ZERO WASTE EUROPE

Rethinking the EU Landfill Target

Report

October 2021 - Equanimator Ltd

E.1.0 Executive Summary

EU policy developed around an increasingly prominent 'waste hierarchy' for the management of waste. Until well into the 2000s, the waste hierarchy made no clear distinction between material recycling, reuse or reclamation, and the 'use of waste as a source of energy'. Recovery targets sat alongside ones for recycling in the case of packaging, even though it was highly unlikely, at the time, that anyone would build an incineration facility specifically to deal with packaging waste (as opposed to mixed waste, whether from households or businesses, more broadly). Legal rulings from the European Court of Justice (ECJ), which have not always been entirely successful in influencing waste management practice, had already indicated that, where the principal use of a facility was the treatment of waste (rather than the waste being used to generate energy in the context of a production process), the facility should be considered a 'disposal' one . During this period, the quality of waste management systems were frequently assessed at the European level in terms of 'landfill diversion', or 'how little was landfilled', since minimising landfills seemed the overarching goal, then, with no great attention paid to whether the waste that might otherwise have been landfilled was being prepared for reuse, recycled, or incinerated.

Concurrently, various studies were emerging – one funded by DG Environment itself – that challenged the preference - that was reflected in the law at the time - that incinerators were much superior to landfills when their various external costs and benefits were assessed. If it was not always clear that incinerators were worse on environmental grounds, no study seemed to conclude that the difference in the economic costs between landfilling and incineration were justified by a difference in the benefits. In other words, any additional costs of incineration relative to landfill were not justified by the magnitude of the benefits.
With the 2008 revision of the main EU Directive on waste, more 'tiers' were placed in the hierarchy, and recycling was given a status above 'other recovery'. At the same time, however, and in response to the ECJ rulings, a new formula was introduced under Annex II of the new Directive which was designed to enable incineration facilities to be classified as 'recovery' rather than 'disposal'. Presumably - reflecting the view at the time that if enough energy was generated by an incinerator, it could be assumed that the use of fuels to generate energy by other means would be avoided - this formula was based around whether or not an incinerator could generate an amount of heat and power that exceeded a threshold level.

Over these twenty years, the author has been engaged in EU policy debates, and several changes have been taking place:

1. **First, when conducting an assessment of the known externalities, the costs associated with the main pollutants have changed over time.** Regarding the damage costs being used in assessments, these have generally been based on a science base that is increasingly robust, allowing a variety of 'health end-points' to be assessed. Interestingly, the EU itself has no clear rules regarding the valuation of greenhouse gas emissions, but over the same period, recognition of the threat posed by climate change has increased, and so has the urgency applied to addressing the issue. The value of EU allowances has increased significantly in recent years (though these should not be assumed to accurately reflect 'a damage cost', or even 'a social cost'). Nonetheless, especially relevant for landfills, the science seems to move to progressively high values of the 'global warming potential' for methane (relative to CO_2), and there is an urgent need to bear down on all methane emissions as a means to slow the pace at which the planet is warming.

2. **Second, the benefits associated with generating energy from the use of waste have changed significantly**. Not so long ago, it was frequently claimed (depending on the circumstances) that

incineration would 'displace coal-fired power generation', or a similarly carbon-intense fuel such as oil-based heating. As the EU has progressively come to grips with climate change, so the carbon intensity of power especially, and heat, have declined: coal is being phased out. The argument that incinerators or landfills now generate energy that displaces the same dirty, carbon-intense forms of energy that they may have claimed to displace some years ago has little or no validity, other than in very specific circumstances, and these are unlikely to prevail in the coming years.

3. **Third, although twenty years ago, the sanity of relying on the use of 'dirty MRFs' (material recovery facilities) to extract materials for recycling was being called into question, today, technologies for sorting have improved to the extent that the burgeoning quantities of plastic found in the waste stream can be sorted from mixed waste, and where they are hot-washed, a high quality can be achieved.** Also, the sorting efficiency of such equipment may be enhanced, and in some cases, already is, by the introduction of separate collection for organic waste, these being made mandatory in the EU as of the end of 2023, as stipulated by art. 22 of the Waste Framework Direction (WFD). Other materials that have not been accurately separated by residents who are provided with separate collection services can also be extracted -including metals, textiles, glass, and also some paper and card, though this will generally be of a lower quality than from source separation.

These factors combine to force a reappraisal not so much of 'whether landfill is better than incineration', but what might be the best way to manage the mixed waste that is left after separate collection - recognising the imperative to bear down on greenhouse gas emissions, but recognising also the need to ensure an environmentally responsible management of such waste. Evidently, the best solution to any waste problem is likely to be to eliminate the waste at source, but for the foreseeable future, this challenge – to manage waste remaining after source separation - is not about to disappear, albeit the challenge itself should not distract us from the goal of minimising its magnitude.

In the past, one could be forgiven for thinking that 'landfill' was bad merely by virtue of its name. Yet policy and law should now reflect (changing) knowledge and evidence, and not be based on a dogmatic view regarding the supposed superiority of one or other technology, irrespective of the changing circumstances. This should not be taken as a 'pro-landfill' argument. The aim to minimise landfilling is desirable as we seek to implement a circular economy, but the prime means of reducing landfilling should be through reducing residual waste (which even if processed through an incinerator, would produce a corresponding amount of fly/bottom ashes), not switching from one way of managing residual waste to another where neither is optimal. Working to reduce residual waste requires flexibility in the system, which can be negatively affected by (early) investments in incineration, something which existing policy tends to drive. The significance of the discussion relates to:

1. The lack of unequivocal evidence in support of the current state of affairs regarding policy and law;
2. The fact that improvements can be made to managing residual waste which are consistent with the EU Green Deal; and
3. The potential impact of an 'incinerator heavy' strategy for managing residual waste on the potential for moving waste further up the hierarchy, into prevention and recycling.

As regards this last point, we argue in this paper that existing policy tends to push Member States towards an 'incinerator heavy' approach. Furthermore, the effect of other parts of the Directives on Waste, and on the Landfilling of Waste, may be pushing Member States towards committing to incineration earlier than is necessary to meet those targets, increasing the risk that the planned-for capacity may undermine the achievement of targets for recycling.

Given the above, therefore, and although the report presents some 'graduated' options, we commend the following package of measures to the Commission and the Parliament as a means to ensure a sound management of residual waste, and to support the ambitions of the EU Green Deal.

1. **Elaborate a clear definition of 'treatment' as per Article 6 of the Landfill Directive.** It may be more appropriate to define this as 'treatment of waste prior to landfilling', since the terms 'treatment' and 'pre-treatment' are used widely in documents concerning waste. The treatment would be defined to require:

    a. The sorting of the waste, with sorting defined through the process set out at Article 27 of the WFD). Such a definition could, potentially, alter the sorting requirements in line with what is achieved through source separation;
    b. The subsequent stabilisation of any waste destined for landfill. Here, it should be considered that the way in which 'thresholds' have been set in the past have differed across countries. The objective should be to ensure the prospects for fugitive methane emissions are minimised through the combination of stabilisation, and the use of suitable oxidation layers at the receiving landfill.
        i. In respect of the former, a level of stability at, or equivalent to, the level considered in the Draft Biowaste Directive (of 2001), of 10mg O_2 / g dm, or equivalent measure, gives a suitable measure that would reduce the potential for methane generation to a significant degree without incurring excessive cost.
        ii. In respect of the latter, the General Requirements for all Classes of Landfills, set out at Annex I of the Landfill Directive (LFD), could be amended to consider appropriate cover layers, and para 4, regarding Gas Control, could be amended such that the need for gas control was linked to whether or not waste was treated, and the nature of the oxidation layer used.

This definition would, as per reviews undertaken in Section 3.0, ensure that the 'landfill system' was comparable, potentially an improvement upon, incineration in terms of its environmental performance.

2. **Acknowledge, in the LFD, that waste which has been treated in the manner described above is to be regarded as 'no longer biodegradable'**. This would make the link that is lacking in the LFD.

3. **Remove the R1 formula in Annex II of the WFD so that municipal waste incineration is no longer able to be classified as 'recovery'.** This is important since much of the legislation urges an unwarranted preference for 'other [i.e., non-material] recovery' over and above landfill, even if the waste is subject to 'treatment' as defined above. The easiest way to address this is to remove the formula, which has lost relevance in respect of the resources that might be displaced by incinerators in the context of a decarbonising energy system in the EU;

4. **Amend the Article 5(5) target in the LFD to read as follows:**
    - *Member States shall take the necessary measures to ensure that by 2030 the amount of municipal waste landfilled without treatment prior to landfilling, with treatment defined as per Article [X] is reduced to zero.*

Art 5a(1) of the LFD, regarding measuring progress towards the target, would need to be amended accordingly (to align with the preceding target);

5. **Either through Article 44 of the EU Industrial Emissions Directive (IED), or through Article 27 of the WFD (or both), mandate the use of mixed waste sorting systems of a defined quality at the front of all new incineration plants, and those which have been operational for less than ten years.** This could also be defined as a requirement for the 'treatment of waste prior to incineration' (mirroring the requirement in respect of landfill), with elements of the sorting requirements made common to both types of facilities. There may need to be some exception for existing facilities where there are serious spatial constraints;

6. Establish a target to reduce residual municipal waste to less than 175kg/inh, to be achieved on the same schedule as the existing WFD recycling targets. This would be calculated prior to waste entering into the stabilisation process, or at the point it enters the incinerator furnace. The inclusion or exclusion of specific additional components would be established as per the existing Article 5a of the LFD. Some nuancing of this target might be necessary, for example, to make allowances for the role of tourism in the economy of the Member States, and the role played by work-patterns in influencing the figures (Luxembourg providing, perhaps, the best example of this influence). This could occur by creating an adjustment in terms of a net change in 'inhabitant equivalents', linked to overnight stays for work / leisure, for example. The target would be revisited prior to 2030 with a view to reflecting on the level of ambition in the light of more harmonised reporting on MSW, and progress in recycling and waste prevention. The review would anticipate tighter limits in future years;

7. **Include incineration facilities within the EU Emissions Trading System (ETS)** as a means to encourage progress in the quality of sorting systems for removing plastics from the mixed waste remaining after separate collection;

8. **Require Member States to differentiate tax rates for landfilling of:**
    a. **Waste that contained biodegradable waste, including municipal waste, but which has been subject to the treatment referred to above (lower rate); and**
    b. **Waste that contained biodegradable waste, including municipal waste, but which has not been treated in line with the definition of treatment (upper rate).**

If the differentials were set sufficiently high (gap between lower and upper rates no less than, for example, €75 per tonne of waste landfilled), then this would incentivise a swift move away from landfilling of untreated waste in line with the target at Point 4 above.

These changes will significantly improve the climate change emissions associated with the management of waste, and ensure better alignment between planning and the project of fostering a more circular economy. As a final point, the community of academics, consultants and policy-makers does need to appreciate, when discussing waste management and climate change, the difference between '*emissions from the waste sector*', as they are required to be reported to the United Nations Framework Convention on Climate Change (UNFCCC), and in line with Intergovernmental Panel on Climate Change (IPCC) Methodologies, and '*the emissions associated with the management of waste, looked at from the perspective of how waste management can contribute to climate change mitigation.*' It would be helpful if the EU would consider developing better reporting and acknowledgement of this, not least by urging for changes/addenda in national inventories reported to the UNFCCC as a means to ensure clear understanding, and adequate recognition, of the linkages between improved waste management and climate change mitigation.

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1.0 Rethinking the EU Landfill Target

1.1 Background

EU waste legislation has developed, over time, progressively to improve waste management. This evolution has taken policy and legislation through phases:

1) Improving the management of waste which is not recycled, and setting recycling targets at what now appear as relatively low levels;
2) Increasing recycling targets and seeking to enhance standards of management of non-recycled waste; and
3) Further increasing recycling targets and emphasising separate collection of waste whilst seeking to progressively eliminate landfilling.

In the current stage of evolution, the focus is on developing a circular economy, with greater emphasis on reuse, but still higher recycling targets, and a further reduction in residual waste.
Where the waste which is not separated out for recycling – the 'residual' waste, or 'rest' waste - is concerned, thus far, EU legislation has focused on, in the main, reducing emissions; and other associated problems, from landfilling and incineration of such waste. Three interesting exceptions have been:

- The requirement, under Article 6d, of the Landfill Directive (LFD) to ensure all waste was pre-treated prior to landfilling. This requirement was, however, worded loosely in the legislation, and notwithstanding the ECJ's ruling on the Malagrotta landfill, Member States' implementation of the requirement to treat all waste prior to landfilling varied considerably, and interpretations were often at variance with what the case law had envisaged;
- The establishment of a criterion, under the Waste Framework Directive (WFD), related to the efficiency of the conversion of the energetic value within waste into useful energy. This has been used to distinguish between facilities that are to be considered as 'recovery' as opposed to 'disposal';
- The inclusion, in line with Article 11a(6) of the Waste Framework Directive (WFD), of the metals separated after incineration (extracted from residues) which are actually recycled (and subject to certain rules) within the recycling targets for municipal waste set out in Article 11(2) of the WFD.

As well as these approaches to influencing the management of residual waste, Member States have introduced various mechanisms to 'steer' the management of waste which has not been separated at source for the purpose of recycling. These instruments have included (amongst others):

- Taxes on landfill and incineration;
- Restrictions on landfilling, in terms of the criteria which have to be met in order that waste can be landfilled;
- Bans on materials which are allowed to be landfilled;
- Bans on specific wastes which are allowed to be incinerated.

These instruments generally reflect preferences which Member States have developed for the management of those wastes not separated at source for recycling. These preferences have, in various ways, informed, and been informed by, developments and tendencies in EU policy and law.

1.2 Objectives and Outline

As the issue of climate change rises remorselessly up the political agenda, Member States are adapting and reconfiguring their economies, and notably, their energy sectors and their use of transport fuels. For several years, the performance of Member States' waste management was appraised partially on the basis of 'how little was landfilled'. Even though analysis conducted on behalf of the EU suggested that this might not be justified, 'landfill' became stigmatised almost by virtue of its name rather than how it performed relative to alternative waste management options (notably, incineration).

Historically, many studies challenged the view that landfill was the worst option from a waste management perspective. More recently, several studies have looked at the climate change performance of landfill and incineration and questioned the preference ordering currently enshrined in EU policy in various ways. Now seems a pertinent time, therefore, to re-examine some of the policy and law which has developed over time with the intent of improving the management of waste which is not recycled.

The work focuses on the management of municipal waste, which is a waste stream which is strongly affected by policy directly, and which is also the waste stream that contains a significant proportion of packaging (at least, where the definition of municipal waste as set out in Article 3 of the WFD is fully applied). It is also the waste stream for which a target for reducing landfill has been set in the Landfill Directive, as amended.

2.0 EU Policy and its Consequences

This Section highlights some of the policy and law that affects, and has affected, the management of the fraction of municipal waste which is not recycled.

2.1 Landfill Directive

The Landfill Directive's overall Objective, as per Article 1, is:

> *by way of stringent operational and technical requirements on the waste and landfills, to provide for measures, procedures and guidance to prevent or reduce as far as possible negative effects on the environment, in particular the pollution of surface water, groundwater, soil and air, and on the global environment, including the greenhouse effect, as well as any resulting risk to human health, from landfilling of waste, during the whole life-cycle of the landfill.*

Article 5(2) set out targets for progressively reducing the amount of biodegradable municipal waste sent to landfill, the amount acceptable being expressed as a proportion of the total amount of biodegradable municipal waste generated in 1995.

Article 6(a) required Member States to take measures such that:

> *only waste that has been subject to treatment is landfilled. This provision may not apply to inert waste for which treatment is not technically feasible, nor to any other waste for which such treatment does not contribute to the objectives of this Directive, as set out in Article 1, by reducing the quantity of the waste or the hazards to human health or the environment;*

In turn, Article 2(h) defined 'treatment' as follows:

> *'treatment' means the physical, thermal, chemical or biological processes, including sorting, that change the characteristics of the waste in order to reduce its volume or hazardous nature, facilitate its handling or enhance recovery;*

In practice, the Article 5(2) targets were, more or less, unenforceable. Consider that Article 15 required reporting by Member States once every three years. How compliance could have been checked some years after waste had been landfilled would have been challenging, to say the least, other than in cases where non-compliance was obvious.

As regards Article 6(a), the main issue was with the definition of 'treatment', and by association, 'biodegradable'. Many Member States interpreted the definition of treatment, not without good reason given the wording, in such a way that any waste that had undergone any form of sorting could be considered to have been treated. So, as long as some attempt to recycle some waste had been made prior to the remainder being landfilled, the waste could be considered to have been treated. Others, such as Germany and Austria, took a different view, establishing criteria for the treatment of waste which set out how waste would need to be treated before landfilling so as to reduce its potential to generate methane once when it was deposited at landfills. These developments took place in the context of broader actions regarding landfill restrictions and bans, and involved

the use of proxy methods for measuring the tendency of waste to generate methane, effectively based on respirometric tests: achieving the desired standard was linked to the respirometric activity of waste falling below a threshold limit value. Italy also established such a standard. Where this standard was achieved, the treated waste would effectively be considered 'no longer biodegradable' from the perspective of the Landfill Directive targets at Article 5(2).

Relatively shortly after the Landfill Directive was passed, the EU considered – and issued draft text – for a so-called composting Directive. This included text that would have established a similar principle, indicating that if waste had been treated so that its respirometric activity fell below a specific value, it could be considered 'no longer biodegradable' from the perspective of the Landfill Directive.

The definition of the term 'biodegradable' in the Landfill Directive itself was set out at Article 2(m):

> *'biodegradable waste' means any waste that is capable of undergoing anaerobic or aerobic decomposition, such as food and garden waste, and paper and paperboard*

As with 'treatment', this definition was also left somewhat open to interpretation. Member States treated 'textiles' quite differently, and the definition did nothing to settle the question which other Member States were grappling with regarding the point at which hitherto biodegradable waste could be considered 'no longer biodegradable'. The UK sought to define a way of measuring 'biodegradability', moving away from the purely binary approach in some other countries (and proposed in the Draft Composting Directive) which (would have) allowed a specified level of treatment to be treated as though the biodegradability had been reduced to zero.

These two issues were interrelated, but not necessarily so. The requirement for treatment could have been established to require the reduction in the tendency of waste to generate methane when landfilled. On the other hand, that did not necessarily lead to waste being formally considered as no longer biodegradable. Equally, if a Member State did not clearly recognise that reducing the tendency of waste to generate methane could be considered to have reduced the quantity of biodegradable municipal waste landfilled, then that would reduce attractiveness of such treatment given the need to meet the Article 5(2) targets.

In short, as the Article 5(2) targets tightened, then as long as these were not being met through waste prevention, recycling and composting, the way in which residual waste would be managed would be influenced by a Member State's interpretation of whether or not biological treatment of waste could be credited with reducing the amount of biodegradable municipal waste being landfilled. Where they did not, the principal resort was to incineration, which it was generally accepted would render waste no longer biodegradable from the perspective of the Landfill Directive.

2.1.1 The Malagrotta Ruling

On 15 October 2014, in case C-323/13 European Commission v. Italian Republic, the European Court of Justice (ECJ) declared that Italy had failed to comply with relevant EU waste law. In particular:

a) It failed to adopt all necessary measures to avoid that municipal waste is landfilled without having undergone treatment, including an adequate selection of the different waste streams and the stabilisation of their organic fraction; and
b) It failed to establish, in one of its regions, an integrated and adequate network of waste management installations, taking into account best available techniques.

The first of these is of some relevance to the matter under discussion. As indicated above, the definition of treatment under the Landfill Directive was interpreted in different ways. In 2018, one report suggested that ten Member States had not transposed the definition, whilst five Member States considered separate collection as a form of pre-treatment.[1] The ECJ effectively stipulated that this was insufficient and that stabilisation of waste was also a necessary component of treatment. The reasons for this are somewhat convoluted, but it would be difficult to read the Landfill Directive (and the remaining body of EU legislation) as requiring biological stabilisation of all wastes which were capable of undergoing it prior to landfilling. Indeed, if that was the intention, then why would that not have been made clear in the Directive?

The Malagrotta ruling did not itself define 'stabilisation', still less how stabilising waste might affect biodegradability. The contradictions within the ruling and the wider content of the Directive, and the rest of EU law, have not been resolved by the ECJ ruling. If, for example, treatment implies stabilisation, and if the reason for that is that stabilisation reduces the potential for generating methane in landfills, then how 'biodegradable' is the stabilised waste? It would make little sense to say that its biodegradability is unchanged relative to the waste prior to stabilisation. But if it has changed, and if treatment of waste prior to landfilling was always intended to be a requirement of the Directive, then why was it necessary to set targets for a reduction in the landfilling of biodegradable waste?

In principle, the ECJ ruling should have dramatically affected EU waste management practice. Perhaps for the reasons just mentioned, it is not clear that it did. The aforementioned study, published in 2017, made several recommendations targeting the EU-level, and the Member State level. These are summarised in the report's Executive Summary:

- *EU level: clarify the meaning of pre-treatment; clarify if separate collection can constitute pre-treatment; support Member States in complying with pre-treatment requirements; address pre-treatment in waste management plans; support the development of adequate waste management infrastructure.*
- *Member State level: improve the transposition of pre-treatment requirements, as well as national regulatory frameworks regarding pre-treatment; appropriately develop waste management infrastructure; improve separate waste collection systems; improve compliance at the landfills visited under this study; strengthen inspections.*

These tend to suggest that the ECJ ruling has not done enough to clarify the situation (or else, that the Member States have not appreciated its ramifications). Equally, the cross-referencing by the Commission of the LFD, published in 1999, to the objectives WFD as published in 2008 as a means to press for a particular definition of "treatment" also seems illogical: legislators cannot be expected to be able to anticipate the shape of future legislation.

2.1.2 The 2018 Revision

The Landfill Directive underwent significant revision in 2018 in the context of the Circular Economy Package. The targets under Article 5(2) remained as per the original version. However, new targets were added as set out below. Key elements to the change were as follows:

The overall objective in Article 1 was amended with the following addition:

[1] Milieu and Ricardo (2017) Study to assess the implementation by EU Member States of certain provisions of Directive 1999/31/EC on the landfill of waste, Final Report to European Commission, March 2017

> *With a view to supporting the Union's transition to a circular economy and meeting the requirements of Directive 2008/98/EC of the European Parliament and of the Council (1), and in particular Articles 4 and 12 thereof, the aim of this Directive is to ensure a progressive reduction of landfilling of waste, in particular of waste that is suitable for recycling or other recovery....*

This essentially sought to reinforce the waste hierarchy in the Directive.

A new paragraph 3a was added under Article 5 as follows:

> *Member States shall endeavour to ensure that as of 2030, all waste suitable for recycling or other recovery, in particular in municipal waste, shall not be accepted in a landfill with the exception of waste for which landfilling delivers the best environmental outcome in accordance with Article 4 of Directive 2008/98/EC.*
>
> *Member States shall include information on the measures taken pursuant to this paragraph in the waste management plans referred to in Article 28 of Directive 2008/98/EC, or in other strategic documents covering the entire territory of the Member State concerned.*

This again seeks to give force to the waste management hierarchy. Of relevance here is that it really does restrict the use of landfill unless it can be shown to be delivering the best environmental outcome as per Article 4 of the WFD. Here, Article 4(2) of the WFD is especially relevant:

> *Member States shall take measures to encourage the options that deliver the best overall environmental outcome. This may require specific waste streams departing from the hierarchy where this is justified by life-cycle thinking on the overall impacts of the generation and management of such waste.*
>
> *Member States shall ensure that the development of waste legislation and policy is a fully transparent process, observing existing national rules about the consultation and involvement of citizens and stakeholders.*
>
> *Member States shall take into account the general environmental protection principles of precaution and sustainability, technical feasibility and economic viability, protection of resources as well as the overall environmental, human health, economic and social impacts, in accordance with Articles 1 and 13.*

Taken together, Article 5(3)(a) of the LFD and Article 4(2) of the WFD place significant restrictions on what can be landfilled. To the extent that incinerators are able to be classified as 'recovery', and to the extent that most municipal waste can be incinerated, landfilling is only permitted as long as it can be justified by "life-cycle thinking" to be superior. Otherwise, all municipal waste would be destined for incinerators, at least as long as they can be classified as 'recovery'.

In the WFD itself, "life-cycle thinking" is not defined. The Commission's Guidance, dating from the 2008 version of the Directive, includes the following:

> *The fundamental objective of life-cycling thinking (LCT) is to be aware of the overall environmental impact of the product or service. It aims to ensure that certain environmental impacts are not omitted when evaluating alternatives and to avoid simply shifting an environmental impact from one environmental medium to another. It thus makes decisions transparent, as well as based on sounder grounds and more efficient.*

Under the conceptual framework defined by LCT, a number of quantitative decision-support methods exist, such as Life Cycle Assessment (LCA), Cost-Benefit Analysis (CBA), Life Cycle Costing (LCC), and Social LCA (S-LCA). These methods provide comprehensive, science-based support for decision-making and policy-making, in that environmental, social, and cost-related aspects can be simultaneously considered. However, it should be noted that when applying LCT there is no legal obligation under Article 4(2) WFD to use any of these available support methods.

The application of life-cycle thinking, therefore, affords some latitude in approach.
Further new paragraphs (5 to 9) were added under Article 5. Paragraph 5 contains a new and important target:

5. *Member States shall take the necessary measures to ensure that by 2035 the amount of municipal waste landfilled is reduced to 10 % or less of the total amount of municipal waste generated (by weight).*

This target effectively replaces the target on biodegradable municipal waste. The nature of this target, set in relation to the quantity of municipal waste generated, makes it somewhat easier to oversee as opposed to the previous one based on BMW, which was difficult to enforce.

Paragraphs 6-8 set out rules regarding derogations for those who were landfilling more than 60% of municipal waste in 2013:

6. *A Member State may postpone the deadline for attaining the target referred to in paragraph 5 by up to five years provided that that Member State:*

(a) landfilled more than 60 % of its municipal waste generated in 2013 as reported under the Joint Questionnaire of the OECD and Eurostat; and
(b) at the latest 24 months before the deadline laid down in paragraph 5 of this Article, notifies the Commission of its intention to postpone the deadline and submits an implementation plan in accordance with Annex IV to this Directive. That plan may be combined with an implementation plan submitted according to point (b) of Article 11(3) of Directive 2008/98/EC.

7. Within three months of receipt of the implementation plan submitted pursuant to point (b) of paragraph 6, the Commission may request a Member State to revise that plan if the Commission considers that the plan does not comply with the requirements of Annex IV. The Member State concerned shall submit a revised plan within three months of receipt of the Commission's request.

8. In the event of postponing the deadline in accordance with paragraph 6, the Member State shall take the necessary measures to reduce by 2035 the amount of municipal waste landfilled to 25 % or less of the total amount of municipal waste generated (by weight).
Paragraph 9 makes provision for the target to be reviewed by the end of 2024:

9. By 31 December 2024, the Commission shall review the target laid down in paragraph 5 with a view to maintaining or, if appropriate, reducing it, to considering quantitative target per capita on landfilling and to introducing restrictions to the landfilling of non-hazardous waste other than municipal waste. To that end, the Commission shall submit a report to the European Parliament and to the Council, accompanied, if appropriate, by a legislative proposal.

A new Article 5a was included, setting out the rules to be used for calculating whether the targets had been attained. This included the following:

1. For the purpose of calculating whether the targets laid down in Article 5(5) and (6) have been attained:

(a) the weight of the municipal waste generated and directed to landfilling shall be calculated in a given calendar year;

(b) the weight of waste resulting from treatment operations prior to recycling or other recovery of municipal waste, such as sorting or mechanical biological treatment, which is subsequently landfilled shall be included in the weight of municipal waste reported as landfilled;

(c) the weight of municipal waste that enters incineration disposal operations and the weight of waste produced in the stabilisation operations of the biodegradable fraction of municipal waste in order to be subsequently landfilled shall be reported as landfilled;

(d) the weight of waste produced during recycling or other recovery operations of municipal waste which is subsequently landfilled shall not be included in the weight of municipal waste reported as landfilled.

Article 5a(4) made provision for the introduction of implementing acts establishing rules for the calculation, verification and reporting of data. The relevant Implementing Decision was prepared in 2019.[2]

The matter of what is implied by 'treatment', and how, if at all, this should link to the issue of whether waste is biodegradable or not, or its 'biodegradability', was not addressed in the revision. On the other hand, text was added to Article 6a, seemingly intending to address the potential for an interpretation of the term 'treatment' to obstruct the wider objectives of the revised WFD, notably, the recycling targets therein:

Member States shall ensure that measures taken in accordance with this point do not compromise the achievement of the objectives of Directive 2008/98/EC, notably on the waste hierarchy and on the increase of preparing for re-use and recycling as set out in Article 11 of that Directive;

It should be considered that the position remains somewhat confusing:

- All waste to be landfilled should be treated before landfilling;
- The definition of treatment – if the ECJ ruling is applied – requires an unspecified level of sorting, and an undefined level of 'stabilisation'. The term 'stabilisation' is used in three different ways in the Directive, and is not defined (the term 'stability' is used twice to refer to the stability of the structure following emplacement of the waste);
- Whilst all waste must be "treated" today, ensuring such treatment should not compromise the achievement of targets for 'preparation for reuse' and recycling (which are set for 2025, 2030 and 2035);
- As of 2030, no waste should be landfilled that cannot be otherwise recovered unless landfilling delivers the best environmental outcome in line with life-cycle thinking;
- As of 2035, no more than 10% of waste (which should, in any case, be 'treated') may be landfilled.

There would appear to be somewhat contradictory requirements in this list. The contradictions are heightened given the reference, in Annex I (General Requirements for all classes of landfills) to the requirement that:

[2] Commission Implementing Decision (EU) 2019/1885 of 6 November 2019 laying down rules for the calculation, verification and reporting of data on landfill of municipal waste in accordance with Council Directive 1999/31/EC and repealing Commission Decision 2000/738/EC.

Landfill gas shall be collected from all landfills receiving biodegradable waste and the landfill gas must be treated and used. If the gas collected cannot be used to produce energy, it must be flared.

If 'treatment' required that biological stabilisation was undertaken to reduce the potential of the waste to generate methane, it is less than clear why there would be a requirement to collect and flare gas (other than at those sites that may already have received the majority of their waste prior to the requirement for treatment becoming mandatory, in which case, attention might have been expected to be given to dates on which a site first accepted waste, and then, ceased to accept waste.

2.2 Incineration Directive / Industrial Emissions Directive

Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste has been superseded by the Industrial Emissions Directive, though it might be accurate to say that the Incineration Directive has been 'moved under' the Industrial Emissions Directive (Incineration is one of the activities regulated under the IED).

Article 1 sets out the Objectives for the Directive:

The aim of this Directive is to prevent or to limit as far as practicable negative effects on the environment, in particular pollution by emissions into air, soil, surface water and groundwater, and the resulting risks to human health, from the incineration and co-incineration of waste.

This aim shall be met by means of stringent operational conditions and technical requirements, through setting emission limit values for waste incineration and co-incineration plants within the Community and also through meeting the requirements of Directive 75/442/EEC.

Article 4 essentially sets out that incineration or co-incineration cannot operate without a permit and that a permit must include (as per Article 4(2)):

'*a description of the measures which are envisaged to guarantee that:*

(a) the plant is designed, equipped and will be operated in such a manner that the requirements of this Directive are taking into account the categories of waste to be incinerated;

(b) the heat generated during the incineration and co-incineration process is recovered as far as practicable e.g. through combined heat and power, the generating of process steam or district heating;

(c) the residues will be minimised in their amount and harmfulness and recycled where appropriate;

(d) the disposal of the residues which cannot be prevented, reduced or recycled will be carried out in conformity with national and Community legislation

Article 6(6), on Operating Conditions, reiterates the point regarding energy recovery:

6. *Any heat generated by the incineration or the co-incineration process shall be recovered as far as practicable.*

Most of the rest of the Directive is concerned with limiting emissions to the air, water and land in respect of human health. There was no consideration of the impact on climate change. The emissions of concern did not include carbon dioxide, fossil-derived or otherwise. "Pre-treatment" was suggested only in relation to ensuring completeness of combustion (Article 6(1)). Pre-treatment was not defined in the Directive.

Article 9 notes that:

> *Residues resulting from the operation of the incineration or co-incineration plant shall be minimised in their amount and harmfulness. Residues shall be recycled, where appropriate, directly in the plant or outside in accordance with relevant Community legislation.*

This Article has not, as far as we are aware, been used as the basis to propose any form of pre-treatment, but it would be consistent with the ECJ ruling on the Malagrotta case to argue that some form of prior treatment of waste would be required, so as to meet the objectives of this Article.

The Directive itself was amended, to a limited extent, by a Regulation ((EC) No 1137/2008) in October 2008 which made provision for, amongst other things, the introduction of continuous monitoring of specific pollutants, as a requirement, from a date which it left to be determined through a committee procedure.

2.2.1 Recovery or Disposal?

In 2003, two ECJ rulings clarified that the incineration of waste constitutes recovery only if its main objective is to generate energy, replacing the use of other materials that would have had to be used to fulfil that function, and thereby conserving natural resources.[3]

Where that was not the case - for example, if the main objective was the treatment of waste - then incineration could not be defined as recovery, but would be defined as disposal. The European Commission summarised the situation thus:[4]

> *In recent jurisprudence the European Court of Justice developed a criterion for distinguishing between waste recovery and waste disposal. According to the Court, a waste treatment operation is to be classified as recovery when the fundamental objective of the operation is that the waste substitutes the use of primary resources. The Court has notably concluded that filling a mine with waste could be a recovery operation if the waste is used in replacement of primary resources that would have otherwise been used for the purpose of filling the mine. This could for instance be the case when, for the purpose of stabilising land a mine must be filled. The Court also concluded that use of waste as a fuel in a cement kiln is recovery when excess heat is generated and this heat is used in the process. In contrast, the Court decided that incineration in a dedicated municipal waste incinerator has for primary objective to dispose of the waste. The Court added that, in the cases analysed, this classification as disposal operation would not be changed if, as a secondary effect of the process, energy is generated and used.*

[3] See Article 3, Point 15, and Recital 19, WFD. In cases C-228/00 (Commission v Germany) and C-458/00 (Commission v Luxembourg).

[4] European Commission (2003) Communication from the Commission: Towards a thematic strategy on the prevention and recycling of waste, Brussels, xxx; COM(2003) yyy final.

The European Commission then saw fit to set out a basis, in the WFD of 2008, for establishing a performance criterion that would allow an incinerator to be defined as 'recovery' as opposed to 'disposal', even though the ECJ ruling did not seem to allow for such an performance threshold to determine whether a facility was a recovery one or not. The eventual outcome was the inclusion, in Annex 2 of the WFD in 2008, which defines recovery processes, of a threshold criterion linked to the efficiency of energy recovery by facilities processing municipal waste, that allowed it to be included as an R1 process, which is to say:

R1 Use principally as a fuel or other means to generate energy.

The fact that the ECJ had already indicated that incineration processes were not to be defined as such raises questions as to why this was considered so important.

It also seems inconsistent with what was already required under the Waste Incineration Directive (WID). As noted above, all facilities were required to demonstrate that the heat generated during the incineration and co-incineration process was '*recovered as far as practicable e.g. through combined heat and power, the generating of process steam or district heating*', this being repeated at Article 6(6). This was set as a condition for an operator to obtain a permit, without which it was not allowed to operate. Setting a threshold in relation to energy efficiency would – as long as the WID conditions for permitting were being properly enforced – simply distinguish between facilities where the achievement of the threshold was 'practicable' and those for whom it was not. Indeed, the threshold level for achieving R1 status was based on methods developed under the BAT reference document. This document informs how operators should demonstrate BAT under a permitting process. As such, and especially given the requirement to recover energy as far as practicable under the WID, they should not be considered 'optional': they are required in order for a permit to be issued. If the Commission's R1 threshold simply reiterates what is required to obtain a permit, then in reality all incinerators are recovery installations; there is no meaningful basis for distinguishing one type of incinerator from another; and the outcome is a complete reversion of the decision of the European Courts. This point is given added force by Amending Directive EU Directive 2015/1127, whose main rationale was to ensure that the R1 threshold could be met in countries with warmer climates. In other words, the R1 criterion was amended to ensure it could be met everywhere.

To further demonstrate this point: suppose the operator of an incineration plant desires to achieve recovery status (rather than disposal) through increasing the efficiency of energy generation as measured through the equation set out in Annex II of the WFD. The act of making such improvements suggests improvement was possible, one might say, 'practicable'. Consequently, such a process should have been considered a requirement for the purpose of the permitting process. Accepting that incinerators cannot permanently operate at the 'frontier of efficiency' because of the lifetime of investments involved, efficiency improvements made 'well within' that frontier ought, arguably, already to have been in place. The R1 criterion simply offered a 'leg-up' to incineration, even though, as we show in Section 3.1 below, work funded by the Commission offered no obvious basis for doing so.

Note that, notwithstanding the Courts' rulings, the R1 criteria made no reference to materials recovery: to the extent that incineration plants seek to extract metals from ash following combustion, it might be considered a lost opportunity that no specific performance criteria were set for this (let alone any for pre-sorting as a form of 'treatment').

It should be noted that the distinction between 'recovery' and 'disposal' status also had particular significance for the movement of waste across frontiers within the EU. The status of 'recovery' was touted as enabling a freer movement of waste across boundaries to those countries who had installed more capacity for incineration than was required for their own purposes. Without 'recovery' status, it was argued that some facilities may have been

progressively starved of feedstock, not least as recycling targets and aspirations increased. There are some sound reasons for wanting to ensure existing assets are fully utilised, not least if the alternative is that other Member States simply build the same, or similar, assets, duplicating the infrastructure. That having been said, there may be other ways to ensure, within the EU, that such movements are permitted which do not require designation of receiving installations as 'recovery'. Finally, as we will discuss in Section 5.1.4, the relevant Regulation, in defining 'disposal' and 'recovery', still references the predecessor Directive to define these terms.

2.2.2 Industrial Emissions Directive

In November 2010, the Industrial Emissions Directive (IED) was published.[5] This effectively subsumed the WID within a Directive seeking, in the main, to control pollution from installations within its scope.

We noted above how the WID was silent on emissions of greenhouse gases from incineration. Article 9 of the IED addresses the overlap between installations covered by the IED, and those under the Scope of Directive 2003/87/EC (the Emissions Trading Scheme Directive). It states:

> 1. *Where emissions of a greenhouse gas from an installation are specified in Annex I to Directive 2003/87/EC in relation to an activity carried out in that installation, the permit shall not include an emission limit value for direct emissions of that gas, unless necessary to ensure that no significant local pollution is caused.*
>
> *2. For activities listed in Annex I to Directive 2003/87/EC, Member States may choose not to impose requirements relating to energy efficiency in respect of combustion units or other units emitting carbon dioxide on the site.*

In essence, the Article seeks to address the 'overlap' between limit values in permits, and the economic incentive implied by the EU Emissions Trading System (ETS). Despite paragraph 1 appearing to allude to the desirability of including such limit values for installations not within the ETS (and see below regarding the omission of incineration in this regard), the IED includes no such limit values for incineration.

Article 44 includes slightly revised wording from the WID regarding what an operator must guarantee:

> *(b) the heat generated during the incineration and co-incineration process is recovered as far as practicable through the generation of heat, steam or power;*

It adds the reference to power, which did not appear in the WID, effectively sanctioning the recovery of energy through heat or/and power (which, surprisingly, the WID did not obviously allow). But Article 50(5), however, retains more or less the same wording as the WID vis-a-vis Operating Conditions requiring the recovery of heat as far as practicable.

Article 53 retains WID-style wording on residues:

> 1. *Residues shall be minimised in their amount and harmfulness. Residues shall be recycled, where appropriate, directly in the plant or outside.*

[5] Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control)

Nonetheless, there is nothing on what should happen to (pre-)treat waste whereas the considerations in respect of Reception of waste focus on matters of safety alone.

As with the WID, the IED includes an Annex (VI, Part 2) which lists Toxic Equivalence factors for dibenzo-p-dioxins and dibenzofurans. This focuses only on the chlorinated variety, with no reference to brominated dioxins and furans (PBDDFs and PCDD/Fs, respectively). The limit values for emissions of pollutants – set out in Annex VI Part 3 - remain unchanged from the WID that was published a decade earlier. They remain unchanged today, twenty years after the publication of the WID, and there remains no incentive, other than those resulting from Member State action, for actions to reduce greenhouse gas emissions.

2.2.3 Waste Treatment BREF

Article 11 of the IED requires installations to be operated according to specified principles, including (11(b)) 'the best available techniques are applied'. Article 13 sets out how Best Available Techniques (BAT) Reference Documents will be prepared, and the procedure for arriving at so-called BAT Conclusions. The significance of these is made clear by Article 15 (3):

3. The competent authority shall set emission limit values that ensure that, under normal operating conditions, emissions do not exceed the emission levels associated with the best available techniques as laid down in the decisions on BAT conclusions referred to in Article 13(5) through either of the following:

> *(a) setting emission limit values that do not exceed the emission levels associated with the best available techniques. Those emission limit values shall be expressed for the same or shorter periods of time and under the same reference conditions as those emission levels associated with the best available techniques; or*
>
> *(b) setting different emission limit values than those referred to under point (a) in terms of values, periods of time and reference conditions.*
>
> *Where point (b) is applied, the competent authority shall, at least annually, assess the results of emission monitoring in order to ensure that emissions under normal operating conditions have not exceeded the emission levels associated with the best available techniques.*

At the same time, under the IED, Incineration is covered by a specific Chapter – Chapter IV – and the Chapter repeatedly references the limit values in Annex VI. The role of the Best Available Techniques Reference (BREF) and the BAT Conclusions, therefore, is of interest since, in principle, whilst the IED sets out emissions limit values, these are values not to be exceeded: there appears to be no reason why BAT Conclusions for Incineration resulting from the BREF process should not tighten these emissions further. In addition, there is no reason why they could not set limit values, or specify techniques, designed to limit greenhouse gas emissions.

The BREF for Incineration was published in 2019 and the associated BAT Conclusions were published in November of that year. The BREF lists emissions from incineration, and includes carbon dioxide among them, but adds that this is *'not covered under the IED or this BREF'.* The absence of any EU mechanism that regulates, or incentivises reductions in, greenhouse gas emissions from incineration remains, therefore, a major omission. Rather sadly, the BREF includes the following paragraph:

Most municipal and commercial wastes, including refuse-derived fuels, contain a significant share of biogenic content (reaching 60 % and more in some cases). For sewage sludge incinerators treating sludges from biological waste water treatment and for dedicated wood waste incinerators, this share can typically be above 95 %. The energy derived from the biomass fraction may be considered to substitute for fossil fuel and therefore the recovery of energy from that fraction may be considered to contribute to a reduction in the overall carbon dioxide emissions from energy production. In some countries, this attracts subsidies and tax reductions. [64, TWG 2003]

This looks out of place and out of date (the cited reference is from 2003), and is disappointing, coming from the body that claims to be the EU's leading research arm. Indeed, much of the BREF falls back on sources that are almost twenty years old, there being also a lengthy presentation of long-outdated information on gate fees. Later, the BREF notes, regarding carbon dioxide:

For every tonne of municipal waste combusted, approximately 0.7–1.7 tonnes of CO_2 are generated.

Because municipal waste is a heterogeneous mixture of biomass and fossil material, the portion of CO_2 from MSWIs of fossil origin (e.g. plastic) which is considered relevant to climate change is generally in the range of 33% to 50%.

No sources are given for the figures quoted. The clause *'which is considered relevant to climate change'* is of interest. IPCC Guidelines generally indicate that only fossil-derived emissions of CO_2 from incineration are of relevance to national inventories, but that does not mean that emissions of non-fossil origin are of no consequence for climate change. The range 33% to 50% is the same as that which was quoted in a paper for the IPCC, though the range 0.7-1.7 tonnes is different.[6] The figures in the IPCC report were based entirely on facilities operating in Germany, and none of the study's references are dated later than 1999, indicating that things may have changed since then. Nonetheless, the BREF offers no perspectives on how to alter the direct emissions of CO_2 from incineration of waste, fossil-derived or otherwise.

Where materials recovery is concerned, notwithstanding that some sorting of materials might be expected to be considered as a means to comply with Art 53(1) of the IED, the focus is entirely on what can be recovered from bottom ash.

The discussion of 'pre-treatment options' also looks outdated with no reference to the potential for sorting prior to incineration (even though this seemed to have been made a requirement of 'treatment' prior to landfilling by the ECJ). In addition, Annex III of the IED, setting out criteria for determining best available techniques, includes:

1. *the use of low-waste technology; [...]*

3. the furthering of recovery and recycling of substances generated and used in the process and of waste, where appropriate; [...]

[6] Note that only under very specific (somewhat unlikely) conditions would a tonne of waste, whose combustion led to emissions of 1.7 tonnes CO_2, have a fossil carbon content of no more than 50%. This is due to the fact that the biomass fractions tend to have lower carbon content as a share of dry matter (the molecules are generally more complex than those of most of the base plastics) as well as a higher moisture content, whilst the plastics have a low moisture content and a higher share of carbon in dry matter. In essence, the material would likely need to have been dried, or it would need to have unusually low food / garden waste content. A recent study analysing the fossil CO2 share of RDF which contained MSW, and which led to around 1.7 tonnes of CO2 per tonne of waste, was assessed for its fossil carbon content using 4 different methods. Three of the four methods gave values above 75%, with the third giving a figure of 65% (see Therese Schwarzböck, Philipp Aschenbrenner, Stefan Spacek, Sönke Szidat, Helmut Rechberger, Johann Fellner (2018) An alternative method to determine the share of fossil carbon in solid refuse-derived fuels – Validation and comparison with three standardized methods, Fuel, Volume 220, 2018, pp.916-930).

10. the need to prevent or reduce to a minimum the overall impact of the emissions on the environment and the risks to it;

It does reference brominated dioxins and furans, but dismisses these by:

a) suggesting that their formation is linked to 'insufficiently controlled combustion processes', and

b) referring to their origin as 'contaminants in the commercial Polybrominated diphenyl ether (PBDE) flame-retardant mixtures in household waste, though it then suggests de novo synthesis cannot be excluded:

During insufficiently controlled combustion processes, significant amounts of PBDD and PBDF may be formed, including those with the most toxic dioxin-like properties. The origin of these PBDF may partly be explained by their presence as contaminants in the commercial PBDE flame-retardant mixtures in household waste, but de novo synthesis cannot be excluded.

Another source of bromine in incineration processes is the use of techniques for the enhanced oxidation of mercury (thereby enabling efficient mercury removal in the downstream FGC[7] system) by means of high-temperature bromide injection. [116, van den Berg et al. 2013] – p152

The BREF makes no mention of the number of studies that have considered the issue over the last twenty years.[8] The factors influencing the formation of PBDD/Fs are less well studied than the formation of PCDD/Fs. Nonetheless, it is questionable to suggest that only insufficiently controlled combustion processes are of concern, whilst the presence of PBDD/Fs in ash may also be of concern. It would be useful for the BREF process to review this more seriously in the near future, and to consider the implications for BAT (including pre-treatment).

The BREF notes a number of 'split views' expressed during the work of the Technical Working Group. designed to achieve a consensus on BAT conclusions. Several of these were views of those who expressed a desire to lower air emission limit values below those that are in the IED (and were in the WID). Nonetheless, the BAT conclusions do lead to some proposed Best Available Technologies - Associated Emission Levels (BAT-AELs) which are lower than those in the IED, though even the BREF's own assessment suggests that the limit values could have been tightened further: indeed, for key pollutants, such as NOx, it is difficult to comprehend why, given that the BREFs

[7] Flue Gas Conditioning

[8] D. Schuler and J. Jager (2004) Formation of chlorinated and brominated dioxins and other organohalogen compounds at the pilot incineration plant Verona, Chemosphere, 2004. 54(1): p. 49-59; L.-C. Wang and G.-P. Chang-Chien (2007) Characterizing the Emissions of Polybrominated Dibenzo-p-dioxins and Dibenzofurans from Municipal and Industrial Waste Incinerators, Environmental Science and Technology 2007. 41(4): p. 1159-1165; B. Wyrzykowska et al. (2008) Levels of brominated diphenylether, dibenzo-p-dioxin, and dibenzofuran in flue gases of a municipal waste combustor, Paper Presented at Dioxin 2008, 29th International Symposium on Halogenated Persistent Organic Pollutants, Birmingham UK; World Health Organisation (1998) Environmental Health Criteria 205: Polybrominated dibenzo-p-dioxins and dibenzofurans. 1998, International Programme on Chemical Safety (IPCS): Geneva; B. Zier et al. (1991) Surface catalyzed halogenation-dehalogenation reactions of aromatic bromine compounds adsorbed on fly ash, Chemosphere, 1991. 22(12): pp. 1121-1129; G. Soderstrom and S. Marklund (2002) PBCDD and PBCDF from incineration of waste containing brominated flame retardants. Environmental Science and Technology, 2002. 36(9): p. 1959-64; S.-i. Sakai et al. (2001) Combustion of brominated flame retardants and behavior of its byproducts, Chemosphere, 2001. 42(5-7): p. 519-531; R. Dumler et al. (1989) Thermal formation of polybrominated dibenzodioxins (PBDD) and dibenzofurans (PBDF) from bromine containing flame retardants, Chemosphere, 1989. 19(1-6): pp. 305-308; J. R. Donnelly et al. (1990) Bromo- and bromochloro-dibenzo-p-dioxins and dibenzofurans in the environment, Chemosphere, 1990. 20(10-12): p. 1423-1430; S. Song, X. Zhou, C. Guo, H. Zhang, T. Zeng, Y. Xie, J. Liu, C. Zhu, X. Sun (2019) Emission characteristics of polychlorinated, polybrominated and mixed polybrominated/chlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs, PBDD/Fs, and PBCDD/Fs) from waste incineration and metallurgical processes in China, Ecotoxicol. Environ. Saf., 184; L.C. Wang, H.C. Hsi, Y.F. Wang, S.L. Lin, G.P. Chang-Chien (2010) Distribution of polybrominated diphenyl ethers (PBDEs) and polybrominated dibenzo-p-dioxins and dibenzofurans (PBDD/Fs) in municipal solid waste incinerators, Environ. Pollut., 158, pp. 1595-1602; B. Wyrzykowska, B.K. Gullett, D. Tabor, A. Touati (2011) PBDDs/Fs and PCDD/Fs in the raw and clean flue gas during steady state and transient operation of a municipal waste combustor, Environ. Sci. Technol., pp. 5853-5860. A useful review is provided in Lili Yang, Guorui Liu, Jia Shen, Minxiang Wang, Qiuting Yang, Minghui Zheng (2021) Environmental characteristics and formations of polybrominated dibenzo-p-dioxins and dibenzofurans, Environment International, Volume 152, July 2021.

are supposed to rule on Best Available Techniques, the BREF proposes using 'an appropriate combination' of a range of techniques including those whose abatement performance is obviously inferior. The analysis in the BREF, reproduced below in Figure 1, would seem to make it obvious that Selective Catalytic Reduction (SCR), and not Selective Non-Catalytic Reduction (SNCR), is the preferred abatement technique. In this regard, the BAT Conclusions do not really reach anything that might be termed a conclusion at all; operators are free to choose how they achieve the AELs proposed. As if to highlight the non-conclusion that was drawn, the footnotes to Table 6 in the BAT Conclusions read:

> *(1) The lower end of the BAT-AEL range can be achieved when using SCR. The lower end of the BAT-AEL range may not be achievable when incinerating waste with a high nitrogen content (e.g. residues from the production of organic nitrogen compounds).*
>
> *(2) The higher end of the BAT-AEL range is 180 mg/Nm^3 where SCR is not applicable.*

Footnote 2, in particular, raises questions as to why the limit values (where SCR, implicitly, is applicable) were not specified more tightly.
It also worth noting, as the BREF does, that:

> *SCR de-NOX has an additional destruction effect on dioxins if designed (sized) accordingly*

The BAT Conclusions, reflecting the BREF itself, require no monitoring of CO_2 or the fossil carbon content of waste. This is despite the fact that reporting of fossil (and non-fossil) CO_2 emissions from incineration is:

a) necessary under reporting to the UNFCCC;
b) likely to be wrong where using proxy (let alone, IPCC default) methods; and
c) possible through relatively precise methods.[9]

[9] See, for example, Therese Schwarzböck, Philipp Aschenbrenner, Stefan Spacek, Sönke Szidat, Helmut Rechberger, Johann Fellner (2018) An alternative method to determine the share of fossil carbon in solid refuse-derived fuels – Validation and comparison with three standardized methods, Fuel, Volume 220, 2018, pp.916-930.

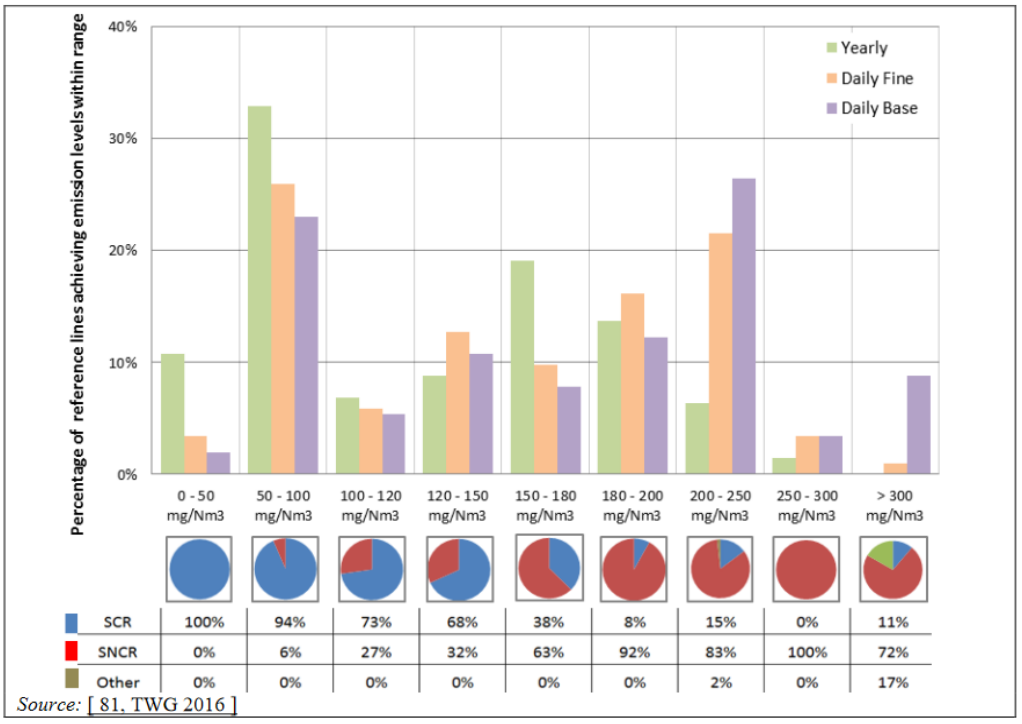


Figure 3.11: Continuously monitored NO_X emissions to air from reference lines incinerating predominantly MSW

Figure 1: NOx Emissions from Incineration Linked to Abatement Technology (SCR=Selective Catalytic Reduction, SNCR=Selective Non-catalytic Reduction)

2.3 Waste Framework Directive (revision of 2008)

Some relevant matters under the WFD have already been discussed, notably, the waste hierarchy (Article 4) and its preference ordering, and the related issue of the R1 criterion for distinguishing between those municipal waste incinerators which could qualify as 'recovery' installations, and those that would be classified as 'disposal'.
The most recent amendment to the original (2008/98/EC) Directive, the Directive EU 2018/851, was made as part of the so-called Circular Economy Package. The Objective, at Article 1, is stated thus:

> *This Directive lays down measures to protect the environment and human health by preventing or reducing the generation of waste, the adverse impacts of the generation and management of waste and by reducing overall impacts of resource use and improving the efficiency of such use, which are crucial for the transition to a circular economy and for guaranteeing the Union's long-term competitiveness.*

Article 10 effectively mirrors the position in the Landfill Directive by requiring Member States to ensure that waste is not sent for disposal.

The new Directive also allowed for (Article 11a(6)) inclusion, as contribution towards recycling targets, *'the recycling of metals separated after incineration of municipal waste provided that the recycled metals meet certain quality criteria',* and not – as the ECJ interpreted treatment prior to landfilling – to provide an overall improvement in the environment (there was no reference, for example, to a need for minimum levels of sorting).

Article 12, regarding disposal, included provision for a review at 12(2):

> *By 31 December 2024, the Commission shall carry out an assessment of the disposal operations listed in Annex I, in particular in light of Article 13, and shall submit a report to the European Parliament and to the Council, accompanied, if appropriate, by a legislative proposal, with a view to regulating disposal operations, including through possible restrictions, and to consider a disposal reduction target, to ensure environmentally sound waste management*

Article 27(1) and (2) indicates that minimum standards may be set for treatment activities, '*including for sorting and recycling of waste*'. It goes on to say that such standards will cover only '*those waste treatment activities that are not covered by Directive 96/61/EC [this has been superseded by the IED], or are not appropriate for coverage by that Directive.*' This potentially retains the separation between sorting, as an element of (pre-)treatment for incineration, and the incineration process itself.

By Article 38(2), the Commission is empowered to amend the R1 formula to take into account, inter alia, climatic conditions; this follows on from a previous amending Directive (2015/1127) which effectively further weakened the rationale for a distinction between incineration which is 'disposal', and incineration which is 'recovery'. The rationale for the amending Directive was that local climatic conditions affected the potential for the R1 criterion to be met in hotter climates. It will be recalled, from the above discussion, that all incinerators are required to recover energy as far as is practicable. The rationale, at the time, for the distinction was related to what resources the generation of energy might effectively displace. The resulting climate correction factor effectively lowers the hurdle which must be overcome to qualify as 'recovery', and hence, the quantum of resources that might be expected to be displaced. Furthermore, considering the decarbonisation of energy, it might reasonably be argued that such climates offer greater potential for use of renewable sources of electricity and heat at relatively low cost.

2.4 EU-Emissions Trading Scheme

In relation to climate change, installations which treat waste are not required to be included under the EU ETS. Article 24 of the EU ETS Directive (Procedures for unilateral inclusion of additional activities and gases) enables Member States to expand the coverage of the EU-ETS by opting in activities, installations and greenhouse gases not originally covered by the scheme. During Phase I of the EU ETS, Member States were allowed to add installations that operated below defined capacity limits. Five Member States chose to take advantage of this: Austria, Finland, Latvia, Slovenia and Sweden added combustion installations (below the 20MW threshold which implied automatic inclusion). After 2008, the scope for adding installations was broadened, and the Netherlands, for example, included facilities in the chemical industry emitting nitrous oxide.[10]

A report by Ecofys in 2006 considered the potential for including incineration of waste under an EU-ETS with expanded scope. It noted:

> *At first sight, finding a scope for emission reductions with the numerous legal requirements waste incineration plants face, seems rather difficult, especially in the case of hazardous waste incineration. The scope in the municipal waste sector should be further explored.*[11]

It noted also (p.51) that the fact that the cement industry was included within the ETS was relevant to competitiveness considerations: cement kilns frequently burn wastes, and indeed, they actively seek to do so in

[10] See A. Denny Ellerman, Frank J. Convery, Christian de Perthuis (2010) Pricing Carbon: The European Union Emissions Trading Scheme, p.261.

[11] Ecofys (2006) Inclusion of Additional Activities and Gases into the EU-Emissions Trading Scheme, October 2006, p.39

order to claim reductions in greenhouse gas emissions. Where they burn waste, they are classified as co-incineration. Cement kilns are included within the scope of the EU ETS.

It is interesting to note that under the system of reporting of greenhouse gas inventories, in line with the IPCC Guidelines, emissions from incineration plants, where the incinerators generate energy, are not reported under the waste chapter. Instead, they are reported under the energy sector as part of the emissions from 'stationary combustion':[12]

> *When energy is recovered from waste combustion, the associated greenhouse gas emissions are accounted for in the Energy sector under stationary combustion. Waste incineration with no associated energy purposes should be reported in the Waste source category; see Chapter 5 (Incineration and Open Burning of Waste) of Volume 5. It is good practice to assess the content of waste and differentiate between the part containing plastics and other fossil carbon materials from the biogenic part and estimate the associated emissions accordingly. The CO_2 emission from the fossil-carbon part can be included in the fuel category Other fuels, while the CO_2 emissions from the biomass part should be reported as an information item.*

The omission from the ETS is becoming all the more glaring: as the rest of the energy sector decarbonises, there is no incentive for incinerators that generate energy to decarbonise other than in Denmark (see below). Where incinerators operate efficiently, then where they generate power only, the carbon intensity of the power generation from incinerators is typically above 700g CO_2 / kWh generated, even when the non-fossil emissions are excluded (the figure can be roughly doubled where they are). A recent investigative report in the UK noted:[13]

> *In 2019, Veolia's plants emitted an average of 970 grams of CO_2 equivalent emissions for every kilowatt hour of electricity exported to the grid, while Viridor's plants averaged 889g. (Viridor argues that this figure should be lower to account for times when plants are broken and burning waste without producing electricity, a methodology experts consulted by SourceMaterial dispute.) The UK's coal-fired power plants emitted an average of 985g.*

These figures exclude the non-fossil CO_2 emitted: including them would likely lead to the intensities more or less doubling.

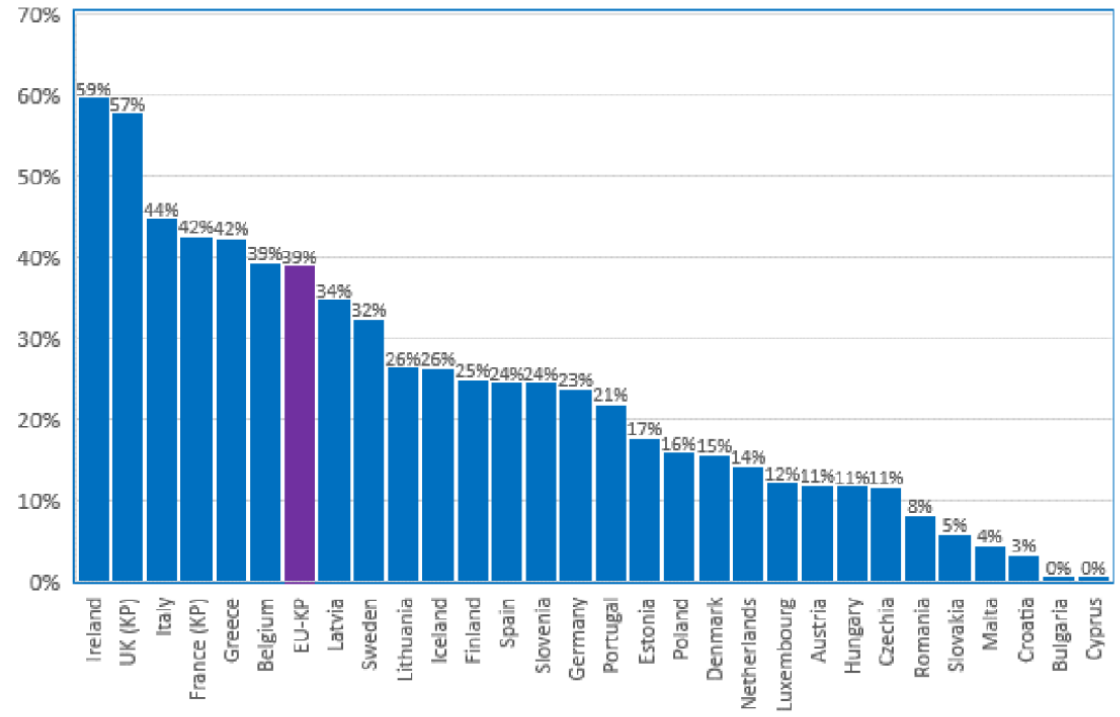
Once coal is phased out, incineration plants will be by far the most carbon intense form of power generation in the EU. As we have indicated above, there are ways to improve their carbon performance, but at present, there is no incentive to do so.

Where landfills are concerned, similar considerations may be said to apply as regards their absence from the EU ETS, although as noted above, taxes on landfill are more prevalent than for incineration, and those taxes are always higher than for incineration. Nonetheless, some equality of treatment, and some incentive to improve climate change performance, would be of merit, notably, an incentive to reduce fugitive emissions through stabilisation of the biodegradable fraction prior to landfilling. The Figure from the European Environmental Agency (EEA) below shows the variation across Member States in reported captures of methane from landfills (for energy generation and flaring) as a proportion of the total generated. This Figure indicates why it might be important to address the landfill site, even after closure, given that these emissions may relate to material

[12] IPCC (2006) Volume 2: Energy, Chapter 2: Stationary Combustion, p.2.33, downloadable from https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf
[13] Josephine Moulds (2021) Dirty white elephants: Incinerators were supposed to solve the UK's waste crisis. Are they making it worse? Downloadable from https://www.source-material.org/blog/dirty-white-elephants

landfilled some years previously. Landfill taxes only affect the activity of landfilling at the point the tax is implemented.

The direct measurement of landfill emissions is an ongoing area of research activity, with various methods now under consideration that may offer a relatively low cost approach to assessment of these emissions. To the extent that such methods can be agreed upon, then they offer a route to including landfills under the EU ETS. Alternatively, New Zealand, which is one of few countries that includes landfills within its emissions trading scheme, operates a scheme whereby default emission values are applied, but where participants can apply to the regulator to have approved their 'unique emissions factor' if they believe default values overstate their emissions.[14]



CH_4 recovery and flaring in % = (CH_4 recovery in Gg + CH_4 flared in Gg)/ (CH_4 recovery in Gg + CH_4 flared in Gg + CH_4 emissions 5A1/0,9 in Gg)
CH_4 emissions from 5A2 unmanaged landfills are not included in this calculation
Source: CRF 2021 Table 5A

Figure 2: Landfill Gas Capture Rates Based on Member State Reporting
Source: European Environment Agency (2021) Annual European Union Greenhouse Gas Inventory 1990–2019 and Inventory Report 2021, Submission to the UNFCCC Secretariat, 27 May 2021EEA/PUBL/2021/066, p.785. Data are for the year 2019.

[14] See New Zealand EPA (2021) Waste: Information for disposal facility operators on their ETS obligations https://www.epa.govt.nz/industry-areas/emissions-trading-scheme/industries-in-the-emissions-trading-scheme/waste/ (accessed August 2021)

Although the EU ETS effectively exempts incineration of municipal waste and hazardous waste, both Denmark and Sweden have elected to include incineration within the scope of the EU ETS, both doing so from 2013.[15] [16] Part of the rationale relates to the use of incineration for district heating (where its exclusion might lead to competitiveness concerns). Hence, in Denmark:[17]

> *Waste incineration plants which are primarily used for district heating were included in the ETS in Denmark by 1st of January 2013, while about 30 installations exclusively using biomass were excluded of the ETS. The inclusion of waste incineration plants led to an increase in the total amount of CO_2-emission from the ETS in Denmark in 2013 compared to 2012.*

It is interesting to note that both Sweden and Denmark also apply taxes to incineration. In Sweden, in 2020, the tax was set to SEK75 per tonne of waste (approx. £6.50 per tonne), and is planned to increase annually. In Denmark, the tax is rather higher. The extant incineration tax was replaced, in 2010, by a tax based on the energy content of the waste. Nowadays a combination of taxes applies to waste incineration. According to the Organisation for Economic and Co-Operational Development (OECD), these are:[18]

1. The waste heating tax based on the amount of heat produced from waste incineration, including heat used at the plant for indoor heating or water heating. In 2018 this tax amounted to DKK 19.80 (EUR 2.66) per gigajoule (GJ). It is coupled with an additional tax based on heating production according to the energy content of the input waste, which amounts to DKK 26.50 (EUR 3.56) per GJ. These two taxes ensure that the same energy tax rate is levied on heat whether it is generated from waste incineration or fossil fuels, which are subject to energy taxation.
2. The CO_2 tax is levied per tonne of CO_2 emissions from waste incineration, except for waste loads containing pure biomass. By 2018 the tax amounted to DKK 173.20 (EUR 23.2) per tonne. (This is in addition to waste incineration plants' participation in the EU ETS). Waste incineration plants are therefore subject to double regulation on CO_2 emissions.
3. Taxes on emissions of NO_X and sulphur are imposed on some waste incineration plants. The tax on sulphur emissions is DKK 10.50 (EUR 1.41) per tonne, and that on NO_X emissions is DKK 5.10 (EUR 0.68) per tonne (PwC, 2018[15]).

In 2020, in answering a question regarding the rising emissions of CO_2 from incineration, the Executive Vice-President of the European Commission, Frans Timmermans, indicated that:[19]

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[15] Ellen Philipsson (2020) Emissions trading for waste incineration plants with energy recovery in Sweden, Master's thesis in Energy and Environmental Engineering, Linköping University Department of Management and Engineering, Spring Semester 2020.

[16] Energistyrelsen (2018) Annex 1 to Denmark's First DRAFT Integrated national energy and climate plan pursuant to Articles 3-11 and ANNEX I of Regulation [ ][Governance] on the GENERAL FRAMEWORK FOR INTEGRATED NATIONAL ENERGY AND CLIMATE PLANS. Part 1: General framework, SECTION A: NATIONAL PLAN, 30 November 2018.

[17] Energistyrelsen (2018) Annex 1 to Denmark's First DRAFT Integrated national energy and climate plan pursuant to Articles 3-11 and ANNEX I of Regulation [ ][Governance] on the GENERAL FRAMEWORK FOR INTEGRATED NATIONAL ENERGY AND CLIMATE PLANS. Part 1: General framework, SECTION A: NATIONAL PLAN, 30 November 2018.

[18] OECD (2019), OECD Environmental Performance Reviews: Denmark 2019, OECD Environmental Performance Reviews, OECD Publishing, Paris, https://doi.org/10.1787/1eeec492-en.

[19] EN P-000678/2020 Answer given by Executive Vice-President Timmermans on behalf of the European Commission (https://www.europarl.europa.eu/doceo/document/P-9-2020-000678-ASW_EN.html) (24.3.2020).

Emissions from waste incineration are already included in the EU Emissions Trading System (ETS) Directive, except for municipal and hazardous waste. When a Member State classifies an installation as co-incinerator, it is also covered by the EU ETS[20].

Member States may choose to opt in emissions from additional activities not covered by the EU ETS Directive[21]. In addition, the Effort-Sharing Decision (ESD)[22] and later the Effort-Sharing Regulation (ESR)[23] were added to the climate acquis, which establish emission reduction targets for the non-EU ETS sectors, i.a. the waste sector[24], for the periods from 2013 to 2020 and from 2021 to 2030 respectively.

As announced in the Green Deal Communication[25], the Commission will carry out an in-depth impact assessment for increasing the Union's 2030 target for greenhouse gas emission reductions to at least -50% and towards -55% in a responsible way. The Commission will then review and by June 2021 propose to revise, where necessary, the relevant energy and climate legislation implementing that target, including the EU ETS Directive.

The 'Fit for 55' legislative proposals from the European Commission have now been released. They indicate, insofar as incineration is concerned, no change, with municipal waste incineration left out of the ETS unless Member States actively choose to opt it in.

There is an interesting question as to whether, when considering greenhouse gas emissions from waste installations, these should include, or exclude, the greenhouse gas emissions associated with wastes of non-fossil origin. There are strong arguments, in our view, for their inclusion. The consequences of burning paper, or card, or wood, or food waste, or garden waste, as part of a batch of municipal waste, are that the carbon present in those materials is immediately released as carbon dioxide. The processes by which those emissions are re-absorbed into the atmosphere are unaffected in any way by the incineration process: they happen as a consequence of activities in the forestry or agriculture sectors, and whether or not they happen, or how quickly they take place, will not be affected by whether the waste is incinerated, or landfilled, albeit there may be some effect, at the margin, if, for example, paper and card are recycled (because of the effect, at the margin, on the forest stock). What matters is the consequential effect of the activity on the climate, and as far as the climatic system is concerned, there is no basis for differentiating the impact of a tonne of CO_2 of fossil origin from a tonne of CO_2 derived from biogenic sources, especially where it cannot reasonably be argued that the activity giving rise to these emissions alters the capacity of the biosphere to act as a sink for CO_2 emissions.[26]

[20] It is the case for the plant referred to in the submitted question.

[21] Based on Article 24 of the ETS Directive [https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:02003L0087-20180408]

[22] Decision 406/2009 [https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2009.140.01.0136.01.ENG]

[23] Regulation 2018/842 [https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.156.01.0026.01.ENG]

[24] Installations for the incineration of municipal waste or hazardous waste are excluded from the scope of the EU ETS in Annex I to the EU ETS Directive. However, if a Member State considers that a waste incineration unit is a co-incineration unit such an installation is covered by the EU ETS.

[25] COM(2019) 640 final

[26] Note that this argument around the impact of the activity on the capacity of the biosphere to act as a sink for CO_2 may be more difficult to make for energy derived from biomass, where the resource may be managed with this in mind. On the other hand, questions might reasonably be asked – not least given the hierarchy of options for managing wastes – as to whether cultivating biomass for the express purposes of generating energy makes sense. Might it not be more sensible for biomass materials to be utilized before they are used to generate energy?

2.5 Renewable Energy Directive

Art 2(1) of the Renewable Energy Directive (EU) 2018/2001 defines renewable energy as follows:[27]

> *'energy from renewable sources' or 'renewable energy' means energy from renewable non-fossil sources, namely wind, solar (solar thermal and solar photovoltaic) and geothermal energy, ambient energy, tide, wave and other ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas, and biogas;*

Biogas and landfill gas are effectively defined as renewable energy sources irrespective of source. Biomass is defined, under Art 2(24) of the same Directive (EU) 2018/2001 as:

> *'biomass' means the biodegradable fraction of products, waste and residues from biological origin from agriculture, including vegetal and animal substances, from forestry and related industries, including fisheries and aquaculture, as well as the biodegradable fraction of waste, including industrial and municipal waste of biological origin;*

This definition in particular is counterproductive: the 'biodegradable fraction of waste' is never, at incineration plants, combusted without there also being fossil-derived materials present. The definition allows renewable energy support to be made available to a technology that is powered from a substance – waste – which, far from being renewable, EU policy indicates that we should be minimising. Wastes are not 'renewable'. Whatever the origin of the waste – and it may be a product or some food derived from a resource that has some of the characteristics of being renewable – the waste itself is not something which existing policies want to see generated repeatedly, let alone in a manner that could be considered 'renewable'. As indicated below, incineration also generates power at a carbon intensity that already makes it the most carbon intense source of power in some Member States.

2.6 Summary

The state of existing policy is one where:

1. There are targets for recycling of municipal waste and for packaging waste
2. For waste which is not recycled:
    a. Where an incineration facility treating municipal waste exceeds a threshold which is a proxy for efficiency, it can be classified as 'recovery'. This is the case even though the IED, and before it, the WID, required operators of incinerators to guarantee the recovery of heat 'as far as practicable' in order to secure a permit to operate;
    b. Neither the BREF for incineration, nor any other policy measure (other than where Member States have taken action to fill this gap) considers, let alone, established BAT in relation to, the climate change performance of incineration facilities;
    c. Related to the preceding points, the BREF for incineration plants excludes any meaningful of (pre-)treatment that could improve the performance of the incineration facility;
    d. Where landfilling is concerned, the LFD, through Article 5(3)(a), urges a shift towards recovery of wastes which are suitable for such. This tends to push materials towards municipal waste incinerators that meet the R1 recovery threshold, though not towards those that do not.

[27] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001&from=EN

3. The latest version of the LFD retains the vague wording of the term 'treatment' which the ECJ has sought, with limited success, to interpret. Exactly what 'treatment' means, even under the ECJ's ruling, remains unclear: in particular, what qualifies as 'an adequate selection' of the different waste streams, and 'the stabilisation of their organic fraction' has not been defined;
4. There is no consideration as to whether or not the biodegradability of waste should be considered to be altered by the (as yet, undefined) stabilisation process. Despite the fact that this would be a central component of the rationale for stabilisation, there is no effect, therefore, on the achievement or otherwise of the Article 5(2) targets regarding landfilling of biodegradable waste (BW);

This leads to some key questions:

a) What is the case for expressing – through policy and legislation - a clear preference for R1 incineration relative to landfill in the waste management hierarchy?
b) Is there a case for limiting quantities to be landfilled, irrespective of whether waste has been treated?
c) If the ECJ ruling takes the view that 'treatment' – including the 'adequate selection' of waste - should reduce the environmental impact of landfilling, why is the consideration of 'pre-treatment' under the IED, to be applied to incineration, so limited?
d) To the extent that the ECJ ruling interprets 'treatment' to imply reducing the greenhouse gas emissions from landfill, why are the greenhouse gas emissions from incineration apparently left unabated by any policy or law?

There is, in short, a clear preference for incineration that deserves to be scrutinised. This is closely linked to a lopsided perspective in the procedural approach adopted to the regulation of landfilling and incineration.

3.0 The Case for Revision of Current Policy

The description of existing policy and law in Section 2.0 has highlighted a range of omissions and unsubstantiated positions regarding the way in which the EU currently regulates the main options through which most Member States manage waste which is left after source separation. In this Section, we consider the case for changing the existing body of policy and law, based on an examination of evidence regarding the impact of different approaches to dealing with these 'leftover' materials.

3.1 Evidence from Previous EU Studies

In 2000, a report commissioned by the European Commission was published, presenting economic valuation estimates for externalities associated with landfill and incineration of waste.[28]
The following externalities were considered:

- greenhouse gases;
- air pollutants;
- leachate; and
- disamenity effects.

As is the nature of such studies, the examples included external benefits in the form of displaced emissions from energy recovery.

Three examples were defined for incineration, reflecting different technological standards and levels of energy recovery.

- I1. Plant fulfils the (then proposed) directive on the incineration of waste (Common Position (2000/C 25/02)). Energy recovered will generate electricity and heat (CHP). The percentage recovery is assumed to be 83%.
- I2. Plant fulfils the (then existing) directive on the incineration of waste (89/369/EEC). Energy recovered will generate electricity only. The percentage recovery is assumed to be 25%.
- I3. Plant does not fulfil the (then existing) directive. The flue gas cleaning technology is an electrostatic precipitator. There is no energy recovery.
-

Two examples were defined for landfill disposal of waste, reflecting different technological standards and levels of energy recovery.

- L1. a modern containment landfill that fulfils the demands of the Landfill Directive. The landfill has a leachate collection and treatment system. Further, the landfill gas is collected to generate electricity and heat (CHP).
- L2. an old site without a liner and landfill gas is not collected.

The resulting external costs are shown in Table 1.

[28] COWI (2000) External Costs of Landfill and Incineration, Final Report to the European Commission.

Impact	I1	I2	I3	L1	L2
Global warming	0.8 (0.5 to 1.0)	0.8 (0.5 to 1.0)	0.8 (0.5 to 1.0)	5 (1 to 14)	8 (2 to 23)
Damage from air pollution	20 (5 to 27)	50 (15 to 72)	69 (20 to 108)	0.1 (0.02 to 0.2)	0 (-)
Damage from leachate	0 (0 to 0.3)	0 (0 to 0.3)	0 (0 to 0.3)	0 (0 to 1)	1.5 (1 to 2)
Disamenity	8 (4 to 14)	8 (4 to 14)	8 (4 to 14)	10 (6 to 19)	10 (6 to 19)
Total external costs	**28 (10 to 43)**	**58 (20 to 88)**	**77 (25 to 124)**	**15 (7 to 34)**	**20 (9 to 44)**
Pollution displacement (coal)	-71 (-115 to -19)	-21 (-29 to -4)	0 (-)	-4 (-10 to -1)	0 (-)
Net external costs (displacing coal)	**-43 (-72 to -9)**	**37 (19 to 84)**	**77 (25 to 124)**	**11 (6 to 24)**	**20 (9 to 44)**

Table 1: Summary of externality costs for incineration and landfill scenarios (€/tonne)
Source: COWI (2000) External Costs of Landfill and Incineration, Final Report to the European Commission

The headline conclusion ought, arguably, to have been that even a non-compliant landfill (L2) had lower environmental externalities associated with it than a legally compliant (at the time) incineration facility generating electricity (I2) that was assumed to displace coal-fired power generation. The Scenarios did, however, show a significant improvement (and advantage relative to landfill) of moving to I1, where not only were the air emission limit values tightened as a result of the (at the time, proposed) Incineration Directive, but the assumption was that the energy recovery was much higher. I1 was assumed to be a facility generating combined heat and power (CHP), a configuration which delivers a higher quantity of useful energy. The assumption for the facility was that the energy it would displace was generated from coal. Closer inspection reveals that the study incorrectly assumed that the CHP facility would generate the same amount of electricity (25% relative to the lower heating value of waste) as the efficient electricity generating facility, with the balance of the 83% energy recovery (58% of the net calorific value of the waste) recovered as heat. Technically, such performance is probably impossible to achieve since the generation of power usually occurs at the expense of the possibility for heat recovery, typically in the ration of 1 unit of power to 3-4 units of heat. The effect, in the analysis, was to overstate the benefit from avoided emissions (especially, those linked to CO_2, NO_x, SO_x and particulate matter) where the CHP incinerator was concerned.

Nonetheless, it is a trivial change to simply 'swap', in I2, the figures for the 'damages from air pollution' to those for I1. This would give externalities from an I2 variant compliant with the (at the time proposed) WID compliant of €7 per tonne, as opposed to €11 per tonne for a landfill compliant with the Landfill Directive. These are not enormous differences.

The study did also consider what might be the position, for incinerators, if the source of energy which was being displaced was different. It assumed 'oil' as the alternative source in a sensitivity analysis. Oil is, clearly, not exactly a low-carbon source of energy, but nonetheless, this change worsens I2's net performance by €7 per tonne. Once again, if one reduces the net position to reflect compliance with tighter limit values, then once one assumes displacement of oil rather than coal, the position is one where an incinerator generating power, and complying with the WID, generates (marginally) greater externalities than a Landfill Directive compliant landfill.

Impact	I1	I2	I3	L1	L2
Total external costs	**28 (10 to 43)**	**58 (20 to 88)**	**77 (25 to 124)**	**16 (7 to 34)**	**20 (9 to 44)**
Pollution displacement (oil)	-37	-14	0	**-3**	
Net external costs (displacing oil)	**-9**	**44**	**77**	**13**	**20**
Complying with the WID limit values		**14**			

Table 2: Summary of externality costs for incineration and landfill scenarios (€/tonne)

It was clear, even then, that the supposed superiority of incineration relative to landfill rested significantly on the reliability of the assumption that the source of energy being displaced would always be derived from a fossil-carbon source, especially one which also emitted considerable quantities of air pollutants.

3.2 Review of Other Studies

3.2.1 Cost-benefit Analysis

Research undertaken for the UK's HM Customs & Excise (HM C&E - the body responsible for tax collection in the UK, since renamed HM Revenue and Customs) was intended to inform an ongoing debate concerning the merits of an incineration tax.[29] Like the CSERGE et al study in 1993 that the government had used to inform setting the landfill tax, the valuation of externalities was confined to a relatively narrow range of pollutants. The focus was on PM, SO_x, NO_x and VOCs, as well as CO_2 and CH_4. Given that the study identified estimates from the literature associated with a wide range of pollutants, this is quite surprising. At one point in the study. The authors note:

> *The remaining air pollutants are: HCl/HF, 1,1-Dichloroethane, Chloroethane, Chlorothene, Chlorobenzene, Tertrachloroethene, Arsenic, Benzene, Cadmium, Nickel, Mercury, Dioxins and Furans, Polychlorinated Biphenyls. Valuation studies for these air pollutants are limited to their health impacts, i.e. cancer and deaths brought forward, as identified in the scientific study and covered in Section 4.1. Thus, to determine*

[29] Enviros, University of Birmingham, RPA Ltd., Open University and Maggie Thurgood (2004) Review of Environmental and Health Effects of Waste Management: Municipal Solid Waste and Similar Wastes, Final Report to Defra, March 2004); Enviros and EFTEC (2004) Valuation Of The External Costs And Benefits To Health And Environment Of Waste Management Options Final Report for Defra, December 2004.

per kg estimates per pollutant, these health impacts need to be multiplied by the number of cancer cases and deaths brought forward per kg of pollutant.[30]

The statement is never really followed up, either in the externalities report, or the 'combining' report of HM C&E. Evidently, to the extent that many emissions which may be of significance are effectively attributed a zero damage cost, then other things being equal, the externalities from both landfill and incineration are likely to be different from their actual value. Whether they should be higher or lower depends upon the balance of direct impacts and the offsets associated with avoided pollution. It is, perhaps, worth commenting in this context that a more recent Norwegian study suggested that pollutants such as chromium, manganese (two pollutants not mentioned in the italicized paragraph above) and dioxins account for up to 85-95% of the total socioeconomic costs of waste incineration.[31]

Second, the valuation of the damages associated with the individual pollutants is at variance with the estimates being derived from other sources. In itself, this is not surprising, and indeed, it is positive to the extent that the study seeks to derive project-relevant estimates. Rather, it is difficult to find two studies that give identical results.

In Europe, successive attempts had already been made (at the time of the study) in the context of the ExternE programme, the development of the Benefits Table (BeTa) database, and shortly after the study was published, damage cost estimates from the Clean Air for Europe (CAFE) programme, to arrive at a 'best estimate' of the damages associated with the pollutants being examined.[32] Given that knowledge of the health effects of various pollutants is always 'work in progress', and that some methodological issues are generally contestable in the approaches to valuation, it is to be expected that estimates will vary across studies. However, the values derived for use in the HM C&E study are almost all lower than those derived for the UK in the CAFE study. Indeed, only for PM does the high end of the range used in the body of work we are discussing overlap with any part of the range deemed appropriate from the UK-based modelling under CAFE.

The estimates are considered conservative partly because a view from COMEAP - put forward in 1998 – suggested that several impacts should not be valued because 'accurate' dose response functions could not be agreed upon. The values in the report, therefore, omit a range of health effects typically captured in EU studies, such as:

1. Congestive heart failure;
2. Restricted activity days;
3. Bronchodilator use;
4. Cough;
5. Lower respiratory symptoms – on children;
6. Cerebrovascular hospital admission;
7. Chronic bronchitis;
8. Chronic cough;

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[30] Enviros and EFTEC (2004) *Valuation Of The External Costs And Benefits To Health And Environment Of Waste Management Options* Final Report for Defra, December 2004.

[31] ECON, Senter for økonomisk analyse (Centre for Economic Analysis) (2000) *Miljøkostnader ved avfallsbehandling.* ECON-report 85/00. The study is one of a number which were not considered in the review of external costs of waste management undertaken in the context of the health Effects work, including a number undertaken for the European Commission.

[32] See European Commission (1998) *DGXII (JOULE Programme) Externalities of Energy. ExternE Project, Report Number 10, National Implementation.* Edited by CIEMAT. Report available from European Commission DG Research; M. Holland and P. Watkiss (2002) *Benefits Table Database: Estimates of the Marginal External Costs of Air Pollution in Europe,* Database Prepared for European Commission DG Environment; AEAT Environment (2005) *Damages per tonne Emission of $PM_{2.5}$, NH_3, SO_2, NO_x and VOCs from Each EU25 Member State (excluding Cyprus) and Surrounding Seas,* Report to DG Environment of the European Commission, March 2005.

9. Asthma attack;
10. Minor restricted activity day.

The report from HM C&E derived, from the Enviros et al study and the Enviros and CSERGE study, values for the externalities from landfills and incineration. Results for what is termed the Central High scenario are given in. Taking the results at face value, then as Table 2 shows, the effect of using relatively low unit damage costs for non-greenhouse gas emmisions is to render nothing important other than greenhouse gases. This is not exactly profound.

Externality	Incineration with Energy Recovery	Landfill (medium) – Gas Flared	Landfill (medium) – Gas Used to Generate Electricity
Costs	-£19.11	-£9.83	-£12.04
of which:			
CO_2	-£19.09	-£3.82	-£5.73
CH_4	-£0.01	-£5.99	-£6.30
VOCs	-£0.00	-£0.00	-£0.00
SO_2	-£0.01	-£0.02	-£0.01
Health	-£0.01	-£0.00	-£0.00
Benefits	£6.16	n/a	-£2.15
Net Costs	-£12.95	-£9.83	-£9.89

Table 3: Externalities as reported by HM C&E for Central High Scenario
Source: HM Customs & Excise (2004) Combining the Government's Two Heath and Environment Studies to Calculate Estimates for the External Costs of Landfill and Incineration, December 2004.

Interrogating these figures and their provenance, it is very difficult to reproduce the same numbers using the underlying data. The air pollution effects appear to have been miscalculated. In the central high scenario, the effects from SOx, NOx, VOCs and PM, even using the relatively conservative damage costs used in the study, are around £3.19 per tonne for incineration (319 times what is stated in the report) and £0.83 and £0.35 for the two landfill scenarios.

By way of comparison, if the same emissions data were used, but one used the high end estimates from the CAFE work, the externalities associated with the same pollutants are in excess of £15.00 per tonne for incineration, and around £6.00 per tonne for landfill with flaring. The difference in estimate is driven mainly by the emissions of NOx. In the majority of studies we have reviewed, especially where the approach to valuation is a conservative one (focusing on a restricted range of pollutants), NOx-related externalities have usually been the most significant contributors to the non-GHG externalities associated with incineration. The Enviros and EFTEC report effectively reduces their significance by assigning what appears to be an extremely low unit damage cost for NOx. The incorrect calculation in the HM Customs & Excise work merely exacerbates this.[33]

[33] The Enviros and EFTEC report reviews ten secondary studies which provide valuation data for NOx. Only one has used a figure for NOx which is lower than the 'high' value derived in the context of the Enviros and EFTEC study. That study was carried out in 1995. All the others that were reviewed have been conducted more recently.

Notwithstanding the above, the externalities of incineration exceed those of landfilling. This is despite the omission of disamenity from the analysis, justification for which appears to have been that transferring the estimate from a US study gave figures that '*seem disproportionately large*'. A Dutch study, conducted around the same time, indicated:[34]

> *Given these findings, we assume that the disamenity effects differ between landfilling and incineration. First, the reduction in house prices seems to be more pronounced with incineration. This may be due to the fact that incineration is mainly disliked because of the perception of air pollution. In the Netherlands, since the negative publicity of the emissions of the highly toxic dioxins in the early 1990s, people are more reluctant to live near an incinerator. Even if the legal standards are met, the fear will not disappear immediately. Second, due to the importance of air emissions and the height of the stack, the impact area of an incinerator is significantly larger than the area affected by a landfill site. Therefore, the area of affected houses around the landfill site is limited to a buffer of 1 kilometre around the site. The impact area of incinerators in the Netherlands is assumed to reach as far as 5 kilometres from the actual site.*

Even though the UK had already implemented a tax on landfilling, despite the greater externalities from incineration, no action was taken to implement a tax on incineration.

As part of a larger report by the Copenhagen based Environmental Assessment Institute, Dijkgraaf and Vollebergh ask whether available social cost-benefit evaluations of waste disposal provide support for the strict application of the waste hierarchy.[35] Of studies reviewed, two found incineration to be preferable to landfill from a social cost perspective, in support of the EU hierarchy. However, three other studies found that landfilling was the better option.

The report also refers to an earlier study by the authors.[36] This detailed the findings in terms of private, environmental and total social costs arising from landfilling and incineration. This multiplied the net private and environmental costs per tonne of each treatment option in each of the EU-15 countries by total municipal waste arisings for that country. While total environmental costs for landfill are shown to be higher, the private costs of incineration are more significant, with the overall result that the net costs to society of incineration are greater than those for landfill.

The authors added a number of qualifications that must be borne in mind when interpreting these results, for example, the extent to which methane is used as a source of energy generation. This can have a great influence on the relative social costs of landfilling versus incineration.[37] This is due not only to savings in energy production, but mainly the much lower emissions to air if methane is collected and used as an energy source. In addition, they noted that the benefits of incineration due to displaced emissions from electricity generating plant can sometimes be overstated. It is therefore important to know the reference energy generation technology that is assumed to be displaced. Some studies assume this to be a coal fired plant. Others assume gas-fired plants, which result in a much lower saving in emissions from incineration

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[34] Bartelings, H., P. van Beukering, O. Kuik, V. Linderhof, F. Oosterhuis, L. Brander and A. Wagtendonk (2005) Effectiveness of Landfill Taxation, R-05/05, Report Commissioned by Ministerie von VROM, November 24, 2005.

[35] E. Dijkgraaf and H. Vollebergh (2005) Literature review of social costs and benefits of waste disposal and recycling, in EAI (2005) *Rethinking the Waste Hierachy*, EAI: Copenhagen, pp. 80-98.

[36] E. Dijkgraaf and H. Vollebergh (2004) Burn or bury? A social cost comparison of final waste disposal methods, *Ecological Economics*, 50, pp.233-247.

[37] E. Dijkgraaf and H. Vollebergh (2004) Burn or bury? A social cost comparison of final In addition, the benefits of incineration due to displaced emissions from electricity generating plant can sometimes be overstated. It is therefore important to know the reference energy generation technology that is assumed to be displaced. Some studies assume this to be a coal fired plant. Others assume gas-fired plants, which result in a much lower saving in emissions from incineration waste disposal methods, *Ecological Economics*, 50, pp.233-247;

Indeed, previous work by the authors had concluded the following for facilities in the Netherlands:[38]

> *Our average cost estimate of the two best available options in the Netherlands indicates a much higher gross environmental cost for a WTE plant than for a modern landfill. Only if the current energy system is rather polluting are WTE plants attractive relative to landfills from an environmental cost perspective alone. Certainly, in countries such as France and Belgium, with their much lower climate change emissions from the electricity sector, WTE plants may be a very expensive climate change abatement option. The net private cost is so much higher than that for landfilling that it is hard to understand the rationale behind the current hierarchical approach towards final waste disposal methods in the EU. Landfilling with energy recovery is much cheaper, even though its energy efficiency is considerably lower than that of a WTE plant.*

Once again, therefore, the suggestion is that the balance of the externalities assessed does not so obviously favour incineration over landfill. Furthermore, to the extent that any environmental advantage of incineration may be said to exist, the authors' work suggests that those benefits would be generated at an excessive private cost.

These studies, and the related insights, were in the public domain at the time the Commission undertook specific actions to define, through the R1 criterion, municipal waste incinerators as 'recovery', as opposed to 'disposal'. As far as we are aware, no Member State sought to re-define the hierarchy, as it might well have sought to do, on the basis of 'life-cycle thinking': there would have been a reasonable argument for re-defining incineration as 'disposal' in all cases, especially in those countries where energy systems were already significantly decarbonised.

Later, in the context of the development of the new landfill target, analysis was undertaken of Scenarios 'with' and 'without' landfill restrictions (with other things remaining equal). The analysis indicated that the inclusion of such limits, which were modelled as having the effect of shifting landfilled waste into other options, mainly incineration, then the effect on net social costs was to increase them:[39]

> *The inclusion of a landfill reduction target on top of the MSW and packaging waste recycling packages lead to reduced benefits at society level even though these benefits remain overall positive. For example, Option 3.9(c) sees the benefits at society level reduced by € 2.5 billion over the period 2015-2035 relative to Option 3.9(a): the only difference between these two variants is a restriction on landfilling of MSW to 10% of the total in the case of option 3.9(c).*
>
> *The main reason for this is that the environmental benefits generated by a switch from landfill to other residual waste treatments are not sufficiently high to compensate for the financial costs of such a switch. Indeed, a landfill reduction target would force any residual waste out of landfill into more expensive residual waste treatment options, such as incineration or mechanical biological treatment. This explains why for many countries, and the EU28 as a whole, the addition of a landfill diversion target would be slightly more costly than the options which do not include it.*

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[38] Dijkgraaf, Elbert; Vollebergh, Herman R.J. (2003) Burn or Bury? A Social Cost Comparison of Final Waste Disposal Methods, Nota di Lavoro, No. 46.2003, Fondazione Eni Enrico Mattei (FEEM), Milano.

[39] European Commission (2015) Commission Staff Working Document: Additional analysis to complement the impact assessment SWD (2014) 208 supporting the review of EU waste management targets, Brussels, 2.12.2015, SWD(2015) 259 final.

The underlined element above can be read as indicating that any benefits of the switch away from landfill are not justified by the much higher costs. Nonetheless, the landfill restriction was introduced, as indicated above. The document sought to rationalise this decision:

> *it should be noted that some important environmental benefits linked to landfill reduction measures (e.g. leachates and water pollution, effects of odours and bio-aerosols as well other nuisances, impacts on landscape and financial inconveniences linked with living in the vicinity of waste treatment facilities) cannot be monetised and are therefore not factored in the cost-benefit analysis. This is mainly due to the absence of proper methods to quantify such impacts. As explained in the impact assessment (page 30) social acceptance remains a key issue and this is particularly valid in the case of landfilling even though it might also be valid in case of incineration in some Member States. For all these reasons, the benefits of the options aiming at reducing landfilling are likely to be underestimated.*

This, though, cannot be stated with certainty: most studies indicate – mainly owing to the higher local population densities – that disamenity impacts associated with incineration plants are higher, per tonne of waste, than for landfills (which are generally sited away from more densely populated areas). The study cited above – by COWI – is an exception. However, it assumed a population density around the typical incinerator of 120 per square mile. Eunomia et al suggested incinerators are rarely located in such sparsely populated areas, and that the population densities are typically an order of magnitude larger. They suggested if COWI had used a figure of 1,200 households per square mile (469 per square kilometre), the values derived for a 200,000 tonne incineration facility, with the annual disamenity being set at 8% of the total, would have been around €75 per tonne (around ten times the level reported in the study).

The justification for decisions that have been taken, therefore, to:

a) demarcate incineration as 'recovery' rather than 'disposal' (thereby placing incineration in a privileged position relative to landfill); and
b) impose restrictions on landfill over and above what might be implied by targets in relation to targets for waste prevention and for recycling

is extraordinarily shaky, and weakening by the year as energy systems decarbonise (a process which diminishes the benefits that were previously linked to incineration).

3.2.2 Greenhouse Gas Emissions

Eunomia's work for Friends of the Earth in 2006, ***A Changing Climate for Energy from Waste***, examined both the carbon intensity of energy generation from incineration plants under various assumptions, and also, compared incineration with other technologies for managing residual waste. Regarding the latter, Figure 1 shows how different landfill and incineration scenarios fared alongside various Mechanical Biological Treatment (MBT) configurations. The assumption regarding the source of energy avoided was that gas-fired power, and gas-fired heat, were being displaced where power and/or heat were generated, respectively.

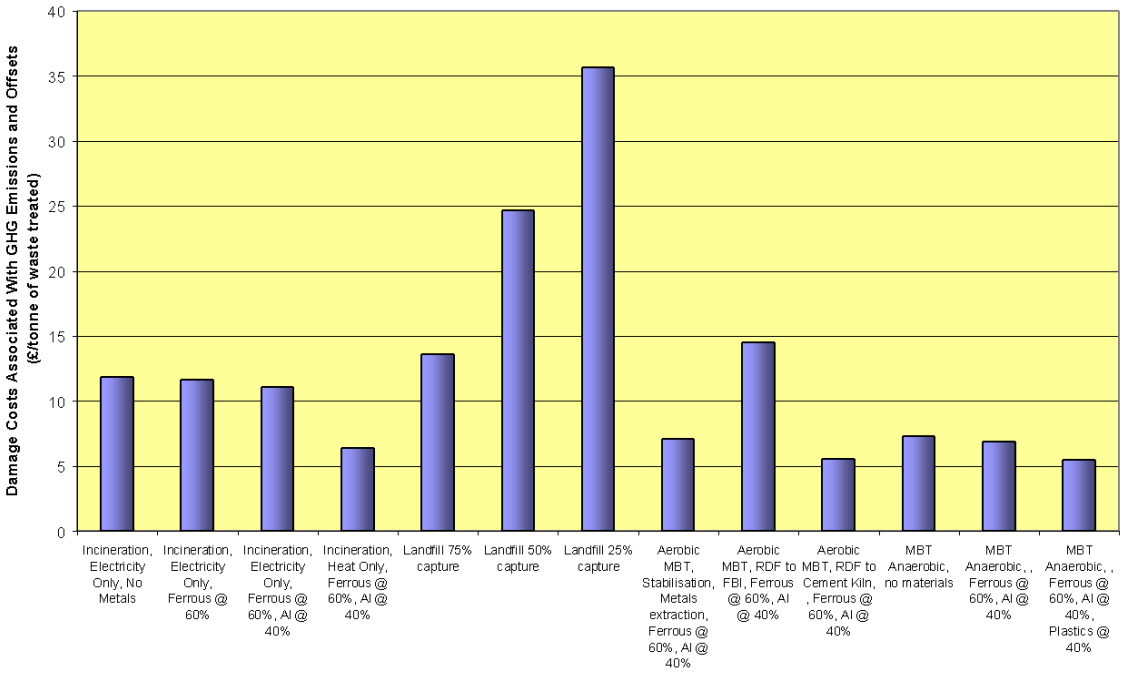

Figure 3: Social Costs of GHG Emissions from Residual Waste Treatments (£/tonne)
Source: Eunomia (2006), A Changing Climate for Energy From Waste - Final Report for Friends of the Earth, p. 19

Regarding plastics, the report made clear the fact that incinerating plastics was problematic:

> *the preferred approach to dealing with plastics from a climate change perspective is not 'using them to generate energy' in incinerators equipped to deliver electricity only since it is extremely difficult – impossible at present – to generate energy from the plastics in such a way that the emissions of CO_2 which result could be sufficiently offset by the generation of electricity from their combustion. On the other hand, the possibility for 'climate credits' from recycling plastics is possible, and with separation technologies improving, this is becoming quite feasible.*

The report concluded:

> *Conventional wisdom has held that climate friendly options for managing residual waste depend upon us generating energy from it. This report challenges that view. It makes clear that if emissions of GHGs are considered as and when they occur, so that impacts on climate changes are understood in the round, then the following attributes are all favourable:*

1. The extraction of materials for recycling;
2. Slower release of GHGs (notably those from biogenic sources which have tended to be overlooked in conventional life-cycle approaches); and
3. The generation of energy, especially where the offset effect is high (in other words, high efficiencies if generation or where there is direct displacement of fossil fuel);

From this, it might be stated that a more climate friendly plant might aim to do the following:

1. *Extract materials for recycling, the emphasis (tonne for tonne) being on aluminium, plastics; steel, and (possibly) textiles;*
2. *Stabilise biodegradable fractions prior to landfilling, preferably generating energy in that process through, for example, anaerobic digestion;*
3. *Generate energy from residual fractions, ensuring that where the materials contain non-biogenic sources of carbon, either the efficiency of generation is very high, or that the material is used in processes where fossil fuels are directly displaced (i.e. what are currently termed recovery processes).*

There are other approaches on the horizon. Extraction of gases, or chemicals for synthesis or use in fuel cell technologies are likely to be possible in years to come.

The key point to be made, however, is that the bland, uncritical and undifferentiated statement that 'energy from waste is good for climate change' is at best partial, is almost certainly incorrect under some entirely reasonable assumptions, and masks a rather more complex reality than most have been prepared to admit.

Studies in some other countries have tended to be more positive regarding incineration. The Umweltbundesamt, for example, has taken a more positive role towards the role of both incineration and co-incineration in relation to climate change. This might be traced, in part, to the focus being partly on 'what has been achieved', the existing incineration facilities having ensured the avoidance of energy sources with relatively high carbon intensity. Germany's power generation remains at just under double the carbon intensity of EU power generation. Equally, some studies have posited low levels of fossil carbon in residual waste being incinerated: work by Prognos, ifeu and INFU published in 2008 indicated that process emissions (before credits) were of the order 300kg CO_2, which (even without consideration of parasitic energy use) implies a fossil carbon content of waste of marginally more than 8% by weight, which is relatively low for residual waste in our experience.

Work by Environmental Resources Management (ERM) for the UK Government's Department for Environment, Food & Rural Affairs (DEFRA) in 2014 looked at how different factors would affect the climate performance, measured in terms of CO_2 emissions only, of energy from waste.[40] The work sought to understand, under various sensitivity analyses, the point at which incinerators would no longer be superior to landfills. It also modelled some specific scenarios for incineration plants depending on the year in which operation was due to (or had) commence(d). This is relevant since the relevant Government departments in the UK have produced trajectories for the expected carbon intensity of displaced power sources into the future.

Consistent with views already expressed, this highlighted the worsening of performance over time for incinerators configured to deliver power only:

> *Using conventional analysis (disregarding biogenic carbon) the model indicates a good carbon case for continuing to include EfW as a key part of the hierarchy. However, as time goes on this case will get progressively worse for electricity only generation as the carbon intensity of the marginal energy mix decreases and if technology for landfill gas capture improves.*
> *The model supports the conclusion that existing plants can and should continue to operate as a better solution than landfill. However, once that plant reaches the end of its planned life (assumed to be 25 years) then a detailed analysis should be conducted to determine whether extending its life is the best environmental option as the model indicates there is a significant likelihood that, from a carbon*

[40] ERM (2014) Energy Recovery for Residual Waste – A Carbon based Modelling Approach, Report for Defra, February 2014.

perspective at least, this will not be the case. Modifying processes to use fuel with a higher proportion biogenic material and with increased efficiency throughout the lifetime of a plant, for example through greater use of heat, will improve its overall environmental performance and may help extend its environmentally beneficial operational lifetime. In particular even relatively little use of heat can significantly improve the lifetime benefits of a plant.

Note that this view assumes that biogenic carbon dioxide should not be counted in the emissions from incineration. That view is consistent with attributing a sequestration credit to that element of biogenic carbon which remains sequestered in landfills. In this regard, the study noted:

> *Including an element of sequestered biogenic carbon in the analysis has a significant impact on the conclusions, dramatically reducing the benefit of EfW over landfill, or alternatively significantly increasing the biogenic content required in the waste for a given plant [to achieve parity with landfilling]. However, it also significantly increases the uncertainty in the model as it becomes highly sensitive to the assumed sequestration levels. The baseline assumptions used in the model assume a very high level of sequestration (around 50%) which could be considered to be an upper limit. On this basis all new plants would need to operate with some degree of refined fuel, where significant fossil plastic recycling occurs resulting in high biogenic content residual waste and/or with significant use of heat.*

This is a somewhat odd perspective: the sequestration is simply the component of the biogenic waste fraction that is not assumed to be otherwise emitted. There is no separate assumption for what is sequestered: the emissions from the landfill are based on the assumed behaviour of material in the landfill, and the sequestered fraction of carbon should, presumably, be determined 'by subtraction'.

Zero Waste Scotland (ZWS) also considered the matter of the climate change impacts of burning municipal waste in Scotland.[41] The central finding was:

> *The average greenhouse gas emissions resulting from sending one tonne of municipal waste to incineration in Scotland in 2018 was 246 kgCO_2e/t. This is 27% less than sending the same tonne of waste to landfill.*

A footnote added that the incinerator emissions per tonne of waste treated would increase to 310 kg CO_2e/t if, instead of using the UK figure for the carbon intensity of displaced power, the Scottish average grid intensity factor was used.
The study considered sensitivity of the outputs to variation in the composition of the input waste, notably plastics, and food and paper. It noted:

> *The net emissions of residual municipal waste sent to both EfW and landfill is highly dependent on the composition of that waste. The fossil content of waste is the most significant factor affecting greenhouse gas emissions per tonne of waste burnt in EfW plants. For landfill, the most significant factor is the biogenic content of waste entering landfill. In this sensitivity analysis, the fossil and biogenic content of waste was varied by changing the composition of residual municipal waste. Waste categories with high fossil carbon content (plastic waste) and biogenic carbon content (food and paper waste) were varied. When fossil carbon increases (e.g. if the proportion of plastic waste in municipal residual waste rises), EfW greenhouse gas emissions rise as more fossil carbon is released into the atmosphere. The net calorific value of waste also rises – burning more carbon releases more energy. EfW and landfill impacts are equal*

[41] Zero Waste Scotland (2021) The Climate Change Impacts of Burning Municipal Waste in Scotland, June 2021.

when the proportion of plastic in residual municipal waste is increased from the main model assumptions by 4.6% from 15.0% to 19.6%.

The study itself noted:

> *The lack of published information on composition and carbon content of waste, along with the natural variability of waste itself means that there is a high degree of uncertainty surrounding these parameters.*

The ZWS study made the same assumptions as the ERM study regarding the carbon content of plastic. The figure used was 52%, and came from a 2006 study, which in turn, sourced the figure from analysis conducted at the turn of the century. This is likely to be an underestimate, recognising that the only polymer with a carbon content lower than this is Polyvinyl chloride (PVC). Polyethylene terephthalate (PET) has a carbon content of around 63%, but is likely to be the polymer recycled at the highest rate in Scotland. Polyethylene, polypropylene and polystyrene (PE, PP and PS, respectively), on the other hand, each have carbon constituents of 85% and more. Of course, waste composition analyses would be expected to be unable to eliminate moisture, for example. The non-plastic element in the separated plastics would, however, have to be of the order 40% to render the 52% figure likely.

The study also omitted to include any sequestration credit for biogenic material sequestered in landfill: the significance of the omission can be appreciated by considering the relevant quote from the ERM study already cited (see above).

Eunomia also conducted a further review of greenhouse gas emissions from residual waste treatment in work for Client Earth. The main conclusions, regarding greenhouse gas emissions from different forms of residual waste management, were:[42]

> *Today, incineration performs better than landfill, largely because of its electricity credit, i.e. the emissions reduction brought about by avoided electricity production elsewhere. Incineration plants operating as CHP perform better than plants generating only electricity. However, in both cases it should be noted that the energy generation performance assumed here is consistent with the best available technology operating in the UK. Many older facilities generating only electricity will perform worse than those modelled here, and the analysis considers one of the best-performing CHP facilities in the UK at the time of writing.*
>
> *Pre-treatment of waste prior to either landfill or incineration would result in a net emissions benefit today due to the additional credit arising from recycled materials, provided that, in the case of landfill, the remaining organic waste in the residual stream was also bio-stabilised prior to sending it to landfill. Under this scenario, the pre-treatment option with incineration performs somewhat better than that of the bio-stabilisation with landfill option. This is because pre-treatment also effectively removes a significant proportion of the remaining fossil carbon contained within the residual waste stream sent to the incineration facility.*
>
> *In the Expected-2035 scenario, which represents the expected residual waste composition and energy context in 2035, electricity-only incineration performs worse than landfill, while incineration operating in CHP mode and landfill are essentially equivalent in climate terms. Note that these results depend to a certain extent on the carbon intensity of the marginal sources of energy: if electricity and heat provision decarbonise less quickly than needed and anticipated, incineration may continue to perform better than*

[42] Eunomia (2020) Gas and Air Quality Impacts of Incineration and Landfill, Report for Client Earth, December 2020.

landfill at this point. This is, again, subject to the previously mentioned caveat that many existing facilities generate energy at lower efficiencies than those considered here.

The results are shown graphically in Figure 4 below.

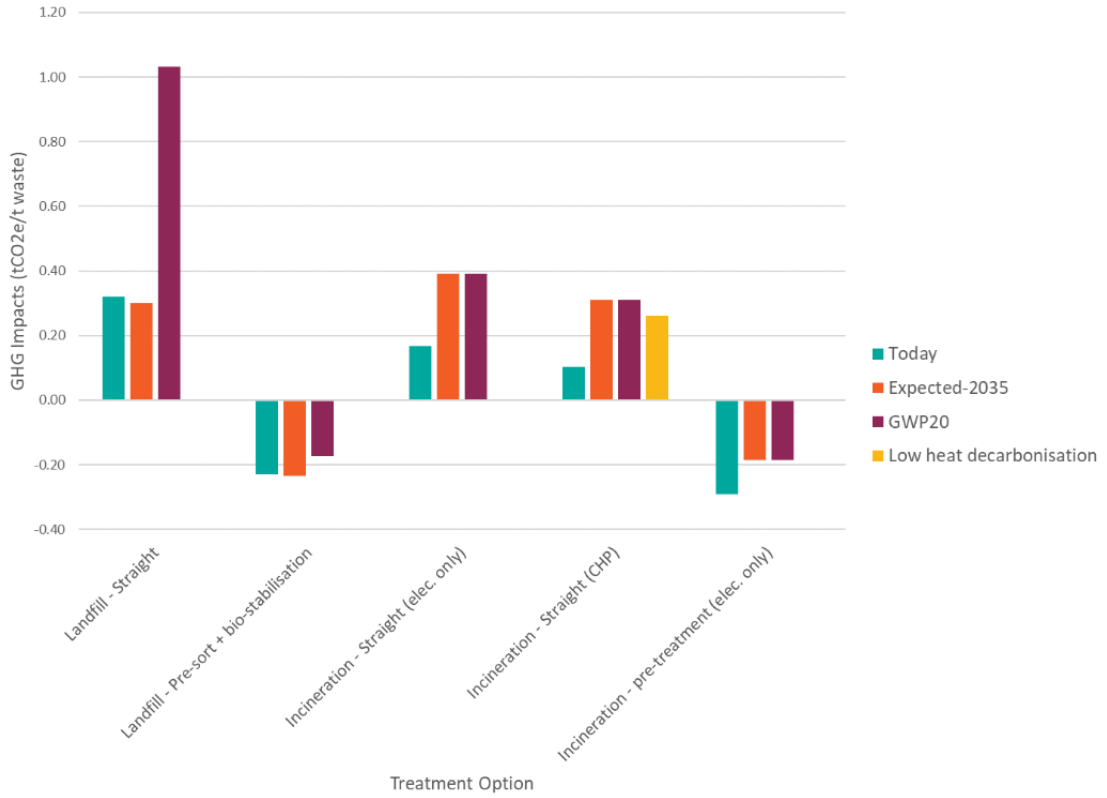

Figure 4: GHG Impacts of Residual Waste Management Approaches under Different Scenarios (tonnes CO_2 equ / tonne waste managed) Source: Eunomia (2020) Greenhouse Gas and Air Quality Impacts of Incineration and Landfill, Report for Client Earth, December 2020.

Interestingly, the same study also reviewed the air quality impacts of the same residual waste treatment options. The study based the externalities on UK government figures for damages associated with specific pollutants, taking the central case for each pollutant. Using these figures, the case for a preference of incineration over landfill is not established. The report does not show the case of incineration with low NOx emissions and 'pre-treatment' (i.e., sorting of waste prior to incineration). The suggestion is that such an option may be the best performing option, or would at least be on par with the landfill plus biostabilisation option.

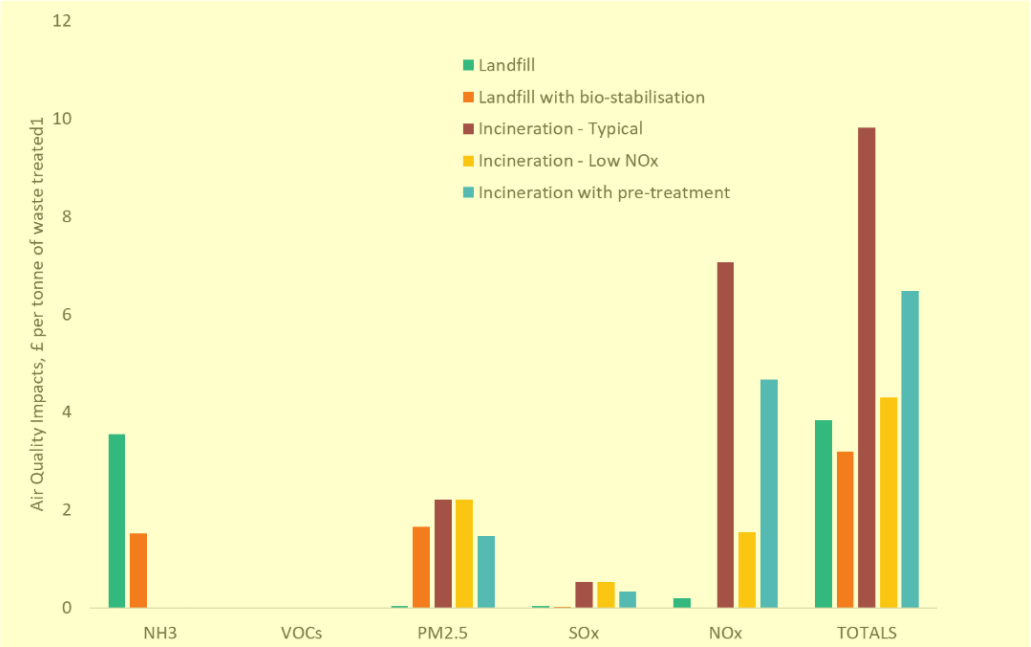

Figure 5: Externalities Associated with Air Quality-Relevant Emissions (£/tonne of waste treated)
Source: Eunomia (2020) Greenhouse Gas and Air Quality Impacts of Incineration and Landfill, Report for Client Earth, December 2020.

Zero Waste Europe has also published an analysis of a similar nature, indicating, stepwise, how different assumptions / background features impact upon the performance of the different technologies.[43] This highlighted not only the impact of changing assumptions about the carbon intensity of 'avoided' energy sources, but also, the impact of introducing mixed waste sorting at the front of landfills or incinerators. It also indicated (see the difference in the two options at the right of Figure 6 below) the impact of introducing stabilisation of the fraction to be landfilled after sorting. The analysis indicated that incineration performs far better when combined with mixed waste sorting. In addition, where waste is subject to mixed waste sorting followed by landfilling of stabilised waste - the Material Recovery and Biological Treatment, or MRBT, option -, the performance is marginally better still, albeit that the difference is small.

[43] Zero Waste Europe (2021) ***Building a Bridge Strategy for Residual Waste: Material Recovery and Biological Treatment to Manage Residual Waste within a Circular Economy***, Policy Briefing, January 2021, https://zerowasteeurope.eu/wp-content/uploads/2020/06/zero_waste_europe_policy-briefing_MRBT_en_with-annex.pdf

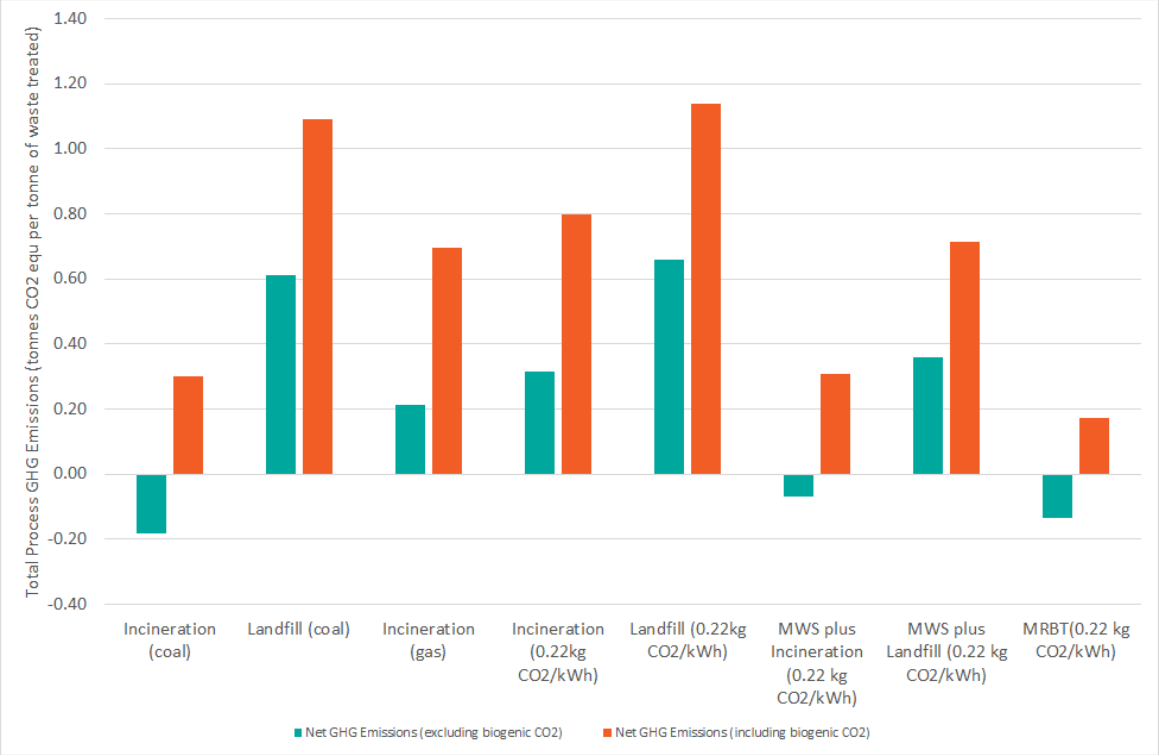

Figure 6: GHG Emissions from Managing 1 tonne of Residual Waste through Different Methods, Assuming Different Carbon Intensities of Energy being Avoided (MWS = mixed waste sorting)
Source: Zero Waste Europe (2021) Building a Bridge Strategy for Residual Waste: Material Recovery and Biological Treatment to Manage Residual Waste within a Circular Economy, Policy Briefing, January 2021, https://zerowasteeurope.eu/wp-content/uploads/2020/06/zero_waste_europe_policy-briefing_MRBT_en_with-annex.pdf

3.3 Summary

The following can be said regarding the environmental impacts of landfilling and incineration:

- Where analyses of the monetised externalities are concerned, the ranking of landfill vis-a-vis incineration of residual waste (which has not been subject to further sorting or stabilisation) has not, over the last twenty years, unequivocally favoured one relative to the other;
- As central estimates of damage costs have changed, the absolute level of the externalities from both sources has increased. This is true for air pollutants, as well as for greenhouse gas emissions;
- The adoption of higher GWP values for methane has tended to worsen the position of landfill vis-a-vis incineration;
- As the source of energy being displaced by both technologies increases, so the position of landfill vis a vis incineration improves;
- Where the residual waste is richer in fossil-carbon sources, so the position of landfill vis-a-vis incineration improves;
- Where the residual waste is richer in non-fossil carbon sources, the position of landfill vis-a-vis incineration worsens.

Once one considers the broader context where energy systems are decarbonising, alongside the potential for sorting and stabilisation to improve the performance of either landfilling or incineration, then the following seems to hold true:

- Whether landfilling or incinerating, deploying systems which sort waste – and enable a 'second pick' at recyclables – improves performance of both landfill and incineration;
- To the extent that each receives the same residual waste, the contribution made by sorting itself to improving performance is the same for both landfilling and incineration. However, the effect of sorting on the remainder – to the extent that such sorting schemes focus disproportionately on the non-degradable wastes as opposed to the degradable ones – is to favour incineration of the remainder rather than landfilling. The majority of the degradable waste that enters the sorting process remains in the output of the process. For incinerators, the main source of fossil-derived CO_2 is significantly diminished;
- It follows that, for landfills, further improvement requires a key source of the remaining externalities – the emissions of fugitive methane – to be addressed. This can be achieved through biostabilisation of the remainder of the waste;
- Where sorting of mixed residual waste is deployed, then if, prior to landfilling, the remaining waste is subject to biostabilisation, then the performance of such a system is potentially superior to the performance of an incinerator. The extent to which the 'landfill route' is superior to the 'incinerator route' depends, at least where greenhouse gas emissions are concerned, on what source of energy is displaced by the management of residual waste. The lower is the carbon intensity of the sources being displaced, the more likely it becomes that the landfill system 'wins';
- At the limit, once energy is fully decarbonised, given that both systems benefit from sorting, then the comparison, as far as greenhouse gases are concerned, reduces to one of the emissions related to the stabilisation and landfilling process, mainly related to any fugitive methane and N_2O, net of sequestered biogenic CO_2, versus the incineration and residuals management process, mainly fossil-derived CO_2 and trace N_2O. As the focus shifts towards achieving a net zero world, so the attention given to these 'minor' greenhouse gases, which though thought to be emitted in limited quantities, have high global warming potentials, seems likely to (and indeed, should) increase;
- Whilst it might be argued that generating more energy from incineration might reduce the requirement for other energy sources to be used, two issues need to be considered:
    - The intention is to reduce waste, not sustain its generation;
    - Of that waste which is generated, neither landfill nor incineration represent a positive approach to managing waste – the aim should be to minimise the generation of residual waste.

We are now in a better position to answer the questions posed at the end of Section 2:

a) **What is the case for expressing – through policy and legislation - a clear preference for R1 incineration relative to landfill in the waste management hierarchy?**
This case has never been especially strong on environmental grounds. It may have been strongest when incinerators operated in a mode where they recovered energy as heat at high efficiencies, and where the heat could be clearly demonstrated to a) be put to a useful purpose and b) displace sources of heat that were of fossil origin. In these cases, not only were the carbon credits highest, but the air quality benefits may also have been significant. The R1 criterion, however, does not limit the qualifying incinerators in this way – it is much more permissive, and makes no reference to the nature of energy sources being displaced.
It may also be considered that the R1 criterion was intended in part to give some effect to the ECJ ruling that the term 'recovery' should denote the replacement of primary resources. Where energy is concerned, the primary resources displaced will increasingly constitute (directly or indirectly) energy

from the wind, or the sun.

The R1 criterion was effectively devised at a time when the relevance of its underpinning rationale was already declining. Furthermore, to the extent that policy should consider not only the environmental costs and benefits, but also the private ones, then one struggles to find any analysis that concludes that the environmental benefits of switching from landfill to incineration – such as they were considered to be positive (and they were not always) – could justify the private costs of the same switch (excluding explicit and implicit subsidies). The Commission was already in receipt of analysis that ought to have led it to focus its attention on more deserving matters.

b) Is there a case for limiting quantities to be landfilled, irrespective of whether waste has been treated?

The case for limiting quantities being landfilled without any treatment is a strong one. In our view, reflecting:

i. the fact that gas capture systems achieve a 'contested' level of capture;
ii. that methane is a powerful greenhouse gas (and one whose warming potential is reassessed on an ongoing basis); and
iii. that the pace of climate change is increasingly influenced by emissions of methane (and other short-lived greenhouse gases);

no waste should be landfilled unless it has been treated. The necessary form of treatment should be one that seeks to reduce the potential of waste to generate methane once it is landfilled in an appropriately designed landfill site (or cell). The definition of treatment needs, therefore, to be clearly articulated. The opportunity to do this, following the Malagrotta ruling, was not taken in the revision of the LFD in 2018. The existing limit on landfilling – alongside this lack of clarity – makes it possible for there to be a continuation of the landfilling of waste that has been subject to limited forms (definitions) of 'treatment' for some time to come. There remains a strong argument, not least given the absence (still) of clarity on how 'treatment' is defined, to ban landfilling of municipal waste that has not been treated prior to consignment to the body of the landfill. This, though, requires a very clear articulation of what is meant by the term 'treatment';

c) **If the ECJ ruling takes the view that 'treatment' – including the 'adequate selection' of waste – should reduce the environmental impact of landfilling, why is the consideration of 'pre-treatment' under the IED, to be applied to incineration, so limited?**

There appear to be three parts to the explanation of this. The first is that the focus of what was the WID, and is now the IED, has been 'pollution'. Carbon dioxide, perhaps oddly, is sometimes not considered as a pollutant in the sense that NOx, or Particulate Matter (PM), are; it does not directly (at least not at existing concentrations) harm human health. Furthermore, many of the installations under the IED (including co-incineration) are subject to the EU ETS, whilst incinerators are not. No pressure, therefore, comes from either the IED/BREF route, nor the EU ETS, to address climate change emissions from incineration facilities. The assumption has been that incinerators displace fossil-derived energy, and hence the emphasis on matters such as the R1 formula under the WFD, and energy efficiency under the BREF/BAT conclusions. It is less than clear that the changed, and still changing, reality in terms of the nature of the energy sources being displaced by incineration plants has really permeated the debate. If it has, its significance (in terms of how this affects the 'net performance' of incinerators) does not seem adequately to have been appreciated. The second part of the explanation relates to the way in which any consideration of 'sorting', even if it was considered relevant to (pre-) treatment prior to incineration, has been balkanised under the IED/BREF process. This 'siloing' of thinking – about 'incineration', and about 'sorting' – is unfortunate. It did not seem to be present when the ECJ mentioned 'adequate selection' as part of its elaboration of what 'treatment' should require. Finally, the potential for mixed waste sorting to play a positive role in a) enhancing materials recovery (and contributing to the Article 1 Objective of the WFD) and b) reducing fossil carbon emissions from incinerators both on an absolute,

and normalised (per tonne) basis, has not been widely understood. Its potential role, however, is significant; and just as the BAT Conclusions make some distinctions between existing and new facilities, it would seem timely to mandate the use of mixed waste sorting (MWS) at the front end of incineration facilities. Clearly, however, MWS has a role to play at landfills also. In conjunction with the answer to b) above, 'treatment', as applied to landfilling of municipal waste should – in line with the ECJ's ruling – include both MWS, and a form of biological stabilisation designed to eliminate methane emissions. In addition, the receiving landfills / cells should be adapted to receive the biostabilised material outputs, notably, in deploying active cover layers designed to ensure that any remaining fugitive emissions of methane are oxidised as they move through this cover layer.

d) **To the extent that the ECJ ruling interprets 'treatment' to imply reducing the greenhouse gas emissions from landfill, why are the greenhouse gas emissions from incineration apparently left unabated by any policy or law?**

As noted above, the IED and the BREF are 'blind' to the greenhouse gas emissions from incineration. This may help explain why the matter of (pre-)treatment is not given closer consideration in these documents. Another explanation may simply be that the matter falls through the cracks: the IED (and the WID before it) focused very much on the emissions from, operation of, and permitting of, the incinerator itself, whilst a separate waste treatment BREF deals with similar matters in respect of other processes. There is no obvious place where consideration is given as to what might best be done to waste that is destined for incineration. This is disappointing since the BREF is supposed to articulate best available techniques: if BAT consists of combining two technologies which can never be considered as a combination, something will be missed.

That this is being missed is disappointing given the way the ECJ rulings have interpreted 'treatment', this being, broadly understood, 'what should happen to waste before it is landfilled'. Given that the ruling did more than simply hint that two things were required – 'selection' and stabilisation – then the fact that the examination of BAT, as regards (pre-)treatment prior to incineration, is limited to matters such as shredding implies inconsistency in the approach. There are, clearly, things that can be done to (pre-)treat waste in ways which improve its performance: even sorting out plastics and sequestering the associated fossil-carbon in a landfill would improve matters as the energy system decarbonises.

Finally, the fact that neither landfill nor incineration are included under the EU ETS is disappointing. Given the potential for overlapping regulation, then it is of relevance that many Member States have made use of taxes on landfilling, albeit few have done so with any recognition given to the role that could be played by stabilisation; the Austrian system was an exception in this regard (and helped incentivise a shift towards treatment prior to landfilling). Also, many taxes remain at low rates.

Some Member States have chosen to include incineration within the EU ETS, but given that co-incineration (cement kilns) is included, and given also that power stations (incinerators generating power are included under the 'energy' Section of the IPCC's inventory) are included and have had free allowances progressively reduced, then including incineration and landfill under the EU ETS would seem an obvious thing to do. Evidently, there would then be a need for Member States to consider their domestic approaches where there was an issue in relation to the overlapping nature of policy instruments.

4.0 Potential Effect of Current Policies

The analysis in Sections 2.0 and 3.0 has highlighted the nature of existing policy, and the case for change. This Section considers what may be the effect of current policies.

4.1 Influence on Waste Management Planning and Practice

In terms of planning for the future management of waste, the focus of Member States is on achieving recycling rates, and also, ensuring they are meeting the targets in relation to the landfill limits under Article 5.
Regarding municipal waste, the targets run as follows:
WFD Article 11(2) (a), (c)-(e):

> *(a) by 2020, the preparing for re-use and the recycling of waste materials such as at least paper, metal, plastic and glass from 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;*
> *(c) by 2025, the preparing for re-use and the recycling of municipal waste shall be increased to a minimum of 55 % by weight;*
> *(d) by 2030, the preparing for re-use and the recycling of municipal waste shall be increased to a minimum of 60 % by weight;*
> *(e) by 2035, the preparing for re-use and the recycling of municipal waste shall be increased to a minimum of 65 % by weight.*

Some Member States may be eligible for derogations, and if they take these up, the above targets are reduce by 5%, and the 65% target is effectively postponed for five years.

Regarding landfilling, under the LFD Article 5(5), Member States are paying close attention to the following:

> 5. *Member States shall take the necessary measures to ensure that by 2035 the amount of municipal waste landfilled is reduced to 10% or less of the total amount of municipal waste generated (by weight).*

Again, some Member States may be eligible for a five year derogation, in which case, they must have reduced the amount of municipal waste landfilled to 25% or less of the total amount of municipal waste generated (by weight). Derogations from the landfill target are available for those Member States who landfilled more than 60% of their municipal waste generated in 2013 (as reported under the Joint Questionnaire of the OECD and Eurostat). This would appear to make the following eligible for the derogation, should they wish to take it up: Bulgaria, Greece, Croatia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Romania and Slovakia.

In addition, Estonia would be eligible for the derogation from the recycling target by virtue of its reported recycling rate for municipal waste being below 20% in 2013 (all the above countries, except Latvia, Lithuania and Hungary, also had recycling rates below 20%).

If one considers the targets alone, and their sequencing, then in principle, the recycling targets ought to take precedence in time. The Member States could wait until 2030 before they needed to be unduly concerned about the limit on landfill. After all, the nature of what is required might be achieved through a switch from landfill to incineration as long as that commences sufficiently in advance of the target date.
In practice, some Member States seem to be responding to the landfill limit much sooner than the targets alone would suggest is required. This is not surprising, for some of the reasons we have reviewed above.

Notwithstanding the weakness of the argument for doing so, policy repeatedly exhorts Member States to avoid disposal, or avoid landfilling, or to prioritise any form of recovery over disposal, and these exhortations are ones that have effect well in advance of the landfill target.

The concern this raises is principally in regard to the potential for locking-in excess capacity for incineration at a relatively early stage in the development, by Member States, of a strategy to achieve a 65% recycling rate, and ensure responsible management of 'the rest'. This is by no means inevitable, but there are tendencies in this direction, and we explore some of them here.

First of all, waste is not managed locally by means of percentages. The analysis of how to manage waste in future is generally affected by the assumptions which are made regarding the likely evolution of waste quantities over time. In the case of incineration facilities, given the expected lifetime of the facilities, or indeed, the anticipated length of any contract which may be concluded with a service provider. The latter may vary depending on the nature of the contract, but the former might typically be of the order of twenty years.

It is challenging, on the basis of poor quality data, whose quality may also be evolving over time, and where consumption trends and economic trends may exert varied influences, to predict how the world will look in twenty years' time. We are experiencing rapid social and economic changes, and Member States seeking to understand how much residual waste might be present in twenty years' time need to consider:

1. How much waste they will be managing in future (and this might not simply reflect 'quantitative change', but could also reflect changes in scope of operations, for example); and,
2. How much waste they will be recycling in future (and this has to consider not only 'targets', but the potential to go further).

From personal experience, these are extremely challenging projections to make. We would go further than that – they are actually impossible to make with any accuracy given the range of influencing factors. Nonetheless, there is a tendency to allow for growth in the former factor (the amount to be managed), and waste industry representatives are generally supportive of this. The concept is usually that there is 'likely to be' growth in the economy, or in consumer spending, or in population, or in housing, or in a combination of these. In short, there is a tendency to avoid planning for a reduction in waste 'in case we do not have sufficient capacity'. The 'precautionary principle' is applied not in terms of actions, but in respect of planning, reflecting the perspective of bureaucrats whose greatest fear is that there might, in future, be no place for residual waste to go.

This fear is understandable, but it also highlights the root of the problem why incineration may be the most likely technology to undermine waste prevention and recycling. The nature of the facility appears to demand that the facility is sized for the largest amount needing to be managed over a twenty year or so lifetime. This, coupled to the concerns that waste needs 'a place to go', and with those responsible for procurement/financing persuaded of the merits of economies of scale, tends to lead to overspecification of capacity.

This overspecification happens at a local or regional level, not a national one. The often presented graphic of Member State data that supposedly showed the easy co-existence of incineration with high recycling rates somewhat misses the point: the overspecification has greatest relevance in a local context. Ironically, the solution to overcapacity in northern Europe has been to increase reliance on imports of waste from countries such as the UK. This has helped avoid the worsening of a problem which could otherwise have led to companies having to sell facilities at prices sufficiently low that new owners could cover their costs through the gate fees they might have expected to attract.

An incinerator has the character of a 'flow' facility – it can handle a maximum quantity, influenced by the calorific value of the waste. Its economics work on the basis of the capital investment being paid down over time by a

stream of 'net revenues', or the amount by which revenues exceed operating costs. Revenue streams include the sale of heat and power, the sale of recovered metals / other materials, and the gate fees which the operator is paid by the user for the service provided. Costs, on the other hand, include labour, maintenance, auxiliary materials, and (usually) payments for the handling of both bottom ash, and air pollution control residues. Without a high and constant flow of wastes, either the rate at which the capital and financing costs are paid down is reduced, or perhaps more likely, as capital repayments are likely to be required, the net revenues decline, and may even go negative. The fixed capital amount is important in this respect.

The economics of incineration therefore tend to command a flow of materials for the project to succeed, and this is why, where private companies, and private funders are involved, it can be the case that contracts are concluded in which there is a guaranteed minimum tonnage (GMT), or 'put-or-pay' tonnage, specified. This tonnage is the amount the procuring authority agrees to guarantee to the operator, enabling financial backers to have sufficient certainty that the financing can be repaid with the relevant rate of interest/rate of return on investment.
If forecast quantities are other than what the procuring authority may have envisaged, then the quantities that the procuring authority has to be treated as residual waste may decline significantly (relative to forecast). It is not unheard of for authorities then to fall below the GMT, or indeed, for them to put the brakes on recycling performance to ensure that the GMT is maintained. If the quantity falls below the GMT, then typically, a contract will require the authority to pay the associated gate fee for the quantity by which the GMT is 'missed', albeit the authority may be able to find wastes from other sources to fill that gap (depending on the wording of the contract). The point here is that if the authority does, or can do better, on recycling and waste prevention than was forecast, then it may be confronted either with financial penalties or with a decision to de-emphasis these programmes.

Landfill itself has more of the character of 'a stock facility'. There is a 'stock' of void space to be filled which, in principle, can be filled at a varying rate. A reduction in quantities for a landfill is not of no significance: landfills have operating costs, and their construction also incurs the deployment of capital. The quantum of capital involved, however, is far lower than for incineration facilities. That tends to lead to contracts being of somewhat shorter duration (even if the site has a longer life), and their being less likely to include provisions for a GMT (and even if they do, the shorter contract duration makes it less risky to agree to that). There are, for a landfill receiving untreated waste, fewer revenue streams: the main one is in relation to the sales of energy generated from methane captured for energy generation from the site. Not only are there ongoing costs, but the gate fees paid for the service offered typically include an element that has to be used to accrue revenues to fund aftercare once the site closes. If sites never receive the quantity of waste they were expecting to fill their void space, then this can lead to problems in respect of funding that aftercare.

Whatever the shortcomings of landfills, their flexibility can be helpful as strategies to improve waste management evolve. There is a reduced (not zero) potential for regret in terms of facility sizing, and there is a lower sensitivity in relation to the rate of throughput into a site, at least within reasonable ranges. The associated capital costs are relevant here. Also, it should be considered that where facilities are not benefiting from inflated prices for heat in particular (for example, as a result of heat from waste being exempted from taxes applied to domestic heating fuels), then the costs of landfills are much lower than the cost of incinerators, viewed from an economic perspective.

4.2 Potential Implications for a Circular Economy

The concerns, therefore, that arise at present are that several Member States are embarking on a path that:

1. May imply additional costs during the transition to a more circular economy, and to the existing EU recycling targets;
2. Because of their early commitment to incineration, as opposed to more flexible means of managing waste, reduces the emphasis likely to be give to either exceeding recycling targets, or more importantly, reducing waste generation; and
3. Because there is still no consideration through the BREF process to how best to treat waste prior to incineration, it remains likely that these facilities will be significant emitters of fossil carbon, and forego the potential for improved recycling through sorting of mixed waste prior to the incineration process.

For this reason, Member States need an option that allows them to avoid over-commitment to incineration, whilst managing residual waste responsibly.

This can happen to a limited extent under the existing targets. If the 10% landfill limit is based on a 'landfill system' where:

- Sorting removes 15%, by weight, of materials for recycling;
- The subsequent stabilisation process leads to a further 25-35% mass loss in respect of moisture, and loss of carbon in the organic fraction of waste as CO_2;

then the 10% limit might translate into a maximum of around 23% of material being treated through this type of process. Only if the Member State concerned achieved a 77% recycling rate prior to mixed waste sorting would they be able to avoid committing some waste to incineration or co-incineration. Note that there is no way that incineration can be avoided at 65% recycling, even if, for example, there was a herculean effort made in respect of waste prevention. That is because of the way that the landfill limit is set – in terms of a percentage of what is generated – which does not recognise the effect of reducing the quantity of municipal waste generated. The previous Article 5(2) target did credit prevention, but only within a target which was too awkward to properly measure.

For Member States seeking to implement a truly circular economy, especially those starting from a lower base in terms of recycling (some of whom may generate lower quantities of municipal waste), avoiding too much capacity for incineration, especially in local / regional contexts, is important. A sensible strategy for Member States to adopt under the existing policies might be to consider how, spatially, and over time, the different residual waste treatment options might best be deployed. Flexibility is likely to be key given uncertainties over projections of quantities needing treatment over the longer term, and the desirability of avoiding making fixed investments in capacity that might not be needed under the most positive scenarios for prevention and recycling. Evidently, introducing high quality mixed waste sorting facilities as well as the necessary facilities for biostabilisation, changes 'the landfill system'. For a start, the capital requirement per tonne of waste being received increases relative to the case of landfilling untreated waste. The costs of the sorting (and washing) infrastructure and the costs of the stabilisation operation are largely additional. Furthermore, although the final output – the stabilised biowaste to be landfilled – still has the character of a 'stock' facility, the economics of the sorting facility will be affected by the fluctuating revenues received for material sales. The stabilisation process also needs to be appropriately sized. This has more the character of a 'flow facility', albeit with a lower capital commitment than for an incineration facility. Some of the 'limited regrets' flexibility of untreated landfilling are, therefore, sacrificed in favour of enhanced performance when switching to a facility based on sorting,

stabilisation, and then landfilling of the treated fraction. Even so, the magnitude of regret will be more limited, in line with the reduced overall capital commitment.

There is also some potential in the case of mixed waste sorting systems – whether at the front of landfills or incinerators – to capitalise on the potential for financial support (or even, direct financing) via extended producer responsibility schemes. The targets for recycling of plastic packaging are likely to challenge some, if not all, Member States. The additional contribution that can be made, therefore, by mixed waste sorting facilities could be supported by Extended Producer Responsibility (EPR) schemes.

5.0 Proposals for Change

Following on from the preceding analysis, there are a number of possible changes to existing EU policy and law that may be considered. The fundamental principle, however, is based around 'levelling' the playing field for the management of residual waste so that there is no longer a presumption against landfill irrespective of the treatment, and irrespective of the effect of a decarbonising energy system on the performance of incineration. These are presented in a 'tiered' form, broadly implying a progressively increasing number of changes. All of them, however, imply a need to address the imbalance if not between 'landfill' and 'incineration', then between 'incineration' of waste, and 'treating and then landfilling waste in a suitably adapted site or cell'. The clear case for implementing sorting of residual waste prior to incineration is also made in some of the options proposed, recognising the potential benefits in terms of reducing emissions of greenhouse gases. Depending on the ambition of the EU, given what we understand about different waste management options, then where residual waste is concerned, the aim ought to be to minimise the quantity generated, and ensure that what is generated is managed so as to minimise its environmental impact. In a world where energy generation must become progressively cleaner, improving environmental impact is no longer synonymous with generating as much energy as possible.

5.1 Option 1

This Option is based around changing the existing Article 5(5) targets in the LFD, restricting landfilling of municipal waste, to focus on landfilling of waste which has not been treated in line with a clearly agreed specification of 'treatment'. This requires a number of changes to be made to existing policy and law.

5.1.1 Define 'Treatment'

We have highlighted in this document the lack of clarity regarding the definition of 'treatment' as regards what should happen prior to any waste being landfilled.
It is necessary to define 'treatment' as per Article 6 of the LFD. Indeed, it may be more appropriate to define this as 'treatment of waste prior to landfilling', since the terms 'treatment' and 'pre-treatment' are used widely in documents concerning waste. The treatment would be defined to require:

- The sorting of the waste, with sorting defined through the process set out at Article 27 of the WFD). Such a definition could, potentially, alter the sorting requirements in line with what is achieved through source separation;
- The subsequent stabilisation of any waste destined for landfill. Here, it should be considered that the way in which 'thresholds' have been set in the past have differed across countries. The objective should

be to ensure the prospects for fugitive methane emissions are minimised through the combination of stabilisation, and the use of suitable oxidation layers at the receiving landfill.

- In respect of the former, a level of stability at, or equivalent to, the level considered in the Draft Biowaste Directive, of 10mg O_2 / g dm, or equivalent measure, gives a suitable measure that would reduce the potential for methane generation to a significant degree without incurring excessive cost.
- In respect of the latter, the General Requirements for all Classes of Landfills, set out at Annex I of the LFD, could be amended to consider appropriate cover layers, and might para 4, regarding Gas Control, could be amended such that the need for gas control was linked to whether or not waste was treated, and the nature of the oxidation layer used.

This definition would, as per reviews undertaken in Section 3.0, ensure that the 'landfill system' was comparable, possibly better than, incineration in terms of its environmental performance.

5.1.2 Make the Link Between 'Treatment', and Whether Waste is 'Biodegradable'

Acknowledge, in the LFD, that waste which has been treated in the manner described above is to be regarded as 'no longer biodegradable'. This would make the link that is lacking in the LFD.

5.1.3 Change the Existing Targets to Reduce Landfilling of Untreated Waste

Article 5(5) of the LFD currently reads:

> 5. M*ember States shall take the necessary measures to ensure that by 2035 the amount of municipal waste landfilled is reduced to 10 % or less of the total amount of municipal waste generated (by weight).*

In the above paragraph, replacing the word 'landfilled' with 'landfilled without treatment prior to landfilling, with treatment defined as per Article X,' would have the desired effect. 'Article X' would cross reference the definition of 'treatment of waste prior to landfilling' indicated above.

In addition, Art 5a(1) of LFD would need to be amended, notably subparagraphs (b) and (c). These relate to what should be included in the scope of the landfill target, and currently, these read:

> (*b) the weight of waste resulting from treatment operations prior to recycling or other recovery of municipal waste, such as sorting or mechanical biological treatment, which is subsequently landfilled shall be included in the weight of municipal waste reported as landfilled;*
>
> *(c) the weight of municipal waste that enters incineration disposal operations and the weight of waste produced in the stabilisation operations of the biodegradable fraction of municipal waste in order to be subsequently landfilled shall be reported as landfilled;*

Having given proper effect to the term 'treatment prior to landfilling', it would be appropriate to exclude the landfilling of appropriately stabilised waste, albeit including the landfilling of unstabilised sorting rejects, for example. There is also no meaningful rationale for including the weight of municipal waste entering incineration disposal operations. What would be landfilled from a disposal incineration process is likely to be much the same as what is landfilled from an R1 incinerator.

5.1.4 Remove the Formula that Allows Municipal Waste Incinerators to Qualify as R1 Recovery

As indicated in Section 2.0 and Section 3.0, there are a number of clauses in existing Directives which either:

1. have the effect of establishing the superiority of incineration, where it is classified as recovery, over any form of landfilling, or
2. require the progressive elimination of either landfilling of any sort, or disposal.

Regarding point 1., we do not feel it appropriate to seek to define landfilling of any form as 'recovery'. On the other hand, means to address the imbalance in existing policy should be given due consideration.

We have noted on many occasions that the IED, inter alia, requires all incinerators to recover heat as far as is practicable, and so no incinerator should be capable of improving its position vis-a-vis R1 by making changes which are not already implied in order to receive a permit. At a time when the decarbonisation of energy makes the efficiency of energy recovery diminishingly relevant as a measure of resources displaced (the meaning of 'recovery'), it is questionable that R1 Operations, described as 'Use principally as a fuel or other means to generate energy', should be classified as recovery, whatever the form of the operation. It is particularly questionable that there should be a formula in place for the specific purpose of allowing municipal waste incinerators to qualify as 'recovery'. However useful generating energy may be, the extent to which resources are being directly displaced is, and will be, diminishingly clear.

Another possible benefit of removing the R1 formula is that instead of energy efficiency/generation, the focus in respect of performance shifts towards improving the performance of incineration in respect of pollutant removal, and in terms of greenhouse gas emissions. The tendency, sometimes, to argue against additional efforts to abate pollutants on the basis that there is likely to be 'an energy penalty' is weakening as the alternative energy sources become cleaner. That is not to say that energy generation is of no value, more that the BREF process and the BAT Conclusions should be wary of construing incineration facilities as power plants. As energy systems decarbonise, their principle role – as installations for the treatment of waste – becomes more obvious. Given that the roots of the R1 criterion lay in ECJ rulings regarding, amongst other things, the fact that the true purpose of incineration facilities rendered them 'disposal' facilities, then the rationale for retaining the R1 distinction seems to be weakening by the day.

This change would be a relatively simple one to achieve. It would also enable policy to reflect environmental outcomes in a relatively straightforward manner.

There are some clauses in Directives which would still be worthy of changing. For example, Article 3a of the LFD reads:

> *all waste suitable for recycling or other recovery, in particular in municipal waste, shall not be accepted in a landfill with the exception of waste for which landfilling delivers the best environmental outcome in accordance with Article 4 of Directive 2008/98/EC.*

It is difficult to understand what effect was intended here beyond what is already set out in Article 4 of the WFD. If additional effect was intended, it does appear to be a 'ban' on landfilling wherever R1 compliant incineration is an option. If the intention was simply to reiterate the hierarchy, then if the R1 criterion is effectively abolished, Article 4 of the WFD would suffice, and Article 3a of the LFD could be deleted.

A Note on Transfrontier Shipments

The removal of the R1 criterion could, in principle, be considered problematic for some installations if the change in status – from 'recovery' to 'disposal' – was to impose additional limitations on the ability of waste to move from incinerators in one country to incinerators in another. After all, in principle, where the destination of waste is

'recovery', then it is sometimes considered that the rules for moving waste across frontiers should be simplified (relative to disposal).
However, under the Waste Shipment Regulation 1013/2006/EC, shipments of municipal waste for incineration, even where the receiving installation fulfils the criteria to be considered as R1 recovery, are always submitted to a notification procedure, according to Article 3.5. This states:[44]

> *5. Shipments of mixed municipal waste (waste entry 20 03 01) collected from private households, including where such collection also covers such waste from other producers, to recovery or disposal facilities shall, in accordance with this Regulation, be subject to the same provisions as shipments of waste destined for disposal.*

Furthermore, the Regulation itself, despite having been amended 12 times since the version of the WFD that introduced the R1 criterion becoming law at the end of 2008, still defines 'disposal' and 'recovery' through reference to an earlier Directive on waste (Directive 2006/12/EC) (see Articles 2(4) and 2(5) of the Regulation). This is aligned with the foundational OECD position, which makes no explicit provision for the definition of incinerators as 'recovery'. Indeed, the OECD Guidance Manual notes two definitions for R1, as does Annex IC of the EU Regulation:[45] [46]

> *Use as a fuel (other than in direct incineration) or other means to generate energy (Basel/OECD)*
> *Use principally as a fuel or other means to generate energy (EU)*

It is understandable why this might give rise to confusion. A study funded by DG Environment actually presents both perspectives; that the R1 criterion has no bearing on the transfrontier movements because of the aforementioned Article 3.5 in the relevant regulation, but also, suggesting that the R1 criterion was intended (in part) to help facilitate movement of wastes intended for incineration. Regarding the latter, it stated:[47]

> *An important principle of the Waste Framework Directive is that waste for recycling and recovery activities shall move freely within the EU without any unjustified restriction imposed by national, regional or local policy and legislation. In order to help achieve this the R1 status for incinerating municipal waste was clarified to help facilitate its transboundary movement.*
>
> *R1 status is defined in the Waste Framework Directive. The Directive introduced the waste treatment hierarchy as discussed above. Within this frame, annex II of the Directive defines R1 as a waste recovery operation, where the waste is to be 'Used principally as a fuel or other means to generate energy'. This means that waste can be moved between Member States if the facility it is destined for is classified as R1 on the basis that this movement is enabling a treatment option that is higher up the waste hierarchy than incineration without energy recovery or landfill.*

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[44] Regulation (EC) No 1013/2006 of the European Parliament and of the Council of 14 June 2006 on shipments of waste (OJ L 190, 12.7.2006, p. 1), https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02006R1013-20210111&from=EN

[45] OECD (2009) *Guidance Manual for the Implementation of Council Decision C(2001)107/Final, as Amended, on The Control of Transboundary Movements of Wastes Destined for Recovery Operations*, Paris: OECD, https://www.oecd.org/env/waste/guidance-manual-control-transboundary-movements-recoverable-wastes.pdf

[46] Regulation (EC) No 1013/2006 of the European Parliament and of the Council of 14 June 2006 on shipments of waste (OJ L 190, 12.7.2006, p. 1), https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02006R1013-20210111&from=EN

[47] Arcadis and Trinomics (2016) *The efficient functioning of waste markets in the European Union legislative and policy options*, Final Report, July 2016

It went on to say that the Dutch policy on waste was one of keeping open borders well prior to the R1 criterion being established.
In principle, given the current formulation of the Regulation, there would appear to be no need for change (the Regulation includes definitions of R1 and D10 that effectively exclude incineration, though not co-incineration, from the definition of recovery).
Interestingly, the same report cited above states, regarding R1 and D10:

> *The distinction between R1 and D10 (energy recovery and incineration as disposal operation) is a market distortion if D10 and R1 do not technically differ from each other, with equivalent environmental impact, or if costs or administrative burden allocated to D10 are of a nature to send materials to landfill.*

The opposite may actually be true: the distortion is between R1 and other forms of disposal that may be no worse than incineration (including D10 incineration). Rather than leading to materials being sent to landfill because there are burdens associated with D10 facilities, it seems more likely that more waste is moved from options such as landfilling of properly treated waste to R1 incineration despite the fact that the justification for such a switch – which was never strong - looks to be increasingly shaky over time.

Our understanding is that a new version of the Waste Shipment Regulation will shortly be produced, and it will seek to make changes regarding the distinction between recycling and R1 recovery. As noted above, however, that distinction is already in the regulation. The more important issue, therefore (and the 'cleaner' way forward), is the removal of the R1 criterion, and with it, the ability of an incinerator to claim the status of 'recovery'.

5.2 Option 2

Option 2 seeks to go further than Option 1, suggesting that instead of a maximum 10% of MSW being permitted to be landfilled by 2035, the Article 5(5) target is changed so that 'landfilling of untreated waste' is banned completely by 2035 (or, possibly, sooner).

One of the challenges for those seeking to improve, on a continuous basis, efforts to prevent waste, and to recycle more of what is produced, is to implement a responsible approach to managing residual waste as, over time, the quantity of residual waste declines. In this respect, landfilling of waste which has been treated in line with what was suggested under Option 1, offers a compromise between responsible management of waste, and giving 'flexibility' to the overall system to allow for progressive reductions in residual waste. Given the enhanced focus being given to methane emissions in the climate change discourse, not least following the IPCC's most recent report, the rapid elimination of landfilling of untreated waste is justified.

5.2.1 Change the Existing Targets

Article 5(5) of the LFD currently reads:

> *5. Member States shall take the necessary measures to ensure that by 2035 the amount of municipal waste landfilled is reduced to 10 % or less of the total amount of municipal waste generated (by weight).*

In the above paragraph, three changes are proposed:

- *replacing the word 'landfilled' with 'landfilled without treatment prior to landfilling, with treatment defined as per Article X,' would have the desired effect. 'Article X' would cross reference the definition of 'treatment of waste prior to landfilling' indicated above;*
- *replacing the term, 'reduced to 10 % or less of the total amount of municipal waste generated (by weight)' with the term 'reduced to zero'; and*
- *replacing the term 'by 2035' with 'by 2030'.*

This would finally give meaningful force to Article 6 of the LFD.
As under Option 1, Art 5a(1) of LFD would need to be amended, notably subparagraphs (b) and (c). These relate to what should be included in the scope of the landfill target, and currently, these read:

> *(b) the weight of waste resulting from treatment operations prior to recycling or other recovery of municipal waste, such as sorting or mechanical biological treatment, which is subsequently landfilled shall be included in the weight of municipal waste reported as landfilled;*
>
> *(c) the weight of municipal waste that enters incineration disposal operations and the weight of waste produced in the stabilisation operations of the biodegradable fraction of municipal waste in order to be subsequently landfilled shall be reported as landfilled;*
>
> *(d) the weight of waste produced during recycling or other recovery operations of municipal waste which is subsequently landfilled shall not be included in the weight of municipal waste reported as landfilled.*

These rules would need to be changed so that it was clear what should be included and excluded from the target. Having given proper effect to the term 'treatment prior to landfilling', it would be appropriate to exclude the landfilling of appropriately stabilised waste, albeit including the landfilling of unstabilised sorting rejects, for example. Rather than focusing on what should be included in the target, these clauses might be better phrased in terms of excluded from the target. So, for example, residues from all incineration facilities could be excluded, as could be the untreated rejects from sorting operations where these met specific criteria, for example, in terms of their average biological stability.

5.3 Option 3

The above option ensures that municipal waste (some of) whose final destination is a landfill should be subject to sorting prior to biological stabilisation. The studies reviewed in Section 3.0 suggest that sorting of waste whose final destination is incineration can also make good sense, especially where the removal of additional plastics is concerned. This is highlighted in Figure 5 for different polymers, and shows the reduction in CO_2 equ emissions achieved, at different carbon intensities of displaced power, if closed loop recycling occurs as a result of the sorting. At the current average carbon intensity of power generation in the EU, the benefits of recycling an additional tonne of plastic instead of incinerating it are of the order 4 tonnes CO_2 equ per tonne of plastic removed.

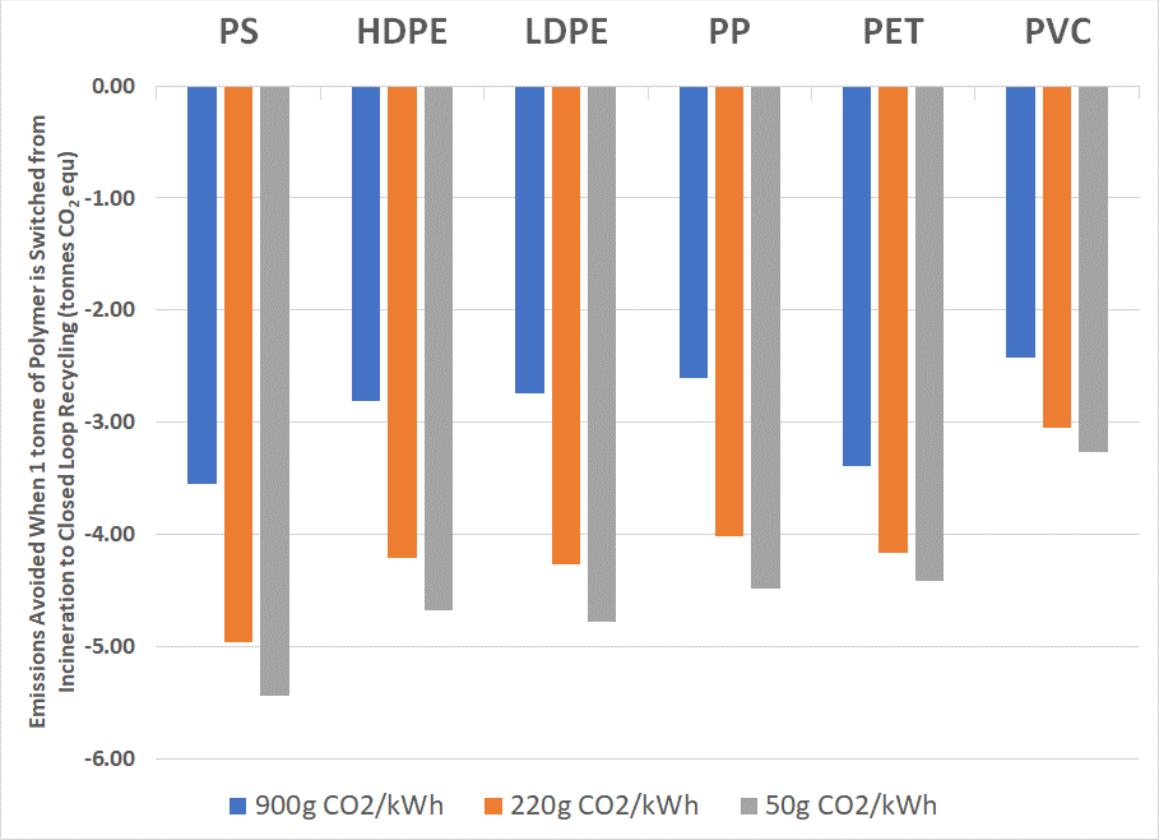

Figure 7: Climate Change Benefits from Removing Plastics from Incineration and into Recycling
Source: Equanimator (2020), Greenhouse gas and air quality impacts of incineration and landfill, https://www.clientearth.org/media/1h2nalrh/greenhouse-gas-and-air-quality-impacts-of-incineration-and-landfill.pdf _Reassigned to Dominic Hogg_

Option 3 builds on Option 2, therefore, but also includes amending legislation (IED or WFD, or both) so that it is made a requirement that prior to incineration, all mixed municipal waste shall be subject to sorting, and that this must be undertaken to a minimum standard. The minimum standard could be defined through BAT Conclusions, or through the process set out at Article 27 of the WFD, and would be defined so as:

- To give effect to the waste hierarchy, and contribute to the objectives of the WFD (as per Article 1); and,
- So as to reduce the fossil carbon emissions from the incineration process.

If this was achieved through the IED, the means could be through either, or both, of Article 44, which sets out the requirements which an applicant's permit must guarantee will be met through the deployment of measures described therein, and Article 50, setting out Operating Conditions. The existing Article 50(1) states:

> *1. Waste incineration plants shall be operated in such a way as to achieve a level of incineration such that the total organic carbon content of slag and bottom ashes is less than 3 % or their loss on ignition is less than 5 % of the dry weight of the material. If necessary, waste pre- treatment techniques shall be used*

The Article already references pre-treatment techniques, though this is in order to ensure completeness of combustion.

Whatever the precise means, the intention is to ensure that MWS are implemented as a means to enhance recycling, reduce the quantity of waste incinerated, and reduce the greenhouse gas emissions associated with the waste.

5.4 Option 4

In addition to one of Options 1 to 3, this option includes a target to reduce the quantity of residual waste generated. The rationale for such a target is that, if set in an appropriate way, then in order to meet it, Member States could either reduce the quantity of waste being generated in the first place, or increase recycling rates above what is required under the WFD (and the Packaging & Packaging Waste Directive - PPWD). It makes clear that whatever the relative merits of landfilling of waste that has been subject to mixed waste sorting and biological stabilisation, and incinerating waste after mixed waste sorting removes some of the remaining fossil carbon fraction, there are better ways of managing waste.

It highlights that focussing on 'just meeting' a recycling target might not channel sufficient efforts into waste prevention. Indeed, as is well known, some suburban areas might find it easier to meet recycling targets if they seek to collect as much garden waste as they can, but this might simply achieve recycling targets at the expense of an increased quantity of measured waste generation. A residual waste target might, for the same reason, level the playing field between suburban / rural areas and urban ones (and Member States with differing proportions of their residents in those circumstances). Furthermore, the residual waste target may level the playing field across Member States with varying levels of waste generation, and hence (to the extent that there is a relationship between levels of income and waste generation), per capita GDP.

It is proposed, therefore, to set a target for residual municipal waste, expressed in terms of a quantity per inhabitant per year, or in terms of residual household waste, expressed in terms of a quantity per inhabitant per year (Option 5). The next subsection explores which might be a better focus for such a target. After that, we consider what might be an appropriate level for the target.

5.4.1 Municipal or Household Waste?

A brief examination of Eurostat data in relation to per capita municipal waste, and household waste, highlights some relevant issues which should be considered in setting such a target. These data were taken from, respectively, the data on municipal waste generation reported to (and by) Eurostat, and the data regarding waste from 'Households' within Member State submissions under the Waste Statistics Regulation.
First, the reported data on household waste, and on municipal waste, make little sense when considered alongside each other. The definition of municipal waste under the WFD is as follows:

'municipal waste' means:

(a) mixed waste and separately collected waste from households, including paper and cardboard, glass, metals, plastics, bio- waste, wood, textiles, packaging, waste electrical and electronic equipment, waste batteries and accumulators, and bulky waste, including mattresses and furniture;

(b) mixed waste and separately collected waste from other sources, where such waste is similar in nature and composition to waste from households;

Municipal waste does not include waste from production, agriculture, forestry, fishing, septic tanks and sewage network and treatment, including sewage sludge, end-of-life vehicles or construction and demolition waste.

This definition is without prejudice to the allocation of responsibilities for waste management between public and private actors;

The above definition, given subparagraphs (a) and (b), would suggest that municipal waste includes 'more than' household waste. Indeed, household waste would only be 'more than' municipal waste if it included some of the wastes which are explicitly excluded in the definition of municipal waste, and if the quantity of such wastes was greater than the totality of wastes from 'other sources' set out in subparagraph (b). This would seem to be highly unlikely. Yet the reported data (displayed in Figure 6) show that there are 7 Member States who report household waste quantities in excess of municipal waste, and 3 who report exactly the same figures. In addition, 1 Member State reports that municipal waste exceeds household waste by a very small amount.

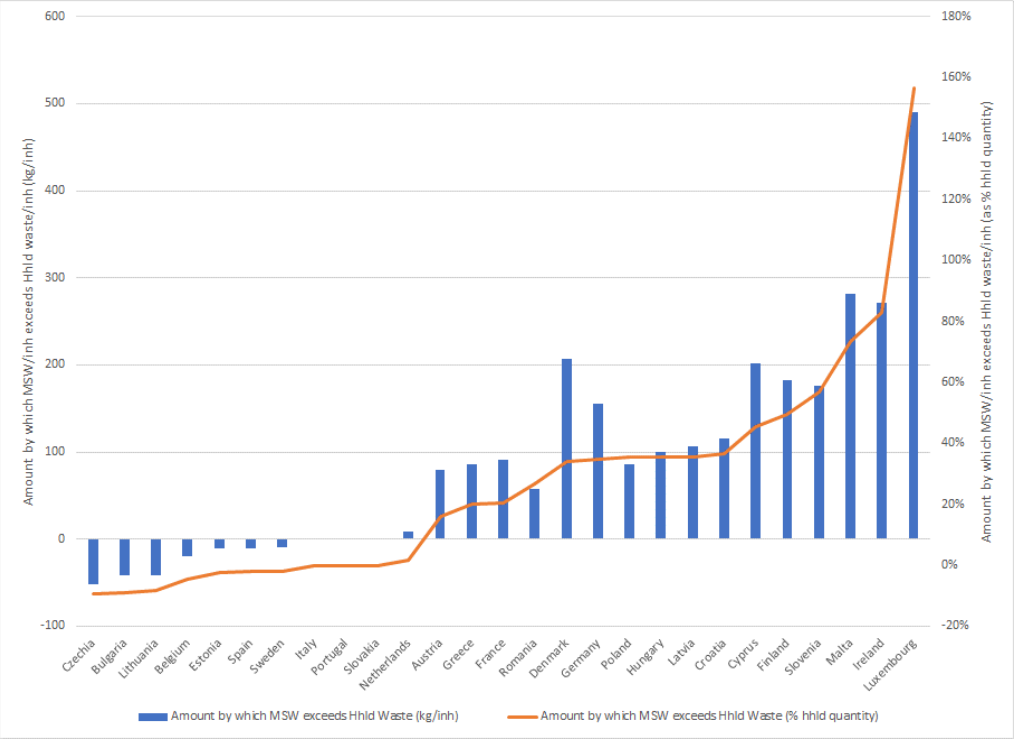

Figure 8: Plot Showing Extent to Which Reported Municipal Waste per inhabitant Exceeds Reported Waste from Households per inhabitant (kg/inhabitant)

Source: Equanimator, based on data from Eurostat (for household waste data, the data were taken from the Dataset, 'Generation of waste by waste category, hazardousness and NACE Rev. 2 activity'; for municipal waste, data were taken from the dataset Municipal waste by waste management operations [env_wasmun])

By contrast, 12 Member States report quantities of municipal waste which exceed the household waste amount by more than 30%. For 11 Member States, municipal waste exceeds household waste by more than 100kg per inhabitant, and for 5 of these, the figure is in excess of 200kg per inhabitant.

One can try to explain the reported figures, but that will not necessarily help in the setting of targets of the nature we are considering. For many years, it has been well known that reporting of data on municipal waste is not at all well aligned. Member States have tended to use their own interpretations of the term 'municipal waste', figures for which have been reported in the past in response to a joint OEC /Eurostat questionnaire, where attempts to ensure Member States used the same definition when reporting were never successful. It seems likely that the

differences between 'household' and 'municipal' waste reflect the extent to which Member States have properly incorporated the wastes highlighted at subparagraph (b) above (the meaning of which remains somewhat opaque). This does not necessarily explain why some Member States report lower figures for municipal waste than for household waste. Taken together, however, these issues suggest that the data on household and municipal waste are not of sufficient quality (in terms of how consistently they apply the definition of municipal waste) to enable a comparative assessment of performance to be made using the data.

The data on municipal waste should converge over time as Member States begin to report in a manner consistent with the definition in the WFD. The reporting of waste from households under the Waste Statistics Regulation would appear to be subject to limited checks, partly because no target currently attaches to the category. A look at data from the two most recently reported years, 2016 and 2018, shows some enormous changes from the one reporting year to the next. The largest upward movement was by 61%, with the figure moving from one less than municipal waste to a figure in excess of municipal waste, and the largest reduction being 72%, with the change being from a figure above municipal waste to a figure less than municipal waste.

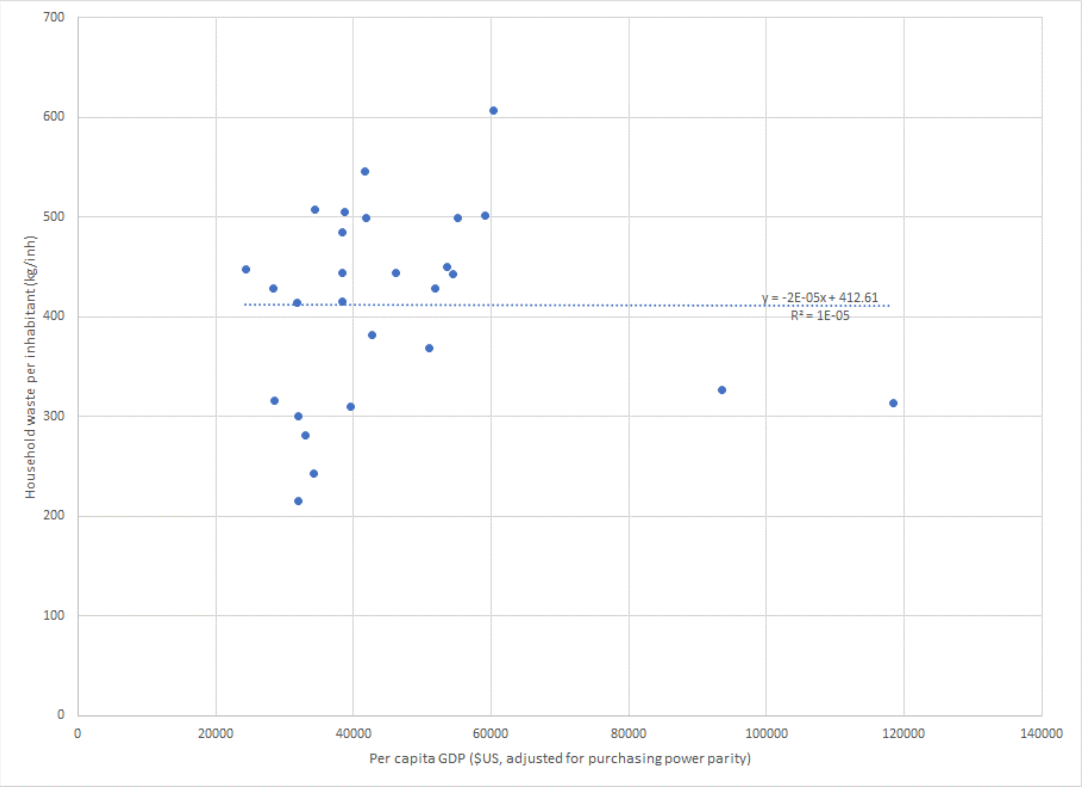

Figure 9: Scatter Plot of per capita Household Waste Generation v GDP per capita, expressed in $US adjusted for Purchasing Power Parity Source: Equanimator. The source of household waste data was the same as for Figure 8. The PPP adjusted GDP data were taken from the World Bank (see https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD)

Whatever the inconsistencies across Member States regarding municipal waste, the household waste data appear, for the time being, even less reliable than the data on municipal waste. There is, as Figure 4 shows, no obvious link between per capita income and per capita household waste generation across the EU, and whilst, in theory, it is possible that no such relation exists, in practice, the apparently random distribution of the household waste quantities seems more likely to reflect the quality of the data capture and reporting.

5.4.2 At What Level Should the Target be Set?

Figure 5 shows both current per capita residual municipal waste (essentially derived from 'what is not reported as recycled') alongside what per capita residual municipal waste might look once a 65% recycling rate is achieved, assuming no change in waste generation. Unsurprisingly, given the enormous variation in existing recycling performance, the figures in future are lower, and show less variation across the Member States. There are 7 Member States with figures above 200kg/inh. There are 8 Member States with figures below 200kg/inh. There is a correlation between Purchasing Power Parity (PPP) adjusted GDP per capita and the residual municipal waste quantities at 65% recycling. This is shown in Figure 8.

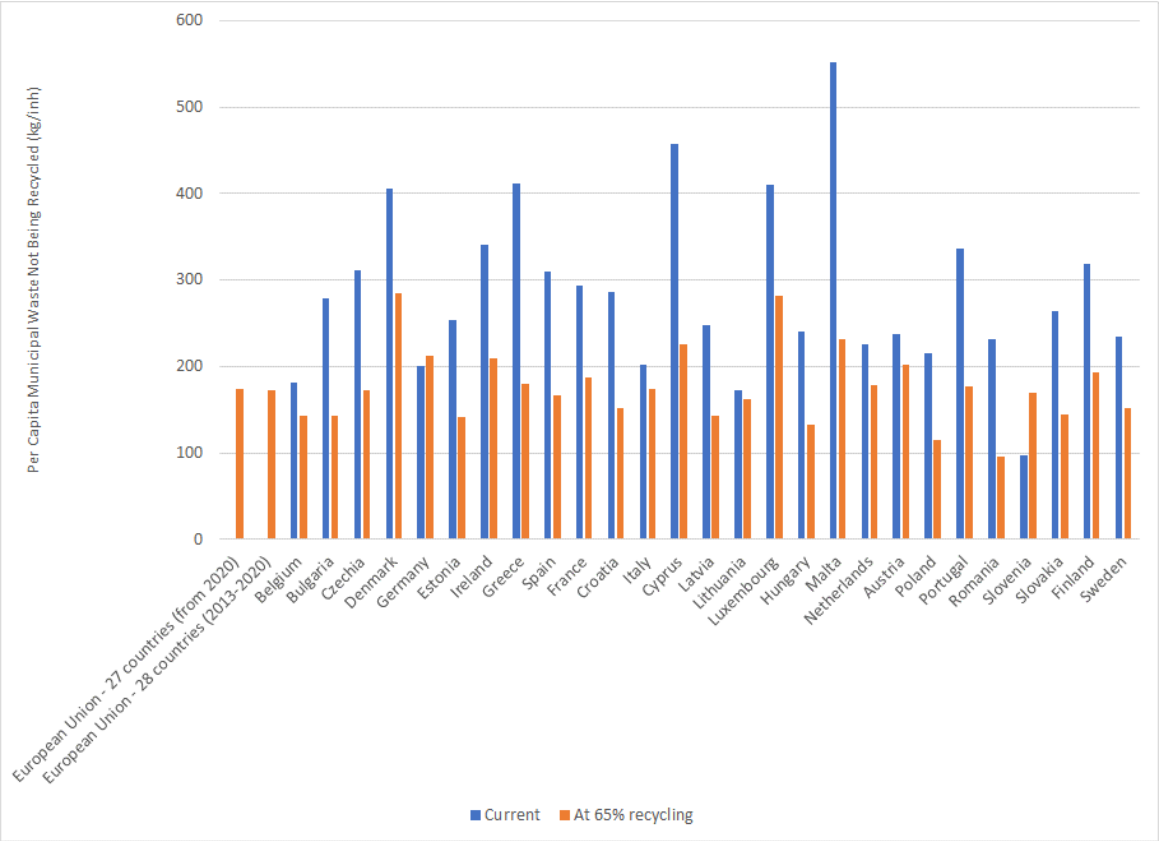

Figure 10: Residual Municipal Waste in 2018, and at 65% Recycling (assumes reporting as in 2018, and no change in waste generation)

Source: Equanimator, based on Eurostat data Municipal waste by waste management operations [env_wasmun])

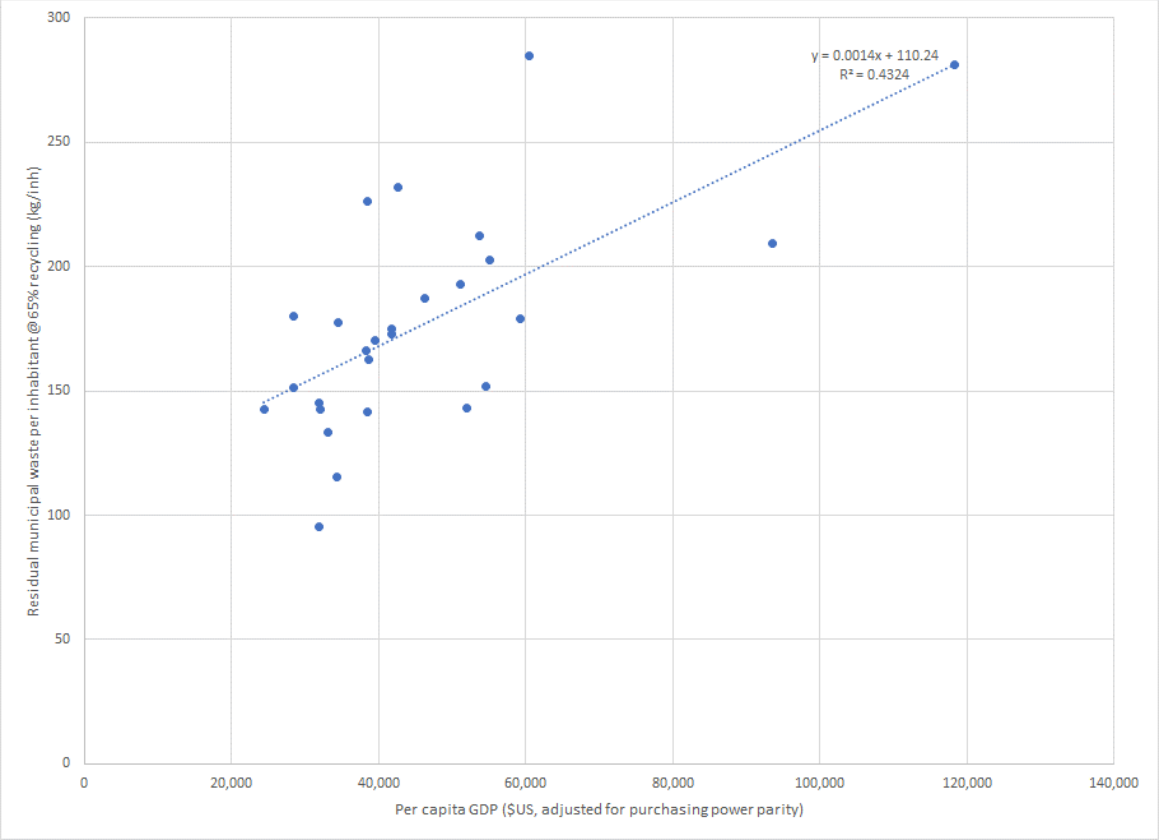

Figure 11: Scatter Plot of per capita Residual Municipal Waste at 65% Recycling v GDP per capita, expressed in $US adjusted for Purchasing Power Parity
Equanimator, based on Eurstat dataset (Municipal waste by waste management operations [env_wasmun]) and data from the World Bank (see https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD)

In order to understand the extent of changes required to achieve given target levels of residual municipal waste per inhabitant, we have expressed the further reduction required in residual waste in terms of the percentage reduction necessary from recycling or waste prevention. We have shown this for three different target levels; 150 kg/inhabitant (kg/inh); 175 kg/inh; and 200 kg/inh. If a Member State's figure is already below the target level, a zero percentage figure is shown. The results are shown in Figure 10.

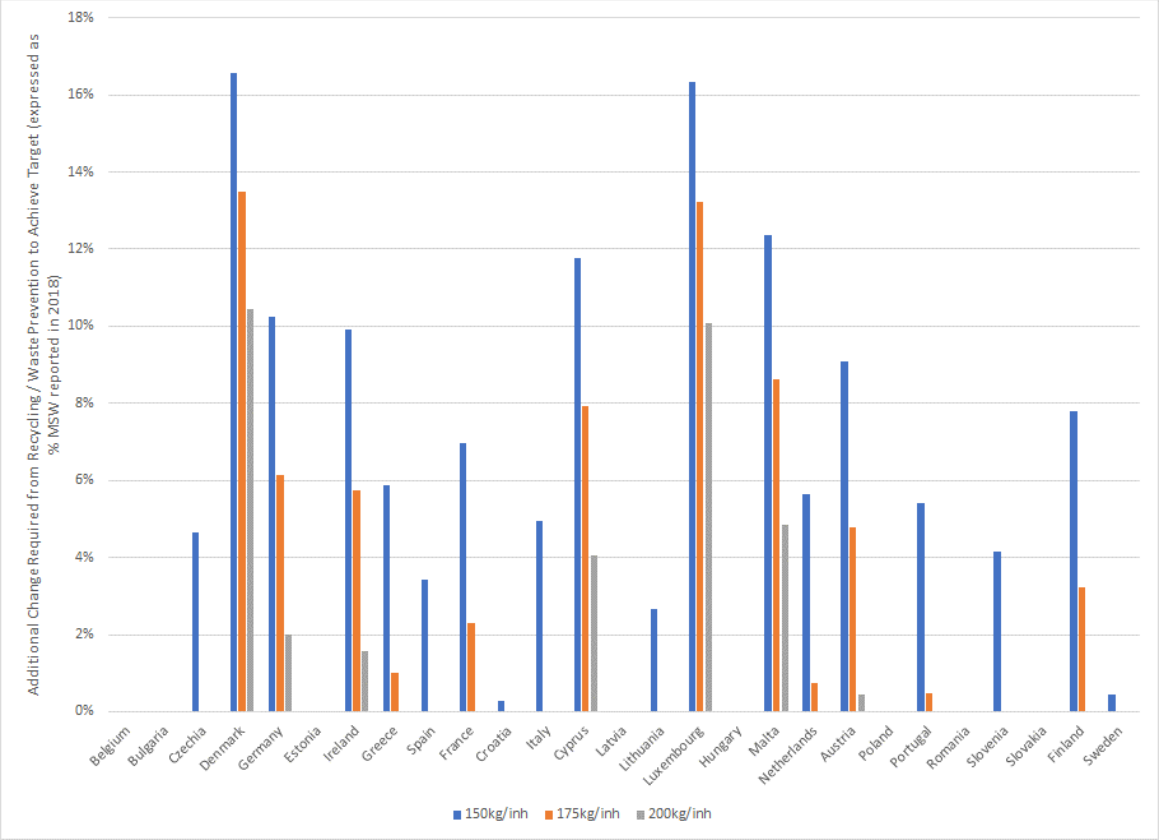

Figure 12: Additional Change Required from Recycling / Waste Prevention to Achieve Target (expressed as % MSW reported in 2018)
Source: Equanimator, calculated based on Eurostat dataset (Municipal waste by waste management operations [env_wasmun])

In order to meet the 150kg/inh target, 19 Member States would need to take additional action; 12 Member States would need to take action to meet the 175kg/inh target; and 7 Member States would need to take action to meet the 200kg/inh target.

Evidently, as reporting by Member States of their municipal waste quantities improves, so these figures may change. For most Member States, we expect this to result in an increase in reported quantities of municipal waste, but for some, there may also be a reduction. Furthermore, the above analysis does not allow for any growth in municipal waste that may occur.

Notwithstanding the above, the figure of 175kg/inh would seem to be a fair one; a reasonable number of Member States would need to take action. Those required to do so are, for the most part, those with relatively high per capita incomes (and waste generation). The target would be set for the same year in which the 65% recycling target is to be met. The target could be revisited, in the light of both performance, and better reporting on municipal waste, by 2030, with a view to setting targets further into the future.

Possible nuancing of this target might include making allowances for the role of tourism in the economy of the Member States, and the role played by work patterns in influencing the figures (Luxembourg providing, perhaps, the best example of this influence). This could occur by creating an adjustment in terms of a net change in 'inhabitant equivalents', linked to overnight stays for work/leisure, for example.

As indicated above, the merit of this target is that it seeks to give an incentive for waste prevention as well as recycling. It prevents the situation occurring in which recycling targets are met through collecting larger quantities of more recyclable waste. The approach is consistent with, for example, seeking to prevent food waste, and also, seeking to prevent Member States with a large share of homes with large gardens meeting targets through collecting large quantities of garden waste for recycling.

5.5 Dealing with Climate Change Emissions from Landfills and Incineration

The recently published Fit for 55 Package sets out the Commission's proposals for a revised climate change policy. Somewhat unfortunately, the analysis undertaken for the package seems to have reflected inventory reporting. As a result, and because of problems with the reporting of emissions under the 'waste' chapter of inventories reported to the UNFCCC, the analysis proceeds as though 'waste' emissions are associated largely with methane from landfills. The package is generally upbeat regarding what it expects to occur as a result of existing waste policy and law because landfill emissions are falling. The fact that incinerator emissions are on the rise is, therefore, not properly addressed. The fact that under inventories, waste incinerators are treated as 'power stations', but are not included under the EU ETS, is also not addressed. Once again, therefore, incineration seems to have escaped being targeted by any specific instrument, outside the EU ETS, and not even included under the 'waste' emissions being considered under the Effort Sharing Regulation (ESR) which focuses on those reported under the 'waste and wastewater' chapter of inventories reported by Member States. This lack of understanding is long overdue a correction, and it is disappointing to see the same old misunderstandings being repeated. The emissions associated with the management of waste are very different from the emissions reported under the waste chapter of the inventories as they are prepared in line with IPCC Methodologies.
Although our above proposals have been designed in part to ensure that the management of residual waste shifts towards options which offer mitigation opportunities relative to landfilling or incinerating directly, the question remains as to why it should not be possible to use market-based instruments to address emissions from the management of residual waste. It would be relatively straightforward to include incineration under the EU ETS. This would, most likely, encourage efficient removal of plastics from the waste intended for combustion. Our view is that this is an obvious way to proceed. Some Member States already include such facilities, and some have incineration taxes in place. Those taxes might deserve attention in those countries where incineration is not currently under the EU ETS if incineration was included in the EU ETS in the future.

Some other countries, notably New Zealand, have included landfills in emissions trading schemes. In principle, they could also be included in the EU ETS. However, the measurement of the level of fugitive emissions may, even today, prove problematic, though methods for doing this are emerging.

Most countries already have (albeit at varying levels) landfill taxes in place. A more promising route by which to account for the emissions (or encourage their reduction) would be to set taxes on landfill that are differentiated between:

a. Waste that contained biodegradable waste, including municipal waste, but which has been subject to the treatment referred to above (lower rate); and
b. Waste that contained biodegradable waste, including municipal waste, but which has not been treated in line with the definition of treatment (upper rate).

If the differentials were set sufficiently high (gap between lower and upper rates no less than, for example, €75 per tonne of waste landfilled), then this ought to incentivise a swift move away from landfills receiving untreated waste.
We note also that the proposed revision to the Renewable Energy Directive (of Article 3) is weakly worded. It states that no support for renewable energy generation should be given to incineration of waste *'if the separate*

collection obligations laid down in Directive 2008/98/EC have not been complied with.' The qualifier is disappointing, not least given the weakness of the implied threshold, and given that plastics seem not to be so well captured through separate collection. It remains impossible for 'renewable energy' to be generated through incineration without at the same time combusting large quantities of fossil-derived carbon. The above proposals for mixed waste sorting would improve that situation, but they would not eliminate it. The qualifier should, in our view, be removed so that no support for renewable energy is offered to incineration facilities. Waste must not be considered 'a renewable resource'.

5.6 Why Not Simply Replace the Landfill Target with one for Residual Household Waste?

As the review in Section 2.0 has indicated, there are a number of clauses, principally in the LFD and WFD, which – notwithstanding the timing of the targets themselves – have the effect of requiring landfill, in whatever form, to be minimised. These clauses – to the extent that they mention a preference for 'recovery', still denote a clear preference for R1 incineration vis-a-vis other forms of managing residual waste, despite there being no clear cut basis for that preference. As noted in Section 4.0, Member States are already acting to reduce landfill in favour of other options, mainly incineration, or variants of MBT where a key focus is on delivery of solid recovered fuels, either for co-incineration, or dedicated incineration facilities.

If 'residual waste' is suitably defined, then such a target could encourage, on its own, the wider deployment of mixed waste sorting (as a means to reduce residual waste). However, the push would remain towards incineration and away from other options that may be no worse, and which, on the contrary, may offer greater flexibility in meeting targets.

6.0 Summary and Conclusions

In this study, we have highlighted:

1. How existing policy has evolved, and the lopsided nature of its approach in respect on landfill and incineration as ways of dealing with residual waste;
2. That there has been plenty of evidence from various studies, including some funded by the Commission, to indicate that such a lopsided view, in favour of incineration, is probably unwarranted;
3. How, as the energy system has decarbonised, and as it continues to do so, the benefits of generating energy from residual waste have diminished, and how they are likely to continue to do so;
4. How the R1 formula in the WFD, which was designed to enable municipal waste incinerators to claim 'recovery' status, has lost its relevance as a result of decarbonisation, and as a result of recent changes made to the formula;
5. How the improved technological potential for using mixed waste sorting at the front of landfills and incineration plants enables 'a second go' at the materials that remain in the mixed waste stream following separate collection, and how this can improve the climate change performance of both types of waste management.

These issues call for a fundamental re-think, and realignment, of policy and law. In the past, one could be forgiven for thinking that 'landfill' was bad merely by virtue of its name. Yet policy and law should reflect (changing) knowledge and evidence, not be based on a dogmatic view regarding one or other technology. This should not be taken as a 'pro-landfill' argument: rather, the significance of the discussion relates to:

4. The lack of unequivocal evidence in support of the current state of affairs regarding policy and law;
5. The fact that improvements can be made to managing residual waste which are consistent with the Green Deal; and;
6. The potential impact of an 'incinerator heavy' strategy for managing residual waste on the potential for moving waste further up the hierarchy, into prevention and recycling.

Given the above, therefore, and although the preceding chapter presents some 'graduated' options, we commend the following package of measures to the European Commission and the European Parliament as a means to ensure a sound management of residual waste, and to support the ambitions of the EU Green Deal.

1. Elaborate a clear definition of 'treatment' as per Article 6 of the Landfill Directive. It may be more appropriate to define this as 'treatment of waste prior to landfilling', since the terms 'treatment' and 'pre-treatment' are used widely in documents concerning waste. The treatment would be defined to require:
    a. The sorting of the waste, with sorting defined through the process set out at Article 27 of the WFD). Such a definition could, potentially, alter the sorting requirements in line with what is achieved through source separation;
    b. The subsequent stabilisation of any waste destined for landfill. Here, it should be considered that the way in which 'thresholds' have been set in the past have differed across countries. The objective should be to ensure the prospects for fugitive methane emissions are minimised through the combination of stabilisation, and the use of suitable oxidation layers at the receiving landfill.

i. In respect of the former, a level of stability at, or equivalent to, the level considered in the Draft Biowaste Directive, of 10mg O_2 / g dm, or equivalent measure, gives a suitable measure that would reduce the potential for methane generation to a significant degree without incurring excessive cost.
ii. In respect of the latter, the General Requirements for all Classes of Landfills, set out at Annex I of the LFD, could be amended to consider appropriate cover layers, and might para 4, regarding Gas Control, could be amended such that the need for gas control was linked to whether or not waste was treated, and the nature of the oxidation layer used.

This definition would, as per reviews undertaken in Section 3.0, ensure that the 'landfill system' was comparable, potentially an improvement upon, incineration in terms of its environmental performance.

2. Acknowledge, in the LFD, that waste which has been treated in the manner described above is to be regarded as 'no longer biodegradable'. This would make the link that is lacking in the LFD.
3. Remove the R1 formula in Annex II of the WFD so that municipal waste incineration is no longer able to be classified as 'recovery'. This is important since much of the legislation urges an unwarranted preference for 'other (i.e., non-material) recovery' over and above landfill, even if the waste is subject to 'treatment' as defined above. The easiest way to address this is to remove the formula, which has lost relevance in respect of the resources that might be displaced by incinerators in the context of a decarbonising energy system in the EU;
4. Amend the Article 5(5) target as follows (strikethrough = text removed; underlined text = text added):

> *Member States shall take the necessary measures to ensure that by ~~2035~~ 2030 the amount of municipal waste landfilled without treatment prior to landfilling, with treatment defined as per Article X is reduced to ~~10% zero or less of the total amount of municipal waste generated (by weight).~~*

Art 5a(1) of the LFD, regarding measuring progress towards the target, would need to be amended accordingly (to align with the preceding target);

5. Either through Article 44 of the IED, or through Article 27 of the WFD (or both), mandate the use of mixed waste sorting systems of a defined quality at the front of all new incineration plants, and those which have been operational for less than ten years. This could also be defined as a requirement for the 'treatment of waste prior to incineration' (mirroring the requirement in respect of landfill), with elements of the sorting requirements made common to both types of facilities. There may need to be some exception for existing facilities where there are serious spatial constraints;
6. Establish a target to reduce residual municipal waste to less than 175kg/inh, to be achieved on the same schedule as the existing WFD recycling targets. This would be calculated prior to waste entering into the stabilisation process, or at the point it enters the incinerator furnace. The inclusion or exclusion of specific additional components would be established as per the existing Article 5a of the LFD. Some nuancing of this target might be necessary, for example, to make allowances for the role of tourism in the economy of the Member States, and the role played by work-patterns in influencing the figures (Luxembourg providing, perhaps, the best example of this influence). This could occur by creating an adjustment in terms of a net change in 'inhabitant equivalents', linked to overnight stays for work / leisure, for example. The target would be revisited prior to 2030 with a view to reflecting on the level of ambition in the light of more harmonised reporting on MSW, and progress in recycling and waste prevention. The review would anticipate tighter limits in future years; and
7. Include incineration facilities within the EU ETS as a means to encourage progress in the quality of sorting systems for removing plastics from the mixed waste remaining after separate collection.

These changes will significantly improve the climate change emissions associated with the management of waste.

As a final point, the community of academics, consultants and policy makers does need to appreciate, when discussion waste management and climate change, the difference between *'emissions from the waste sector'*, as they are required to be reported to the UNFCCC, and in line with IPCC Methodologies, and '*the emissions associated with the management of waste, looked at from the perspective of how waste management can contribute to climate change mitigation.*' It would be helpful if the EU would consider developing better reporting and acknowledgement of this, not least by urging for changes/addenda in national inventories reported to the UNFCCC as a means to ensure clear understanding, and adequate recognition, of the linkages between improved waste management and climate change mitigation.

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Zero Waste Europe, 2021

Zero Waste Europe is the European network of communities, local leaders, businesses, experts, and change agents working towards the same vision: phasing out waste from our society. We empower communities to redesign their relationship with resources, to adopt smarter lifestyles and sustainable consumption patterns, and to think circular.

Equanimator Ltd.

Equanimator is the new home for Dr Dominic Hogg. It aims to bring about positive change in environmental strategies and policies by following the evidence base, and making the case for change. A key objective is to stimulate different ways of thinking about critical issues, and to challenge the mentality and paradigms that have allowed the creativity of humankind to manifest itself as a talent for promulgating existential crises. Equanimator's website is under construction, but will be found at www.dominichogg.com .

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