Country fact sheet

Municipal waste management

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Ireland

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European Environment Agency
European Topic Centre on Waste and
Materials in a Green Economy

Context

This country profile was prepared within the EEA's work on municipal waste, resulting in the following outcomes:

- 32 country profiles (this document) – The country profiles were originally produced by the ETC/SCP and were published by the EEA in 2013. The ETC/WMGE updated them for the EEA under its 2015 and 2016 work programme.

- An EEA briefing on Municipal waste management across European countries

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Related country information

Country information on waste prevention programmes can be found at:
http://www.eea.europa.eu/publications/waste-prevention-in-europe-2015

For country profiles on material resource efficiency policies, please visit:
http://www.eea.europa.eu/publications/more-from-less/

Contents

Highlights

- The share of municipal solid waste (MSW) sent to landfill reduced significantly between 2001 and 2013, from 77 % to 38 %. Total MSW recycling, dominated by material recycling, increased from 11 % to 37 % over the same period.
- A dip in recycling volumes followed in 2008, caused by a reduction in MSW generation and demand for recyclates caused by the economic crisis.
- Calculated by the method chosen by Ireland, 45 % of paper, metal, plastic and glass household waste was recycled in 2012.
- Ireland's material recycling rates are currently highly influenced by the global market for recyclables, as a large share is exported for further processing outside Ireland.
- Ireland met its 2010 Landfill Directive target with a reasonable margin. A reduction in MSW generation resulting from the economic crisis was a key driver. Sharp increases in the landfill tax levy after 2007, obligations on landfill operators to limit the proportion of biodegradable municipal waste accepted at sites, and new obligations on commercial and household producers of food waste have also had an impact.
- The 2013 Landfill Directive target has also been met and Ireland is on track to meet the 2016 target but will require the legislative and policy efforts made over the past number of years to be sustained.
- The landfill levy, increased to EUR 75 per tonne in 2013, is considered a key element in meeting this challenge, as are the regulations that have been introduced on household food waste. It is important that treatment capacity in Ireland is maintained to cater for the biodegradable component of residual wastes.
- Lack of regulation and control of the waste collection market in Ireland increases the level of effort that is needed from administrators and regulators for the country to meet policy and legislative objectives. The legislation needed to tighten and strengthen enforcement of waste collection permits has recently been enacted by the government.

1 Introduction

1.1 Objective

Based on historical municipal solid waste (MSW) data for Ireland, and EU targets linked to municipal solid waste (MSW) in the Waste Framework Directive (WFD), the Landfill Directive and the Packaging Directive, the analysis undertaken includes:

- historical MSW management performance based on a set of indicators;
- uncertainties that might explain differences in country performance, which may relate more to variations in reporting methodology than to management performance;
- indicators relating to the country's most important initiatives for improving MSW management;
- possible future trends.

2 Ireland's municipal solid waste management performance

The definition of municipal waste in Ireland is broad, and includes waste from households and street and park cleaning, as well as non-hazardous waste from the commercial and service sectors (shops, offices, etc.) and non-process industrial wastes (for example canteen waste). It does not include municipal wastewater treatment sludge.

The last decade has seen significant changes in how waste is managed in Ireland. The regulatory regime imposed on the waste industry during this period has encouraged Ireland to move from a position of almost total reliance on landfill to a significant recovery of recyclable materials and waste incineration, either as refuse-derived fuel or baled municipal residual waste. A related trend is the dramatic reduction in the number of active landfill sites for MSW; by the end of 2013 there were nine operational landfills in Ireland. The waste sector is almost exclusively operated by the private sector, with only four local authorities involved in household waste collection in 2013 (EPA, 2015b).

Household waste is collected through door-to-door systems. Most households are serviced by an alternate weekly collection of residual waste and comingled collection of dry recyclables. In many households the above-mentioned system is complemented by fortnightly collection of garden and food waste. In line with the EU (Household Food Waste and Bio-Waste) Regulations 2015 this service is being rolled out on a phased basis and will apply to all population agglomerations above 500 people from 1 July, 2016 (EPA, 2015a).

In addition to kerbside collection there are close to 1 900 waste collection points serving households for the collection of glass, metal packaging, textiles and occasionally paper/cardboard, plastic bottles and residual waste. The collection system also uses more than 100 civic amenity sites (Gibbs et al., 2014a), which provide a wide range of segregated receptacles for the separated collection of different types of recyclables.

Commercial waste similar to household waste is typically collected together with household waste. Major commercial waste streams are collected separately by specialist waste collection companies (Gibbs *et al.*, 2014a).

For handling the recyclables from comingled collection, material recycling facilities with a capacity of around 270 000 tonnes operate in Ireland. Organics are mainly treated in in-vessel composting plants with a capacity 328 000 tonnes and a smaller share of non-food waste in open-air windrows. In

2013, there were four compost facilities producing bio-stabilised residual waste from organic fines arising from the mechanical treatment of residual waste. The quantity of input at these facilities was 50 000 tonnes, which produced 24 000 tonnes of bio-stabilised residual waste (EPA, 2014). In 2011 the incineration capacity with electricity recovery was 200 000 tonnes. Additional capacity for close to 270 000 tonnes was available for co-incineration of waste in cement kilns. Ireland also exports waste for incineration (Gibbs *et al.*, 2014a). Significant additional capacity will be available when the Dublin Waste to Energy Facility, currently under construction, becomes operational in 2017 (EPA, 2015a).

Waste management policy at the national level is detailed in a set of policy documents. The policies are implemented through legal instruments – the Waste Management Acts 1996 to 2015, and a wide range of associated legal texts dealing with such matters as producer responsibility initiatives, taxes, litter, technical standards and incineration – governing the management of waste and outlining the responsibilities of waste generators and waste management organisations. European Union legislation, the WFD, Landfill Directive, producer responsibility initiatives, etc., continues to be a significant driver of waste policy in Ireland.

Although a national waste management plan had been considered and a National Overview of Waste Management Plans was undertaken and published by the Department of the Environment in 2004 waste management plans (WMPs) are developed at the regional level in Ireland. Three regional WMPs, for Eastern-Midlands, Southern and Connacht Ulster, covering the whole territory of Ireland were adopted in May 2015 and it is the firm intention of the regions to continue their close coordination throughout the implementation phase in order to ensure consistent and effective delivery of the polies and actions contained within the plans. In addition to the regional plans, a National Hazardous Waste Management Plan for 2014–2020 has been adopted (EPA, 2015a).

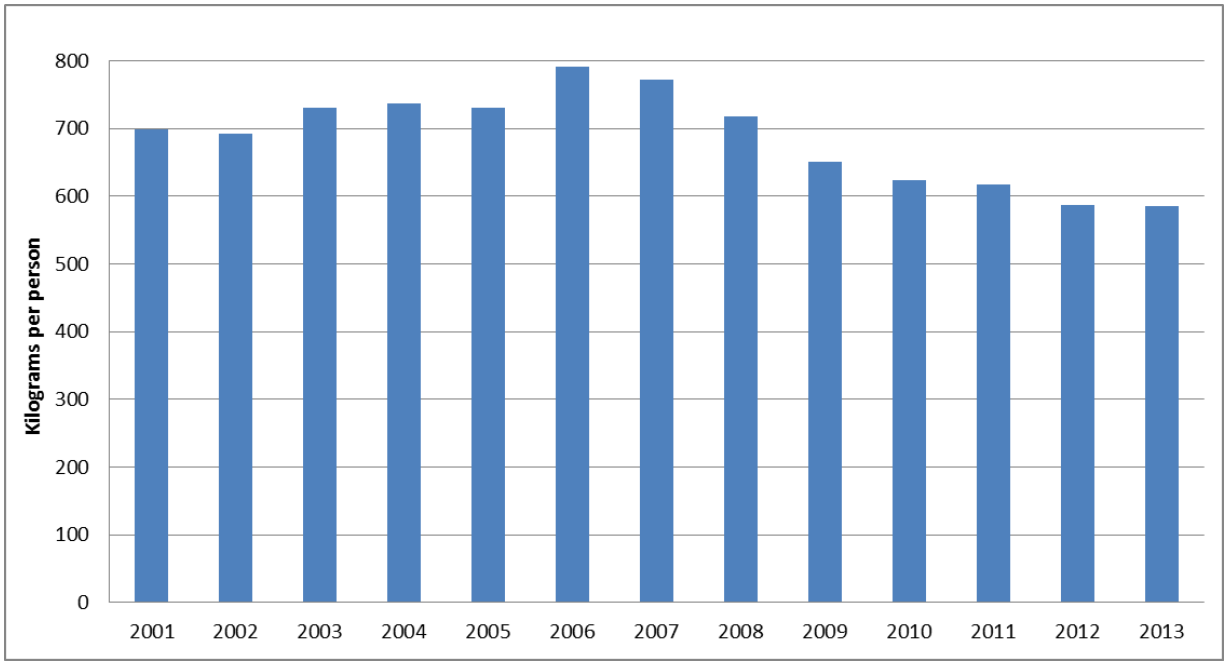
Enforcement of the waste sector regulations in Ireland in 2013 was carried out by a combined effort of the Office of Environmental Enforcement (OEE) in the Environmental Protection Agency (EPA), the local authorities and the National Transfrontier Shipment of Waste (TFS) Office (EPA, 2015b). Three new Waste Enforcement Regional Lead Authorities (WERLAs) have recently been established and will have responsibility for coordinating waste enforcement actions within regions, setting priorities and common objectives for enforcement in the waste area, ensuring consistent enforcement of waste legislation across the three existing waste management planning regions while still leaving local authority personnel as first responders to specific breaches of waste legislation. The EPA works with local authorities to bring about an overall improvement in the level and consistency of enforcement of environmental protection legislation in Ireland. It also audits local authorities' performance in enforcing this legislation. This includes giving directions to local authorities when necessary and prosecuting if directions are not complied with. The recent strengthening of waste legislation places the primary responsibility for achievement of the targets on the individual waste producers (EPA, 2015a).

2.1 Municipal solid waste indicators

The following indicators illustrate the development of Ireland's MSW management for 2001–2013. All percentage figures have been calculated as proportions of generated waste, rather than managed waste. Relating the indicators to managed amounts would generally result in higher rates for all waste management paths.

Figure 2.0 shows the development of MSW generation per person in Ireland in 2001–2013. Generation per person peaked in 2006 at 792 kilograms, and by 2013 had reduced by 26 % to 586 kilograms. One of the reasons is probably the economic recession following the financial crisis that began in 2007.

Figure 2.0 Ireland, municipal solid waste generation per person, 2001–2013



Source: Eurostat, 2015.

Eurostat estimated the generation of MSW in Ireland in 2013, based on data submitted for previous years. The EPA is currently reviewing the methodology for calculating total generated MSW, in particular the estimate for the unmanaged waste portion. Based on preliminary results, it is likely that there will be a reduction in generated MSW waste in 2013 by approximately 5 %. This will have an impact on all the MSW indicators and in particular on any forecasts or trends (EPA, 2015a).

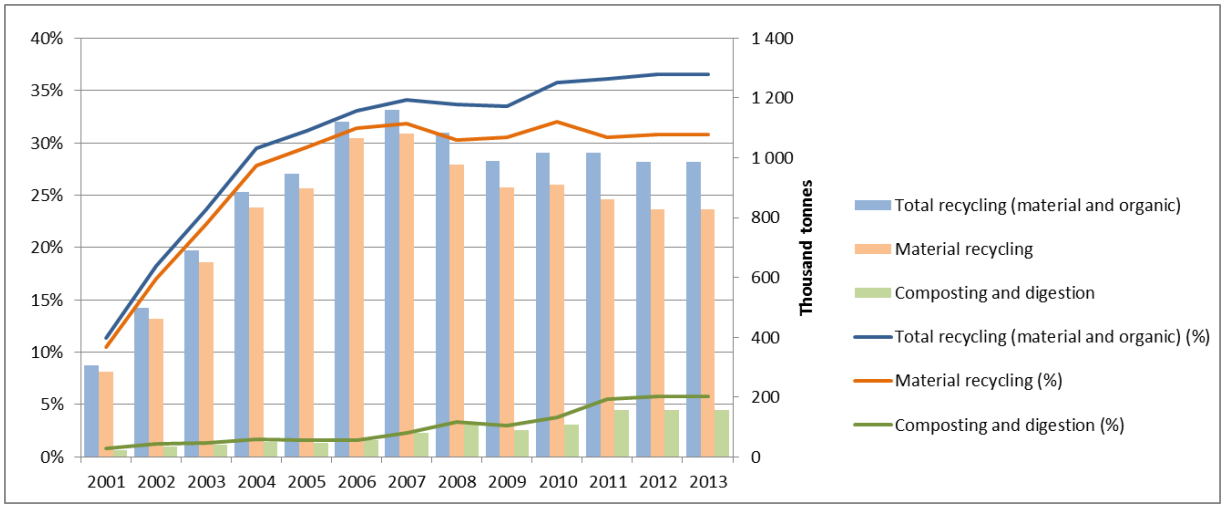
2.1.1 Municipal solid waste recycling, 2001–2013

The share of MSW sent to landfill has decreased significantly since the turn of the millennium, falling from 77 % of the amount generated in 2001 to 38 % in 2013. Material and organic recycling of MSW increased dramatically over the same period, while incineration only began to make noticeable inroads after 2007. By 2013, the share of incineration had reached 16 % of total generated MSW.

Figure 2.1 shows the development of total, material and composting and other biological treatment MSW recycling in Ireland. Total recycling increased from 11 % in 2001 to 37 % in 2013.

Recycling remains dominated by material recovery, which increased from 11 % in 2001 to 31 % by 2013. Due to reductions in total generation of MSW since 2007, however, the amount of waste undergoing material recovery actually peaked in 2007 at 1.08 million tonnes. Since then, material recycling by weight shows a decreasing trend, falling to 0.83 million tonnes in 2013. Meanwhile, the reduction in the amount of waste generated results in a rather stable material recycling rate for 2007–2013, measured as percentages.

Figure 2.1 Ireland, municipal solid waste recycling, 2001–2013, per cent and tonnes



Source: Eurostat, 2015.

The dip in material recycling in 2008 is likely to have been caused by a drop in global demand, and a resulting fall in prices, for secondary materials towards the end of 2008 following the financial crisis (Sheehan, 2011; Hogg *et al.*, 2009). The export market is an important driver for the separation of waste in Ireland for material recovery, as shown in Table 2.1. The United Kingdom is the key market for exports of waste from Ireland (EPA, 2012a), but much of this is likely to be re-exported to Asian markets. China is also the second biggest direct importer of Irish municipal wastes streams (EPA, 2012a).

Table 2.1 shows the dominance of export markets in the recovery of certain Irish municipal waste streams. For ferrous metal wastes and paper and cardboard wastes, export for recovery abroad represents more than 99 % of the total. Export of paper and cardboard wastes for recovery saw a drop of close to 90 000 tonnes between 2008 and 2009, which may have accounted for a large part of the dip in total material recovery rates between 2008 and 2009. It should be noted that the dramatic change in ferrous metal wastes recovered abroad shown in the table results from a change in reporting procedures rather than a change in actual recovery (see note under the table). However, other metal wastes saw a significant reduction in recovery abroad between 2008 and 2009. The table also shows that demand for a number of materials including ferrous metals, mixed metals, plastics, and paper and cardboard for recovery abroad, increased again in 2010.

Table 2.1 Non-hazardous municipal waste generated in Ireland but recovered abroad, in tonnes and as % of total recovery

Material	2008		2009		2010		2011	
	Recovered abroad (tonnes)	Recovered abroad (% of total recovered)	Recovered abroad (tonnes)	Recovered abroad (% of total recovered)	Recovered abroad (tonnes)	Recovered abroad (% of total recovered)	Recovered abroad (tonnes)	Recovered abroad (% of total recovered)
Ferrous metals	605 136	99.6	51 772	100	79 879	100	81 952	100
Composites/ mixed packaging	370	100.0	14 206	100	564	100	311	100
Mixed metals	21 748	82.2	1 411	100	10 070	100	0	-
Aluminium /non-ferrous metals	14 359	82.1	4 344	99.6	6 048	-	5 317	-
Paper and cardboard	590 917	99.1	504 243	99.0	520 623	99.1	540 085	99.6
Textiles	5 061	66.8	7 187	93.8	-	-	-	-
Glass	101 692	83.0	106 988	88.8	106 483	95.4	115 268	94.7
Plastic	52 883	70.2	49 943	68.4	58 758	80.9	48 367	73.8
Refuse-derived fuel	26 171	99.8	11 176	23.4	48 226	51.2	86 911	54.9
Organic waste	6 840	7.0	5 642	5.8	7 241	5.1	4 450	2.6
Wood	8 986	4.9	1 936	1.1	76	0.2	0	-
Total	**1 434 163**	**81.6**	**758 848**	**68.9**	**837 968**	**77.1**	**882 661**	**72.7**

Source: EPA, 2013 Table 6; EPA, 2012a Table 6; EPA, 2011 Table 7.

Note: the figure for recovered ferrous metals abroad reported in 2008 also includes metals included in waste electrical and electronic equipment (WEEE). These were removed from the reporting in 2009.

There must be other factors behind the more general tendency for a dampening in the growth of material recycling of Irish MSW, which began in 2004 after rapid growth in the first years of the decade. According to Hogg *et al*. *(*2009), one factor might be that the 35 % national target for recovery of municipal waste established in 1998 was not revised in subsequent policy documents. However regional plans, developed in 2006, adopted much higher targets; ranging from 43 % to 50 % recycling (EPA, 2015a).

Organic recycling – composting and other biological treatment – has seen faster growth than material recovery since 2007. Organic recycling is much less sensitive to global markets than other material recycling, with 97 % of organic recycling taking place within Irish borders (EPA, 2013).

Despite sharp growth, organic waste remains somewhat under-utilised in Ireland. According to calculations made using data found in the *National Waste Report 2012* (EPA, 2014), 616 000 tonnes of collected municipal waste comprised organic and garden waste, both separately collected and as part of the collected mixed residual waste. Of these, 156 000 tonnes, or 25 %, was recycled in 2012 ([1]). However, organic recycling has been the main driver of the increase in the total recycling rate since 2007.

The EU's 2008 WFD includes a target for certain fractions of MSW: 'by 2020, the preparing for re-use and the recycling of waste materials such as at least paper, metal, plastic and glass from

([1]) According to Tables 6 and 8 of the National Waste Report 2012, MSW collected and managed in 2012 comprised 1 363 million tonnes of household waste (this excludes an estimated uncollected quantity of household waste of 214 000 tonnes) and 1 115 million tonnes of non-household municipal waste. According to Tables H-1 and H-2 in the report, 22.7 % of the gross collected household waste and 27.5% of the gross collected commercial waste comprise organic and garden waste. This gives a total collected and managed organic MSW of approximately 616 000 tonnes. According to Section 3.4.2 in the report approximately 156 000 tonnes of biodegradable municipal waste was composted or fermented in 2012.

households and possibly from other origins as far as these waste streams are similar to waste from households shall be increased to a minimum of overall 50 % by weight'. EU Member States may choose between four different methodologies to calculate compliance with the target ([2]). Ireland has chosen calculation method 1 (Gibbs *et al.*, 2014) and has reported a recycling rate of 45% according to this methodology for the year 2012 (EPA, 2014). The recycling rates shown in this paper correspond to method 4, the only method for which time series data exist. In 2015, the European Commission proposed new targets for municipal waste of 60 % recycling and preparing for reuse by 2025 and 65 % by 2030, based on only one calculation method, and with the option of time derogations for some countries (EC, 2015).

Ireland will have to increase the recycling rate by 5 percentage points in the period 2012-2020 according to the chosen methodology, corresponding to 0.6 percentage points per year. Within the period 2001–2012, the country increased its recycling rate, calculated using method 4 for data reported to Eurostat, by 2.3 percentage points per year.

While the results for the two methodologies are not comparable, these numbers give some indication that Ireland has a chance to meet the targets if efforts on increasing the recycling rate are continued in the coming years.

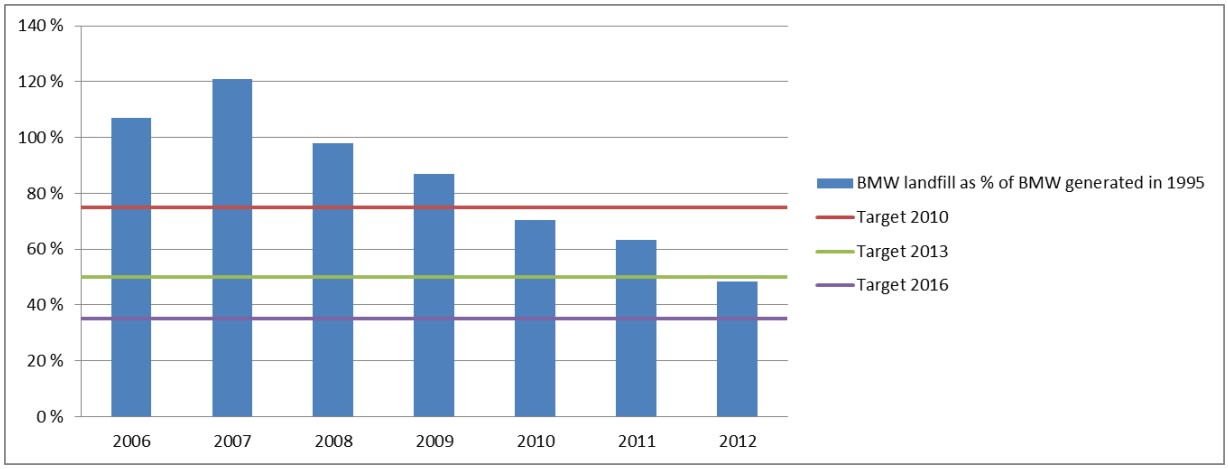
2.1.2 Landfill of biodegradable municipal waste

It is a general requirement under the EU Landfill Directive that all Member States reduce the amount of biodegradable municipal waste (BMW) sent to landfill by a specified percentage by 2006, 2009 and 2016. The targets are set in relation to 1995 BMW generation figures – in Ireland, 1.22 million tonnes. Ireland availed itself of a four-year derogation period provided within the Landfill Directive with respect to the first two targets. As such, Ireland's targets are that BMW landfill quantities must be reduced to 75 % of the amount generated in 1995 by 2010, to 50 % by 2013 and to 35 % by 2016. Ireland has reported BMW landfill amounts to the European Commission for the years 2006–2012 (EC, forthcoming; EC, 2014a).

([2]) Commission Decision 2011/753/EU allows countries to choose between four different calculation methods to report compliance with this target. Member States have the option of considering four alternative waste streams and fractions:

1. paper, metal, plastic and glass household waste;
2. paper, metal, plastic, glass household waste and other single types of household waste or of similar waste from other origins;
3. household waste;
4. municipal waste [this is the method used in this document].

Figure 2.2 Ireland, landfill of biodegradable municipal waste, 2006–2012



Source: EC, forthcoming; EC, 2014a.
Note: the target dates take into account Ireland's 4-year derogation period.

Figure 2.2 shows that the peak year for MSW generation, 2007, was also the peak year for biodegradable waste going to landfill. By 2008, the quantities of biodegradable waste going to landfill reduced somewhat to a level lower than in 2006. Further improvement was seen in 2009 and 2010 saw a significant drop, from 1.1 million tonnes in 2009 to 860 000 tonnes in 2010. The Landfill Directive's 2010 diversion target appears to have been achieved by a good margin. Based on 2012 data Ireland has already met the target set for 2013.

According to the Irish EPA (2012a), the drop in BMW landfill was caused in part by a significant reduction in the generation of MSW. The generation of MSW fell by 16 % between 2007 and 2010. Both the economic recession, and the measures taken according to National Waste Prevention Programme since 2004 and reductions in packaging waste generation following the Waste Management (Packaging) Regulations 2007 may have contributed to this development. The fall came after a continuous trend of rising MSW generation prior to the recession, of 26 % between 2001 and 2007. Should MSW generation begin to rise again following economic recovery, Ireland may be challenged in meeting its 2016 diversion targets under the Landfill Directive Currently Ireland is on track to meet the 2016 target but will require the legislative and policy efforts made over the past number of years to be sustained.

The EPA (2012a) notes, however, that reductions in BMW landfill also resulted from a sharply diminishing share of MSW being sent to landfill. Total MSW generation diminished by 4.6 % in 2012 compared to the previous year, while the quantity of MSW sent to landfill fell by 24 % over the same period (Eurostat, 2015). The reasons for this development include the introduction of Ireland's first waste incinerator and increased mechanical treatment of residual waste to produce refuse-derived fuel (EPA, 2014). Incineration of MSW only began at any noticeable level after 2007. Ireland's first municipal waste incinerator commenced operations towards the end of 2011 (EPA, 2012a). Cement kilns using waste-derived fuels, however, have been established for longer. The most influential driver of this diversion of MSW from landfill is the landfill levy, which was gradually increased between 2007 and 2010. Further and more dramatic annual increases followed between 2011 and 2013. This is discussed in more detail in section 2.1.5.

A further driver was the passing of Food Waste Regulations in 2009, which were designed to promote the segregation and recovery of food waste arising in the commercial sector. The regulations impose obligations on the major producers of commercial food waste to segregate these wastes for separate collection and treatment or to treat them biologically on site. The regulations are described in more detail in Section 2.2. Although these did not come into force until the middle of 2010, they may have been an important factor in the significant reduction of BMW going to landfill during that year. It

should be noted that the Food Waste Regulations require that food waste, which has been separated and collected from businesses, is sent for biological treatment and not for incineration.

Efforts to increase separate kerbside collection of organic waste from households encouraged by the 2006 Strategy on Biodegradable Waste have not so far had a large effect on BMW sent to landfill. Although 39 % of serviced Irish households were given a separate dustbin for collection of organic waste in 2013, up from 24 % in 2009, the separate collection of organic waste is still on a low level (increase from 62 447 tonnes in 2009 to 83 389 tonnes in 2013) (EPA, 2014). This is in part due to lack of control over the waste collection market in Ireland and the low numbers of households that are serviced. The Organisation for Economic Co-operation and Development (OECD) commented that, "*despite improvement, [the] municipal waste collection [market] is fragmented and not adequately regulated*" (OECD, 2010). This has now been addressed with the new regulatory regime introduced in May 2015 (EPA, 2015a).

In a further effort to reduce the BMW sent to landfill the EPA published a technical guidance document *Municipal Solid Waste – Pre-treatment & Residuals Management* in 2009 (EPA, 2009). The guidance requires operators of landfill and incineration facilities to demonstrate through their waste acceptance policy (as established by licence conditions) that waste accepted at these facilities has been subjected to appropriate pre-treatment. As the waste infrastructure in a region develops over time or new standards are required due to evolving national or EU waste treatment obligations, it will be necessary for landfill and incinerator facility operators to periodically revisit the rationale put forward by them in relation to confirming to the EPA that an adequate and appropriate pre-treatment effort has been applied (EPA, 2015a).

2.1.3 Regional differences in municipal solid waste recycling, 2001–2013

No regional-level municipal waste data are reported to Eurostat that would allow analysis of regional differences in recycling rates.

2.1.4 Recycling and landfill taxes

A levy of EUR 15 per tonne on the landfill of waste was introduced in Ireland on 1 June 2002, under the Waste Management (Landfill Levy) Regulations 2002, to encourage the diversion of waste away from landfill. All levies were earmarked for an Environment Fund in support of waste minimisation and recycling initiatives ([3]).

However, unlike a number of countries where regular, predictable increases in landfill tax were established by landfill tax escalators, the Irish landfill levy saw no further increase until 2008, when it rose to EUR 20 per tonne. This EUR 5 per tonne increase was repeated in 2009 and again in 2010, taking the landfill levy from EUR 20 to EUR 30 per tonne ([4]), a number of subsequent increases brought the landfill levy to EUR 75 per tonne in 2013 ([4]).

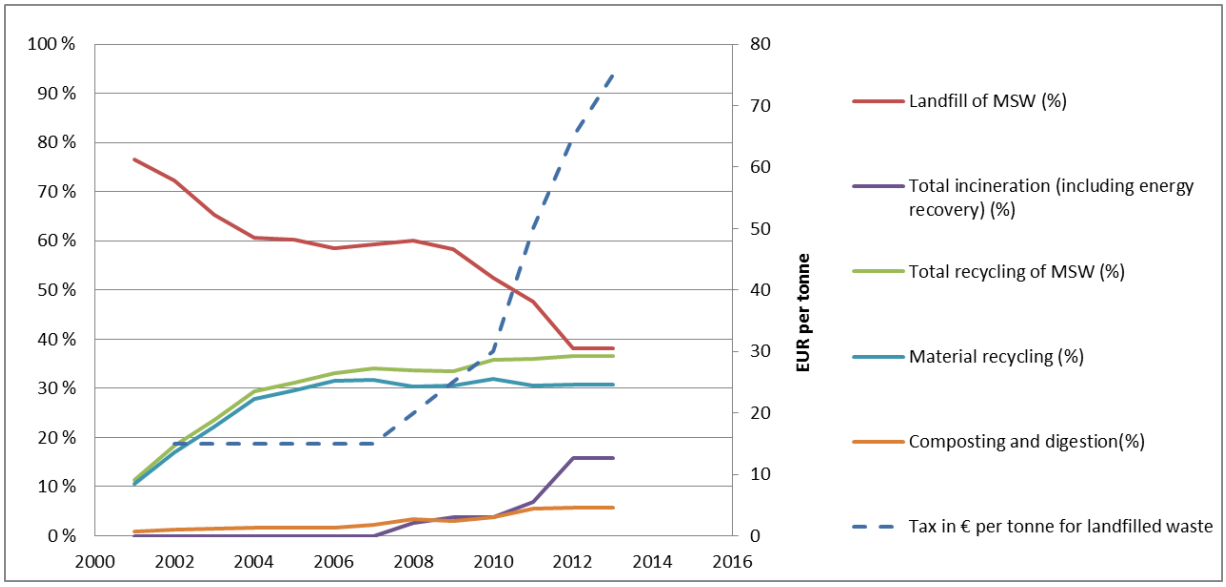
Development in the tax rates between 2001 and 2013 is presented in Figure 2.3 along with trends in the share of MSW recycled, incinerated and sent to landfill. The period 2001–2006 saw reductions in the share of MSW being sent to landfill despite no increase in the landfill levy. Since the majority of material recovery of Irish MSW takes place in other countries, these reductions may have resulted from developments in the international market in secondary materials that have little to do with the levy in Ireland. However, a further reduction in the share of MSW going to landfill was seen over the period 2007–2010, during which the levy doubled. The gain is even greater when overall quantities of

([3]) http://www.environ.ie/en/Environment/Waste/LandfillLevy/

MSW landfill are considered: the total quantity of MSW landfill decreased by 26 % between 2007 and 2010.

At first glance it may appear that the increasing levy from 2008 onwards might have been a driving factor in the growth in waste incineration during the same period. The planning and building incineration facilities, however, is typically a long process. The 2002 adoption of the levy may well have been a driver in the original planning of facilities that first came into operation after 2007. It is interesting to note that the 2007 Programme for Government stated "*we will not alter the landfill levy in such a way as to give a competitive advantage to incineration*" (Department of An Taoiseach, 2007). As such, the intention of the levy has been to divert waste from landfill to material recovery and not to incineration.

Figure 2.3 Ireland, landfill tax and the development of recycling, landfill and incineration of municipal solid waste, 2001–2013, per cent and EUR per tonne



Sources: Eurostat, 2015; ETC/SCP, 2012.

Despite the increases in the landfill levy between 2008 and 2010, by 2011 it had become clear that the levy was not acting as a sufficiently strong economic driver. The Minister of Environment, Heritage and Local Government noted that "*right now, disposal – which is the most environmentally unsound option for dealing with our waste – is the cheapest*" (DEHLG, 2011). In response, the levy was raised to EUR 50 per tonne in 2011 followed by further raises to EUR 65 per tonne in 2012 and EUR 75 per tonne in 2013 (EPA, 2014).

This was also the first time that increases in the landfill levy were announced in advance, with the aim of giving the waste treatment industry and regional authorities the economic certainty needed to make investments in new recycling, mechanical-biological treatment (MBT) and composting facilities. At the same time an incineration levy was announced in order to implement the government's commitment not to give a competitive advantage to incineration through the landfill levy. This is still under consideration.

The trend from 2010 onwards shows a further decrease in the share of MSW sent to landfill and an increasing share of incineration. Furthermore, the share of organic recycling increased only slightly and material recycling even had a slightly falling trend, resulting in a stagnation of the total recycling rate.

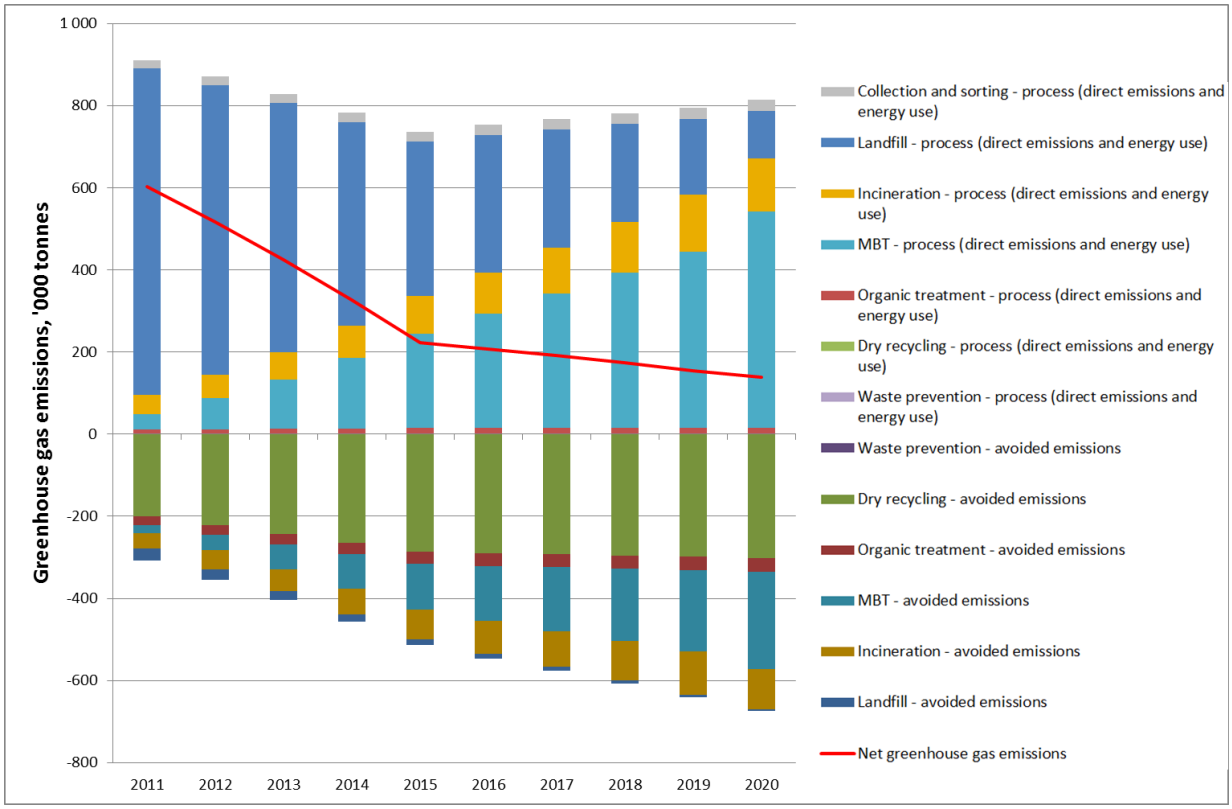
2.1.5 Environmental benefits of better municipal solid waste management

Figure 2.4 shows a scenario for the development of greenhouse gas emissions from MSW management in Ireland. The scenario assumes that municipal waste generation remains static in 2011–2016 and then increases linearly from 2.82 million tonnes by approximately 830 000 tonnes by 2030. The scenario also assumes that the EU targets for municipal waste are fully implemented. The calculation of emissions is based on data and assumptions contained in the European Reference Model on Municipal Waste Generation and Management. The approach taken in the model is rooted in life-cycle thinking, in that it considers not only direct emissions, but also avoided emissions associated with the recycling of materials or the generation of energy from waste management processes. The more detailed methodology is described in Gibbs *et al* (2014b). The level of greenhouse gas emissions depends on the amount of waste generated and the treatment it undergoes each year.

Figure 2.4 shows direct emissions, avoided emissions and net emissions resulting from the management of MSW. All the emissions (positive values) represent direct operating emissions for each waste management option. The phases of the waste management chain covered include waste prevention; material recycling; composting and anaerobic digestion; MBT and related technologies; collection and sorting; and incineration and landfill.

For avoided emissions (negative values), the calculations integrate the benefits associated with energy recovery and material recycling of paper, glass, metals, plastics, textiles and wood, and bio-treatment of food and garden waste from MSW (Gibbs *et al.*, 2014c).

Figure 2.4 Ireland, scenario for greenhouse gas emissions from municipal solid waste management, 2011–2020



Source: ETC/WMGE, calculation based on the European Reference Model on Waste.

Note: results presented in this figure should not be used for the compilation of greenhouse gas reporting for the Intergovernmental Panel on Climate Change (IPCC) national inventory report, or be compared with IPCC figures, as the methodology employed here relies on life-cycle thinking and, by definition, differs substantially from the IPCC methodology. MBT means mechanical-biological treatment.

Based on the modelled scenario with full policy implementation, net greenhouse gas emissions from the treatment of municipal waste in Ireland are expected to decrease in the period 2011–2020, with the rate lower from 2015 onwards. The reduction in net emissions will mainly be due to increased MSW recycling, which results in more and more avoided greenhouse gas emissions as well as decreasing emissions from landfill. In the first modelled years of the scenario the direct greenhouse gas emissions related to municipal waste management are linked almost exclusively to landfill.

Greenhouse gas emissions from landfill are caused by the breakdown of organic wastes accumulated in landfill over past decades. In the model, which calculates landfill impacts over a 100-year period, the longer-term emissions from any given waste are attributed to the year in which that waste is deposited (Gibbs *et al.*, 2014b). The positive effect of diverting BMW from landfill therefore shows in the figures as an immediate reduction in greenhouse gas emissions from landfill. According to the model, towards 2020 greenhouse gas emissions from waste management in Ireland will increasingly originate from MBT processing and waste incineration.

2.2 Uncertainties in the reporting

Some uncertainties or differences in how countries report MSW recycling can result in different recycling levels. This applies, for example, to the following issues:

- the extent of packaging waste from households and similar packaging from other sources that are included or not included in the MSW recycling reported;

- the definition of municipal waste used by the country, such as the inclusion or exclusion of home composting;
- the methodology used to report the inputs and outputs of MBT and sorting plants.

The definition of municipal waste in Ireland is similar to that used in the WFD, and the Irish EPA uses the definition suggested by Eurostat when categorising municipal waste for the purpose of statistical reporting (Gibbs *et al.*, 2014a). Thus, packaging waste is included in the reporting of municipal waste recycling.

Mechanical-biological treatment is seen as important for residual waste in Ireland. It is, however, only reported as treatment capacity and not in final recycling or recovery figures unless it is the final destination for any specific waste stream (EPA, 2012c).

Some uncertainty in waste reporting is due to the fact that around 30 % of households are not serviced by the formal waste collection system and the Irish EPA uses corresponding estimates of waste generation for national statistics (Gibbs et al. 2014a).

2.3 Important initiatives taken to improve municipal solid waste management

Waste management policy in Ireland at the national level is detailed in a set of five policy documents:

- *Changing Our Ways, 1998*
- *Delivering Change – Preventing And Recycling Waste, 2002*
- *Waste Management – Taking Stock and Moving Forward, 2004*
- *National Guidance for Pre-Treatment of MSW, 2009*
- *A Resource Opportunity – Waste Management Policy in Ireland, 2012.*

Changing Our Ways (1998) set the targets to be achieved by 2013: diversion of 50 % of overall household waste away from landfill; 65 % reduction in BMW consigned to landfill; and material recycling of 35 % of municipal waste. The subsequent policy document, *Delivering Change* (2002), identified a range of measures to be taken aiming at waste prevention and encouraging recycling to achieve the targets set out in *Changing Our Ways*. This policy document initiated the establishment of important measures relevant to municipal waste such as a National Waste Prevention Programme, the landfill levy and a National Waste Management Board with the aim, *inter alia*, of evaluating the contribution of local and regional WMPs to national waste management targets. *Taking Stock and Moving Forward* (2004) reviewed the waste management policy provided by the earlier documents to ensure that they were in line with the WFD's waste hierarchy, and reviewed progress in the implementation measures set out previously. The latest Irish policy document, *A Resource Opportunity* (2012), sets out how it will be ensured that regionally or locally developed WMPs are more aligned with national policy in the future. It promised a strengthening of the waste collection permit system and use of producer responsibility initiatives to encourage households to reuse and recycle their wastes. The policy document also promised the introduction of Household Food Waste Regulations ensuring the separate collection of organic waste from households and requiring households to make use of the collection (DECLG, 2012a).

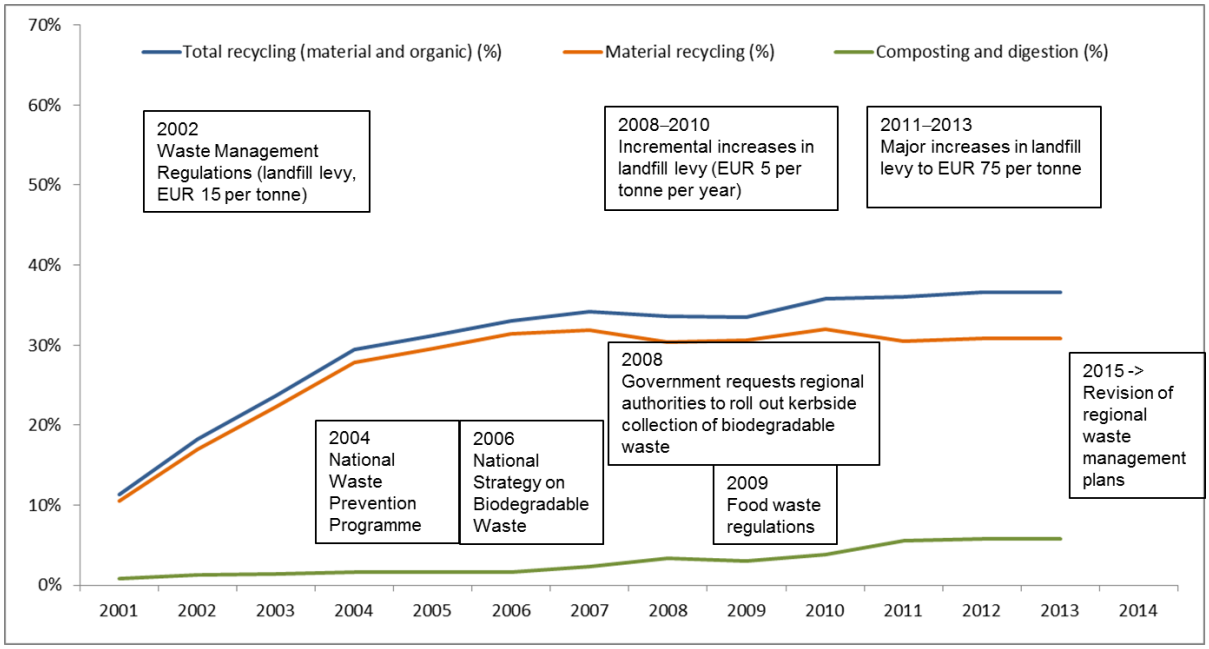
A national WMP for MSW does not exist, with the exception of a national plan for the BMW component of MSW that was made in 2006, and a plan for hazardous waste that was adopted in 2014. Under the 1996 Waste Management Act (as amended), regional authorities are required to develop regional WMPs to implement the national waste policies set out in the various waste policy documents. The 34 local authorities were originally configured into ten separate regions and some concerns were expressed that this approach was leading to inconsistencies and inefficiencies in waste

management planning and practice across the State. Each of the regional plans was evaluated by the end of 2012 ([4]) to ensure that they contribute to national targets and are compliant with national waste policy and also that they are compliant with the EU WFD. The review was carried out by the regional authorities under guidance from the National Waste Management Co-ordination Committee for the Evaluation of the Waste Management Plans (EPA, 2015a).

Based on the evaluation and following the adoption of a national policy in *A Resource Opportunity* to re-constitute the regions into a more effective configuration, the local authorities made a significant change in waste management planning in Ireland by reducing the number of regions from ten to three. The regions work together in close co-operation and the three waste management plans for non-hazardous waste have been developed on a common basis with a broadly similar structure and much shared content. In particular, the strategic vision, headline targets, strategic policy objectives, policies and policy actions are identical in each of the plans. The updated plans were adopted in 2015 (EPA, 2015a; Gibbs *et al.*, 2014a).

The implementation of the regional WMPs is supported by a national coordination committee comprising the key statutory bodies and lead authorities in each of the three regions, ensuring that the co-ordinated approach taken in developing the plans is maintained in their implementation. The plans contain an array of actions clearly assigned to waste stakeholders to achieve and are easily measurable. This will facilitate the assessment of the implementation of the plans and allow for the timely introduction of corrective measures if and where necessary. The reduction of the number of regions from ten to three is likely to make for more streamlined and improved implementation, particularly since the plans have been developed through close co-ordination between the regions (EPA, 2015a).

Figure 2.5 Ireland, recycling of municipal solid waste in Ireland and important policy initiatives, 2001–2015



Source: Eurostat, 2015

([4]) http://www.connachtwaste.ie/media/Media,17845,en.pdf

Ireland's National Waste Prevention Programme was launched in 2004 and is currently marketed under the BeGreen banner. As a result of the programme, several waste prevention initiatives have been developed targeting local authorities as well as a number of business sectors. The programme was revised and rebranded in 2014 as Towards a Resource Efficient Ireland, A National Strategy to 2020, and now has a broader resource efficiency focus (EPA, 2015a).

In order to facilitate more efficient recycling the competent authorities of Ireland have introduced several initiatives. A Market Development Group was established in 2004 with the aim of improving the stability and economic attractiveness of the recyclables market, focusing especially on paper, plastic and compost. Barriers to the use and marketing of recycled materials were identified and tackled by the group (EC, 2014b) In 2014, *Best Practice Guidance for Waste Plastic Management* was published by rx3, a programme team established by the Market Development Group. The guide covers the different stages of the plastic supply and recycling chain and gives related recommendations for the sector to improve and maintain the quality of recycled plastics throughout the value chain (rx3, 2014). The rx3 team also produced a similar *Assessment of the Recovered Paper Supply Chain in Ireland* (rx3, 2011) and a *Market Report on Irish Organic Compost Production and Use* (rx3, 2012).

The National Strategy on Biodegradable Waste (2006) set specific objectives for the contributions that recycling, biological treatment and thermal treatment should contribute to the achievement of the 2016 target for diversion of BMW from landfill, and established a longer-term target of 80 % diversion of biodegradable waste from landfill. In addition, the government announced its intention to introduce MBT facilities as one of a range of technologies (Department of An Taoiseach, 2007).

A key implementation element of the strategy was the passing of the Food Waste Regulations into law in 2009 and the implementation of the EPA Municipal Waste Pre-Treatment obligations ([5]). The regulations are designed to promote the segregation and recovery of food waste arising in the commercial sector. They impose obligations on major producers of food waste, including supermarkets, restaurants and cafés, canteens, hotels, supermarkets and other food retailers, to segregate food waste and make it available for separate collection and subsequent biological treatment. Alternatively, these materials can be biologically treated on site under specified conditions. In 2011 the *National Waste Report* (EPA, 2013) estimated that 25 % of available commercial food waste had been collected.

While no such binding regulations applied at that time to household organic waste, it was signposted in the most recently published Waste Policy, *A Resource Opportunity – Waste Management Policy in Ireland* (DECLG, 2012a). In 2008 the national government requested local authorities to implement collection systems for organic waste separated at source along with educational awareness campaigns and targeted enforcement to ensure that separation systems are used by households. Similarly, local authorities must ensure that waste collectors introduce source segregation and collection of dry recyclables. Typically, this is realised as comingled collection of at least paper, metal, aluminium, plastics and glass in certain areas. By 2011, 98 % of those households in Ireland that are serviced by official waste collection had been offered separate collection of dry recyclables and 37 % had been provided with an additional waste bin for the separate collection of organic waste (Gibbs *et al.*, 2014a).

In May 2015 the Department introduced two pieces of legislation; S.I. 190 amended the Commercial Food Waste Regulations and S.I. 191 which revoked and replaced the Household Food Waste Regulations. The new regulations provide for the following additional measures:

([5]) http://www.epa.ie/downloads/advice/waste/municipalwaste/name,26146,en.html

- the definitions of "authorised treatment process" and "anaerobic digestion" have been changed in order to restrict Type 8 "stabilisation" plants to only treating residual biowaste which is not suitable for separate collection/biological treatment;
- a definition of "Type 8" plant has been added to the regulations in order to clarify that source-segregated biowaste cannot be sent to a Type 8 plant for treatment;
- to provide an explicit requirement on authorised collectors to deliver brown bin receptacles to the addresses of their customers;
- on and from 1 July, 2016 a requirement to collect the brown bin as frequently as the residual waste bin.

New Household Regulations, S.I. 430 of 2015, provides for explicit rules on the management of food waste - prohibiting collectors from contaminating food waste or disposing of it, obliging producers to source segregate their food waste regardless of whether they are using a waste collection service or home-composting, or directing the waste to an authorised facility and prohibiting the contamination of food waste at authorised facilities. These provisions mirror existing requirements in the commercial food waste regulations (EPA, 2015a).

In addition to the regulations described above, a number of other legal instruments, such as the Waste Management Acts 1996–2012, governing the management of waste and outlining the responsibilities of waste generators and waste management organisations have been adopted by parliament.

The 2003 Packaging Regulations, updated in 2007 and 2004, implemented the EU Packaging and Packaging Waste Directive by placing responsibility on packaging producers, including retailers, to segregate packaging waste arising on their own premises into specified waste streams and have it collected by authorised operators for recycling. In addition, major producers were given additional responsibilities with regard to the recovery of packaging waste from their customers, either through carrying this activity out themselves or by participating satisfactorily as a member of a packaging waste compliance scheme (EPA, 2012f). The regulations proved successful and the 60 % recovery target, to be met by 2011, was actually reached in 2007 (EEA, 2010). In 2012 the fees paid by the producers participating in the producer responsibility schemes for packaging ranged from EUR 9.18 per tonne for glass to EUR 89.16 per tonne for plastic. In the same year, municipalities were reimbursed for 40 % of the costs of operating the recycling scheme (EC, 2012).

Finally, as described in Section 2.1.5, the landfill levy established in 2002 may not initially have been a strong driver in diverting waste from landfill towards energy and material recovery due to the low and static level (in comparison to many other EU countries) of the levy at EUR 15 per tonne between 2002 and 2007. The yearly increases of EUR 5 per tonne during 2008–2010 and the further more dramatic rolling increases announced in 2011, which resulted in a EUR 75 per tonne levy by 2013, have established the landfill levy as a far more persuasive driver than it was earlier in the decade.

Pay-as-you-throw (PAYT) schemes are in place in Ireland based on volume, weight or tagging. National instructions requiring a weight/volume-based waste management charge has been in force since 2005. In practice, however, implementation on a local level was significantly delayed and in 2012 some collectors were still charging flat rates for waste disposal services. One probable reason for this is the extensive privatisation of the waste collection sector in Ireland limiting the direct role of local authorities. Positive impacts of PAYT schemes that have been observed in some areas include increased recycling rates and diminishing amounts of waste generated and sent to landfill. Some negative consequences, however, have also been observed, such as waste burning by households (EC, 2012).

The system is under revision with the two-stage introduction of pay by weight on track, first as an operating condition for all collectors as a permit condition from 1 July 2015, followed by mandatory charging on a pay-by-weight basis from 1 July 2016. Pay-by-weight will apply equally to Pay-through-Use units (PTUs), civic amenity sites at which residual household waste is accepted and

facilities that accept residual waste directly from households. From 1 July 2015 the Waste Management (Collection Permit) Regulations 2015 (S.I. 197 of 2015) require that:

- household kerbside waste collected in approved reusable receptacles (such as bins or caddies, but not bags) must be weighed by appropriate weighing systems and that this weight be reported to the householder at a frequency of at least once a month, and that only vehicles fitted with approved weighing mechanisms are authorised to collect such waste;
- recyclate from households must be collected at least every two weeks and that a minimum list of recyclable materials set out in the seventh schedule to the Regulations be collected;
- a customer charter be prepared in the prescribed form set out in the sixth schedule to the regulations and to the satisfaction of the nominated authority.

Amendments to the Waste Management Act, carried through the Environment (Miscellaneous Provisions) Act 2015, introduced the necessary enabling powers to provide for mandatory charging for household waste collection on a pay-by-weight basis. The changes to section 34 of the Act provide for the introduction of the core new permit conditions for collectors of household waste. The key new requirements are:

- the obligation to charge on a pay-by-weight basis;
- the requirement to provide a three-bin service;
- the requirement to maintain a database of customers;
- mandatory customer charter.

Bags are being effectively phased out from 1 July 2016 and will only be permitted in certain areas designated by local authorities as being only suitable for the collection of such waste in non-reusable receptacles, such as bags (EPA, 2015a) However, in June 2016 Ireland postponed plans for the pay-by-weight system, and the environment minister and waste companies agreed a 12-month freeze for domestic waste charges (Flynn, 2016).

It can be concluded that waste management policy in Ireland seems to be driven largely by European requirements and the key targets set in the various Irish policies go no further than what is required under the EU Directives. As far as implementation is concerned, the key binding policy measures relevant to MSW include the landfill tax levy, the food waste regulations, the packaging regulations producer responsibility initiatives for WEEE with new comprehensive producer responsibility initiatives on waste tyres and end-of-life vehicles (ELVs) in development, the forthcoming introduction of pay-by-weight charging for household waste collection, the planned introduction of pay by weight for the collection of commercial waste and EPA licensing and enforcement operations at landfill sites (EPA, 2015a).

Lack of regulation and control of the waste collection market in Ireland seems to be a potential weakness in the waste management sector making it more difficult for the administration of waste management policy and enforcement of legislation, thereby challenging the potential for the Irish government to achieve its own objectives and obligations under EU Directives. The policy document *A Resource Opportunity* (DECLG, 2012a) stresses that this will be tackled by a tightening and stronger enforcement of the waste collection permit system (DECLG, 2012a).

Deregulation of household waste collection services in Ireland in favour of a competitive market-based system has led to a fragmented and not adequately regulated service (OECD, 2010). An estimated 30 % of occupied Irish households did not use, or were not offered, a kerbside collection service in 2011 (Gibbs *et al.*, 2014a). Moreover, according to a recent regulatory impact analysis the current regulatory system for waste collection services results in a system with a number of weaknesses, including low rates of householder participation, insufficient levels of segregation of household waste, and pricing structures that do not incentivise sustainable behaviour. This is in part

due to lack of control over whether the conditions included in waste collection permits are being adhered to (DECLG, 2012b).

Such issues are now being tackled through the reform of the regulatory regime that applies to household waste collection and new enforcement structures. This is now being achieved by a tightening and stronger enforcement of the waste collection market as previously described and as recommended in the Regulatory Impact Analysis on the organisation of Household Waste Collection (EPA, 2015a)

2.4 Possible future trends

As identified in Section 2.1.3, due to a sharp fall in the quantity of BMW deposited at landfill sites between 2009 and 2010, Ireland achieved its 2010 target for diversion of BMW from landfill by a relatively large margin. This was achieved through a combination of factors including a reduction in the quantity of BMW generated and the opening of an incinerator in 2011, EPA licensing and enforcement activities at landfill sites and BMW commercial food waste diversion successes. The substantial 16 % reduction in the generation of MSW between 2007 and 2010 was, however, perhaps the most significant factor behind achieving the 2010 target and is more likely to have been a result of the economic recession rather than intrinsic waste prevention methods.

Should MSW waste generation begin to rise again following economic recovery, Ireland may be challenged in meeting its 2016 diversion targets under the Landfill Directive, even though the current trend indicates that the country is on track to meet the targets and a number of measures have been and will be introduced to further divert BMW from landfill. The Economic and Social Research Institute in Ireland predicts an 830 000 tonne increase in MSW over the next 15 years following economic recovery (EPA, 2013). The landfill levy escalator may be one of the key policy measures in meeting the challenge, as described in Section 2.1.5. In addition, an incineration plant with a capacity of 600 000 tonnes per year is scheduled to commence operation in Dublin in 2017 (EPA, 2015a).

Responding to this economic driver, however, will require both more widespread separation of organic waste from household and commercial waste streams and the installation of facilities to process the resulting separate organic fractions. As described earlier, the Food Waste Regulations, if sufficiently enforced, should ensure the separation of commercial food waste for biological treatment – incineration of these wastes is prohibited under the regulations. Regulations for household food waste segregation and treatment have been introduced progressively since 2013 and a number of authorities, encouraged by the Strategy on Biodegradable Waste, have set up separate kerbside collection of food waste from households, with 39 % of serviced Irish households being covered by this amenity in 2013. The recent introduction of the Household Food Waste Regulations, which oblige all waste collectors to provide for such separate collection of food wastes, should result in a further increase in the amount of separately collected food waste (EPA, 2015a).

More generally, the policy document *A Resource Opportunity* aims at improving collection coverage from the current 70 % by obliging households to prove that they receive an official waste collection service or otherwise manage their waste in an environmentally sound manner (Gibbs et al., 2014a).

Even with separate collection there is currently no guarantee that this will lead to significantly greater separate capture of organic waste from households. Even in those households with separate collection, up to 47 % (by weight) of the contents of the residual waste bins has been found to comprise biodegradable waste (EPA, 2012a). A National Communications Strategy is under development for the purpose of informing and educating householders in the source segregation of waste into separate fractions in order to improve the level and standard of segregation practices in the household (EPA, 2015a).

An additional need is for further development of capacity to treat the biodegradable component of residual household and commercial waste. This could be either incineration or MBT facilities. The

first commercial municipal waste incinerator came into operation in 2011 with a capacity of 0.2 million tonnes per year, adding to the 0.27 million tonnes annual capacity represented by cement kilns using waste-derived fuels in co-combustion (EPA, 2012b). Expansion of incineration capacity to a total of 0.8 million tonnes a year is now underway with the construction of the Poolbeg waste-to-energy facility due to be fully operational in 2017. There are also plans to build further capacity for composting – an additional 400 000 tonnes per year by 2018 – and anaerobic digestion – 100 000 tonnes per year by 2018. The ultimate decision to proceed with investments in waste treatment infrastructure will be made by the private sector (EPA, 2015a; Gibbs *et al.*, 2014a).

According to the EPA (2012a), "*Ireland remains underdeveloped with respect to the sophistication of essential waste infrastructure for the pre-treatment of municipal waste prior to disposal (e.g. anaerobic digestion, waste to energy, mechanical biological treatment etc.). It will be a challenge to meet waste diversion and waste recovery targets if municipal waste generation increases with economic recovery and the necessary waste infrastructure is not in place*".

The Irish EPA recommended priority policy action to ensure adequate infrastructure both for treatment of kerbside-collected separated organic waste and for treatment and bio-stabilisation of the organic components in residual wastes destined for landfill. The EPA further recommended a policy requiring householders to use organic bins, which have subsequently been provided, and continuation of food waste prevention programmes if the 2016 target is to be met. In this regard, the Regional WMPs published in May 2015 contain policies and policy actions that are designed to ensure that the full potential of the organic bin is achieved (EPA, 2015a).

Turning to the 2020 goal for 50 % recycling of household waste set by the WFD, the latest data indicated that Ireland is, according to the calculation option used by the country, on track to meet the target. It should, however, be noted that the vast majority of dry recyclables in Ireland are exported for recovery due to a lack of recycling facilities. Thus, continuing to achieve the 50 % recycling of household waste target in the future is subject to volatile global markets for recyclates. The economic viability of separate waste fraction collection in Ireland is strongly influenced by these prices. In this regard, the Department of the Environment, Heritage and Local Government (DECLG) published a public consultation in November, 2015 inviting views on potential measures that can enable Ireland to make better use of its waste resources to create jobs in recycling, composting, processing and recovery enterprises. Furthermore, the waste management plans support the development of up to 300 000 tonnes of additional thermal recovery capacity nationally to treat non-hazardous waste, as well as the development of additional biological treatment at a regional level (EPA 2015a)

References

Department of An Taoiseach, 2007, *An Agreed Programme of Government: A Blueprint for Ireland's Future 2007–2012* (http://www.taoiseach.gov.ie/index.asp?locID=512&docID=3493) accessed 21 August 2016.

DECLG, 2012a, *A Resource Opportunity – Waste Management Policy in Ireland*, Department of Environment, Community and Local Government, Dublin (https://www.epa.ie/pubs/reports/waste/plans/Resource_Opportunity2012.pdf) accessed 18 October 2016.

DECLG, 2012b, *Summary of Regulatory Impact Analysis – Household Waste Collection*, Department of Environment, Community and Local Government, Dublin (http://www.housing.gov.ie/sites/default/files/migrated-files/en/Legislation/Environment/Waste/WasteManagement/FileDownLoad,30784,en.pdf) accessed 18 October 2016.

DEHLG, 2011, *Minister Hogan moves to provide certainty on waste policy*, news item on Dept. website 14/04/11, Department of the Environment, Heritage and Local Government, Dublin (http://merrionstreet.ie/en/News-Room/Releases/minister-hogan-moves-to-provide-certainty-on-waste-policy.html) accessed 18 October 2016.

EC, 2012, *Use of economic instruments and waste management performances*, Final Report, 10 April 2012, European Commission – DG Environment Contract ENV.G.4/FRA/2008/0112.

EC, 2014a, Member States' reporting to the Commission according to the Landfill Directive (1999/31/EC), email from Bartosz Zambrzycki (European Commission) to Almut Reichel (EEA), 16 January 2014.

EC, 2014b, Ex-post *evaluation of certain waste stream Directives*, final report 18 April 2014, European Commission – DG Environment.

EC, forthcoming, *Final Implementation Report for the Directive 1999/31/EC on the Landfill of Waste*, prepared by Eunomia Research and Consulting Ltd, ENT Environment and Management, EPEM S.A., Ekokonsultacijos and the Environmental Research Institute (ORZ) for the European Commission, DG Environment under Study Contract DG ENV.C.2/FRA/2013/0023. Draft report, forthcoming.

EC, 2015, Proposal for a Directive of the European Parliament and of the Council amending Directive 2008/98/EC on waste (COM(2015) 595 final of 2 December 2015).

EEA, 2010. *The European environment – State and outlook 2010 – Country fact sheets: Ireland*, European Environment Agency, Copenhagen, Denmark (http://www.eea.europa.eu/soer/countries/ie), accessed 21 August 2016.

EPA, 2009, *Municipal Solid Waste –Pre-treatment & Residuals Management*, amended 2011.

EPA, 2011, *National Waste Report, 2009*, Irish Environmental Protection Agency, Wexford. (http://www.epa.ie/pubs/reports/waste/stats/EPA_NWR_09_web.pdf) accessed 18 October 2016.

EPA, 2012a, *National Waste Report, 2010*, Irish Environmental Protection Agency, Wexford. (https://www.epa.ie/pubs/reports/waste/stats/EPA_NWR_2010_web.pdf) accessed 18 October 2016.

EPA, 2012b, *Ireland's Environment: An Assessment,* Irish Environmental Protection Agency, Wexford. (https://www.epa.ie/pubs/reports/indicators/00061_EPA_SoE_2012.pdf) accessed 18 October 2016.

EPA, 2012c, Information received during the Eionet consultation of the paper, email of 4 October 2012 from Jonathan Derham, Irish Environmental Protection Agency, Wexford.

EPA, 2012d, 'Waste Management Plans', internet resource, Irish Environmental Protection Agency, Wexford. (http://www.environ.ie/en/Environment/Waste/WasteManagementPlans/) accessed 31 July 2012.

EPA, 2012f, 'Packaging Waste', internet resource, Irish Environmental Protection Agency, Wexford. (http://www.environ.ie/en/Environment/Waste/ProducerResponsibilityObligations/PackagingWaste/) accessed 31 July 2012.

EPA, 2013, *National Waste Report, 2011*, Irish Environmental Protection Agency, Wexford. (http://www.epa.ie/pubs/reports/waste/stats/EPA_NWR11_12Nov11_haz%20tables%20updated%20as%20per%20errata.pdf) accessed 21 August 2016.

EPA, 2014, *National Waste Report, 2012*, Irish Environmental Protection Agency, Wexford. (http://www.epa.ie/pubs/reports/waste/stats/EPA_NWR12_Complete_to_web_5Aug14.pdf), accessed 21 August 2016.

EPA, 2014b, *Bulletin 4: Compost and Anaerobic Digestion Statistics for 2013*, Irish Environmental Protection Agency, Wexford. (http://www.epa.ie/pubs/reports/waste/stats/compost/#.VmhAVbh95mN) accessed 21 August 2016.

EPA, 2015a, Information received during the Eionet consultation of the paper. E-mail of 4 December 2015 from Helen Searson, Irish Environmental Protection Agency, Wexford.

EPA, 2015b, *EPA Licensed Sites – Report on Waste Enforcement*, Irish Environmental Protection Agency, Wexford. (http://www.epa.ie/pubs/reports/enforcement/epalicensedsites-reportonwasteenforcement.html#.VUtnNfmqpBd) accessed 21 August 2016..

ETC/SCP, 2012, *Overview of the use of landfill taxes in Europe*, ETC/SCP Working paper 1, 2012, European Topic Centre on Sustainable Consumption and Production, Copenhagen, Denmark. (http://scp.eionet.europa.eu/publications/WP2012_1) accessed 21 August 2016.

ETC/SCP, 2013, *Municipal waste management in Ireland*, Watson, D. (ed.). European Topic Centre on Sustainable Consumption and Production, Copenhagen, Denmark.

Eurostat, 2015, 'Waste database municipal waste. (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_wasmun&lang=en), accessed March 2015.

Flynn, V., 2016, Ireland rows back on per-kilo waste charge plan. *ENDS Europe DAILY*, Thursday 23 June 2016. (http://www.endswasteandbioenergy.com/article/1400148/ireland-rows-back-per-kilo-waste-charge-plan) accessed 21 August.

Gibbs, A., Elliott, T., Vergunst, T., Ballinger, A., Hogg, D., Gentil, E., Fischer, C., Bakas, I. and Ryberg, M., 2014a, *Development of a modelling tool on waste generation and management – Appendix 1: Baseline report*, Final report for the European Commission DG Environment under Framework Contract No ENV.C.2/FRA/2011/0020.

Gibbs, A., Elliott, T., Ballinger, A., Hogg, D., Gentil, E., Fischer, C. and Bakas, I., 2014b, *Development of a modelling tool on waste generation and management – Appendix 6: Environmental modelling*, Final report for the European Commission DG Environment under Framework Contract No ENV.C.2/FRA/2011/0020.

Gibbs, A., Elliott, T., Vergunst, T., Ballinger, A., Hogg, D., Gentil, E., Fischer, C. and Bakas, I., 2014c, *Development of a modelling tool on waste generation and management – Headline project report*, Final report for the European Commission DG Environment under Framework Contract No ENV.C.2/FRA/2011/0020.

Hogg, D., Gibbs, A., Ballinger, A. Coulthurst, A., Elliott, T., Fletcher, D., Russell, S., Sherrington, C., Taylor, S., Wilson, D., Finlay, S., Grehan, D., Hogan, M., O'Neill, P., Steiner, M., Hermann, A., Buchert, M., Laureysens, I., van Acoyleyn, M., Favoino E. and Caimi, V., 2009, *International Review of Waste Management Policy: Summary Report*, commissioned by the Department of Environment, Heritage and Local Government (http://www.environ.ie/en/Publications/Environment/Waste/WasteManagement/FileDownLoad,21596,en.pdf) accessed 21 August 2016.

OECD, 2010, *OECD Environmental Performance Reviews – Ireland*, Organisation for Economic Co-operation and Development, Paris, France.

Rx3, 2011, *Assessment of the Recovered Paper Supply Chain in Ireland*.

rx3, 2014, *Best Practice Guidance for Waste Plastic Management in Ireland* (http://www.rx3.ie/MDGUploadedFiles/file/rx3%20Publications/Best%20Practice%20Guidance%20for%20Plastic%20Waste%20Management%20in%20Ireland_%20PDF.pdf) accessed 21 August 2016.

Rx3, 2012, *Market Report on Irish Organic Compost Production and Use.*

Sheehan, J., 2011, *Recycling Markets in the Current International Economic Climate*, Australian National Packaging Covenant Industry Association, Background Paper Series 1, Sydney, Australia.