EEA Report | No 3/2011

Waste opportunities

Past and future climate benefits from better municipal waste management in Europe

ISSN 1725-9177

European Environment Agency

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Luxembourg: Publications Office of the European Union, 2011

ISBN 978-92-9213-221-7
ISSN 1725-9177
doi:10.2800/79764

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Environmental production
This publication is printed according to high environmental standards.

Printed by Schultz Grafisk
— Environmental Management Certificate: DS/EN ISO 14001:2004
— Quality Certificate: ISO 9001: 2008
— EMAS Registration. Licence no. DK – 000235
— Ecolabelling with the Nordic Swan, licence no. 541 176

Paper
Reprint Delux — 90 gsm.
CyclusOffset — 250 gsm.

Printed in Denmark

EMAS
Verified environmental management
REG.NO. DK-000244

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Contents

1 Introduction

Using a life-cycle perspective, this report analyses the greenhouse gas emissions from municipal solid waste management in the EU, plus Norway and Switzerland. Among other important conclusions, it finds that:

- improved municipal solid waste management in these countries has already cut annual net greenhouse gas (GHG) emissions by 48 million tonnes CO_2-equivalent between 1995 and 2008;
- the two main factors responsible for this improvement are reduced methane emissions from landfill and increased avoided emissions through recycling;
- if all countries fully meet the Landfill Directive's waste diversion targets, potential life-cycle GHG emissions from municipal waste management in 2020 could be cut by a further 62 million tonnes, which equals 1.23 % of their total GHG emissions in 2008;
- a complete ban on landfilling could cut emissions even further, reducing potential net emissions from waste management in 2020 by 78 million tonnes compared to 2008 — an amount slightly greater than Hungary's total emissions in 2008.

As this report makes clear, better management of municipal solid waste can reduce greenhouse gas emissions significantly. But to tap this potential, the EU's waste directives must be implemented fully — in particular the Landfill Directive.

In its 6th Environment Action Programme (2002–2012), the EU set the objective of decoupling waste generation from economic growth. The European Commission's thematic strategy on the prevention and recycling of waste (EU, 2005) called for life-cycle thinking in waste policies and moving towards a recycling society. And in its recent review of the thematic strategy (EU, 2011), the Commission also called for 'better information and forecasts of life-cycle-based environmental and health impacts of the waste policies with a specific focus on resource and climate policies'. This has in turn highlighted the opportunities for improved coherence between policies on waste and those on climate change and resource efficiency.

To help achieve these objectives, the EU has adopted directives to reduce environmental impacts from the waste stage of the product life cycle. The Waste Framework Directive (EU, 2008) aims to improve waste management, mainly by preventing waste and increasing recycling, while the Landfill Directive (EU, 1999) introduced targets to reduce the landfilling of biodegradable municipal waste. These measures will also improve resource efficiency in the EU, since recycled materials can partly replace virgin resources.

The objective of reducing waste generation, including municipal solid waste, has not yet been achieved. Eurostat data indicate that, on average, an EU citizen produced 468 kg of municipal solid waste (MSW) in 1995 and 524 kg in 2008. According to the analysis in the present report, that figure is projected to rise to 558 kg in 2020 if effective policies to reduce waste generation are not put in place. However, all EU Member States are obliged to draw up waste prevention programmes that can help reduce this projected amount.

Encouragingly, ever more MSW is recycled and less is landfilled. The EU recycled 17 % of its MSW in 1995 and 40 % in 2008. In that period, the landfill share dropped from 68 % to 40 %.

This short report shows that full implementation of existing European waste legislation in the EU-27 (excluding Cyprus), Norway and Switzerland

Box 1.1 Two different perspectives on GHG emissions from waste: the sector approach and the life-cycle approach

The EU-27 reports GHG emissions annually pursuant to the United Nations Framework Convention on Climate Change (UNFCCC). All emission sources are divided into sectors according to Intergovernmental Panel on Climate Change (IPCC) recommendations. The waste sector includes 'solid waste disposal on land' (landfills), 'wastewater handling' (anaerobic digestion) and 'waste incineration' (without energy recovery). Other emissions related to waste management, such as emissions from recycling, waste transport, and waste incineration with energy recovery, are reported under other IPCC sectors and thus not classified as being linked to the waste management system.

This classification is used in the annual EU greenhouse gas inventory reports (EEA, 2011 and previous editions) as well as in a recent Eurostat publication on GHG emissions from the waste sector (Eurostat, 2011). Following this approach, the waste sector contributes around 3 % to all GHG emissions in the EU-27. Since 1990, it has reduced its emissions by 31 %, mainly via reduced methane emissions from landfills (EEA, 2011).

This report adopts a different, life-cycle perspective on the waste management system — including its effects on other parts of the economy. According to this approach, the waste management system includes all processes and activities that are directly or indirectly influenced by waste management measures. The waste life-cycle assessment (which includes only the waste stage of the life cycle and excludes the production stage) takes into account the full implications of waste management. For example, credits for recovered energy are attributed to waste management, not the energy sector. Accounting for the avoided emissions in this way shows the full extent of waste management's potential for reducing GHG emissions.

A recent OECD study (OECD, 2011) also adopts a life-cycle approach, albeit using a slightly different methodology. The study examines GHG emissions associated with material management across their whole life cycle in four selected countries. It concludes that more than half of national GHG emissions may be associated with material management activities. In addition, the study provides an 'order of magnitude' estimate for the GHG reduction potential of different MSW management options up to 2030 in several OECD regions, calculated according to their respective technical potentials. The modelling demonstrates significant potentials to reduce GHG emissions — similar in scale to current annual landfill gas emissions in the respective regions.

The differences of the two approaches originate from the different scopes of the methodologies: the UNFCCC protocol aims to register and measure emissions for accounting purposes, while the life cycle approach examines the (potential) effects of policies and practices in waste management on GHG emissions.

would reduce greenhouse gas (GHG) emissions significantly by 2020. Annual emissions from the life cycle of the municipal solid waste management system have already been reduced by 48 million tonnes in the period 1995–2008, and would be cut by another 62 million tonnes in 2020 if all countries fully meet the diversion targets of the EU Landfill Directive (see Scenario 2 in Chapter 4). This potential reduction in the period 2008–2020 equates to 1.23 % of these countries' total GHG emissions in 2008 and therefore constitutes a substantial secondary benefit of implementing waste legislation.

2 Municipal waste and GHG emissions

In this report, GHG emissions provide an example of how improving municipal waste management can reduce the waste system's environmental impacts. Life-cycle GHG emissions from the municipal solid waste management system can be divided into two categories:

- **direct emissions** that originate from waste management activities such as methane from landfills and CO_2 emissions from transport, incineration and recycling plants;
- **avoided emissions,** which represent the life-cycle benefits from resource recovery (using waste as a secondary material or energy source) and replacing the use of virgin materials or fuels.

In this study, the EEA and its European Topic Centre on Sustainable Consumption and Production (ETC/SCP) used the life-cycle approach to model GHG emissions from MSW management, combining direct and avoided emissions. The life-cycle approach can demonstrate the effects of any given change in the waste management system on other sectors of the economy.

First results from the study were published in 2008 (EEA, 2008). They revealed a potential reduction in net GHG emissions from MSW of 45 million tonnes of CO_2-equivalent between the late 1980s and 2020.

The present report presents the outcomes of an improved and updated model. More details about the model, assumptions, data and scenario building are available in an ETC/SCP working paper (ETC/SCP, 2011).

Figure 2.1 shows the modelled GHG emissions associated with MSW management in the EU-27 (excluding Cyprus due to lack of data), plus Norway and Switzerland, assuming a business-as-usual scenario (defined below in Chapter 4). Each waste treatment option (landfilling, incineration, recycling) is attributed both direct and avoided emissions except for waste transport, which only has direct emissions. The sum of all emissions (direct emissions minus avoided emissions) is the net GHG emissions from MSW management in the EU plus Norway and Switzerland, represented by the red line in Figure 2.1.

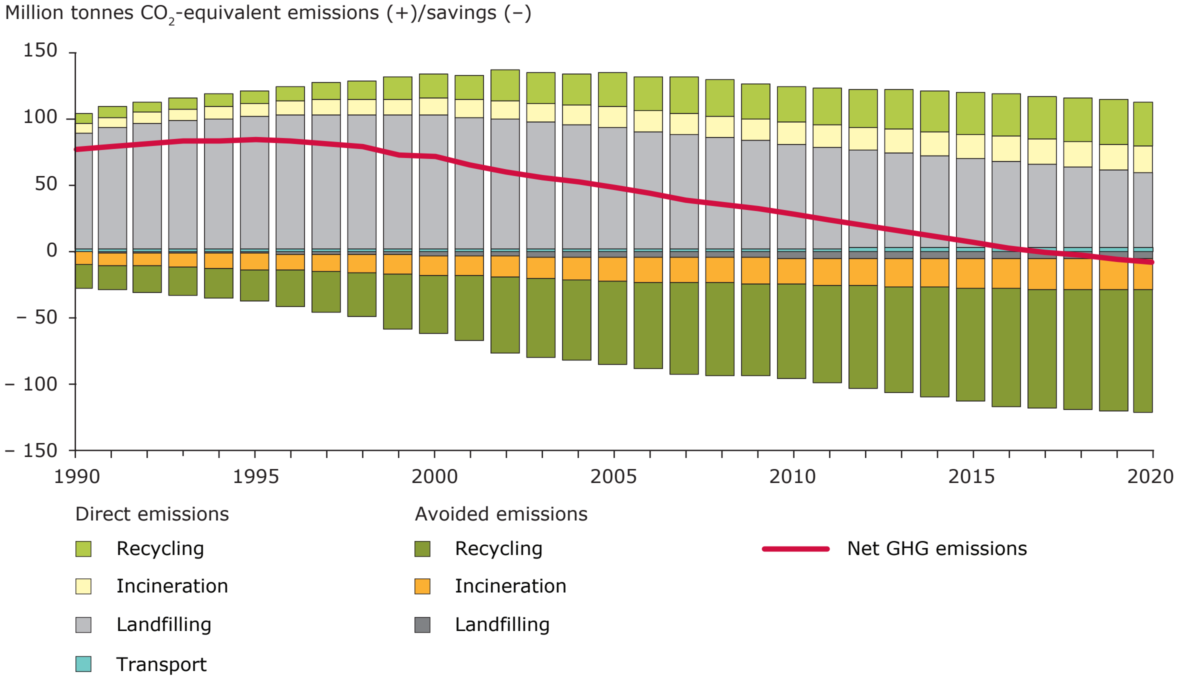
Harvesting the GHG mitigation potential of better municipal waste management can make an important contribution to combating climate change.

Figure 2.1 shows that improved MSW management in several European countries during the late 1990s produced clear effects. Direct GHG emissions from waste management activities peaked in 2002 and have decreased continuously since. Meanwhile, avoided emissions have increased consistently since 1990, mainly as a result of more material recycling and, to a lesser extent, energy recovery. As a result, net GHG emissions peaked in 1995 at over 84 million tonnes of CO_2-equivalent and have been decreasing gradually since.

It should be noted that in regulatory terms some of the emissions (especially avoided emissions from recycling and energy recovery) are covered by the European Emissions Trading System (ETS). Although such emissions cannot be counted as reductions in addition to those under the ETS regime, it is still valid to consider them as an effect of good waste management practice.

Figure 2.1 clearly indicates that the two main factors responsible for bringing down net emissions are decreased methane emissions from landfill and increased avoided emissions through recycling. The Landfill Directive's targets on reducing biodegradable municipal waste going to landfill and reducing methane emissions from landfill have acted as drivers of this development, as have the recycling targets in the Packaging Waste Directive (EU, 1994) and the Waste Framework Directive. In addition, national initiatives and various waste-oriented EU directives were also drivers for the shift from landfilling towards more recycling and energy recovery.

Figure 2.1 Modelled GHG emissions from MSW management in the EU (excluding Cyprus) plus Norway and Switzerland — business-as-usual scenario



Source: ETC/SCP.

Note: GHG emissions before 1995 are calculated based on backcasted waste data. GHG emissions after 2008 are projected.

Box 2.1 Recycling and resource efficiency

Paper provides an example of how improved waste management can achieve better resource efficiency. In 2006, according to the model results, approximately 67 % of waste paper from MSW was recycled. This recycled quantity covered 24 % of the total consumption (not only by households) of paper products in the same year.

If 90 % of all paper from MSW were recycled then 32 % of consumption of paper products could be generated from recycled paper. This increased recycling would also reduce landfilling and incineration, yielding additional GHG savings of about 1.73 million tonnes of CO_2-equivalent.

Of course, incineration of paper also avoids GHG emissions due to energy recovery. However, smart, resource-efficient waste management would imply recycling first and only using energy recovery at the end of life of the final recycled product (paper can be recycled maximum eight times).

3 Recycling and recovering biowaste have benefits for the climate

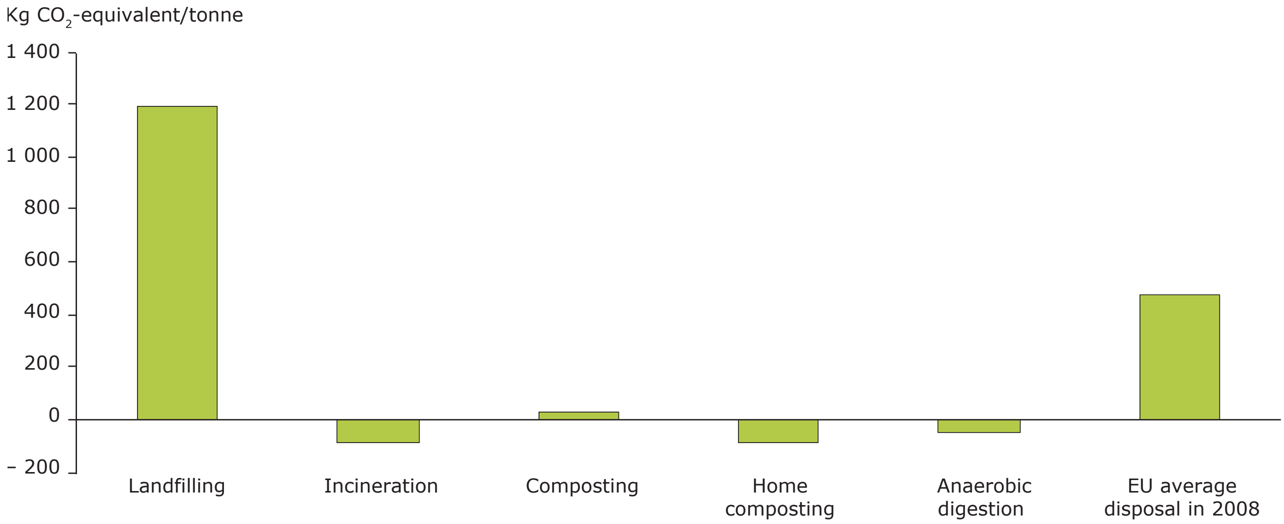
Kitchen and garden waste is the biggest fraction of municipal solid waste in most European countries. The fate of this waste fraction has an important influence on waste management's overall impact on the climate. Collecting and increased recycling of biowaste using established techniques, such as anaerobic digestion and composting, is an example of the many quick opportunities available for GHG mitigation.

Anaerobic digestion produces both an energy source (biogas) and a residual material (digestate). Like digestate, compost produced from separately collected biowaste can be used in agriculture and horticulture as fertiliser or soil conditioner and thus preserve natural resources such as peat from being extracted. However, the heat produced during the composting process cannot be used for purposes other than regulating the temperature of the composting process itself.

Separate collection and recycling of biowaste can lead to significant avoidance of greenhouse gas emissions, especially in countries where landfill is still the prevailing option for disposing of municipal solid waste. The most important factor is the prevention of methane emissions from landfill sites.

Figure 3.1 presents GHG emissions per tonne of biowaste subjected to different treatments, together with the emissions for the average treatment mix in the EU in 2008 (assumed the same as for MSW — 23 % composted, 17 % recycled, 20 % incinerated, and 40 % landfilled). Home composting and anaerobic digestion have small net emissions savings. Incineration also performs well because the emitted CO_2 is of biogenic origin and thus considered not to contribute to global warming. Direct emissions from home composting are negligible (very little methane is emitted) if

Figure 3.1 Net emissions (kg CO_2-equivalent) per treatment option for one tonne of kitchen and garden waste



Note: Emissions cover only the waste management stage of the life cycle.

Source: ETC/SCP.

composting is done well, and there is no transport involved.

The average emissions from municipal biowaste treatment in the EU are largely influenced by the significant use of landfilling in many countries. A shift to recycling or recovery options for biowaste would thus yield important climate benefits.

In 2008 around 44 million tonnes of MSW were composted. According to the model, this led to emissions of 1.4 million tonnes of CO_2-equivalent. Subjecting all this waste to anaerobic digestion instead would reduce the net emissions to – 2 million tonnes of CO_2-equivalent (i.e. avoided emissions exceeding direct emissions by 2 million tonnes).

Photo: © iStockphoto

4 Future potential for cutting GHG emissions from municipal waste

Beyond the progress so far, there is significant further potential to mitigate GHG emissions through better MSW management in the years to 2020.

In order to explore the potential effects on GHG emissions of new waste policies, the EEA and its ETC/SCP developed three scenarios on possible future paths for European MSW management:

- scenario 1 assumes business-as-usual (as presented in Figure 2.1);
- scenario 2 implies full implementation of the EU Landfill Directive;
- scenario 3 models a hypothetical landfill ban on all MSW by 2020 in all countries.

Figure 4.1 illustrates the net emission reduction achieved in the period 1995–2008 (in the first column) and the net GHG emission reductions in 2020 compared to 1995 for all three scenarios (in columns two, three and four). The net emission reduction is calculated as the difference between net emissions in 1995 and net emissions in 2008 or 2020, as appropriate.

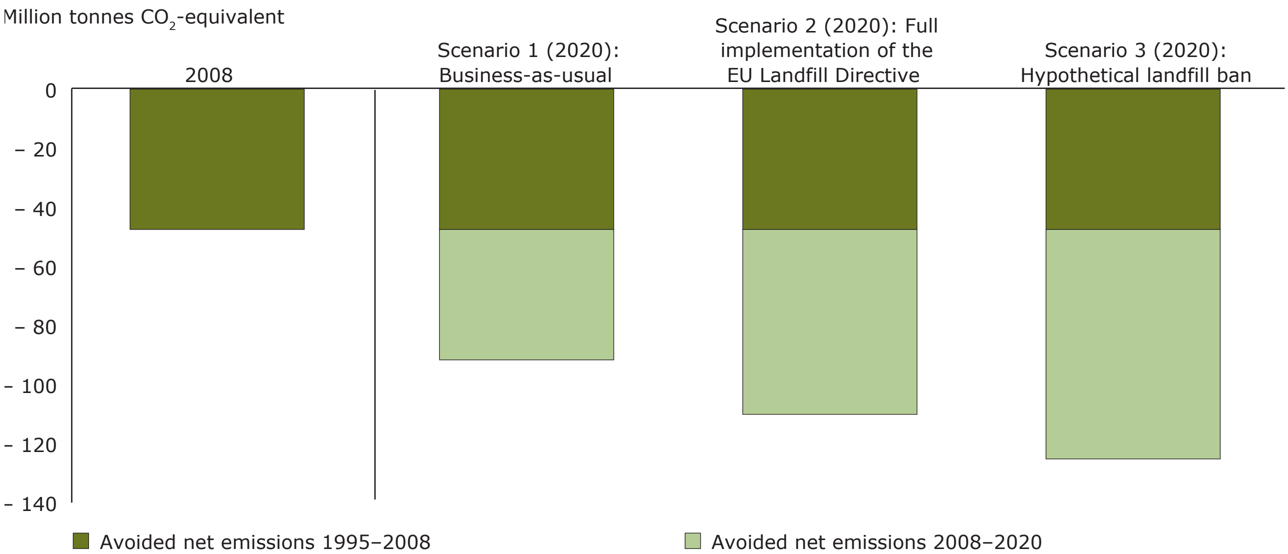
Scenario 1: What if MSW management develops according to current trends?

This is the business-as-usual scenario. It estimates the share of MSW going to landfill, incineration and recycling based on a combination of historical trends and the implementation of planned policy measures. In this scenario, some countries would not meet all of the Landfill Directive's targets for diverting biodegradable municipal waste from landfill.

According to Figure 2.1, which illustrates the results of the business-as-usual scenario, net GHG emissions associated with MSW management have decreased continuously since 1995. In this scenario, the share of landfilling is projected to drop to 28 % and recycling increases to 49 % in 2020.

Reduced landfilling, combined with increased recycling leads to a dramatic increase in avoided emissions due to recycling and energy recovery operations. Net emissions in 2020 would be 92 million tonnes less than in 1995 (a reduction from 84 million tonnes of net emissions to – 8 million tonnes). From 2017 onward, avoided emissions

Figure 4.1 Net emission reductions from MSW management in the EU (excluding Cyprus) plus Norway and Switzerland in 2008 and 2020 compared to 1995



Source: ETC/SCP.

would be larger than direct emissions. Net emissions decreased by 48 million tonnes between 1995 and 2008, and the business-as-usual scenario would yield a further net emission reduction of 44 million tonnes CO_2-equivalent in 2020.

Scenario 2: What if all countries fully implement the Landfill Directive?
If all countries met the Landfill Directive's targets on reducing landfilling of biodegradable municipal waste, less waste would end up in landfills and more would be recycled than in the business-as-usual scenario. In this scenario, recycling would increase to 54 % of MSW and landfilling would drop to 18 % in 2020.

Countries have an additional incentive to realise this scenario because of the recycling targets set for different waste streams in the Waste Framework Directive. However, these targets could not be modelled in detail here as they only apply to certain parts of household waste, not to total MSW.

Full implementation of the Landfill Directive would save 62 million tonnes of CO_2-equivalent: around 42 % more than the business-as-usual scenario. For comparison, 62 million tonnes equates to 1.23 % of these countries' total GHG emissions in 2008.

Scenario 3: What if all countries ban landfilling of all MSW by 2020?
A hypothetical landfill ban would phase out landfilling of MSW by 2020. This scenario aims to demonstrate the potential benefits for climate change mitigation if more ambitious waste policies were implemented. In this scenario, recycling would increase to 61 % of MSW and incineration to 39 % in 2020. Even if such a ban were implemented, however, MSW deposited on landfills before the ban would continue to emit methane for several years. Therefore, the full effect of a landfill ban would only be felt in the medium term.

Full implementation of the Landfill Directive's targets on diverting waste from landfill is crucial to tap its GHG reduction potential.

Nonetheless, as Figure 4.1 indicates, a landfill ban would still save 78 million tonnes of CO_2-equivalent in 2020 compared to 2008, 76 % more than the business-as-usual scenario. That equates to 1.53 % of current total GHG emissions from the EU-27 plus Norway and Switzerland.

For comparison, 78 million tonnes is slightly more than Hungary's annual GHG emissions in 2008. Put another way, in this scenario the savings in the period 2008–2020 are similar in scale to the GHG reduction that the EU-27 Member States expect to achieve in the period 1990–2020 from implementing the Directive on the Energy Performance of Buildings (EU, 2002; EEA, 2009).

Box 4.1 Uncertainties

The waste management system is complex. Modelling it requires the use of assumptions and a high volume of data processing and calculations. The choice of values for relevant parameters always involves a considerable amount of uncertainty where scientific consensus has not been reached. An important effort towards harmonising life-cycle assessment in Europe is under way at the Commission's Joint Research Centre Institute for Environment and Sustainability.

Among the parameters that most influence the results is the methane recovery rate from landfills for each country because methane has a fairly high global warming potential. Moreover, GHG emissions from fuel combustion in waste management activities and the GHG emissions avoided through the recovery of energy all depend on the fuel mix, which is specific to each country. The choice of the relevant mix is therefore quite important for the overall final results. The presented results for all scenarios are based on the current energy mix in each country, without accounting for changes in fuel mixes in the future. However, a sensitivity analysis showed that even a dramatic change in the future energy mix would not change the overall results significantly.

Another very important parameter is the composition of waste handled in each treatment alternative. Different materials require different treatment processes and impact the environment in different ways. Therefore, better data on waste composition would help to produce more robust results.

5 Waste prevention and the limits of the model

Figure 2.1 shows that from 2017 onwards, more emissions are expected to be avoided per tonne of MSW than emitted via waste management operations. Would that mean that more waste is good for the environment? Of course not. The reason is that the model does not include all the GHG emissions during production of the products that end up as MSW. Such modelling would be extremely complex and could not be undertaken here.

GHG emissions from production of a given product are usually higher than any benefits from sound waste management of the same product could ever be. So although this study does not analyse waste prevention's environmental benefits, waste prevention must clearly be given the highest priority.

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European Environment Agency

Waste opportunities
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2011 — 13 pp. — 21 x 29.7 cm

ISBN 978-92-9213-221-7
EEA Report series: ISSN 1725-9177
doi:10.2800/79764

TH-AL-11-003-EN-C
doi:10.2800/79764

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ISBN 978-92-9213-221-7

Publications Office

European Environment Agency