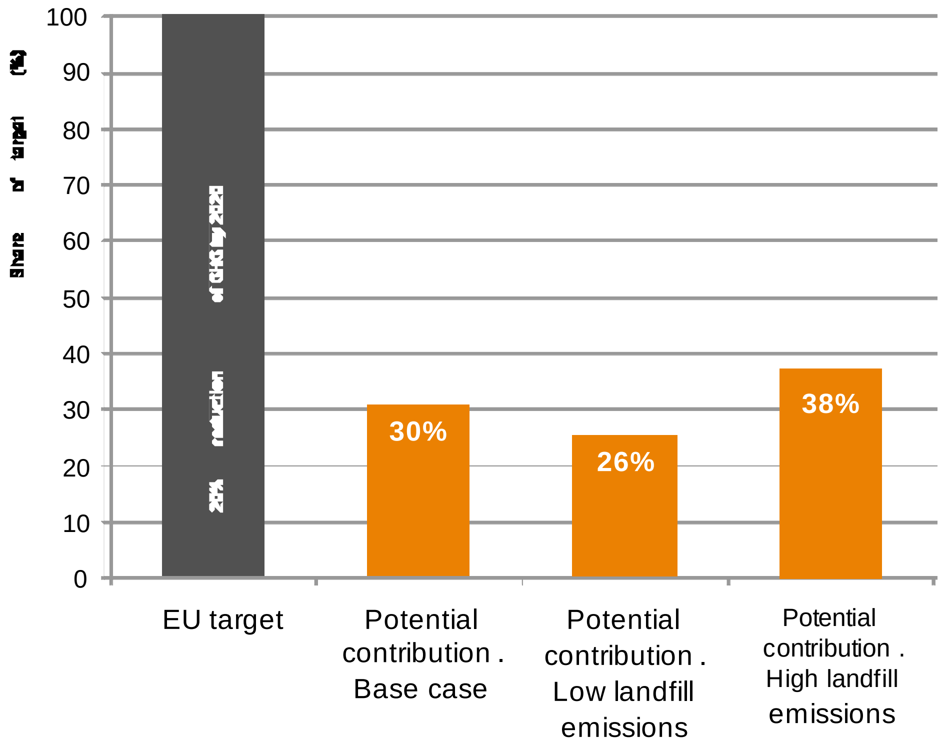


Figure 8.2: Sensitivity analysis for alternative assumptions for landfill emissions for the calculation of the total contribution from energy recovery from waste to the target to decrease the greenhouse gas emissions to 20% by 2020 within EU27.

The emission factors used for the landfills are 320, 450 and 720 kg CO_2,eq/ton (low, base case and high). The factors are the total emissions taking into account what waste fractions that are landfilled, how much methane that is produced, how much methane that is oxidised on the surface and how much methane that is collected and used for energy production (electricity mainly).

9. Biogas for vehicle fuel

Energy recovered from waste for vehicle fuel purposes is mainly biogas from anaerobic digestion.[9] The production of biogas for transport fuel purposes was less than 0.1 TWh in 2006. (Swedish Waste Management, 2008) Much larger quantities of biogas are however recovered from landfills, but these quantities are mainly used for electricity or heat purposes, and not for vehicle fuel. When landfilled, the renewable waste fractions emit biogas, which is collected and used as fuel. The total European recovery (EU-25) of biogas from landfills was around 23 TWh in 2006. (Eurobserver 2008)

The extracted biogas from anaerobic digestion is in comparison very small. However, extensive governmental subsidies from the Swedish government have enabled relative large expansion of the extraction and usage of vehicle fuel from biogas in some regions in the country.

In this study, the potential vehicle fuel is calculated in two scenarios; (1) the potential generation, based on the energy content of the renewable waste fractions suitable for anaerobic digestion, and (2) a doubling of the current extraction of biogas for vehicle fuel.

According to a previous study one tonne of easily biodegradable waste anaerobically digested results in 1 MWh fuel (Swedish Waste Management, 2008). This assumption would give 13 TWh vehicle fuel in 2020, in scenario 1, according to the results and assumptions of this study. In scenario 2, biogas for vehicle fuel would be 0.2 TWh.

One scenario by the European Commission (2007) shows a prognosis of 5101 TWh demand for vehicle fuel in 2020. Of this 10% (510 TWh) is to be renewable in year 2020. Biogas from anaerobic digestion would contribute to 0.03-2.5% of the target of 10%, in the two scenarios.

[9] Anaerobic digestion is the bacterial breakdown of organic materials in the absence of oxygen. The process produces a gas, called biogas, consisting of methane.

References

CEWEP (2008) Waste to energy in Europe 2006. Fact sheet.

CPB (2008) *Two Quantitative Scenarios for the Future of Manufacturing in Europe*. CPB Document. Lejour, A., & Verweij, G. No. 160, March 2008. http://www.cpb.nl/nl/pub/cpbreeksen/document/160/doc160.pdf

DG ECFIN (European Commission, Directorate-General for economic and financial affairs (2006). *Long-Term Labour Productivity and GDP Projections for the EU25 Member States: A Production Function Framework*. ISSN 1725-3187

EEA (2006) *How much bioenergy can Europe produce without harming the environment?* EEA Report 7/2006

EEA (2009) *Diverting waste from landfills. Effectiveness of waste-management policies in the European Union*. EEA Report 7/2009

EEA (2009a) *Annual European Community greenhouse gas inventory 1990–2007 and inventory report 2009*, Technical report No 04/2009, Submission to the UNFCCC Secretariat

ETC/RWM (2007) *Environmental Outlooks: municipal waste*, ETC/RWM working paper 2007/1.

ETC/RWM (2008) *Municipal waste management and greenhouse gases*, working paper 2008/1.

Eurobserver (2007) *Biogas barometer*

Eurobserver (2008) *Biogas barometer*

Eurobserver (2008a) *The state of renewable energy in Europe*

Eurobserver (2008b) *Renewable municipal solid waste barometer*, july 2008.

European Commission (2007) European energy and transport, trends to 2030, update 2007.

Eurostat (2009) Waste Statistics, Municipal, accessdate 2009-06-30

Eurostat (2009a) National accounts, accessdate 2009-06-30

Eurostat (2009b) Newsrelease STAT/09/31, 9 March 2009

Eurostat (2009c) Waste Statistics, generation of waste, accessdate 20090617

E3MLab/NTUA (2008) Model based Analysis of the 2008 EU policy package on climate change and renewables. Primes Model, January 2008. Report to DG ENV.

IEA (2009) OECD database, accessdate 20090626

Swedish Energy Agency (2007) Produktion och användning av biogas 2005. (Production and usage of biogas 2005).

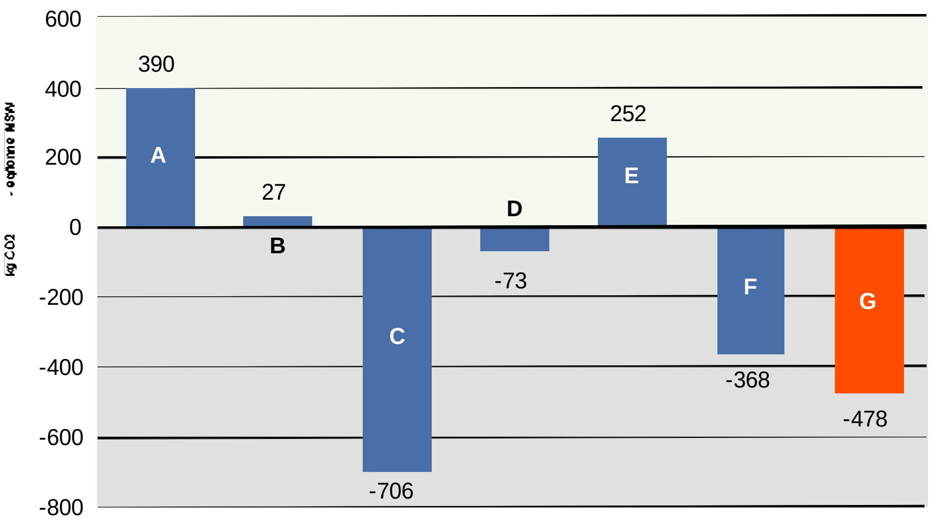
Swedish Waste Management (2008) (Avfall Sverige) *Energy from waste – an international perspective*, Report U2009:05. ISSN 1103-4092.

Sködberg, H., and Unger, T., 2008. Effekter av förändrad elanvändning/elproduktion – modellberäkningar. (Effects of changed electricity usage and electricity production – modelling) Elforsk report 08:30, April 2008.

WasteAtlas (2009) Database, Profu AB.

Appendix 1

Appendix 1 illustrates a typical example of CO_2 savings that can be gained from waste to energy. The example is taken from the city of Gothenburg in Sweden and it illustrates the CO_2 reduction that is made from increasing the incineration capacity with 1 tonne MSW.



A: Direct emissions of CO2 from incineration (the fossil part of the waste).
B: Emissions from transporting the waste (truck 300 km, empty return).
C: Avoided emissions from not landfilling the waste (modern landfill with gas extraction).
D: Avoided emissions from replacing other fuels used in the district heating system.
E: Electricity production from CHP -plants in the DH -system is reduced which needs to be compensated with external electricity production.
F: Avoided emissions from external electricity production from the electricity produced from incineration
G: Resulting emissions from increasing incineration with 1 tonne MSW.

Figure A1 Example of resulting changes in GHG-emissons from increasing incineration with one tonne MSW – Case study Gothenburg

RAPPORTER FRÅN AVFALL SVERIGE 2009

AVFALL SVERIGES UTVECKLINGSSATSNING

U2009:01	Verktyg för bättre sortering på återvinningscentraler
U2009:02	Användning av värmekamera inom avfallshanteringen. Förstudie
U2009:03	Mikrobiologisk handbok för biogasanläggningar
U2009:04	Rening av lakvatten, avloppsvatten och reduktion av koldioxid med hjälp av alger
U2009:05	Energy from waste - An international perspective
U2009:06	Klimatpåverkan från import av brännbart avfall
U2009:07	Torrkonservering av matavfall från hushåll
U2009:08	Alternativa konstruktionsmaterial på deponier. Vägledning
U2009:09	Viktbaserad renhållningstaxa som styrmedel
U2009:10	Uppföljning av slaggrusprovvägar
U2009:11	Detektering och kvantifiering av metangasläckage från deponier
U2009:12	Avfallshantering på öar och i glesbygd
U2009:13	Insamling av återvinningsbart material i blandad fraktion
U2009:14	Substrathandbok för biogasproduktion
U2009:15	Fiskhälsa
U2009:16	Nya lakvatten – Kemisk sammansättning och lämplig behandling
U2009:17	Inventering av återvinningsbart material i verksamhetsavfall - förstudie
U2009:18	Energy from waste - Potential contribution to EU renewable energy and CO_2 reduction tragets

AVFALL SVERIGES UTVECKLINGSSATSNING, BIOLOGISK BEHANDLING

B2009	Certification rules for compost
B2009	Certification rules for digestate
B2009:01	Insamlade mängder matavfall i olika insamlingssystem i svenska kommuner

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D2009:01	Övervakning av tätskikt i deponier med impedansspektroskopi
D2009:02	Behovet av nedströmsskydd ur ett långtidsperspektiv

AVFALL SVERIGES UTVECKLINGSSATSNING, AVFALLSFÖRBRÄNNING

F2009:01	Flygaskors egenskaper i våt miljö
F2009:02	Erfarenheter av miljöpåverkan vid användning av slaggrus som förstärkningslager
F2009:03	PCB- och dioxininnehåll i svenska avfallsbränslen

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