

# **Further Issues in Municipal Waste Management Policy in Ireland: A Response to the Comments Received on *An Economic Approach to Waste Management Policy in Ireland*.**

by

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## **Introduction**

The ESRI published *An Economic Approach to Waste Management Policy in Ireland* on Wednesday 3 February 2010. The Report has been the subject of extensive debate and discussion. We welcome such debate. It is through dialogue and discussion that waste management policy can be improved, thus enhancing the welfare of Irish society.

The purpose of this note is to respond to the key issues raised in the debate over the Report. These issues include:

- By how much is municipal waste likely to grow over the next 15 years?
- What is the impact on the waste levies recommended in the Report given that incineration is exempted from the Emission Trading System (“ETS”)?
- Should the treatment of non-GHG air pollutants be consistent across different emitters (e.g., power generating stations, cement kilns, incinerators and so on) or should incinerators be treated differently?

We believe that the discussion of these issues in this note will, together with the Report, provide a firm basis for developing waste management policy in Ireland.

This note focuses on seven issues that have been raised in the debate following the publication of the Report, together with a conclusion. After careful consideration of these issues we see no reason to change the policy conclusions and recommendations contained in the Report. We are thus amending the Report, not withdrawing it.

In the interests of maximum transparency we include a set of corrigenda for the Report which shows clearly where changes in the Report have been made to deal with the issues raised in the comments received. These changes do not affect our policy conclusions and recommendations.

Before dealing with specific comments made on the Report, we would like to make some general observations on the extensive response by Eunomia,<sup>1</sup> the lead consultancy for the International Review commissioned by the Department of the

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<sup>1</sup> Eunomia, “Response to ESRI report from Eunomia.” 24 February 2010. This may be accessed at: <http://www.eunomia.co.uk/shopimages/Letter%20to%20Professor%20Ruane%20ESRI.pdf>. Accessed 26 February 2010.

Environment, Heritage and Local Government (hereafter, “International Review”)<sup>2</sup> In responding to the specific comments below it is almost inevitable that differences rather than similarities are highlighted. This is unfortunate as there is a great deal of common ground between Eunomia and ourselves which we feel should be built on in developing future waste policy, rather than confining attention to differences.

It is important therefore to note that Eunomia state that it is “largely in agreement with the principles set out in Section 6 [Applying the Economic Approach to Waste Policy]” of our Report. On policy towards the mix of technologies – incineration vs. MBT vs. landfill – again we are in agreement – policy should be neutral with respect to choice of technologies once appropriate levies have been set.<sup>3</sup> In other words, limits on one technology over another are not justified. As will be apparent from the discussion below, where revisions are necessary because of comments received we have made them. It should, however, be noted that there are still differences between Eunomia and ourselves over issues such as whether or not the evidence is strong enough to include disamenities in estimates of waste levies. Reasonable people can disagree on such issues.

## **Responses to Specific Comments**

### **Comment 1: The projected municipal waste generation rates in the Report are implausibly high.**

It has been argued by the Irish Waste Management Association (“IWMA”) that our Report’s estimates of future waste growth are implausibly high. In their view much lower rates are more appropriate. These differences are important. They have implications for the volume of waste that will need to be diverted from landfill, given the targets in the Landfill Directive, and the number and size of alternative waste facilities that will be required to deal with this waste.

In our discussion of this issue, we first describe our own methodology. We then consider the alternative approach of the IWMA to forecasting the growth in waste and its criticism of our approach. Because our methodology takes full account of the particular circumstances of the Irish economy, it is superior to the alternative suggested by the IWMA. As a result, we conclude that our estimates in the Report provide a reasonable baseline for considering possible future policies. Municipal waste quantities are falling because of the recession and are unlikely to recover to 2008 levels until 2012, after which we expect waste arisings to grow by about 4% p/a up to 2025.

### ***The ISus Model***

The ISus model, developed over the past three years with funding from the Environmental Protection Agency (“EPA”), takes EPA *National Waste Report* data for a base year, 2008, and projects baseline national waste growth rates as a function of Irish macroeconomic and demographic variables. For household waste, these variables include the number of households, persons per household and real disposable income. For commercial waste, the driver variable is services sector

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<sup>2</sup> The International Review was published in 2009. It may be found at: <http://www.environ.ie/en/PublicationsDocuments/FileDownload,21596,en.pdf>. Accessed 17 February 2010.

<sup>3</sup> It should be noted that this viewpoint was not stated in the International Review but in one of the sixty five annexes to the International Review. For more details see Annex 56, p. 842.

output. In each case, assumed future values for the external variables are taken from ESRI macroeconomic projections (in this case, Bergin *et al.*, 2009, which takes account of the current recession).<sup>4</sup>

We specify a value for the sensitivity of waste per household to each external variable assumed to influence waste volumes which will be referred to as arisings. We model waste per household in this way and we then multiply by the expected number of households in the country in a given future year. The number of persons per household in Ireland has been falling for some years, and we expect this to continue in the medium term. This fall tends to reduce waste per household, but does so at a lower rate than 1:1. In effect, bigger households are less waste-intensive on average. Based on previous research (Curtis *et al.* 2009),<sup>5</sup> we assume that waste per household increases proportionately with real disposable income. This implies that waste per household is falling rapidly in the current recession but will rise in the subsequent recovery period. Finally, we assume that growth in commercial waste tracks real service sector value added. In effect, we assume that commercial waste generation will maintain a stable share of services sector output. In the absence of published, peer reviewed research into this parameter, stable waste intensity seems a reasonable assumption.

The ISus model has been used by other studies into aspects of waste management, including AP EnvEcon (2008)<sup>6</sup> and EPA (2008, 2009).<sup>7</sup> Indeed, AP EnvEcon, in its report for the Department of the Environment, Heritage and Local Government, states that

“...following a consultation with the Department, the AP EnvEcon team have opted to utilise the projections of the ESRI’s ISUS model. A review of the ISUS model methodology and assumptions showed that the model provides a sound methodological approach to projections of waste generation by various streams and takes account of official national data from the EPA and also the ESRI’s own official forecasts for the Irish economy.” (p.69)

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<sup>4</sup> Bergin, A., T. Conefrey, J. Fitz Gerald and I. Kearney, 2009, *Recovery Scenarios for Ireland*. Dublin: ESRI.

<sup>5</sup> Curtis, J., S. Lyons, S. & A. O’Callaghan-Platt, 2009. *Managing Household Waste in Ireland: Behavioural Parameters and Policy Options*, ESRI Working Paper 295. Dublin: ESRI.

<sup>6</sup> AP EnvEcon, 2008, *Regulatory Impact Analysis on Proposed Legislation to Increase Levies on Plastic Shopping Bags and Certain Waste Facilities*, a Report Commissioned for the Department of the Environment, Heritage and Local Government. Dublin: AP EnvEcon.

<sup>7</sup> EPA, 2008, *Ireland’s Environment*. Wexford: EPA; EPA, 2009. *National Waste Report 2008*. Wexford: EPA.

### ***The Uses of the ISus Model in the Report: National Level***

As explained in the Report (p. 29), we do not make predictions about the waste processing choices that will be made by firms and local authorities. Instead, we provide baseline projections for the final management (or disposition) of waste, distinguishing between recycling of materials (at present principally segregated at source), landfill of biodegradable municipal waste (“BMW”) permitted under the Landfill Directive, landfill of other municipal solid waste (“MSW”) materials, and a residual quantity of BMW that would breach the Landfill Directive limits if it were to be placed in landfill. In our baseline, there is no change in prices or collection/processing arrangements, so the share of recycling in total waste is assumed to remain constant. Note that this does not imply that we think recycling will remain constant as a share of arisings, only that it will require further investment in facilities and processes before it will rise. To illustrate the scale of the incinerators that currently have planning permission, we show waste sent to Poolbeg and Carranstown as a separate segment, making a simplifying assumption that BMW will be incinerated first if available, followed by other MSW. This is an upper bound assumption, imposed to illustrate the maximum amount of BMW that is likely to impose a further “requirement for diversion, presumably to be met through some mixture of collection-side arrangements and post-collection processing infrastructure.” (p. 31)

Our analysis of the projections focuses on the sum of MSW and BMW rather than on household or commercial waste taken in isolation. Due to the somewhat porous boundary between these two streams as they are measured, we consider the aggregate data to be more reliable and useful for policy.<sup>8</sup>

### ***The Uses of the ISus Model in the Report: Dublin***

Our national model was developed to produce baseline projections for the Dublin region. We did this by applying the national growth rates discussed above to Dublin data for 2008. In principle, region-specific growth rates would be desirable, but there are no medium term regionally-disaggregated projections for internal migration, disposable income and service sector output.

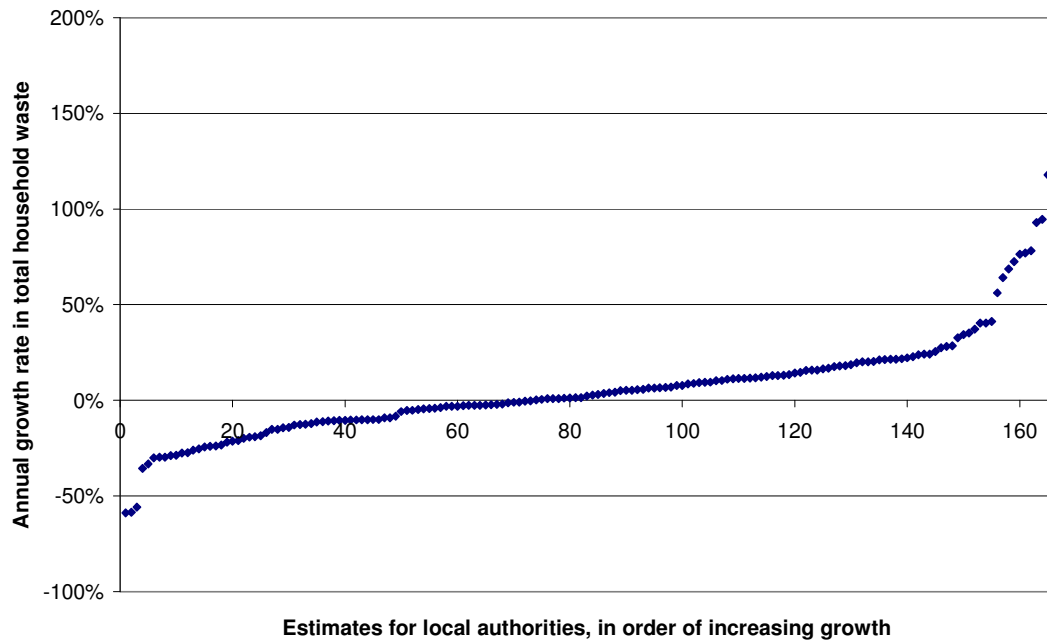
Moreover, the historical estimates of total household waste arisings at local authority level in Ireland are very volatile from year to year. Figure 1 below shows the annual growth rates for household waste in Irish local authority areas from 2001-2006, drawn from successive *National Waste Reports*. Many areas report double-digit increases or decreases in waste from one year to the next.<sup>9</sup>

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<sup>8</sup> For example, we understand that waste from apartments can sometimes be counted as household or commercial depending upon how, and by whom, it is collected.

<sup>9</sup> The highest growth in this sample was 166% for Cavan in 2002-3 and the lowest was -59% for Leitrim in 2002.

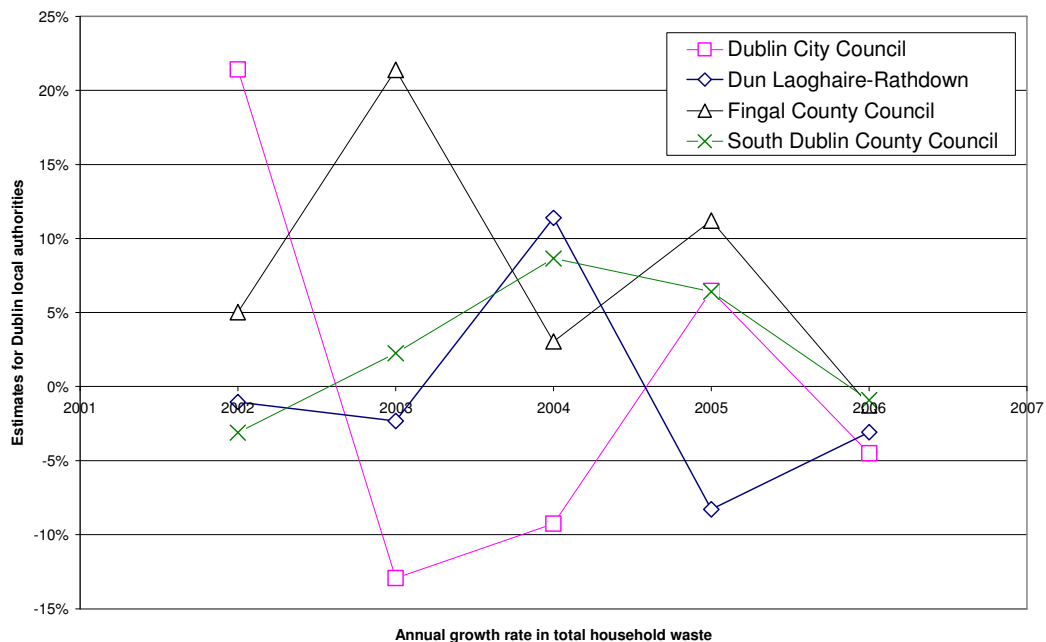
**Figure 1: Annual Growth Rates for Total Household Waste, by Local Authority, Ordered From Lowest to Highest, 2001-2006.**



Source: Analysis of National Waste Report data.

Another way of illustrating the level and pattern of volatility in local household waste figures is to look at a time series for a selection of local authorities. The Dublin region authorities are shown in Figure 2 below.

**Figure 2: Annual Growth Rates for Total Household Waste, by Dublin Region Local Authority, 2001-2006**



Source: Analysis of National Waste Report data.

Such a high level of volatility can only be explained by variations in data collection, definition or changes in cross-border flows, so it is probably unsafe to extrapolate from growth rates in data disaggregated by area and between commercial and household waste.

Our report indicates that if sufficient facilities or collection arrangements are not put in place in the Dublin area, there will be a substantial amount of residual waste destined for landfill (see Table 1 below).

**Table 1: Baseline Prediction of Residual MSW, Dublin & Ireland, Selected Years, 2008-2025 (000's tonnes)**

	2008	2010	2013	2015	2020	2025
Ireland	1,988	1,890	2,062	2,265	2,714	3,279
Dublin	741	700	771	845	1,000	1,197

Source: ISus model.

On the related question of the amount of material that could be incinerated, Table 2 below shows predictions as to how much residual MSW will be combustible.<sup>10</sup> This relates to our point (on page 31 of the Report) that even if the incinerators that currently have planning permission are put in place, additional facilities and/or extensions to collection arrangements are likely to be required after 2015. In our response to Comment 2 below we show an illustration of how national and regional policies might help to further reduce the quantity of residual waste.

**Table 2: Baseline Prediction of Combustible Residual MSW, Dublin & Ireland, Selected Years, 2008-2025 (000's tonnes)**

	2008	2010	2013	2015	2020	2025
Ireland	1,544	1,466	1,691	1,849	2,191	2,622
Dublin	601	568	692	752	876	1,034

Source: Analysis of results from the ISus model.

### ***An Alternative View: The Irish Waste Management Association Forecasts***

Suggesting that our growth rates are too high implies that the application of some other methodology would yield lower estimates. In this respect a report commissioned by IWMA and published by SLR Consulting, *Dublin Region Thermal Treatment Needs Assessment*<sup>11</sup> (hereafter "SLR report"), uses projected growth rates informed by international benchmarking. It predicts a 20% decline in commercial and industrial waste arisings due to the current recession, followed by 1.5% annual growth from 2012 to 2037. These figures are not directly comparable with ours, because its base year is 2007 and ours is 2008; and we do not provide projections beyond 2025. Nevertheless, it is clear that the average growth rates it predicts are lower than in our Report.

The SLR report relies mainly on extrapolation of average historical waste growth for several developed EU Member States – Belgium, the Netherlands, France, the UK and Germany – as well as Ireland. The average economic and demographic makeup of this group of countries is different from Ireland in many important ways. For example, they had relatively little population growth during the period benchmarked (see Table 3 below), and there is no analysis of how variables such as their industrial

<sup>10</sup> For the purposes of this illustration we assume that 100% of BMW and 44% of non-BMW municipal waste are combustible.

<sup>11</sup> SLR, 2009, *Dublin Region Thermal Treatment Needs Assessment*. Final Report to the Irish Waste Management Association. Dublin: SLR. 9<sup>th</sup> November.

structure (e.g. relative growth of the services sector) or the number of persons per household may have changed over the period or how these trends compare with those for Ireland.

**Table 3: Annualised Population Growth in Selected EU Member States, 2000-2007 (CAGR)**

Ireland	1.91%	Netherlands	0.44%
Belgium	0.48%	Germany	0.03%
France	0.71%	UK	0.48%

Source: Analysis of Eurostat data

Moreover, some of the countries in the sample apply very different sorts of waste collection arrangements to those prevalent in Ireland, which may have an effect on arisings. The importance of such unexplained variations is hinted at in the Eurostat data included with the SLR report. Some jurisdictions had high annualised per capita waste growth from 2000-2007, such as Ireland (4.0%) and Norway (4.3%), whereas others had low or even negative growth.

In sum, international benchmarking can be useful in predicting future patterns of activity, but it needs to take proper account of national differences in economic and demographic conditions to be convincing. Such factors were not accounted for in the SLR report’s analysis.<sup>12</sup> Our model uses Irish macroeconomic and demographic projections in a transparent way to estimate a baseline for arisings. We have also used Irish research where available when choosing parameters for the sensitivity of waste arisings to external drivers. As a result, our approach to forecasting waste arisings in Ireland is better attuned to the circumstances of the Irish economy and is likely to provide a better guide for future policy than the alternative.

### ***IWMA Criticisms of the Report’s Waste Forecasts***

In addition to relying on the SLR report’s forecasts, the IWMA also made several statements about the ESRI’s projections.<sup>13</sup> We respond to these below.

<b>IWMA Comment (summarised)</b>	<b>Response</b>
The ESRI report assumes that approximately 39% of municipal solid waste (“MSW”) will be recycled in the Dublin region for all years from 2008 to 2025, which is lower than the recycling rate for 2008 (41%).	<b>This is incorrect: we use the actual recycling rate in 2008 of 41%. The rationale behind this comment is not clear, since neither figure appears in our Report.</b>

<sup>12</sup> In view of this it is not at all clear that the IWMA’s characterisation of these projections as “based on EU established growth criteria” can be sustained. See IWMA’s opening statement before the Oireachtas Joint Committee on the Environment, Heritage and Local Government on Tuesday 19 January 2010. For details see <http://debates.oireachtas.ie/DDebate.aspx?F=ENJ20100119.xml&Node=H3#H3>. Accessed on 12 February 2010.

<sup>13</sup> IWMA, “ESRI Report on Waste is Fundamentally Flawed – IWMA”, Press Release. 2 February. 2010.

<p>Average household waste growth in Dublin between 2003 and 2008 was 0.65% per annum. These are far below economic growth rates and provide a more realistic prediction of long term waste arisings.</p>	<p><b>Ireland's MSW arisings grew 3.9% per annum 2001-2008 (the years for which we have continuous EPA <i>National Waste Report</i> data) and BMW arisings grew 5.5% per annum during the same period. We have not estimated Dublin growth rates in isolation because there are no medium-term , regionally-disaggregated projections for internal migration, disposable income and service sector output, and because historical data on waste arisings in local authority areas are highly volatile.</b></p> <p><b>Interestingly, the Eurostat table included in the SLR report for IWMA shows an annual per capita MSW growth rate of 3.9% for Ireland 2000-2007. This is much higher than 0.65%, but the SLR report does not explain the apparent inconsistency.</b></p>
<p>The population of Ireland increased by 2.0% per annum from 2002 to 2006 household waste growth was 40% of population growth during a similar period (2003 to 2007). However, based on the ESRI's waste growth projections Ireland can expect a population of 15 million people by 2025 and 50 million people by 2037.</p>	<p><b>Our projections assume a population of 5 million in Ireland in 2020. IWMA here applies a simple model of household waste arisings in which only population affects household waste growth. Unlike our model, this simple model is does not take into account the effect of rising real incomes or service sector output, or changes in household size.</b></p>

In a subsequent report for the IWMA,<sup>14</sup> SLR Consulting argues that our macroeconomic assumptions about the timing of the end of the recession and the subsequent speed of growth are "optimistic". They provide no evidence for this view. Our assumptions in this regard are discussed at length in Bergin (*et al.*, 2009). This SLR report also asserts that we have "assumed a direct correlation between GDP and municipal waste growth." As explained above, this is not correct. Finally, it seems contradictory to project a 20% fall in waste growth during the recession, which suggests that municipal waste is highly sensitive to economic activity, but then suggest that waste will grow very slowly in the recovery period, which suggests the opposite.

### **Conclusion**

The projections in our Report rely on the ISus model, which takes into account key drivers of Irish waste arisings: population, household size, growth of the service sector and real disposable income of households. We think this approach is

<sup>14</sup> SLR Consulting, *Dublin Region Thermal Treatment Needs Assessment using ESRI/EPA ISus waste growth data*, Supplementary Report to the Irish Waste Management Association,. Dublin: SLR.13th January 2010.



reasonable and makes best use of the available data. It is also transparent and allows flexibility for those who wish to apply different behavioural assumptions. The model has been used by other agencies, including the EPA, to look at aspects of Irish waste management.

The criticisms made by the IWMA of our approach to waste growth modelling were unfounded. Our original baseline predictions of waste arisings remain unchanged.

The IWMA's alternative approach to forecasting waste quantities relies on the view that waste growth in Ireland is best represented by its past growth rate in selected developed EU Member States. While benchmarking of this nature can usefully inform policy it needs to control for differences between Ireland and these other EU Member States. This has not been done and hence the IWMA's estimates should be regarded with caution.

**Comment 2: The projected recycling rates in our Report for biodegradable municipal waste are too low and/or our Report has incorrectly omitted BMW facilities.**

It has been argued by the IWMA<sup>15</sup> and others that the projected recycling rates are too low in our Report. It is, for example, asserted by the IWMA that the recycling rate used in our Report is 39% whereas the recycling in Dublin has already reached 41%. The IWMA argue that by biasing the level of recycling downwards the Report is abandoning recycling in order to justify the building of incinerators. We disagree with this criticism of our results.

***Appropriate Recycling Rates Were Used.***

It is incorrect to assert that our Report used a recycling rate of 39%. As noted above, in our Report we use the actual recycling rate in 2008 of 41%. The rationale behind this comment by the IWMA is not clear, since neither figure appears in our Report.

***Mix of Facilities***

Many facilities (including new MBT plants and incinerators) have been mooted or are at various stages of the development process. As explained above, our projections are intended to provide a demand-focused baseline to inform the choice of future policy measures. The prospects for new facilities and other new investments, such as more intensive collection systems, are likely to be affected by the policies that are adopted. We therefore omit them from the baseline. This does not mean we think no such new facilities or collection arrangements will be put in place. On the contrary: an important objective of our research is to suggest ways that incentives for efficient investment might be improved.

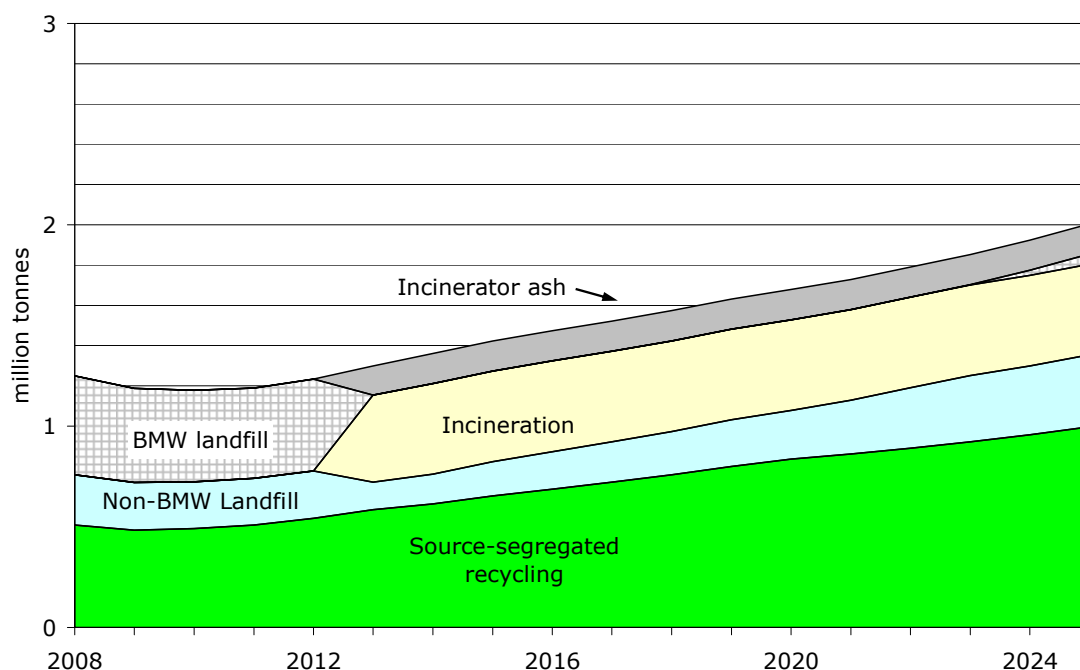
To illustrate how policies leading to increased source segregation of recyclables or entry of additional facilities might reduce residual waste quantities below the baseline, we show the result of a policy scenario. The estimates are generated using the ISus model, starting with the same assumptions as employed in our Report. The scenario adds an extra assumption that recycling rates grow at a constant rate to 45% by 2013 and then to 50% by 2020. Increases in source segregation of waste might be brought about by regional policies such as extending three-bin collection, wider use of per unit

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<sup>15</sup> IWMA, supra, note 13.

charging and continuing implementation of national measures such as the Food Waste Regulations and the EPA pre-treatment guidelines.<sup>16</sup>

**Figure 3: MSW in the Dublin Region, Rising Source Segregation Scenario (2008 data are actuals)**



Source: ESRI/EPA ISus model with increased recycling.

In this scenario, the higher assumed level of recycling, combined with available waste processing facilities, essentially eliminates the need to place Dublin-sourced BMW in landfill after 2012, which would make a significant contribution towards Ireland's Landfill Directive targets. Note, however, that the increased recycling rates in this scenario are assumptions only; suitable implementing measures and appropriate incentives would need to be applied to bring recycling up to these levels.

### **Conclusion**

Our original conclusions are unaltered. Our Report provides a baseline projection prior to the effects of policy on collection arrangements and new facilities. The two such facilities we included in the illustrations in our Report – the incinerators at Poolbeg and Carranstown<sup>17</sup> - have full planning permission and were included to illustrate their scale in relation to the Landfill Directive targets for diversion of BMW from landfill. We have emphasised that further increases in recycling are likely to take place over and above our baseline assumptions, but that achieving such gains is dependent upon the policies adopted and on investment decisions made on foot of those policies.

<sup>16</sup> Waste Management (Food Waste) Regulations 2009, S.I. No. 508 of 2009; and, EPA, 2009, *Municipal Solid Waste-Pre-treatment & Residuals Management: an EPA Technical Guidance Document*. Wexford: EPA.

<sup>17</sup> The IWMA supra, note 13, is wrong when it asserts that our Report does not take into account the Indaver incinerator in Meath. See the Report (p. 34).

**Comment 3: Incinerators are not covered under the Emission Trading System, so the externality associated with their CO<sub>2</sub> emissions should be included in the waste levy applied to incineration.**

A number of commentators<sup>18</sup> have pointed out that although some incinerators have ETS permit allocations for ancillary activities, incineration *per se* is exempt from a requirement to hold ETS permits. This criticism of our Report is correct. Thus the waste levy estimates for incinerators presented in the Report – which assumed that incinerators were part of the ETS – need to be revised upward in order to take into account the fact that the CO<sub>2</sub> emissions of incinerators are not part of the ETS.

***Re-estimating the Levy for Incineration***

We have recalculated the waste levy on incineration to include this additional cost. It increases our estimated levy on incineration of mixed residual waste by about €5.60 per tonne, based on a carbon cost of €15.00 (in line with the new carbon tax).

Our proposed levy rates are altered, but there remains a significant gap between our suggested levy rates and the rates proposed in the International Review. Our revised rates are **€6.00-6.10** per tonne for rural incinerators and **€9.80-10.70** per tonne for urban incinerators, assuming there are no direct transfers from the incinerator operators to the local community. The levy proposed in the International Review (following a phasing-in period) is **€26** per tonne plus non-GHG pollutant related taxes.

We have also taken this opportunity to update our assumed price of greenhouse gas emissions to €15.00, in line with the level of Ireland’s new carbon tax. This has a modest effect on the proposed levy rates for landfill. A comparison of the rates proposed in the International Review to our original rates, and revised rates is shown in Table 4 below.

**Table 4: Comparison of Proposed Landfill and Incineration Levy Rates: International Review & Our Estimates, per tonne**

Levy	International Review*	Our original proposals	Our revised proposals
Landfill	€85.00	44.24-54.89	€44.50-55.10 for landfills with no flaring or gas capture**
Incineration – rural	€26.00 plus non-GHG pollutant related taxes	€0.42-0.50***	€6.00-6.10***
Incineration - urban	€26.00 plus non-GHG pollutant related taxes	€4.22-5.07***	€9.80-10.70***

Notes: \* Final rates after phasing-in period; \*\* with reduced rates for landfills with appropriate methane management; \*\*\* assuming no transfers to local residents.

***Conclusion***

The revisions required to the waste levy for incineration due to the fact that incinerators are not part of the ETS does not alter the substance of our recommendations on the structure of waste levies as between incineration and alternative forms of waste disposal.

<sup>18</sup> See, for example, Eumonia, “ESRI Manufactures Dispute from its Own Mistakes.” Press Release. 3 February 2010.

**Comment 4: Some other CO<sub>2</sub> emissions covered by the ETS or Irish carbon tax are increased or reduced due to waste management activities. We have proposed to exclude these items from waste levies since the carbon involved is already priced. Shouldn't these emissions still be reflected in waste levies because the ETS and carbon tax do not price the damage from CO<sub>2</sub> emissions appropriately?**

We disagree that the waste sector should apply a different price to carbon dioxide emissions than the prices set in national and EU climate policy instruments. If the ETS price and Irish carbon tax do not reflect the true marginal damage cost of greenhouse gas emissions, then climate policy should be intensified across the board; there is no reason to single out the waste sector to carry a heavier burden than do other emitters of greenhouse gases. There are considerable benefits to applying a consistent price across emissions from different sectors in Ireland and across different countries in the EU. Harmonisation of the price minimises distortions to the economic decisions taken by firms and households.

Indeed, many features of recent European and Irish climate policy reflect the importance of having a common price across as wide an area of the economy as possible; for example, the very existence of the ETS, the likely introduction of intra-EU tradability in non-ETS emission limits and the setting of the Irish carbon tax at a level informed by the ETS permit price.

### ***Conclusion***

It is not desirable that Ireland should adopt a special climate policy for its waste sector, with a carbon emissions price that is permanently inconsistent with the price applied across large parts of the Irish and EU economies. If, as some argue, the carbon emission price set through the ETS is inappropriate, this problem should be addressed at a European level rather than piecemeal in particular sectors of individual Member States.

**Comment 5: We should have included a range of non-GHG externality values in our levy rates for incinerators, and if we had done so we would have arrived at about the same rates as the International Review.**

We do not accept the view that that the environmental damage caused by a range of non-GHG air pollutants should be taken into account when setting waste levies for those pollutants that are already regulated through the waste licensing system. As a matter of principle, one should, first, apply only one policy instrument to each objective<sup>19</sup> and, second, ensure that policy is neutral across the sectors and technologies that emit a particular pollutant. Below we explain why our approach meets these objectives and the alternative of applying non-GHG pollution levies to the waste sector in Ireland does not, given that regulatory measures are already in place. We accept that if one designed a regulatory system for Europe from scratch, it would be better to apply emission levies rather than command and control measures, but that is not the position from which this market starts.

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<sup>19</sup> The theory on this was first formalised in Tinbergen, J., 1966, *On the Theory of Economic Policy*, Amsterdam: North-Holland.

### ***The Costs of Double Regulation: Inefficiency and Inconsistency***

Our Report argues that externalities associated with emissions of several air pollutants other than CO<sub>2</sub> should be omitted from the waste levy because they are already regulated. There are two reasons for this: efficiency of regulation and consistency of regulation across sectors. Using two instruments to limit the same emissions leads to needless duplication and excessive administrative and compliance costs. More importantly in this case, emissions from different sources of the same pollutant should be regulated consistently, as they have the same impact regardless of source. This is particularly the case if their outputs are sold in overlapping markets. If not, regulation would unfairly distort markets. For example, incinerators offering electricity to the Single Electricity Market (“SEM”) in Ireland would be at a competitive disadvantage compared to power stations if the latter were not also covered by a levy.

### ***Waste Levies for other air pollutants: the International Review Compared to Our Report***

Excluding already-regulated air pollutants leads to a very significant difference between our recommendations and those in the International Review. By way of illustration, including just two such emissions, SO<sub>2</sub> and NO<sub>x</sub>, could add up to €30 per tonne of waste using the proposed levy rates in the International Review.<sup>20</sup>

The International Review makes no reference to the need to ensure consistent regulation of these emissions across sectors. Incinerators are subject to direct regulatory controls under the waste licensing regime, which is designed to control and reduce the amount of SO<sub>2</sub> and NO<sub>x</sub> they emit over time. The main point sources of SO<sub>2</sub> and NO<sub>x</sub> in Ireland, electricity generating stations, are similarly regulated under IPPC rules. These regulations both set limits on the quantities that may be emitted and specify that best available technologies must be used to abate emissions. This is an alternative approach to using economic instruments such as waste levies and taxes. Some countries, notably the USA, do use economic instruments to regulate some of these emissions, and they have many attractions as an approach to abatement. However, as a member of the EU, Ireland relies mainly on direct regulation to regulate other air pollutants.

Because these emissions are governed by regulation, consistency should be maintained across sectors and Member States within the EU by continuing to omit the externalities from these non-GHG substances from the waste levies.

The approach in the International Review might be appropriate if one were starting from scratch and designing a scheme for the entire EU. If there was no regulation of pollution and no charges on pollutants then the introduction of a regime which perfectly reflected the externalities arising from pollution might be the right answer. However, Irish policy has to be framed within the context of EU law and a range of controls and measures already in place. As indicated in our Report, failure to recognise the existing regulatory framework through the imposition of double regulation would lead to serious distortions which would raise the cost of meeting the required environmental objectives while potentially imposing significant additional costs on society by distorting competition.

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<sup>20</sup> This illustration assumes emissions at licence limits for the Poolbeg incinerator, with the facility running at full capacity.

Our approach is consistent with the economic theory concerning regulatory instruments. It may sometime be necessary to apply more than one control measure to a given pollutant or polluter: multiple instruments may be required in cases where there are multiple policy objectives.<sup>21</sup> There are also cases where it is impossible for practical reasons to regulate all emissions of a given substance in a consistent way.<sup>22</sup> In this case, however, the relevant policy objective is to mitigate the damage caused by emission of the relevant pollutants, so we have only one policy objective to address. That suggests that using more than one measure to address it would be inefficient.

The objective of mitigating damage from emissions may be addressed through regulatory measures embodied in emissions licences (as at present<sup>23</sup>) or through an economic instrument such as a waste levy or tradable permit scheme.<sup>24</sup> Our first principle suggests that using a single measure to meet the single objective has efficiency benefits. We start from a position of regulatory symmetry across types of emitters, so there should be no practical problem in applying our second principle: regulating pollutants in a consistent manner across different emitters – power stations, cement kilns, aluminium smelters and so on.

Waste licences cap the emissions from each waste facility. If emissions are deemed too high, then the licences should be tightened. If a levy is used on top of a licence, emissions may or may not fall. Emissions that are deemed acceptable by the licensing agency are nonetheless taxed. The overall tax burden would increase.

#### ***Another Option to Maintain Consistency: Extend the Levies to All Polluters***

Of course, an alternative approach would be to extend a levy on these emissions to other emitting sectors. Because the power generating sector in particular is a much bigger emitter of some of these substances than the waste sector, such a levy would have a much bigger effect elsewhere than in waste. In particular, the SO<sub>2</sub> and NO<sub>x</sub> externalities from the fuel, power and water sector in Ireland during 2009 would be valued at about €770 million if the levy rates in the International Review were applied to this sector, which compares to roughly €17 million for the Poolbeg incinerator.<sup>25</sup>

If such a levy were imposed in Ireland alone, power generating stations located here would be at a severe competitive disadvantage to those in Northern Ireland. Under the SEM bidding principles, generators covered by the levy would have to bid higher due to their increased marginal costs, just as they do in the case of ETS permits. Of course, in a relatively competitive market Irish fossil fuel plants would have to bid higher anyway or they would lose money. The price of electricity would therefore rise, and industrial exporters in Ireland using electricity as an input would suffer when selling into foreign markets that leave such externalities unpriced. Instead of creating such distortions, we believe that policy should aim where possible to treat different

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<sup>21</sup> For example, in the case of landfill we recommend that a levy be applied to cover *inter alia* methane externalities, but that a system of tradable permits be used to meet the independent objective of complying with Landfill Directive targets concerning diversion of biodegradable waste.

<sup>22</sup> For example, some policies that are applicable to point source emissions may be hard to apply to diffuse emissions.

<sup>23</sup> Note that emissions are licensed according to European law; the Irish government is not at liberty to abolish these licences.

<sup>24</sup> There are other options too, but we leave them aside because they have not been raised in the debate.

<sup>25</sup> The latter illustration is based on emissions at licence limits for the Poolbeg incinerator, with the facility running at full capacity.

emitters of the same pollutant within Ireland (and indeed across the EU) the same way.

While economic instruments are an attractive option for mitigating air pollution externalities efficiently, they should be applied on a non-discriminatory manner across sectors and regions to avoid distortions to competition and harm to societal welfare. This message has been influential in the recent evolution of European Union climate policy, and Ireland has been at the forefront in using economic instruments and ensuring that Europe applies them in an efficient way. Such consistency is also vital in waste management.

### ***Conclusion***

Our original conclusion is unaltered: the externalities from non-GHG air pollutants that are regulated in waste licences should not be included in the levies on waste disposal. Including these emissions in waste levies would lead to needless duplication and excessive administrative and compliance costs, and more importantly, it would introduce inefficient discrimination between emitters in different sectors.

**Comment 6: Shouldn't waste levies be set to make the next level of the hierarchy economically competitive? For example, levies for landfill could be set at a sufficient premium to Mechanical Biological Treatment, EfW [energy from waste], and AD [anaerobic digestion] to facilitate the operation of the waste hierarchy.**

The waste hierarchy is a central part of European waste management strategy. It has been argued that the waste management hierarchy<sup>26</sup> should determine the rates of levies for waste disposal. However, we disagree.

### ***Waste Levies Should be Set to Reflect Unpriced Externalities***

Waste levies for landfill are always likely to be higher than for other disposal options under our proposed methodology, but we do not think levy rates should be based on advantaging or disadvantaging any option *per se*. Instead, levy rates should reflect the external costs of each option, to the extent that these costs have not already been regulated by some other instrument. In this way of thinking, externality-based regulation and rules based on the waste hierarchy are alternative ways to reduce the negative effects of waste management on societal welfare. Economic instruments such as levies are more efficient than direct controls, because they allow more flexibility in abatement behaviour while achieving the desired results. Thus levies should be relied upon to manage these costs, rather than as a mechanism for supporting an alternative and potentially less efficient way to manage them.

### ***Conclusion***

Our original conclusion is unaltered: levies should be set to reflect externalities that are not already regulated.

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<sup>26</sup> The waste management hierarchy is discussed in our Report (pp. 6-7).

**Comment 7: Although the effect of landfill management on methane emissions is discussed in Section 1.3 of the Annex, it is not reflected in Table A.10.**

This omission was unintentional. We understand that landfill management can significantly affect methane emissions (e.g. as illustrated in Table A.2), and the figure given in Table A.10 relates to landfills with no gas capture or flaring. The levy applied to landfill should take variations in management practices into account in order to provide the right incentives for efficient management.

***Conclusion***

Our original text has been amended to emphasise the need for levies that vary with the extent of methane management in landfills. See Item 14 of the attached corrigenda.

**Overall Conclusions**

The roadmap for municipal waste management policy set out in our Report, *An Economic Approach to Municipal Waste Management in Ireland*, remains unchanged after a careful review of the comments and criticisms made since the Report was launched on 3 February 2010. The concerns identified do not change the substance of the Report or its central conclusions. We are thus amending the Report not withdrawing it.

The Report's recommendations include:

- i) a cap and trade system should be introduced to meet the EU Landfill Directive targets for 2013 and 2016;
- ii) the imposition of levies per tonne of municipal waste, depending on the method of waste disposal. The levies are based on the unpriced environmental and disamenity impact of the particular waste disposal method; and,
- iii) competitive tendering for household waste collection in each region, which would address any market power problems.

The only valid criticism of any significance arising from the comments is that incinerators are exempted from the ETS; we had assumed the contrary in the Report. However, when this correction is made the waste levy per tonne for incineration increases for an urban incinerator from €4.22 to €5.07 per tonne to €9.80 to €10.70 per tonne. These numbers compare to €26 per tonne plus non-GHG pollutant related taxes as recommended in the International Review carried out for the Department of the Environment, Heritage and Local Government. Such a revision does not alter the substance of our proposed roadmap.

The response to some of the other criticisms is as follows:

1. The International Review argues that external costs of non-GHG air pollutants should be included in the waste levies for incinerators, despite already being subject to direct regulation. This will lead to needless duplication of regulation and excessive administrative and compliance costs. Still more important, it would amount to discrimination among polluters. Environmental emissions have the same environmental impact irrespective of the source, so it is not appropriate to select incineration for special treatment when other



sources, such as cement kilns and electricity generating stations, are not included. Consistency could be preserved by applying a similar levy to the much larger emissions of some substances from electricity generating stations, but we have noted that this would raise electricity prices substantially and place Ireland at a competitive disadvantage.

2. Projections of future municipal waste growth that rely on simple international benchmarking, such as those published by SLR Consulting on behalf of the IWMA, should be regarded with caution. International benchmarking can be useful in predicting future patterns of activity, but it needs to take proper account of national differences in economic and demographic conditions to be convincing. This SLR did not do.
3. The Report includes baseline municipal waste projections that draw upon extensive research previously undertaken in the ESRI into likely future developments in the Irish economy and in the related production of waste. The IWMA's criticisms of the Report's projections of waste both at the national and Dublin level are unfounded. For example, the IWMA states that the Report used a recycling rate of 39% rather than the 41% recorded in 2008. This is incorrect. The Report did not specify what rate was used, but did use 41%. The IWMA also states that no account was taken of the incinerator at Carranstown in Meath. This is incorrect as reference to the Report (p. 30) makes clear.
4. The IWMA argues that the Report appears to be abandoning recycling in order to justify building the Poolbeg incinerator. This is incorrect. Our projections of waste sent for recycling represent a baseline prior to the imposition of any new policies, construction of new recycling facilities or adoption of extra collection arrangements (also discussed on p.30). If efficient policies are put in place, this will provide incentives for efficient levels of recycling activity.

Our comments on the alternative waste management roadmap put forward by the Department of the Environment, Heritage and Local Government also remain unchanged.

Our Report questions whether the proposed Section 60 policy direction to cap incineration provides a coherent and feasible basis on which to develop waste policy. Arbitrary limits on incineration and consequent expansion of mechanical biological treatment (MBT) are not appropriate. The International Review's setting of residual waste levies suffers from both double regulation and double counting, with the result that some of the proposed levies are much higher than is appropriate. It does not provide the basis for a waste management policy that would minimise the economic cost to Ireland of waste disposal or meet the EU Landfill Directive targets.

We welcome the vigorous debate following the release of our Report. It is only through such debate and dialogue that waste management policy can be improved thus enhancing the welfare of Irish society. We hope that the independent research that we have published, drawing on existing research from the ESRI, the Competition Authority and others, will make a positive contribution in that respect.

## ***Corrigenda to An Economic Approach to Waste Management Policy in Ireland.***

1. **On page v of the Executive Summary**, replace the line “Landfill €44.24 to €54.89 per tonne” with “Landfill €44.50 to €55.20 per tonne minus appropriate reductions for methane-reducing management practices”, replace the line “Urban Incineration €4.22 to €5.07 per tonne” with “Urban Incineration €9.80 to €10.70 per tonne”, and replace the line “Rural Incineration €0.42 to €0.50 per tonne” with “Rural Incineration €6.00 to €6.10 per tonne”.
2. **On page 19**, para 4, insert “a significant portion of” after “System controls...”
3. **In Table 4.1**, replace 967,433 with 916,000; replace 644,956 with 610,000 and replace 451,469 with 427,000. Also replace “2009a, Table 14, p.14” in table source with “2009c, Table 17”.
4. **On page 23**, replace the text “Historically, the majority ... better reporting methods.” with “Historically, the majority of Irish municipal waste has been sent to landfill. As of 2008, 32 authorised landfills accepted municipal waste (slightly more than in 2007 but down significantly from 48 in 2001 and 120 in the late 1990s). Six of these are run by private operators. The reduction in the number of landfills is due to greater regulation of the sector, with all landfill operators now obliged to obtain a waste licence from the EPA. The quantity of biodegradable municipal waste disposed of to landfill was estimated at 1,196,044 tonnes in 2008, about 280,000 tonnes above the first (2010) Landfill Directive target (EPA, 2009c).”
5. **On page 24**, replace the text “There have been changes ... amongst politicians too.” with “There have been changes in waste disposal policy and policy implementation since the mid-1990s. Detailed guidance has been issued on the types of pre-treatment that should be applied to material before it is deposited in landfill or incinerated, which in particular specifies a minimum level of segregation at source (EPA 2009b).

Almost all regional waste management plans include incineration as a solution for dealing with waste. Although work has begun on the incinerator in Carranstown, Co. Meath, and pre-construction work has begun at Poolbeg, incineration as a means of reducing waste disposal will not be operational in Ireland until the end of 2011 (Forfás, 2009). Needless to say, incineration remains a highly contentious and unresolved issue with the public, and, as demonstrated by the Section 60 policy direction, amongst politicians too.”

6. **On page 29**, final para, replace “2009b” with “2009c”.
7. **On page 40**, final para, the text “Incinerators are subject ... in waste management levies.” is replaced by “We do recommend including the component of CO<sub>2</sub> emissions relating to incinerators’ fossil fuel inputs (such as plastics) in the relevant levy, while in landfill non-biodegradable materials such as many plastics do not give off CO<sub>2</sub>. For MBT, fossil fuel use will be captured under the carbon tax, plastics are either recycled or sent to landfill and CO<sub>2</sub> from plant materials is largely carbon neutral, so any process CO<sub>2</sub> emitted should be omitted from the levies.”

8. **On page 41**, first para, the text “We have assumed ... each Waste Licence.” with “While we recommend that some CO<sub>2</sub> emissions from incineration be included in the levy, externalities from a range of other emissions to air that are currently regulated through other instruments such as waste licences and the carbon tax should be omitted from the levies to provide consistency of treatment with other sectors.”
9. **On page 77**, delete the text “It appears at first ... per tonne (i.e., €26.00 + €9.90).”
10. **In Box R8 on page 78**, delete the text “[9.90]<sup>1</sup>” and Footnote 1.
11. **On page 82** delete the text “It is not clear ... add up to €9.90.<sup>70</sup>” and footnote 70.
12. **On page 107**, third para, replace the text “If incinerators are sufficiently ... in terms of a levy.” with “We do recommend including the component of CO<sub>2</sub> emissions relating to incinerators’ fossil fuel inputs (such as plastics) in the relevant levy, while in landfill non-biodegradable materials such as many plastics do not give off CO<sub>2</sub>. For MBT, fossil fuel use will be captured under the carbon tax, plastics are either recycled or sent to landfill and CO<sub>2</sub> from plant materials is largely carbon neutral, so any process CO<sub>2</sub> emitted should be omitted from the levies.”
13. **On page 108**, there is a typographical error: [www.eex.eu](http://www.eex.eu) should read [www.eex.com](http://www.eex.com).
14. **On page 124**, replace the subsection “A summary of the external costs of landfill”, including Table A10, with the following:

***“A summary of the external costs of landfill***

The result of the above analysis in terms of the appropriate levy for refuse sent to landfilled based on the methodology outlined in Section 1.2 above is presented in Table A.10 below. This shows that the external cost of methane per tonne of waste is far more important than the disamenity effects. Bearing in mind that the methane emitted to the air per tonne of waste may be reduced significantly by landfill management practices such as gas capture or flaring (as illustrated in Table A.2 above), we recommend a differentiated levy to give incentives for efficient management. The reduced rates for methane-reducing management practices should be set at levels approximating the externalities associated with the remaining emissions in each case. The exact set of rates to be used should be wide enough to encompass the common types of management practices used in Ireland but narrow enough to be administratively practicable.

**Table A.10: Pricing the External Costs of Landfill, Per tonne, Ireland, 2009**

Externality		Price (2009€/tonne waste landfilled)
Greenhouse Gases	Carbon Dioxide	(omitted since biodegradable waste removes CO <sub>2</sub> from the atmosphere)
	Methane	€33.90 for all methane that is neither captured nor flared
Leachate		0
Air Pollutants		Omitted, regulated through emission limits in waste licence

Disamenities	€10.64 – 21.29
<b>Total</b>	€44.50 - 55.20 minus appropriate reductions for methane-reducing management practices

Source: see above”

15. **On p.125**, para 2, replace “This process, as mentioned ... be calculated here.” with “These benefits, as mentioned previously in the report, have already been internalised by the Emissions Trading Scheme and carbon tax, so they do not need to be reflected in new levies.”

16. **Delete Table A.11.**

17. **On page 126**, replace the text “Assuming that the UK figures ... carbon dioxide emissions (COWI, 2000).” with

“Using the same CO<sub>2</sub> price assumption as for given earlier for landfill (a price of €13.40 per tonne of CO<sub>2</sub>) and an estimate from DEFRA (2004a) of 19 g/tonne of methane per tonne of MSW incinerated, we can estimate the externality effect of GHGs from incineration of mixed residual waste in Ireland. This implies €0.0053 per tonne of externalities associated with methane emissions, which is sufficiently small to ignore in our analysis. Table A.11 sets out an estimate of the appropriate levy on CO<sub>2</sub> emissions from incineration. Assumptions on the composition of mixed residual waste are drawn from the most recent EPA *National Waste Report*, and parameters for the carbon content and the component of CO<sub>2</sub> emissions arising from combustion of renewable feedstocks are drawn mainly from IPCC guidance. This approach yields an estimated levy of €5.00 per tonne of mixed residual waste sent to incineration. Updating this figure to use the new carbon tax as the price of carbon (€15.00 per tonne of CO<sub>2</sub>) implies a levy of €5.60. If materials other than mixed residual waste are to be incinerated, this figure may need to be adjusted.”

18. **On page 128**, para 1, replace the text “When modelling the ... in Table A.13” with “Rabl *et al.* (2008) provides estimates of a range of air emissions from waste incineration – reproduced below in Table A.13. Drawing upon these estimates, Table A.14 below illustrates the externalities associated with selected emissions to air.”

19. **On page 133**, replace Table A17 with the following:

“Table A.17: Pricing the External Costs of Incineration, Per tonne, Ireland, 2009

Externality		Price (2009€/tonne waste incinerated)
Greenhouse Gases	Carbon Dioxide	5.60
	Methane	Omitted due to small scale
Air Pollutants		Omitted, regulated through emission limits in waste licence
Solid Residue		Omitted
Disamenities	Urban	4.20 – 5.10
	Rural	0.40 – 0.50
<b>Total</b>	Urban	9.80– 10.70
	Rural	6.00 – 6.10

*Source: see text*

20. **On page 110, immediately before Table A.1,** add the sentence “Updating this figure to use the new carbon tax as the current price of carbon (€15.00 per tonne), implies a levy of €33.90.”
21. **On page 132,** replace the heading “9.1.1 Residual solid waste” with “Ash residues”
22. **On page 132,** immediately before the heading “A summary of the external costs of incineration” insert the following sub-section:

**“Emissions to water**

Another possible externality that might be considered is the discharge of cooling water from incinerators, which in some cases may include an anti-foulant. However, like some emissions to air we assume this is controlled through the waste licensing process and should be omitted from the levy to ensure consistency of treatment with plants in other sectors that produce similar emissions.”
23. **In Section 1.6 of the Annex,** replace the line “Landfill €44.24 to €54.89 (Table A.10)” with “Landfill €44.50 to €55.20 minus reductions for methane-reducing management practices (Table A.10)”, replace the line “Urban Incineration €4.22 to €5.07 per tonne” with “Urban Incineration €9.80 to €10.70 (Table A.17)”, and replace the line “Rural Incineration €0.42 to €0.50 per tonne” with “Rural Incineration €6.00 to €6.10 (Table A.17)”.
24. **Add Table A.11** shown overleaf immediately before the heading “*Air Pollutants*” on page 126.

**Table A.11: Predicted externality value of CO2 emissions per tonne of mixed residual waste incinerated in Ireland**

	Mixed residual waste composition					Carbon content analysis						
	Household % <sup>a</sup>	Non-household % <sup>a</sup>	HH Q	Non-HH Q	Total Q	Dry matter content in % wet weight <sup>b</sup>	Total Q (dry)	Carbon/dry waste % <sup>b</sup>	Share fossil source <sup>b</sup>	Total C tonnes	Total fossil C tonnes	Total C
Organic waste	24	42.2	277,336	319,951	597,287	0.4	238,915	0.38	0	90,788	-	90,788
Garden waste	6.5	0.2	75,112	1,516	76,628	0.4	30,651	0.49	0	15,019	-	15,019
Papers	12.5	25.5	144,446	193,335	337,781	0.18	60,801	0.46	0.01	27,968	280	27,968
Cardboards	3.6	4	41,600	30,327	71,928	0.24	17,263	0.3	0	5,179	-	5,179
Composites	1	3.4	11,556	25,778	37,334	0.62	23,147	0.525	0.5	12,152	6,076	12,152
Textiles	7.3	4.9	84,356	37,151	121,507	0.19	23,086	0.7	0.2	16,160	3,232	16,160
Nappies	8.4	0	97,068	-	97,068	0.4	38,827	0.6	0.2	23,296	4,659	23,296
Plastics	13.6	10.8	157,157	81,883	239,040	1	239,040	0.75	1	179,280	179,280	179,280
Glass	3.3	1.7	38,134	12,889	51,023	1	51,023	0	0	-	-	-
Metals	3.1	2.1	35,823	15,922	51,744	1	51,744	0	0	-	-	-
Wood	1.2	0.4	13,867	3,033	16,900	0.41	6,929	0.5	0	3,464	-	3,464
Hazardous	0.9	3	10,400	22,745	33,145	0	-	0	0	-	-	-
WEEE	0.3	0.2	3,467	1,516	4,983	0	-	0	0	-	-	-
Unclassified combustibles	1.4	0.4	16,178	3,033	19,211	0.59 <sup>c</sup>	11,334	0.4 <sup>c</sup>	0.5 <sup>c</sup>	4,534	2,267	4,534
Unclassified incombustibles	1.2	0.2	13,867	1,516	15,383	0.94 <sup>c</sup>	14,460	0.07 <sup>c</sup>	0	1,012	-	1,012
Fines < 20mm	11.7	1	135,201	7,582	142,783	0.83 <sup>c</sup>	118,510	0.17 <sup>c</sup>	0 <sup>c</sup>	20,147	-	20,147
Quantity collected 2008	1,155,567	758,178								399,000	195,794	399,000
CO2 price per tonne	13.4											
tCO2/tonne waste	0.764											
Share of CO2 from fossil inputs	0.491											
tCO2/tonne waste from fossil inputs	0.375											
Cost of CO2 per tonne MSW incinerated	5.00											

Sources: <sup>a</sup> EPA National Waste Report, 2008, Table F-1 and F-5; <sup>b</sup> Table 2.4 in Ch. 2 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories, default values; <sup>c</sup> Table 63-10 in International Benchmarking