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GREENHOUSE GAS EMISSIONS AND THE POTENTIAL FOR MITIGATION FROM MATERIALS MANAGEMENT WITHIN OECD COUNTRIES

Key Messages

- Due to the integrated stages of materials production, consumption and end-of-life management, a systems view is needed to assess GHG emissions associated with materials and waste.
- When viewed from a life-cycle perspective, GHG emissions arising from material management activities are estimated in this study to account for 55 to 65 percent of national emissions for four OECD member countries. This suggests that there is a significant opportunity to potentially reduce emissions through modification and expansion of materials management policies.
- Integrated waste management practices represent one set of materials management options available that can achieve GHG reductions in OECD member countries

- An order-of magnitude estimate of life-cycle GHG reductions across potential municipal solid waste management scenarios shows that achievable reductions are on the order of current annual emissions from the conventional waste sector quantified in OECD countries' GHG inventories. In other words, in most countries, at least 4 percent of current annual GHG emissions could be mitigated if waste management practices were improved.
- The new OECD report "Greenhouse gas emissions and the potential for mitigation from materials management within OECD countries" provides support to governments in showing the importance of using a life-cycle approach to analyse GHG mitigation options from materials management. Further, the literature suggests that substantial emission reductions can be achieved at low or zero costs.

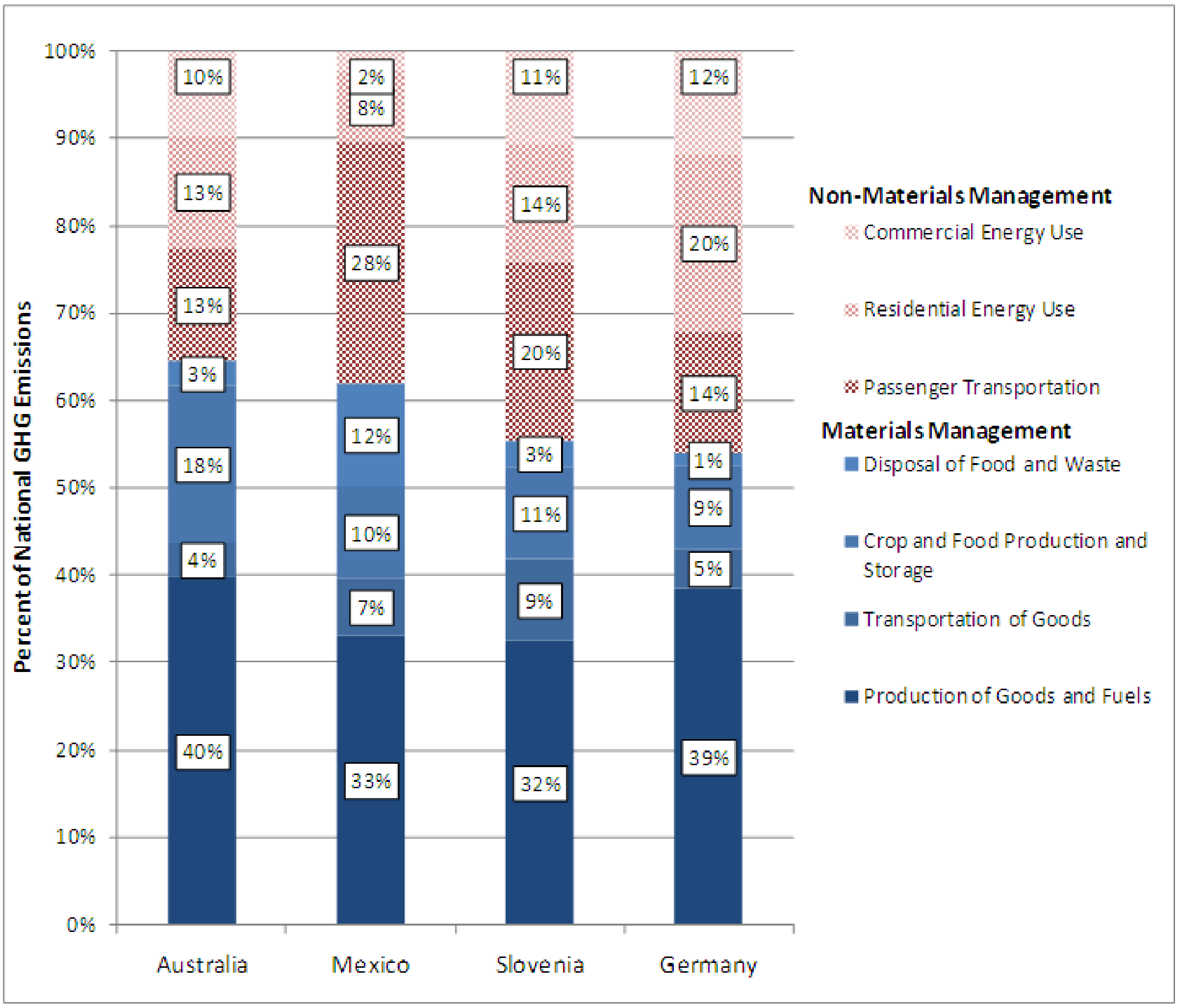
Consider life-cycle analysis in order to assess GHG emissions from materials and waste more accurately

Although GHG emissions from the waste sector typically account for 3 to 4 percent of total emissions in OECD member countries' GHG emission inventories, this emission source only considers direct emissions primarily from landfill methane emissions and incinerators. In contrast, a life-cycle perspective of materials management-related GHG sources encompasses emissions from the acquisition, production, consumption, and end-of-life treatment of physical goods in the economy. This perspective allows policy-makers to evaluate a more complete, systems-based understanding of the relationships between materials management activities and their associated climate-related impacts.

A large share of total country GHG emissions originate from material management activities

The forthcoming OECD report outlines a method for reallocating GHG emissions estimated by sector into systems categories to reveal emissions attributable to materials management from a life-cycle perspective.[1] The materials management categories include: the production of goods and fuels, transportation of goods, crop and food production and storage, and disposal of food and waste. Results from four OECD country case studies (*i.e.*, Australia, Mexico, Slovenia, and Germany) conducted suggest that annual GHG emissions attributable to materials management activities may account for more than half of national GHG emissions (estimated at 64 percent in Australia, 62 percent in Mexico, 55 percent in Slovenia, and 54 percent in Germany). Overall, this study and others[2] find that materials management activities account for a significant share of national GHG emissions in OECD countries (Figure 1).[3]

Figure 1. National GHG emissions for Australia, Mexico, Slovenia, and Germany according to 'systems based' categories related to materials management (MM) and non-MM activities



For more information see www.oecd.org/env/waste

Key findings from Figure 1 include:

- Across the four analysed OECD member countries, materials management related emissions account for more than half of total GHG emissions (ranging from 54 to 64 percent).

- The emissions associated with the production of goods and fuels are the largest emissions source across the four OECD countries analysed.

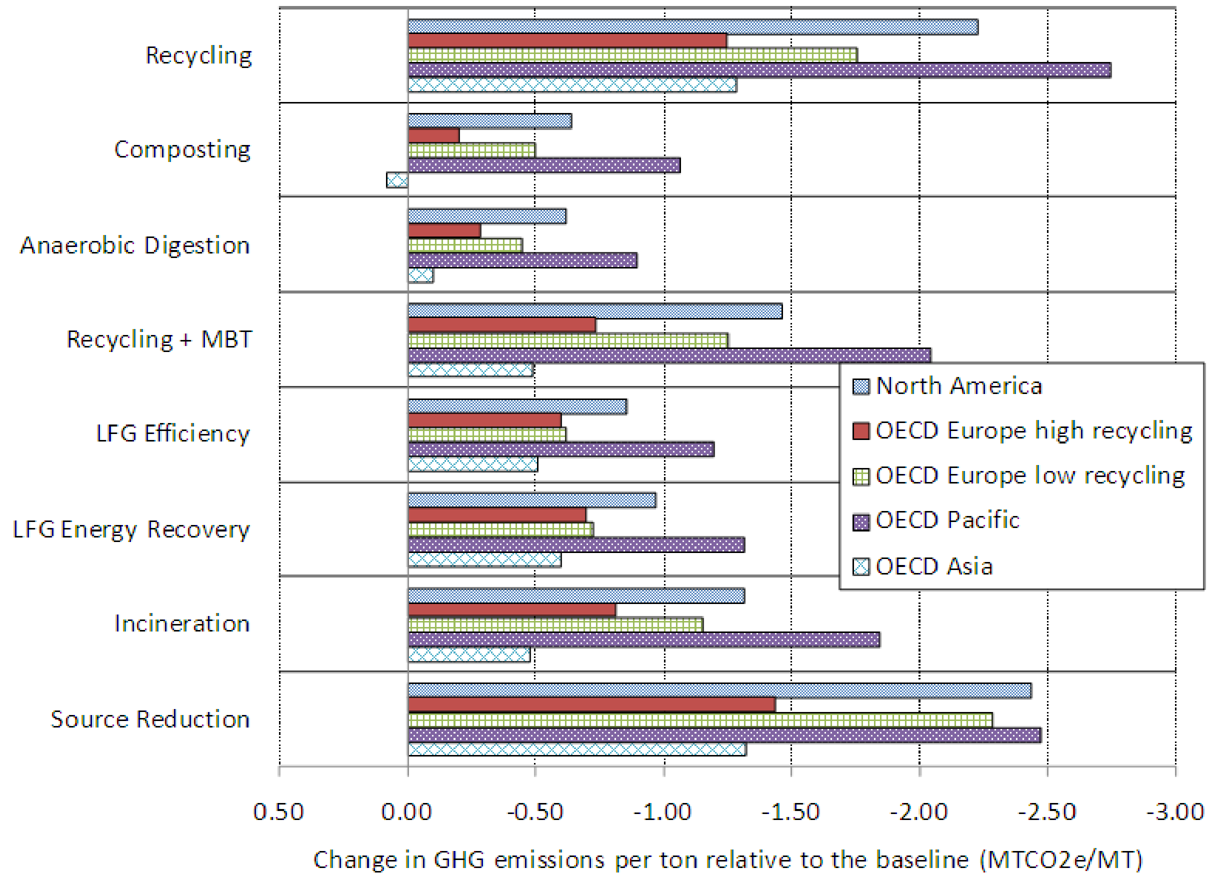
- Emissions associated with the disposal of food and waste represent the minority of total emissions across the four analysed OECD countries (ranging from 1 to 12 percent). This range depends largely on infrastructure and current practices. For example, unlike the high recycling rates in Germany, Mexico relies heavily on landfilling. Not surprisingly, disposal emissions are significantly higher for Mexico at 12 percent, indicating an opportunity to improve technologies and likely reduce emissions.

GHG reductions can be achieved through alternative waste management practices

To assess the role that municipal solid waste (MSW) management practices could play in abating GHG emissions, the report investigated eight different scenarios: (i) MSW recycling; (ii) food and garden waste composting; (iii) anaerobic digestion of food and garden wastes with energy recovery; (iv) recycling and Mechanical Biological Treatment (MBT); (v) landfill gas (LFG) collection; (vi) energy recovery from collected LFG; (vii) incineration, and (viii) source reduction. For each scenario, we modelled the change in GHG emissions between the baseline of unchanged management practices from today and alternative MSW practices individually adopted at their technically achievable potentials.[4]

Figure 2 presents the results from this analysis on the *effectiveness* of each scenario, or the amount of GHG emissions reduced for each metric ton of MSW diverted from baseline practices in 2030 to an alternative MSW practice. In the recycling scenario for example, Figure 2 shows that each additional metric ton of MSW diverted to recycling reduces GHG emissions by 1.3 to 2.7 metric tons of carbon dioxide (CO_2) on average across the OECD regions. Similarly, reducing one metric ton of MSW materials at the source reduces GHG emissions by 1.3 to 2.5 metric tons of CO_2 on average.

Figure 2. Change in GHG's Per Metric Ton of MSW Diverted to Alternative MSW Management Scenarios Relative to Baseline Practices in 2030 across OECD regions[5]



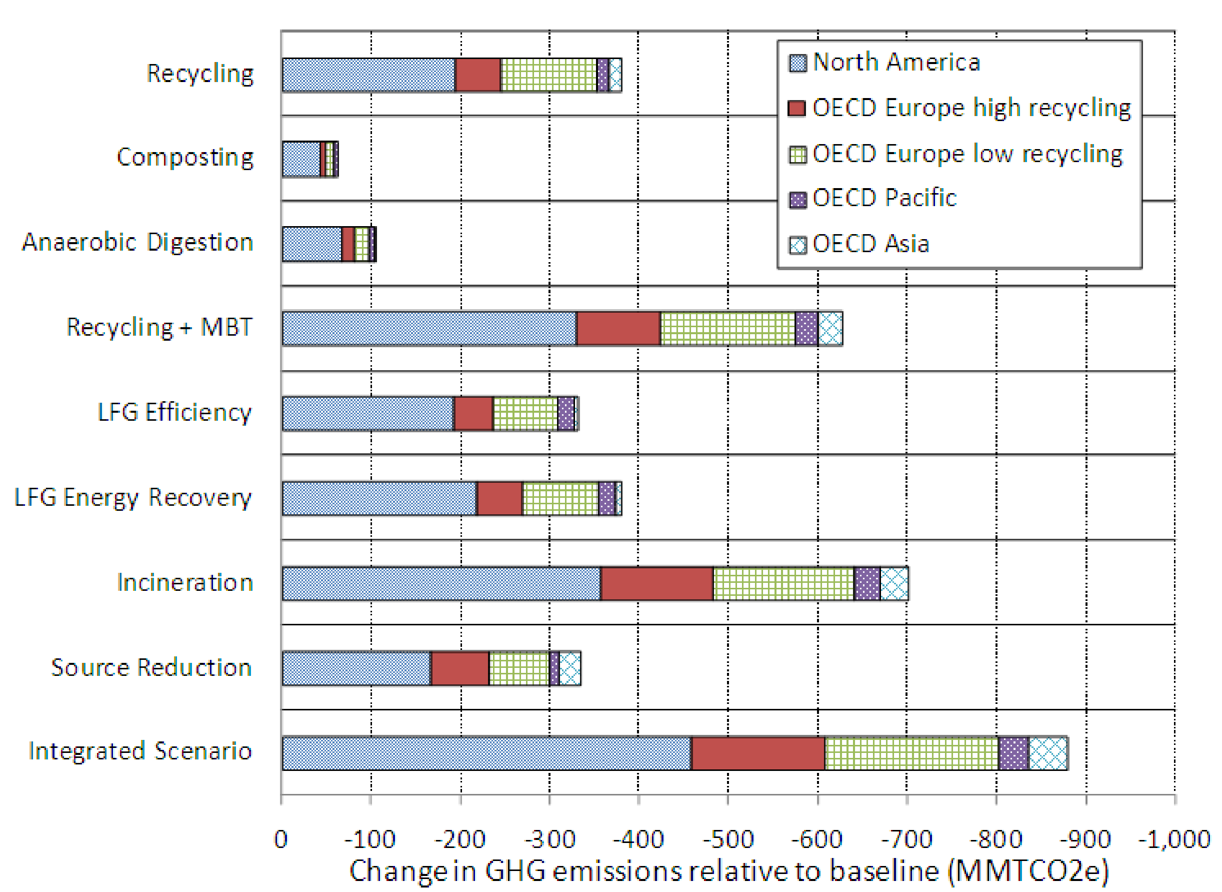
Key findings from Figure 2 include:

- Across all regions, recycling and source reduction provide the highest reduction in GHG emissions per metric ton of MSW diverted.
- Increased energy recovery through LFG collection and incineration provide moderate reductions per metric ton of MSW managed under these practices, and composting and anaerobic digestion provide the least reductions per metric ton, on average.
- Diverting MSW from baseline practices to composting in OECD Asia slightly increases GHG emissions due to the high fraction of MSW that is currently incinerated with energy recovery in this region.
- Current MSW management in each region affects the additional GHG reductions that can be achieved by alternative practices. For example, OECD Pacific and North America achieve a higher reduction per ton of MSW diverted than other regions largely because more MSW is currently sent to landfills without gas capture in these regions; as a result, each metric ton of MSW diverted to alternative MSW practices provides a larger reduction in GHGs than in OECD Europe and OECD Asia.

Estimation of life-cycle GHG reductions across potential waste management scenarios...

In terms of the *absolute* reduction in GHG emissions, the implementation of individual alternative waste management options at technically-achievable levels offers significant GHG mitigation opportunities, ranging from 330 to 700 million metric tons of carbon dioxide equivalent (MMTCO2e) across all OECD member countries when viewed from a life-cycle perspective.[6] In an integrated scenario, where several management options are implemented in concert, the total life-cycle abatement potential increases to nearly 900 MMTCO2e. Figure 3 presents the life-cycle GHG mitigation potential for each alternative MSW management scenario relative to the baseline in each OECD region in 2030. The results of Figure 3 are not meant to imply a ranking of the different management practices; this is represented by the *effectiveness* in terms of GHG reductions per metric ton of MSW diverted for each scenario, as shown in Figure 2. Instead, Figure 3 incorporates both the GHG reductions per metric ton of MSW diverted and the total amount of MSW diverted to yield a range of absolute GHG reductions achievable across the scenarios. The result is an order-of-magnitude estimate of the absolute life-cycle GHG reductions achievable from implementing alternative MSW management practices.

Figure 3. Change in GHGs Relative to Baseline Practices through Implementation of Alternative MSW Management Scenarios in 2030 across OECD Regions



Key findings from Figure 3 include:

- Scenarios that affect a wide range of material types can achieve large absolute GHG reductions. For instance, recycling and source reduction are the most *effective* at reducing GHG emissions for each metric ton of MSW diverted to these options. However the incineration and LFG recovery scenarios reduce GHG emissions from larger portions of MSW.

- Increasing recycling rates in regions with lower rates can provide a sizable reduction in emissions. In most regions, paper and cardboard recycling generates most of the recycling scenario's GHG mitigation.

- The greatest reductions in life-cycle GHGs are achieved through integrated waste management practices. The final integrated scenario—where MSW source reduction, recycling, and composting are implemented and the remaining MSW fraction is processed in highly-efficient incineration facilities with energy recovery—results in life-cycle GHG reductions of 878 MMTCO2e relative to the 2030 baseline scenario. This is 16 percent greater than the largest reduction achieved by the non-integrated management scenarios. To provide context, 878 $MMTCO_2e$ represents over 6 percent of current annual OECD emissions in the aggregate.[1]

- The volume of waste generation in each region largely influences the magnitude of GHG mitigation. For example, because MSW generation in North America is nearly two-and-a-half times larger than in "low recycling" European countries, the total GHG reductions in North America are greater by roughly the same order of magnitude.

Together, Figure 2 and Figure 3 show which practices are most effective at reducing GHG emissions per metric ton of MSW diverted, and the range of GHG reductions achievable when each scenario is exercised to its technical potential. A key finding from this analysis is that recycling and source reduction provide the greatest GHG reductions per metric ton of MSW diverted, on average, while other practices—such as increased energy recovery from LFG capture, incineration, and anaerobic decomposition—can achieve significant GHG reductions by broadly acting on the remaining MSW fractions. The integrated scenario demonstrates this point and underscores the need for an integrated approach to MSW management that emphasises source reduction and recycling, while reducing GHG emissions from remaining fractions that are sent for disposal through strategies such as highly-efficient incineration and landfill gas collection with energy recovery.

Substantial emission reductions can be achieved at low or zero costs

A recent study by Monni *et al.,* (2006) evaluates the relative benefits of various waste management alternatives in terms of costs and mitigation potentials with respect to methane emissions from landfills.[7] A summary of their study is shown on the following page in Table 1. Monni *et al.,* (2006) calculated the maximum landfill gas mitigation potentials of different waste management options at five different marginal emission reduction cost levels.[8]

The table displays the reduction potential of landfill methane emissions by measures whose unit cost is below the overall marginal emission reduction cost level (USD 0, 10, 20, 50, or 100 per metric ton of CO_2). The quantity of emission reductions possible is categorised by waste management option and region, where "OECD" designates OECD countries not included in the economies in transition category, "EIT" designates economies in transition, and "Non-OECD" designates countries included in neither the OECD

[1] Data from OECD.stat. Data on GHG emissions does not include Mexico, Chile and Korea.

nor the EIT category (*i.e.* developing countries). For example, the table shows that a reduction of 43 $MMTCO_2e$ of methane is possible in OECD countries using Landfill Gas Recovery for energy at costs below USD 10 per metric ton of CO_2e reduced.

Table 1. GHG Reduction Potential Landill Methane Emissions by Waste Management Alternative and by Various Marginal Costs in Year 2030

		MMTCO$_2$e of CH$_4$ reduced				
Waste management practice	Region	USD/metric ton CO2e				
		$0	$10	$20	$50	$100
Anaerobic digestion	OECD	0	0	1	5	5
	EIT	0	0	0	20	24
	Non-OECD	0	0	30	68	95
	Global	0	0	31	94	124
Composting	OECD	0	0	0	0	3
	EIT	0	0	0	6	19
	Non-OECD	0	0	0	58	81
	Global	0	0	0	64	102
Mechanical biological treatment	OECD	0	0	0	0	0
	EIT	0	0	0	0	0
	Non-OECD	0	0	0	0	19
	Global	0	0	0	0	19
LFG recovery - energy	OECD	27	43	41	23	22
	EIT	56	29	15	0	0
	Non-OECD	328	368	306	138	43
	Global	411	440	362	162	65
LFG recovery - flaring	OECD	0	6	1	0	0
	EIT	0	17	0	0	0
	Non-OECD	0	12	0	0	0
	Global	0	34	1	0	0
Waste incineration with energy recovery	OECD	124	222	237	266	266
	EIT	0	101	156	156	140
	Non-OECD	0	0	166	515	653
	Global	124	323	558	936	1,059
Total	OECD	151	270	280	295	296
	EIT	56	147	171	182	182
	Non-OECD	328	380	501	779	890
	Global	535	797	953	1,255	1,369

The table indicates that substantial emission reductions can be achieved at low or zero costs.[9] More significant reductions would be possible at higher marginal costs, due mostly to the additional mitigation potential of thermal processes for waste-to-energy. The model indicates that a 151 MMTCO$_2$e reduction is possible for OECD countries at a marginal carbon cost of USD 0, and a 270 MMTCO$_2$e reduction is possible at costs at or below USD 10 per metric ton of CO$_2$e. Globally the mitigation potential is significantly larger at 535 and 797 MMTCO$_2$e at a cost of respectively at of USD 0 and 10 per ton of CO$_2$e.

A separate 2009 study on abatement costs by McKinsey found that direct use of landfill gas, waste recycling, and electricity generation from landfilling have global cost savings of about EUR 12 to 34 per metric ton of CO$_2$e.

For further information on OECD work on materials management: see www.oecd.org, and to access the full report "*Greenhouse gas emissions and the potential for mitigation from materials management within OECD countries*". This study provides a framework for analysing the relationship between materials management and greenhouse gas (GHG) emissions. It seeks to offer policymakers an improved understanding of the importance of considering life-cycle GHG emissions in order to manage materials and wastes more sustainably.

Further reading

OECD (2012), Greenhouse Gas Emissions and the Potential for Mitigation from Materials Management within OECD Countries, Paris

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END NOTES

[1] The approach makes use of GHG inventory data submitted to the United Nations Framework Convention on Climate Change (UNFCCC).

[2] A similar study conducted by the U.S. Environmental Protection Agency found that 42 percent of GHG emissions in the United States were attributable to materials management activities (EPA 2009b).

[3] The GHG emissions inventories obtained from the UNFCCC for the four OECD member countries vary in terms of overall magnitude of emissions, level of detail, and transparency.

[4] The baseline in 2030 assumes no change to current waste management practices, even though there are already policies and voluntary programs in place in OECD countries that will continue to increase the implementation of alternative or improved waste management practices. Our baseline therefore underestimates the extent to which alternative practices will be in place by 2030 even without any additional policies to promote these practices.

[5] We categorized OECD member countries into five groups based on geography and baseline recycling rate to account for differences in MSW generation and composition, management practices, and region-specific factors that affect GHG emissions from management practices.

[6] The composting and anaerobic digestion scenarios are not included in this range because the reductions in these scenarios can be individually added to the recycling scenario since they address mutually-exclusive categories of waste.

[7] This study evaluated emissions reductions in the waste sector using two different modelling approaches to develop future MSW management scenarios. First, the authors developed a set of dynamic emissions scenarios that considered existing policy measures and changes in waste management systems, as well as the timing of GHG emissions from landfills. Second, they use a partial-equilibrium economic model (the Global TIMES model) to develop economic potential scenarios that optimise emissions reductions in 15 world regions in 2030.

[8] The table evaluates reductions from a baseline scenario that assumes (1) waste generation will increase with growing population and GDP (using SRES scenario A1 data), (2) waste management practices will not change significantly, and (3) landfill gas recovery and utilisation will continue to increase at the historical rate of 5 percent per year in developed countries. The estimates were generated using the Global TIMES model, with data taken primarily from EPA (2006a).

[9] It is important to note that the results generated by this model incorporate different boundaries than the mitigation potential results we show in the OECD study since Monni *et al.*, (2006) only incorporates avoided landfill methane emissions from disposal of MSW.