CLIMATE PROTECTION POTENTIALS OF EU RECYCLING TARGETS

January 2008

Knut Sander
Ökopol GmbH (Germany)

Institut für Ökologie und Politik GmbH

Credit

With thanks to
Keith James WRAP (UK)

1. Executive summary

Background and approach

Waste management has a twofold involvement in climate change. On the one hand it is the source of climate change gases (e.g. CH_4 from landfilling, CO_2 from incineration and recycling). On the other hand it contributes to the reduction of climate change potential of production and consumption by providing raw materials and avoiding processes that consume primary resources.

Presently recycling of waste is already a relevant source of secondary raw materials. In 2005 around 95 million tonnes of waste have been recycled in the European Union. The quantitative effect of waste recycling on climate protection is, however, not examined extensively.

This report aims at the identification of climate protection potentials of waste recycling and their quantification as far as possible. With this it shall provide additional background information and data for the ongoing discussion about waste recycling targets and the provisions of the Waste Framework Directive.

Focus is set on recycling of Municipal Solid Waste (MSW). The amount of municipal solid waste increased in the years from 1996 to 2005 between 1.1% per year for as an average. As basis for the calculation of climate protection potentials of recycling the waste amount of the year 2005 has been taken as a starting point and the assumptions was made that the successful efforts of waste prevention result in stable overall amounts of waste in EU27 in the period under consideration (until the year 2020). If this (optimistic) scenario does not take place (and the waste amount increases further) the potentials of recycling would be even bigger than shown in this report.

As data basis for waste management activities in Europe information from EUROSTAT have been used. Regarding the composition of MSW a set of different data sources has been evaluated and account has been taken especially of the data from the OECD Environmental Data Compendium (2007).

As a basis for the determination of climate protection potentials of waste recycling the approach of WRAP[1] was applied. In this comprehensive study 55 life cycle assessments with more than 200 waste management scenarios were analysed. As a result data about climate protection potentials of waste management options have been identified which are based on cradle to grave approach - the benefits of recycling are shown against the whole life cycle to show all the fluxes considered. This delivered more comprehensive insight than approaches where, for example, exclusively the waste phase of the material has been analysed.

[1] Waste & Resources Action Programme (UK) [WRAP 2006]

Two scenarios for future recycling rates have been assessed against the status quo:

Scenario 50+: Here the average recycling rate is 53% and the rate of incinerated waste was set to 25%. The rest (22%) is landfilled in this scenario.

Scenario 65: Here the recycling rate was set to 65% (according to the highest recycling rate achieved so far in a Member State). The incineration rate has been maintained as in scenario 50+ and the resulting average landfill rate for EU27 is 10%.

Results

A methodology for the determination of climate protection potentials of **re-use and waste prevention** is not yet available. For a rough estimation of CO_{2eq} savings from a reduction of waste amounts the CO_{2eq} emissions in two scenarios have been compared. In the first scenario the waste amount increases with a similar rate as it has been in the period from 1996 to 2005 by 1.1% per year. In the second scenario the waste amount has been stable as a result of waste prevention and re-use. In the first year the CO_{2eq} savings from re-use and prevention are still low (7 million tonnes). They increase until 2020 to 133 million tonnes per year (average of 69 million tonnes per year) and sum up over the whole period under consideration to 1.1 billion tonnes.

The analysis of the effect of increased **recycling** rates in the EU revealed the high potentials of CO_{2eq} savings from recycling. Already in 2005, where 37% of the waste in EU27 was recycled, savings of around 158 million tonnes CO_{2eq} have been achieved. By increasing the recycling rate according to scenario 50+ the yearly CO_{2eq} reductions rise to 247 million tonnes. In the scenario 65 the yearly savings of CO_{2eq} are at around 303 million tonnes.

The additional CO_{2eq} savings from recycling (compared to the base scenario) equal the emissions from 31 million (scenario 50+) respectively 51 million (scenario 65) passenger cars on European roads. The CO_{2eq} savings from re-use and prevention of waste in both scenarios equal the emission of 24 million European passenger cars (as an average over the period under consideration).

Taking a valuation factor of 10 € to 40 € per tonne of CO_{2eq} the economic benefit from reduction of emission of CO_{2eq} from increased recycling can be calculated with 2.5 billion € to 9.9 billion € per year for scenario 50+ and 3 billion € to 12 billion € per year for scenario 65. The **additional** economic benefit from reduction of waste amount from re-use and prevention as considered in both scenarios is 0.7 billion € to 2.8 billion € per year.

The results of the modelling exercise have been reviewed for modified waste compositions, CO_{2eq} factors and recycling rates per waste fraction. This sensitivity analysis has shown that the order of magnitude of the CO_{2eq} savings is considered to be an accurate reflection of current and future situation.

Table of content

2. Introduction

Waste management has a twofold involvement in climate change. On the one hand it is the source of climate change gases (e.g. CH_4 from landfilling, CO_2 from incineration and recycling). On the other hand it contributes to the reduction of climate change potential of production and consumption by providing raw materials and avoiding processes that consume primary resources.

Presently recycling of waste is already a relevant source of secondary raw materials. In 2005 around 95 million tonnes of waste have been recycled in the European Union. The quantitative effect of waste recycling on climate protection is, however, not examined extensively.

This report aims at the identification of climate protection potentials of waste recycling and their quantification as far as possible. With this it shall provide additional background information and data for the ongoing discussion about waste recycling targets and the provisions of the Waste Framework Directive.

Chapter 3 of this report describes the data basis and basic decisions taken for the calculation of climate protection potentials of waste recycling. Chapter 5 explains the methodological approach taken. The quantified results of the calculation of climate protection potentials of waste recycling are described in chapter 6 of this report.

3. Data basis

In a first step the situation of waste management in EU27 has been analysed. In this report focus of this analysis is set on recycling of Municipal Solid Waste (MSW). For this type of waste the data basis is relatively far elaborated and the generation mechanisms are comparable in the Member States. For waste from production sites and processes specific wastes additional analysis and case by case approaches would be required.

Availability of waste data for EU27 improved in recent years, but they are still not comprehensive. In order to base the calculation of climate protection potentials on a homogeneous data basis the data from EUROSTAT for the year 2005 were chosen.

The amount of municipal solid waste increased in the years from 1996 to 2005 between 1.1% per year for EU27 and 1.5% per year for EU15 as an average. Two predictions about the further development of waste amounts have been considered (see also figure below):

- In the first prediction ('A') a similar increase of waste amounts as found for the period between 1996 and 2005 has been applied for the period until 2020 resulting in an overall waste amount of 299.6 million tonnes in 2020.
- In prediction B the waste amount of the year 2005 has been taken as a starting point and the assumptions was made that the successful efforts of waste prevention result in stable overall amounts of waste in EU27 in the period under consideration (until the year 2020).

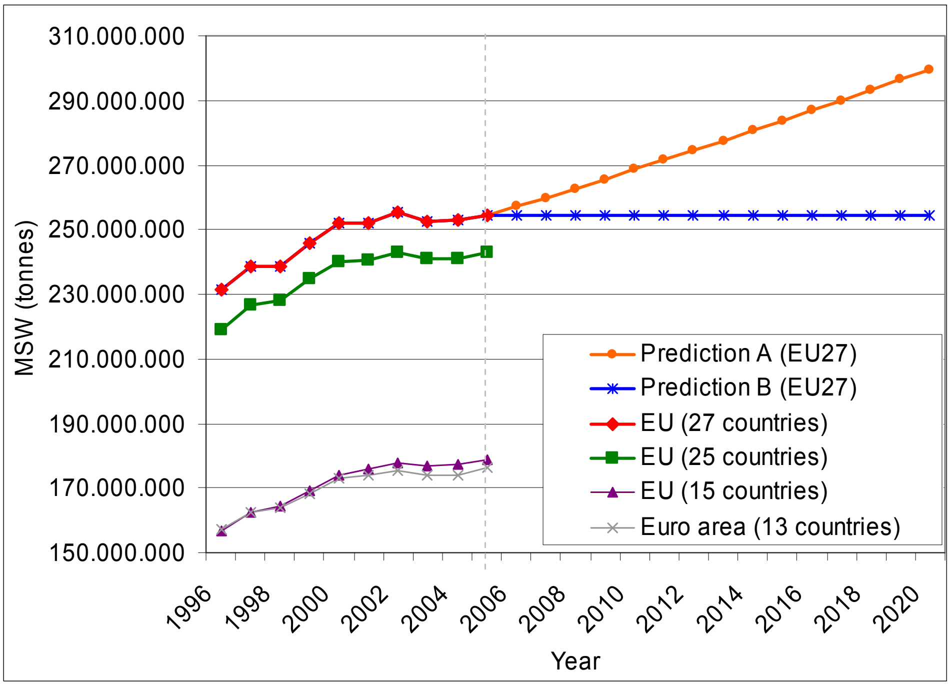


Figure 1: Development of amounts of MSW [EUROSTAT 2007 and own calculations]

Prediction 'B' has been taken as basis for the calculation of climate protection potentials of waste recycling. If this (optimistic) scenario does not take place (and the waste amount increases further) the potentials of recycling would be even bigger than shown in this report.

In 2005 ~37% of the municipal solid waste has been recycled in EU27, 18% has been incinerated and 45% has been landfilled [EUROSTAT 2007]. However, the recycling rate differs significantly between the Member States. While [EU-ROSTAT 2007] mentions a recycling rate of 7% in Poland the rate for Nether-lands according to the same source is 63%. 15% of the Member States already achieved recycling rates above 50% in 2005, 33% above 40% and 48% above 30%, The following figure summarises the share of general waste management options (recycling, incineration, landfilling) in the Member States and for EU27

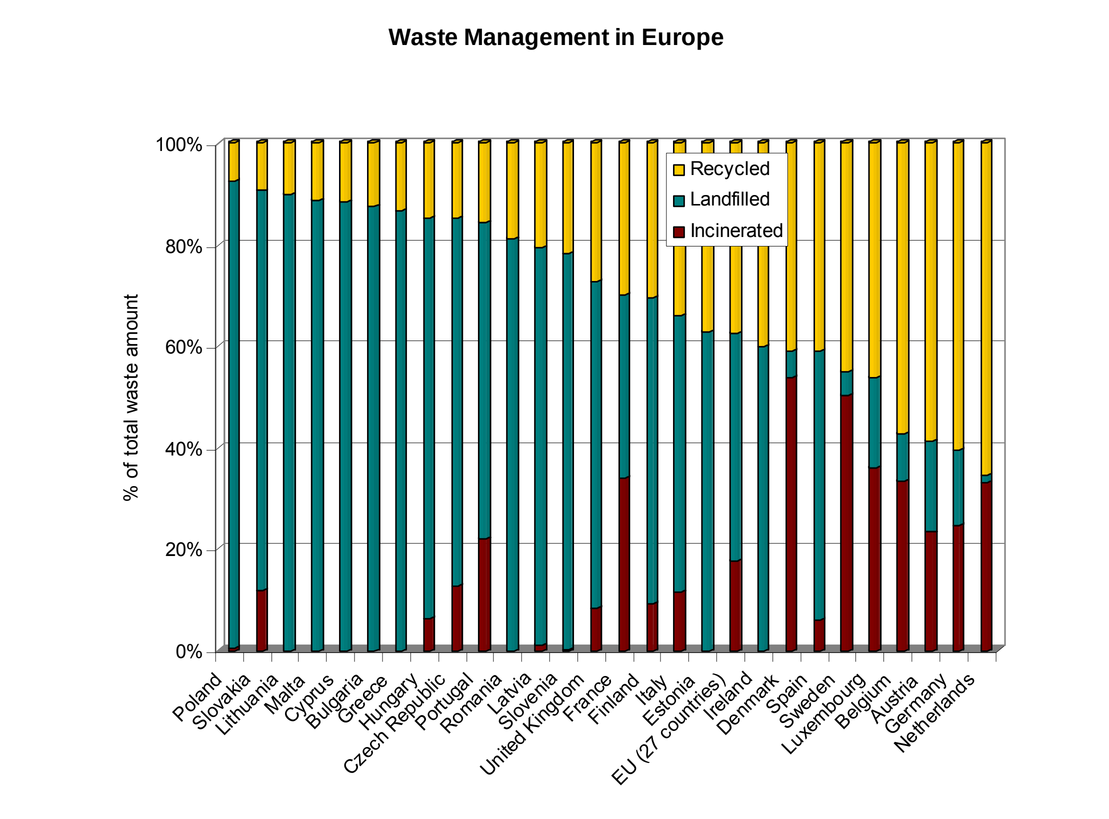


Figure 2: Relative scale of waste management options in EU27 per Member State [EUROSTAT 2007 and own calculations]

4. Approach

Waste prevention and the reduction of waste by re-use reduce the overall climate change potential from waste management activities and from the "loss" of resources. Several examples for re-use of electrical and electronic appliances textiles, furniture or packaging demonstrated this potential. Although probably very large, the quantification of the overall climate protection potentials from re-use of waste still encounters the problem that methodology is not yet developed and data basis is very weak and unsystematic. A rough estimation of the effects of waste reduction by prevention and re-use has, however, been performed based on a comparison of CO_{2eq} emissions in waste prediction A[2] with CO_{2eq} emissions in waste prediction B.

[2] see chapter 3

Relevant data gaps exist regarding the composition of municipal solid waste in the Member States and the average composition for EU27. The amount of solid waste generated per person and its composition varies significantly with social and economic conditions (Maćków 2005). Although several data sources exist, these are in varying degrees of detail. For example, the split may only show. bio and non-biodegradable waste. Organic waste may be split into garden and kitchen waste or shown as one item. The greater the detail the more pertinent the CO_{2eq} factors are that can be applied to the waste category.

Figures from different data sources cover different time periods and geographies and rarely agree with each other. Examples of these are shown in table 1 below. However, in terms of the most significant waste streams, the data sources do agree on an order of priority.

Table 1: Example of Published Compositions for European Municipal Solid Waste (MSW)

	Proportion of MSW (%)							
Component	England MSW composition 2005-06	ACCR (2000) EU15	OECD (2007) (2000 data) EU 15	EIONET (2006)	IPPC (2006) (based on data from 2000)			
					Eastern Europe	Northern Europe	Southern Europe	Western Europe
Plastics	12	9	8	11	6.2	13		
Metals	4	4	5	3	3.6	7		
Glass	5	7	11	6	10	8		
Paper / cardboard	18	26	29	35	21.8	30.6	17	27.5
Textiles	4	5	2	2	4.7	2		
Other	26*	18	13		14.6			
Food Waste	25				30.1	23.8	36.9	24.2
Garden Waste	6							
Organics		29	31	25				
Specials / composites		2						
Wood					7.5	10	10.6	11

*see figure 3 for further breakdown.

The data for England represent a most recent compositional set found, and provides the details on waste composition as shown in figure 2 below. Although there is a difference in age, the data is similar to that for Europe, which is likely to have changed over time, based on changes over the last 15 years as shown in the OECD Environmental Data Compendium (2007).

Although it is unlikely that the data for England will match any single EU state, particularly given variations in climate between southern and northern Europe, it is considered to be relevant to the EU and to provide a realistic indication of municipal waste composition.

The following figure shows the average composition of MSW for EU27 as used for the calculations in this report.

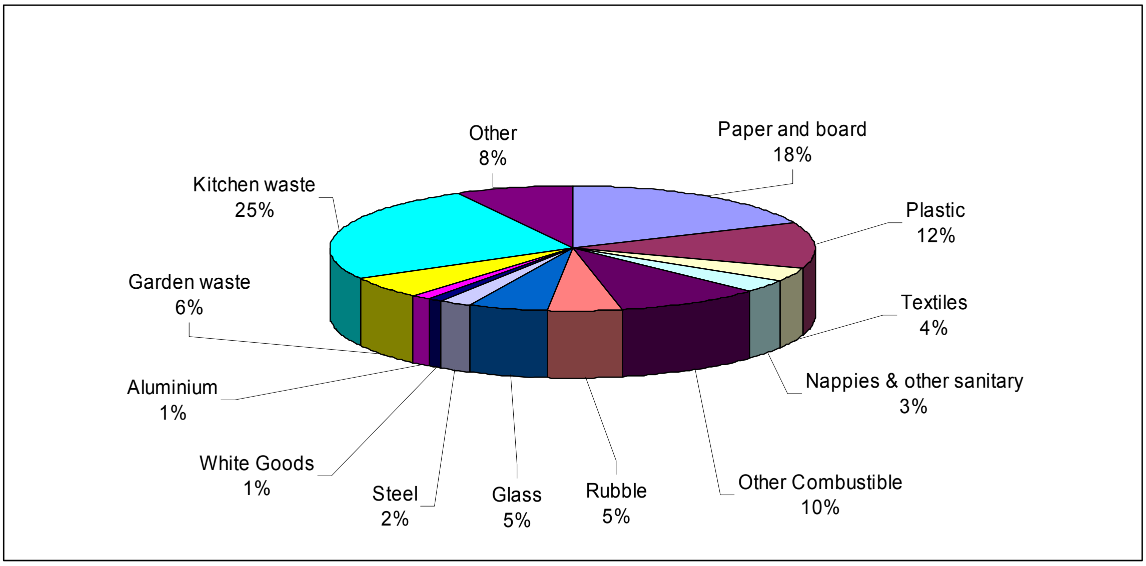


Figure 3: Composition of MSW in EU27 as used in this report

For the calculation of CO_{2eq} of waste management options it is assumed that the composition of residual waste and recycled waste is the same across Europe.

The sensitivity of the results to different compositions is discussed in section 7.

As a basis for the determination of climate protection potentials of waste recycling the approach of [WRAP 2006] was applied. In this comprehensive study 55 life cycle assessments with more than 200 waste management scenarios were analysed. As a result data about climate protection potentials of waste management options have been identified which are based on cradle to grave approach - the benefits of recycling are shown against the whole life cycle to show all the fluxes considered. This delivered more comprehensive insight than approaches where, for example, exclusively the waste phase of the material has been analysed (see following figure).

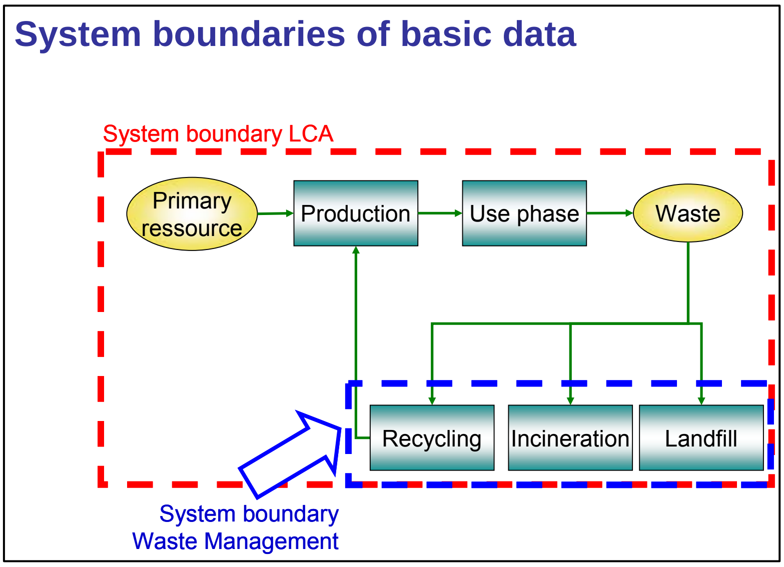


Figure 4: System boundaries

The analysis of [WRAP 2006] resulted in the specific factors for the emission of CO_{2eq} shown in the table below. The figures are based on a review of several Life Cycle Assessments for each material, covering a range of assumptions, efficiencies and processes. As such they are unlikely to agree with figures found in any single LCA covering the given materials.

Table 2: CO_{2eq}- emission factors per fraction of waste

Material	**CO_{2eq}** per t of landfilled fraction	**CO_{2eq}** per t of incinerated fraction	**CO_{2eq}** per t of recycled fraction	Source
Paper and cardboard	3,99	2,56	2,50	[WRAP 2006]
Plastic packaging	3,60	5,00	1,70	[WRAP 2006]
Textiles	18,00	9,00	2,00*	Allwood (2006) [ERM 2006], Morley et al (2006), Woolridge et al.(2006)
Other combustibles	0,29	-0,171	0,00	[ERM 2006]
Glass packaging	0,84	0,84	0,53	[WRAP 2006]
Steel packaging	3,00	1,30	0,70	[WRAP 2006]
White goods	3,00	3,00	0,70	[WRAP 2006]
Aluminium packaging	9,00	11,00	2,00	[WRAP 2006]
Garden waste	0,01	-0,22	0,02	Grant (2003), WRAP calculation
Kitchen waste	4,50	4,20	4,08	WRAP calculation 2007, [Lundie and Peters 2005]

*The figure includes an element of textile reuse as well as recycling. Morley et al (2006) suggest that 70% of textiles collected separately are reused.

5. Analysis

In order to analyse the climate protection potentials of recycling three scenarios have been developed.

The basis scenario summarises the situation in EU27 in 2005 and serves as a basis for comparing the effects of increased recycling rates. It shows the average recycling rate for EU27 of 37% and a portion of incinerated waste of 18%. The rest (45%) is landfilled [EUROSTAT 2007].

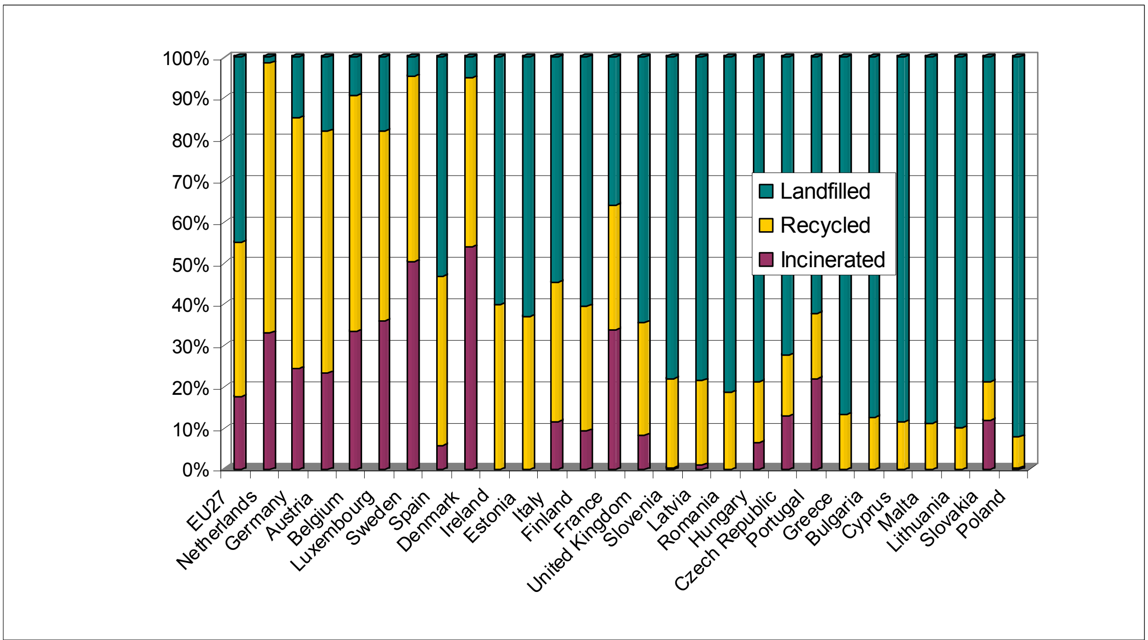


Figure 5: Shares of waste management options in basis scenario

In the Scenario 50+ the recycling rate is set in general to 50%. However, there are some countries that achieved higher recycling rates than 50% already in 2005 (Netherlands, Germany, Austria, Belgium). The higher recycling rates of those countries have been maintained resulting in a (weighted) average recycling rate for EU27 in this scenario of 53%.

The rate of incinerated waste was set to 20% in general. However, here again, some countries already have higher incineration rates (Denmark, Sweden, Luxembourg, France, Belgium, Netherlands, Germany, Austria, Portugal). With a similar approach as for the recycling rates the resulting average incineration rate is 25%.

The rest (22%) is landfilled in this scenario.

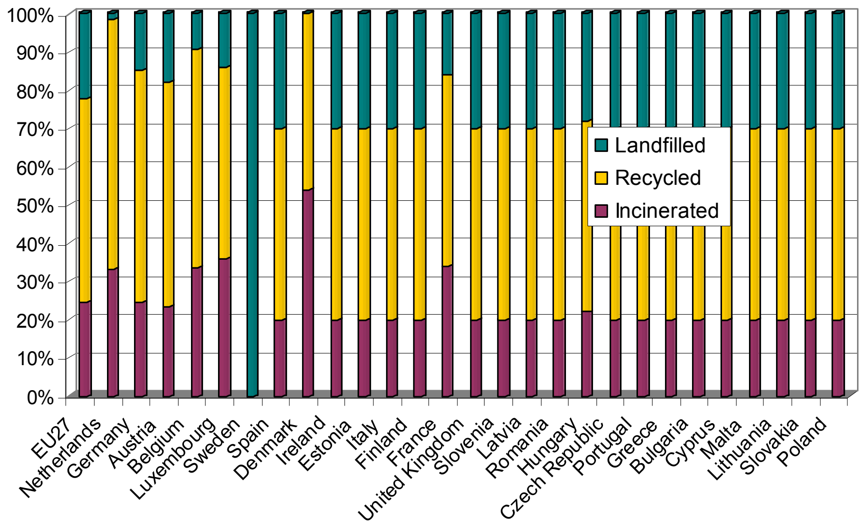


Figure 6: Shares of waste management options in scenario "50+"

In a third scenario called "Scenario 65" the recycling rate was set to 65% (according to the highest recycling rate achieved so far in a Member State). The incineration rate has been maintained as in scenario 50+ and the resulting average landfill rate for EU27 is 10% (see figure below).

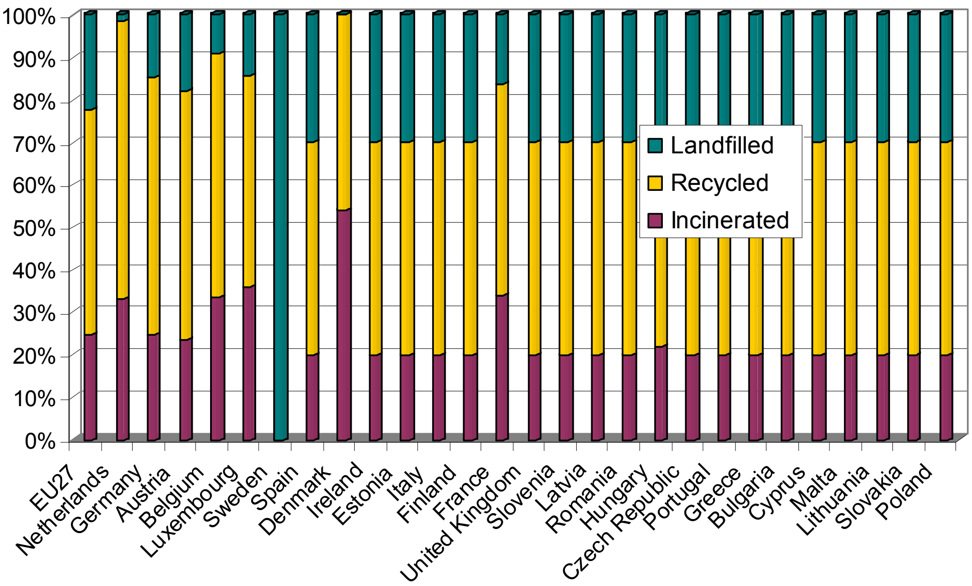


Figure 7: Shares of waste management options in scenario "65"

The following table summarises the elements of the scenarios.

Table 3: Summary of analysed scenarios

	Recycling	Incineration	Landfill	Comments
Basis scenario	37 %	18 %	45%	
Scenario 50 +	50 % (∅ 53 %)	20 % (∅ 25 %)	Rest (∅ 22 %)	Where the recycling rate was >50% and the incineration rate >20% in 2005 in a MS the original rate was maintained /20%. This results in overall average rates for EU27 above 50%/20%.
Scenario 65	65 % (∅ 65 %)	20 % (∅ 25%)	Rest (∅ 10 %)	

6. Results

As explained in chapter 4 a methodology for the determination of climate protection potentials of re-use and waste prevention is not yet available. For a rough estimation of CO_{2eq} savings from a reduction of waste amounts the CO_{2eq} emissions in two scenarios have been compared. In the first scenario ('Prediction A' see chapter 3) the waste amount increases with a similar rate as it has been in the period from 1996 to 2005 by 1.1% per year. In the second scenario ('Prediction B' see chapter 3) the waste amount has been stable as a result of waste prevention and re-use. In the first year the CO_{2eq} savings from re-use and prevention are still low (7 million tonnes). They increase until 2020 to 133 million tonnes per year (average of 69 million tonnes per year) and sum up over the whole period under consideration to 1.1 billion tonnes.

The analysis of the effect of increased recycling rates in the EU revealed the high potentials of CO_{2eq} savings from recycling. Already in 2005, where 37% of the waste in EU27 was recycled, savings of around 158 million tonnes CO_{2eq} have been achieved.

By increasing the recycling rate according to scenario 50+ the yearly CO_{2eq} reductions rise to 247 million tonnes.

In the scenario 65 the yearly savings of CO_{2eq} are at around 303 million tonnes.

The sources of CO_{2eq} savings are mainly the avoided primary production from primary resources and the avoided emissions from landfilling.

The following figure summarises the findings.

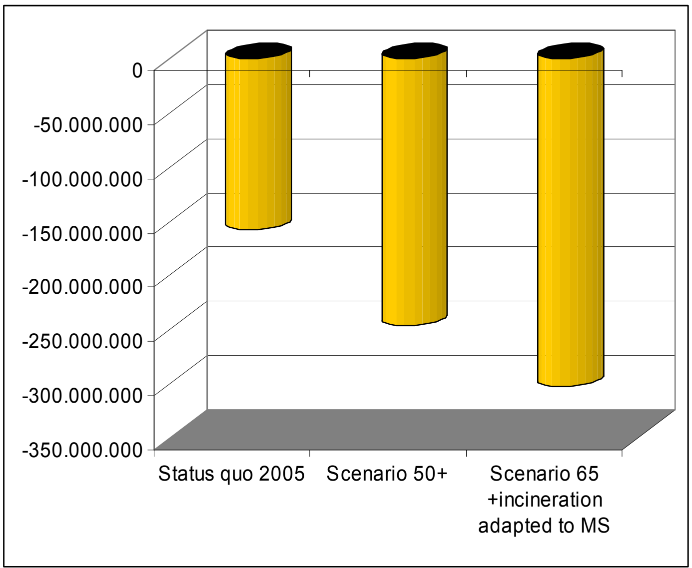


Figure 8: Climate protection potentials of recycling (tonnes of CO_{2eq})

The additional CO_{2eq} savings from recycling (compared to the base scenario) equal the emissions from 31 million (scenario 50+) respectively 51 million (scenario 65) passenger cars on European roads[3].

The CO_{2eq} savings from re-use and prevention of waste in the scenarios equal the emission of 24 million European passenger cars (as an average over the period under consideration).

Taking a valuation factor of 10 € to 40 € per tonne of CO_{2eq} [4] the economic benefit from reduction of emission of CO_{2eq} from increased recycling can be calculated with 2.5 billion € to 9.9 billion € per year for scenario 50+ and 3 billion € to 12 billion € per year for scenario 65. The **additional** economic benefit from reduction of waste amount from re-use and prevention as considered in both scenarios is 0.7 billion € to 2.8 billion € per year.

[3] Calculation basis: Average of 15 000 km per passenger car and year according to [ANFAC 2007] and the TREMOVE database and own calculations and average emission of 180 gCO2 per km (average value related to new vehicles in 1998 according to [DG Env. 2007])

[4] „Calculated taking a valuation factor ranging from €10 to €40 per tonne $_{CO2\ equivalent}$. Most of the valuation factors used in literature as well as the market value of carbon trading fall within this range. However, some methodologies documented in the literature use higher values, for example the EPS method uses 108“ [DG Env 2004]

7. Sensitivity

The results of the modelling exercise have been reviewed for the following alterations:

7.1. Change in waste composition.

The waste composition modelled was varied. For 3 variations of the waste composition the resulting deviations of the CO_{2eq} saving potentials have been calculated. Variation 1 (V1) has an increased share of packaging (doubled amount of packaging), variation 2 (V2) has a reduced share of packaging (halved amount of packaging) and V3 is high in garden-/kitchen waste (+50%).

For V1 the CO_{2eq} varied between -5% and +6%, for V2 between +4% and -5%. The biggest deviation could be observed for V3 (-11% to +12%). However, in an overall view the variations of the CO_{2eq} value are relatively small compared to the variation of the waste composition.

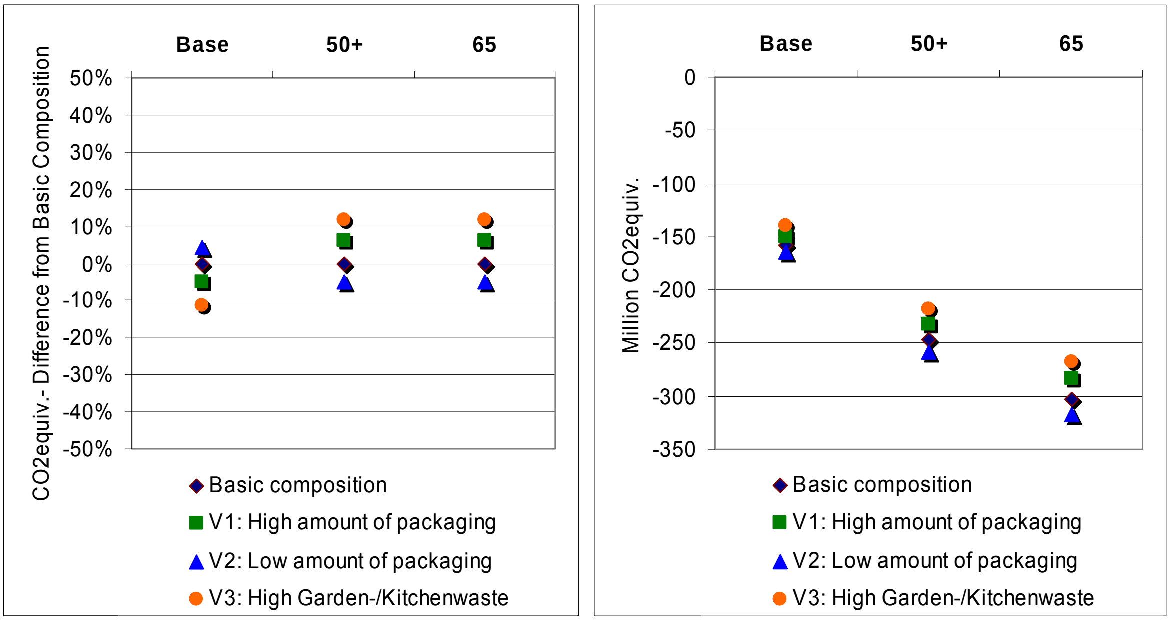


Figure 11: Development of CO_{2eq} saving potentials from variations of the waste composition

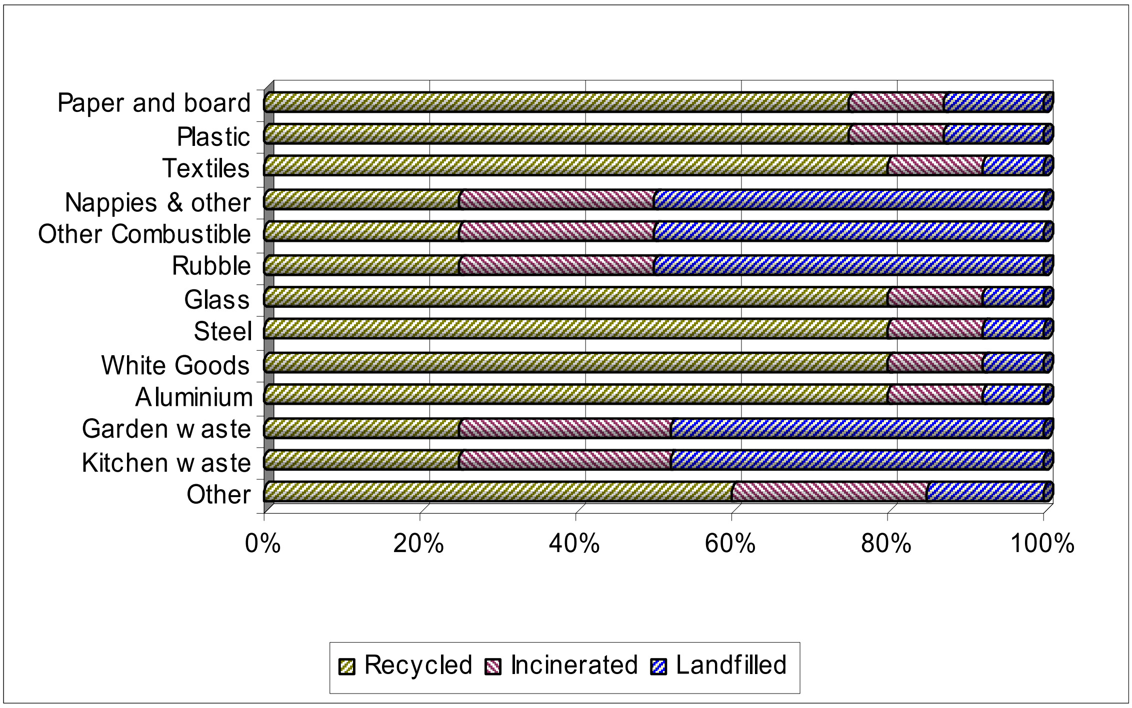
Although changes to the proportions may affect the level of emissions, the differences between the waste management options remains similar. The order of magnitude of the savings is considered to be an accurate reflection of current and future practices.

7.2. Change in CO_{2eq} factors

The factors used are based on a range of data sources, and the results are sensitive to alterations. However, it is considered that the factors utilised are representative of a range of processes and practices across Europe. It is considered that majority of future research will be consistent wit the findings of this review.

7.3. Recycling rates per fraction

In the calculation general recycling and incineration rates per Member State have been applied independently of the situation of the individual waste fractions. In a second calculation ('Approach II') this was counterchecked by a more fraction oriented approach where the recycling rates for all EU27 Member States have been varied per waste fraction (e.g. 75% recycling rate for paper and cardboard, 80% recycling rate for glass and 80% for aluminium but only 25% for rubble - see figures below). The overall average recycling rate in scenario 50+ is here 50% (compared to 53% in Approach I) and 65% in scenario



65. The average incineration rate is here 20% for scenario 50+ and 65.

Figure 9: Recycling rates of scenario 50+ in approach II

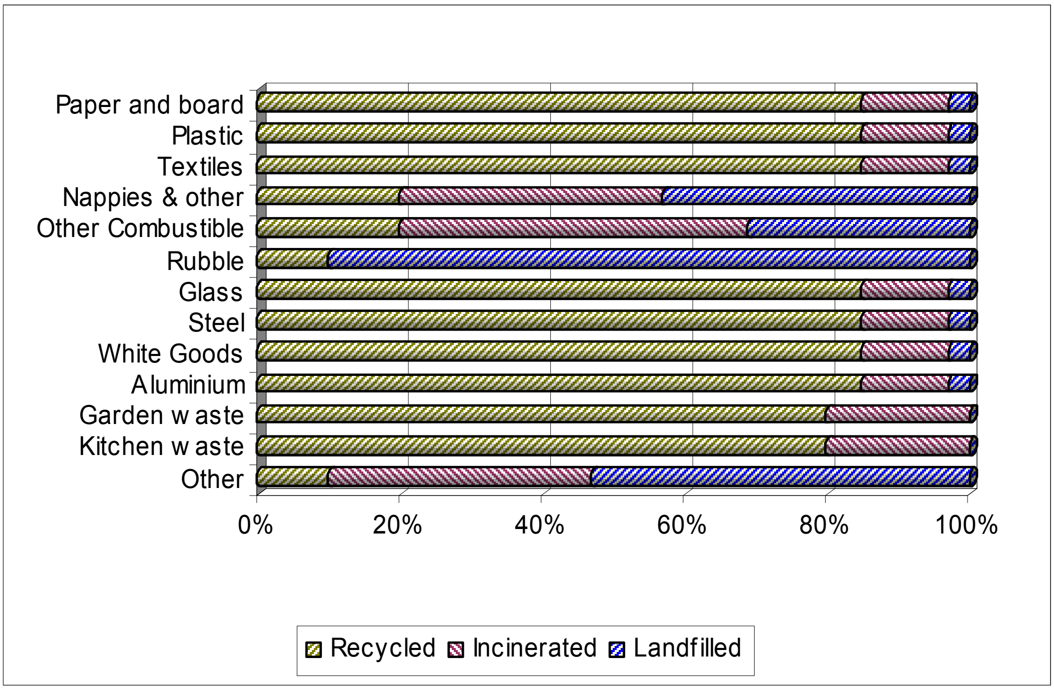


Figure 10: Recycling rates of scenario 65 in approach II

In scenario 50+ of 'Approach II' the savings of CO_{2eq} sum up to 290 million tonnes per year, in scenario 65 of 'Approach II' they sum up to 323 million tonnes per year. This means that for scenario 50+ 17% higher saving potentials for CO_{2eq} result from this fraction oriented approach compared to the calculation per Member State in spite of the fact that here the overall recycling rates are 3% lower. For scenario 65 the additional saving potential equals 7%. It can be assumed that the results of 'Approach I' slightly underestimate the actual saving potentials. However in general the results of 'Approach I' are confirmed by the results from 'Approach II'.

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9. Annex

Waste amounts in EU27 [EUROSTAT 2007 and own calculations]

	Generated	Recycled	Incinerated	Landfilled
EU (27 countries)	254 285 309	95 234 266	44 671 743	114 379 299
Netherlands	10 174 648	6 652 655	3 375 244	146 750
Germany	49 583 010	30 030 309	12 210 126	7 342 576
Austria	5 170 110	3 036 414	1 206 359	927 337
Belgium	4 846 875	2 778 597	1 619 107	449 172
Luxembourg	320 775	147 875	115 115	57 785
Sweden	4 343 491	1 955 472	2 180 757	207 262
Spain	25 693 707	10 544 319	1 506 331	13 643 057
Denmark	3 988 205	1 634 244	2 148 328	205 633
Ireland	3 040 788	1 216 315	0	1 824 473
Estonia	587 514	218 297	0	369 218
Italy	31 686 607	10 757 077	3 624 667	17 304 863
Finland	2 450 734	748 835	225 174	1 476 724
France	33 947 584	10 190 527	11 503 417	12 253 640
United Kingdom	35 074 982	9 609 584	2 942 935	22 522 463
Slovenia	844 981	183 778	1 998	659 205
Latvia	714 995	147 612	6 919	560 463
Romania	8 273 558	1 559 414	0	6 714 144
Hungary	4 634 775	686 633	292 829	3 655 313
Czech Republic	2 953 747	439 485	378 161	2 136 101
Portugal	4 696 048	737 048	1 031 867	2 927 133
Greece	4 854 245	642 800	0	4 211 445
Bulgaria	3 593 366	450 141	0	3 143 225
Cyprus	553 640	64 429	0	489 211
Malta	246 030	27 381	0	218 649
Lithuania	1 294 772	130 162	0	1 164 610
Slovakia	1 556 214	145 390	183 084	1 227 739
Poland	9 352 590	687 129	38 174	8 627 287