Carbon Trust Advisory Services

Review of Methodology for the Carbon Metric for Scotland

Version: Final report

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Content

1 Introduction

1.1 The Carbon Metric

The Carbon Metric has been devised by the Scottish Government and Zero Waste Scotland (ZWS) with input from the Chartered Institution of Waste Management (CIWM) in order to more appropriately measure the environmental impact of waste materials and products in Scotland and monitor progress towards achievement of the Zero Waste Plan.

By extending the consideration of waste reduction purely from a mass basis to carbon impacts, the Carbon Metric enables prioritisation of prevention, reuse and recycling of wastes with the greatest environmental impact along the way to achieving the zero waste goal. The methodology acknowledges the limitations of a single indicator in capturing overall environmental impacts. While the focus on carbon addresses what is generally considered the most pressing environmental threat and is also a useful proxy for a number of other hazards, separate consideration is still required for issues such as land and water contamination on a case-by case basis.

1.2 Aim of This Review

ZWS have commissioned the Carbon Trust Advisory Services (CTAS) to review the Carbon Metric methodology to implement and monitor the waste reduction target. The primary aim of the review is to assess the suitability of the methodology, including data used and implementation mechanism, to satisfactorily reflect the carbon impacts of various waste management options

In order to meet this aim, the review considers the methodological decisions around assessment boundaries, the treatment of carbon in various life cycle stages, sources for secondary data and assumptions made in the calculation of the Carbon Factors and Weightings of materials and products.

1.3 Reference Framework

The reference framework for this review is primarily the Carbon Metric's objective to measure progress against recycling targets with reference to the carbon impact of the materials and products.

In assessing how well the methodology, as defined, delivers against the stated objective, this review also considers its consistency with the various standards referred to in the methodology as underpinning its development:

- ISO 14040:2006: Environmental management — Life cycle assessment — Principles and framework

- ISO 14044:2006: Environmental management — Life cycle assessment — Requirements and guidelines

- PAS 2050 (2008): Specification for the assessment of the life cycle greenhouse gas emissions of goods and services

- The World Resource Institute and the World Business Council for Sustainable Development Greenhouse Gas Protocol Initiative

2 General Framework

2.1 Objective

The primary purpose of the Carbon Metric is to measure progress against Scotland's internal recycling targets, which are formulated on the basis of carbon impact, rather than weight. In the first instance, the Carbon Metric will be applied to local-authority collected domestic waste, due to good data availability. It will subsequently be extended to commercial, industrial, and construction and demolition waste.

It is also expected that the Carbon Metric will help to highlight the merits of alternative waste management options, including prevention.

2.2 Scope of Materials

The scope of materials and products covered by the Carbon Metric were specified by the Scottish Government to reflect domestic waste composition and data availability. The limitations of the current selection with regards to commercial, industrial and construction wastes is acknowledged and will need to be addressed prior to including those waste streams in the Metric.

A number of the products included in the list have not yet been allocated a Carbon Factor or weighting due to lack of data. Whilst these are not major constituents of domestic waste, the Carbon Factors may make some of these products significant in relation to the targets.

2.3 Boundaries

The starting point for the boundary definition in the methodology was a life-cycle approach, which has been pared down to those stages directly affected by the end-of-life treatment.

It is important to ensure that the correct life-cycle stages are included in the assessment with regards to the carbon impact of various waste management strategies. Particularly with respect to material avoidance through recycling or re-use, including the appropriate processing steps is vital. For products, the methodology correctly includes secondary manufacturing of the product, whereas materials only include the primary processing stage.

One anomaly is that filling and packing stages have been excluded, as they are not impacted by the end-of-life treatment whereas distribution to retail is included. The same rationale should apply to both in relation to avoided processes. Where products are reused, rather than recycled, both of these process steps may be considered as avoided, in which case their inclusion would be justified. In all other cases of recycling or energy recovery, these steps are not avoided and should, therefore, be excluded.

Exclusion of the use phase is fully justified within the primary objective of the Carbon Metric. Caution is advised in attempting to extend the use of the data for decision making around reuse of domestic appliances (WEEE). While the avoided waste from reusing a domestic appliance may indicate significant carbon savings, the extended use of an inefficient appliance could have a negative impact compared to replacement with a more efficient model.

3 Technical Decisions

This section considers the specific decisions made within the methodology and assesses their relevance and validity in relation to the Carbon Metric's goal, practical implications and consistency with other standards.

- 3.1 End-Of-Life
- 3.1.1 Recycling
- 3.1.2 Reuse
- 3.1.3 Energy from Waste
- 3.1.4 Landfill
- 3.2 Biogenic Carbon and Carbon Storage
- 3.3 Transport

3.1 End-Of-Life

The methodology describes the underlying data and assumptions for end of life treatment in relation to landfill, recycling and energy recovery through incineration. It does not, however, detail the approach taken in relation to anaerobic digestion (AD) and composting, which are key routes for food and garden wastes. In particular, the treatment of energy recovery from AD needs to be clearly defined.

3.1.1 Recycling

With the Carbon Metric being a measure for recycling targets, the assumptions and calculations around recycling are of critical importance. The methodology distinguishes between closed and open loop recycling with their varying implications for processing the recyclate and the associated avoidance of virgin materials.

Section 4.5 states that the Carbon Metric assumes closed loop recycling for most materials with the only exceptions being glass, and food and garden waste. As indicated in section 4.6, the textiles weighting is based on reuse and Annex 2 outlines a combination of closed and open loop recycling for plastic, although this appears not to have been implemented.

The carbon benefits between open and closed loop recycling can vary significantly and in order to meet the Zero Waste Plan's ambition of a recycling target based on carbon impact, it is important to distinguish between the two routes as best possible. At present, recycling data does not incorporate the ultimate fate of the recyclate, which poses the main obstacle. The exception to this is glass, where some distinction is made on the basis of colour separated or mixed collections.

The assumptions around plastic recycling in Annex 2 are not referenced in the report and the simplistic approach compared to the wide variation in recycling applications for the various polymers is acknowledged. Also, the Carbon Metric calculations to derive the weightings do not follow the assumptions described in Annex 2, which is based on a combination of closed and open loop recycling. Again, capturing the recycling routes of the plastic polymers would allow a much more refined measure of both the carbon impacts and progress towards the recycling targets.

The methodology also accounts for material losses through the recycling process, as outlined in Annex 4. While the emissions associated with recycling a material account for material losses, the emissions factor is per tonne of recycled output, rather than per tonne of input. Thus, it is not clear whether the model fully accounts for material losses, as one tonne of closed loop recycled waste attracts avoided emissions for one tonne of virgin material.

3.1.2 Reuse

The only reuse currently being accounted for within the Carbon Metric is for textiles, where reuse is the predominant destination of material recorded as recycled. As Defra's report on reusing and recycling of UK clothing and textiles highlights, the classification of clothes collected for reuse as non-waste was still the subject of some confusion at the time of publication in 2009. It is, therefore, important to be very clear within the methodology as to what is included within the calculation of arisings in relation to textiles for the purpose of recycling targets and the Carbon Metric.

3.1.3 Energy from Waste

The carbon impact of energy recovery from waste is calculated within the methodology, but does not currently influence the weightings, which are based on a comparison between recycling/composting and landfill. As such, the energy from waste data is provided for any potential future expansion of the carbon metric to a more comprehensive assessment tool for all end of life management options.

The current approach mostly measures the impact of energy from waste based on electricity generation replacing marginal gas generation. In order to fully capture the impact of future changes, other alternatives should also be considered.

Burning waste for heat in an industrial process replacing coal will have a significantly different carbon impact

3.1.4 Landfill

The treatment of biogenic carbon is an important aspect of modelling emissions from landfill. This is discussed in detail in section 3.2, below.

It appears that this methodology does not take into account any biogenic carbon sequestered within landfill over extended periods (beyond a 100 year assessment period).

3.2 Biogenic Carbon and Carbon Storage

The Carbon Metric methodology excludes biogenic CO_2, but includes methane and nitrous oxide from biogenic sources.

While many LCA methodologies count the CO_2 absorbed by plants as sequestration until it is subsequently released at the end of life of a product through decomposition or combustion, this approach has some significant disadvantages. Although less relevant for the Carbon Metric, the main disadvantage is the distortion introduced by this biogenic carbon in a cradle-to-gate partial product footprint. The misleading emission figures associated with combustion of biogenic materials already mentioned in the technical report is another feature of such an approach.

Disregarding biogenic carbon completely, on the other hand, also poses a couple of problems. Firstly, as the technical report points out, this treatment assumes a sustainable production system. The methodology does not propose any compensation for unsustainable practices. PAS 2050, which also disregards biogenic carbon emissions, has separate provisions to account for land use change. Secondly, it can be argued that biogenic carbon from sustainable sources that is kept out of the atmosphere over extended periods of time should receive a credit for carbon sequestration. Such a credit is applied by both PAS 2050 and the WRI/WBCSD methodologies in slightly different ways.

While the former point underestimates the benefits of closed loop recycling, the latter overestimates the impact of landfill, where the slow breakdown of certain biogenic materials can result in a significant proportion of long-term carbon storage. It cannot be assumed that the two effects balance each other out.

It should also be noted that consistency in the treatment of biogenic carbon requires an adjustment to the GWP of methane from biogenic sources. Since methane has a significantly shorter lifetime in the atmosphere before breaking down to CO_2 than the 100-year reference period and the biogenic methane is derived from CO_2 absorbed from the atmosphere through photosynthesis, this difference to fossil methane should be recognised. Based on relative molecular weights of CO_2 and CH_4 (weight ratio of 44/16) the revised GWP of biogenic methane would be 22.25, rather than 25. Recent literature[1] indicates that the differential should actually work in the other direction (i.e. the GWP for fossil CH_4 should be about 27 against 25 for biogenic methane). As IPCC (2006) is still the commonly agreed reference point, it would be inconsistent with other methodologies to change the baseline GWP for CH_4.

3.3 Transport

The road freight calculations are based primarily on DfT, Environment Agency and Defra data. The Metric currently relies on the 2009 Defra greenhouse gas conversion factors. This should be updated to the 2010 data.

The road freight figure takes the average load factor (58% according to Defra 2010). This is the average figure for all journeys carrying a load. Additionally, the metric makes a conservative assumption that all backhaul is empty. This is overly conservative in a national context, as national statistics indicate a 29% empty running rate (DfT table 1.15). The empty backhaul would, therefore, be 58%.

The latest Defra guidelines now also include upstream (Scope 3) emissions for freight), which means that a separate uplift factor is no longer required.

It appears that the transport distances for waste, based on WRATE (2005) and WRAP data, is for the UK. Although unlikely to make a material difference, it would be worth examining the validity of these figures in the Scottish context, particularly for recyclate transport.

As previously mentioned, the distribution to retail should be excluded from the calculation for the same reasons as the filling and packing processes.

4 The Carbon Metric

The Carbon Metric relies on a weighting for each material, which is based on a Carbon Factor. This Carbon Factor is calculated as the carbon benefit of the modelled recycling route over landfilling based on the relevant life cycle emissions. This Carbon Factor is then converted into a weighting for each material based upon their relative carbon impact. Finally the Carbon Metric recycling rate is calculated by comparing the sum of the recycled materials multiplied by their weightings over the total sum of waste arisings multiplied by the weighting.

[1] O Boucher *et al* (2009): The indirect global warming potential and global temperature change potential due to methane oxidation, *Environ. Res. Lett. 4*

4.1 Carbon Factors

The Carbon Factors are calculated on the basis of the chosen recycling routes, as discussed in section 3.1.1, above. One of the main issues with the carbon metric is that it only assigns one Carbon Factor to each material, even when there are multiple recycling routes.

In the case of plastic, the range of open and closed loop recycling options are discussed, but the Carbon Factor is based on a best case scenario of closed loop recycling. This has the effect of overestimating the positive carbon impact of recycling. In practice, this could lead to more mixed plastic collection for open loop recycling, which will be recorded as delivering a greater benefit than is actually the case. Glass is the other key material with significantly different recycling routes and associated carbon impacts.

The Carbon Factor for clothing is based on an unpublished study by French consultancy Bio IS. This makes it very difficult to consider the comparability of these figures with regards to the methodology applied. The figure looks very high considering that cotton textiles are typically around half that figure and make up over 40% of the textile market. The calculation of the Carbon Factor for clothing is based on the average destination of clothes, which includes donations to charity shops and clothing banks. As this is not classified as waste by Defra, these routes should be excluded, as they are presumably not accounted in the recycling target. This will significantly reduce the proportion of reuse in favour of reforming into wipes or filling fibre. The average destination also includes the 4.7% that goes to landfill, which should be removed as an alternative to landfill.

The Carbon Factors for food and garden waste, anaerobic digestion and composting, are used as the recycling routes since "the Scottish Government wish to promote" these options. The use of these scenarios within the Carbon Metric is only valid if they are, indeed, the predominant recycling route. Otherwise, the indicator derived from the Carbon Metric will be misleading. The calculations of emissions associated with anaerobic digestion of both food and garden waste use the wrong GWP figure of 21 for methane.

The Carbon Factor applied to mineral oil is not entirely clear, as mineral oil is banned from landfill sites. As a result, this cannot be the baseline against which recycling is measured.

As the underlying data for WEEE is presented in a different format, it is not immediately obvious how the Carbon Factor was derived. The calculations indicate, however, that the recycling figure already includes the benefit of avoided impact. In this case, the formula used to derive the Carbon Factor in the spread-sheet appears to double-count the avoided emissions.

5 Data

5.1 Data Sources

The methodology relies on secondary data relating to greenhouse gas emissions. For material specific data, this comes mainly from various relevant industry bodies. Other activity data and common emission factors come from national and international governmental organisations, academic journals and the Ecoinvent database. In some cases, unpublished reports have been used, resulting in a lack of traceability.

The Environment Agency's WRATE tool is used extensively as a source for data associated with waste handling and disposal. CTFC does not have access to this tool and was thus unable to assess its characteristics and suitability.

5.2 Data Quality Requirements and Consistency

The data quality standard is laid out in section 5.1 of the methodology. This follows the data quality indicators defined in PAS 2050. In practice, the reliance on published data from a wide variety of sources means that much of it fails to meet at least some aspects of the defined quality standard.

While it is inevitable that a project such as the Carbon Metric has to rely on secondary data, it is important to fully understand the discrepancies between the various datasets and their impact on the final weighting between products.

The deviations from the expected standard are clearly laid out for each material, where relevant. In some cases, the source data might be sufficiently disaggregated to allow some adjustments to be made (e.g. use of a more geographically appropriate electricity emission factor).

Regarding the identified shortcomings of the polystyrene recycling data, the methodology may wish to augment this with the recently certified carbon footprint for recycled polystyrene from Axion Polymers, whilst bearing in mind that this applies to a single, specific product.

The review strategy for the Methodology and underlying data is not clearly outlined in this document, although references are made to a five-yearly review and the first review not taking place until 2020. Considering the relatively rapid growth of data availability and quality in this area against some of the quality issues with the existing data being used, it might be prudent to consider a review within the first 2-4 years of implementation.

6 Conclusions and Recommendations

The Carbon Metric provides a clear methodology to define and monitor recycling targets with reference to their environmental impact. This Metric complements the current weight-based targets, providing a better steer and incentives to choose the most appropriate waste management techniques available for each material.

The Carbon Metric operates within the limitations of available data, which leads to certain compromises regarding consistency across different materials and products. Although the Metric is not intended to be used for any decisions around material substitution within products, it could affect prioritisation of recycling infrastructure for different materials. As a result, the relative weightings attached to materials and products based on their carbon impacts must aim for the highest reasonable consistency. The figures currently proposed in the methodology seem broadly adequate, although the avoided emissions from textile recycling, based on an unpublished Bio IS study, appear very high and should be cross-referenced against other published and peer-reviewed literature.

The methodology is not fully consistent in its approach to some of the recycling options:

- the carbon impact of plastics is based on closed loop recycling,
- glass has a separate figures for colour-separated and mixed collections based on a combination of closed and open loop recycling,
- clothing figures incorporate all end-of-life streams, including reuse through charity shops and clothes banks.

A more consistent approach will result in a more balanced weighting between the different materials. This is currently being hampered to some extent by the lack of data availability around the destination of recyclate. This information is ultimately critical to the ambition of setting and meeting recycling targets based on carbon impacts. Modelling the recycling route for food and garden waste as anaerobic digestion and composting, respectively, is valid as the most appropriate open loop recycling option.

The methodology paper refers to potential future expansion of the Carbon Metric to allow wider assessment of the impacts of the various waste management options. Such expansion will require additional refinement of the existing Carbon factors. Avoided emissions of recycling and reuse, for example, have different boundaries. Additionally, the reuse of electrical and electronic goods would have to consider the use phase, where efficiency of newer models improves over time.

A number of the recommendations included in this report can only be implemented over time as better data becomes available. For this reason, it is recommended that a review be undertaken prior to the current schedule of 2020.