SUPPLY CHAIN SUSTAINABILITY SCHOOL

Measuring progress towards a Circular Economy: Indicators and Metrics Tool Guidance

This guidance document was produced as part of a research project with the University of Nottingham, funded by United Utilities, to evaluate existing and potential indicators and recommend a set of measures for the construction industry to monitor and report on their progress towards the Circular Economy.

The tool and guidance are aimed at organisations that already have a good grasp of circular economy principles. If you are new to the Circular Economy, please start with the introductory e-learning module. For case studies demonstrating how the tool can be used in practice, follow these links: ceiling tiles; asphalt; plasterboard; built assets. For the indicator and metrics tool, click here, and to access the e-learning module on Circular Economy Indicators, click here.

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INTRODUCTION

This document provides guidance on the use of the Circular Economy: Indicators and Metrics Tool for use by individuals or organisations with a working knowledge of circular economy. The Tool is a spreadsheet created to calculate the values of Circular Economy Key Performance Indicators and to record Supplementary Indicators for construction products or materials. The indicators themselves are largely based on the Ellen MacArthur Foundations' work on circular economy metrics in conjunction with Granta Design. This tool can be used along with other commercial information to support the business case for moving to a circular economy. This Guidance starts with a short introduction to the Circular Economy, it then introduces the indicators and describes how to use the Tool to calculate values for them.

"Today's linear 'take, make, dispose' economic model relies on large quantities of cheap, easily accessible materials and energy, and is a model that is reaching its physical limits. A circular economy is an attractive and viable alternative that businesses have already started exploring today" – Ellen MacArthur Foundation

The circular economy is one in which waste is minimised, and resources are used to their fullest extent and value. It is made up of circular flows of materials and resources, as shown in Figure 1 below. Construction products are mostly made of mined or manufactured materials and flow through the 'Technical nutrient' cycles on the right of the diagram. Maintenance or reuse of a product to extend its life will generally make more efficient use of resources than refurbishment, which requires replacement of some product components. Recycled resources can be used for the same or different purpose and involves returning the original product to raw materials.

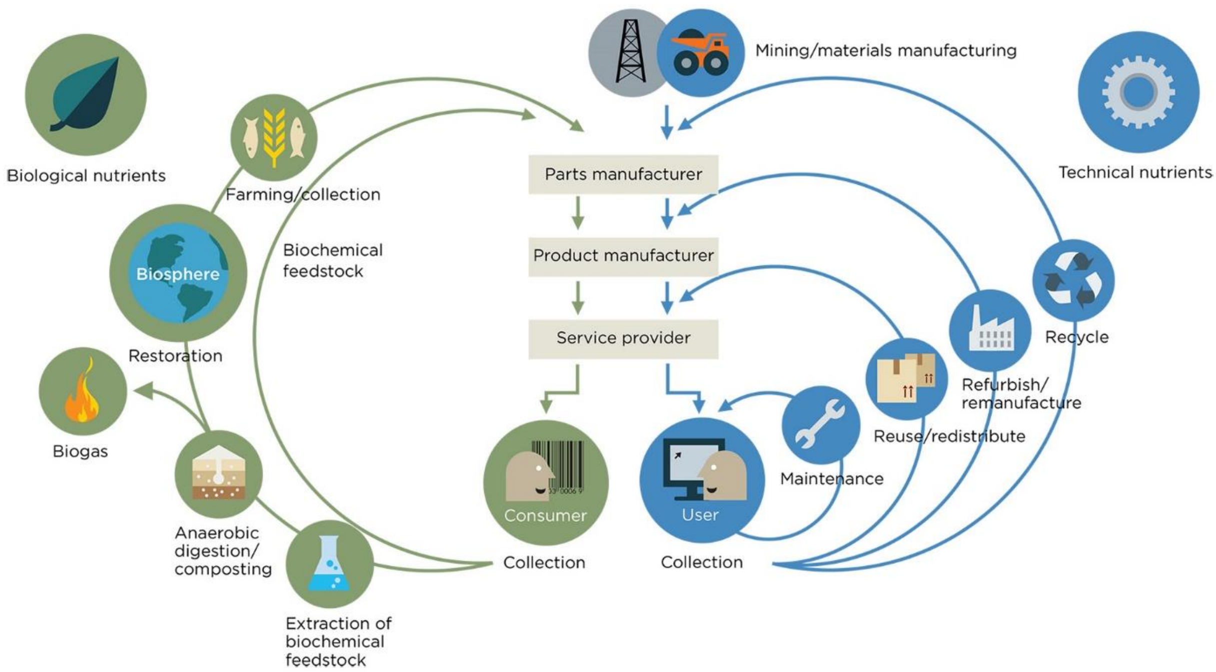

Figure 1: Circular Economy of biological and technical nutrients. Source: Ellen MacArthur Foundation

Becoming more circular can significantly benefit people, the environment, and the economy. In the unsustainable 'take, make, dispose' model, waste is either sent to landfill, incinerated, or is released into the natural environment as pollution. This has detrimental impacts on greenhouse gas emissions and climate change, as well as aquatic life, water pollution levels, and air quality. In a more circular economy, fewer virgin materials are exploited, and waste is significantly reduced. The social benefits of a Circular Economy include the potential creation of c.3M jobs across Europe, largely due to growth in the waste recovery, re-manufacture, and repair sector (WRAP, 2015). But circularity also makes business sense. It is expected that by 2030, Europe will experience a boost to the economy of €0.9 trillion thanks to the Circular Economy (McKinsey, 2015), and individual businesses can benefit from a reduced reliance on virgin materials and associated volatile commodity prices and supply chain risk.

CONSTRUCTION CONTEXT

So, what does circularity mean for the construction and infrastructure industry? And how could this change in the future?

These questions are difficult to answer without an agreed and widely used measure of organisation's current practice and progress and a way of measuring improvements. The construction industry has made significant steps to reduce waste to landfill and increase recycling rates over recent years. However, responses from a 2017 survey of Supply Chain Sustainability School members, and feedback from a Focus Group of partner organisations, indicate that the only well-used metric and Key Performance Indicator (KPI) related to circularity is the percentage of waste diverted from landfill. This indicator, although useful in demonstrating the progress that has already been achieved, no longer effectively represents where the industry is now, and the steps that businesses are taking towards circularity.

Indicators (information that is used to measure progress, for example '% waste diverted from landfill') and metrics (data used to calculate indicators, like 'waste generated'), are extremely useful tools for all members of the supply chain to use. The benefits of effective metrics and indicators include:

- Simple and easy to understand indicators can allow procurement professionals to make more informed decisions on both suppliers that they form contracts with, and the products and materials that they buy.

- They can enable organisations to understand their own progress and compare themselves to their direct competitors, other organisations in the same industry, and even to other sectors. This can drive competition and ultimately, help reduce waste to landfill and encourage the maximisation of resource value.

- They can improve the general understanding of what the Circular Economy is, throughout the industry. The Circular Economy is often viewed as an abstract and difficult to understand concept, which could limit the rate of progress. However, when we consider carbon emissions, businesses already base significant financial decisions on the carbon footprint of organisations and products, because it is a tangible, measured, and easy to understand sustainability indicator.

- They can allow the Circular Economy to gain real traction in businesses, by demonstrating the achievement of targets and highlighting the business case, making it easier to secure corporate and financial backing to continue to improve in the future.

In order to measure performance and progress towards a more circular economy, this project has collated a set of simple product-level indicators, which each have a set of metrics that sit behind the indicators. There are two core indicators and a number of supplementary indicators, along with some suggested commercial information to gather to support the business case for moving to a circular economy, see Table 1. The supplementary indicators and information have been included to ensure that circularity isn't viewed in isolation and is embedded into wider decision making.

The metrics and indicators could be used by any member of the supply chain; however, it is recommended that the main responsibility lies with manufacturers/suppliers, on a product-level basis. This is to ensure the product-specific data is accurately captured and can be supplemented with more information from other organisations in the supply chain and life cycle (e.g., 'in use' data from contractors or clients and recycling or disposal data from waste contractors or recycling facilities – see Figure 2).

It is also acknowledged that it is difficult to apply circularity indicators on a project scale. For more information on the potential ways of incorporating circular economy metrics into projects, please see the project-level case studies: ceiling tiles; asphalt; plasterboard; built assets.

Core Circularity Indicators	
Linear Flow Index (LFI)	A measure of the amount of virgin material used in a product and disposed of at the end of life
Materials Circularity Index (MCI)	A measure of resource efficiency based on the LFI and the lifetime or use of a product
Supplementary Indicators	
Carbon footprint	The greenhouse gasses released during production
Water footprint	The water used during production
Material scarcity	The abundance or scarcity of the materials used
Commercial Information	
Material toxicity	The presence of toxic materials in a product
Price variability	How much the prices of materials varies over time

Supply chain risk	Risks to the continuing supply of virgin materials
Whole life value	The potential value of products or constituent materials at the end of life

Table 1: Product Circularity Indicators

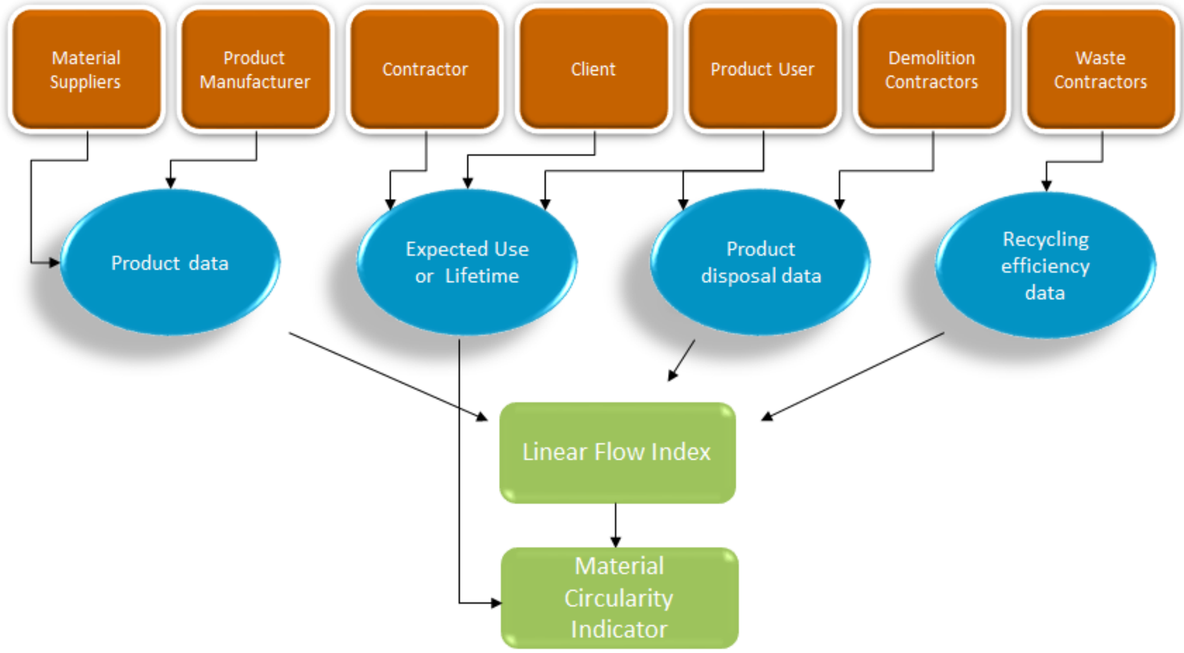

Figure 2: Typical data flows for the core circularity indicators

CORE CIRCULARITY INDICATORS

These are calculated by the Indicators and Metrics spreadsheet tool, based on input data.

Linear Flow Index (LFI): This indicator is an output of the Ellen MacArthur Foundations' work on circular economy metrics in conjunction with Granta Design. It is a measure of the amount of virgin material used in a product and disposed of to landfill or incineration at end of life. It takes into account several metrics relating to the materials within the product, and the likely fate of the product at the end of its life. These include the percentage of the total material mass that is from a recycled or reused feedstock, the percentage mass of the product that is recycled or reused at the end of its life, and the efficiency of the recycling process itself. The LFI has a value between 0 and 1, where 1 is a totally linear flow of materials; the product is made only from virgin materials, all of which are disposed of at the end of life. An LFI of 0 is a completely circular flow of material, where only reused and recycled feedstocks are used, and no materials is disposed of at end of life. See Appendix A for the calculation method for the LFI indicator.

Material Circularity Indicator (MCI): The MCI is potentially the most important indicator to consider when assessing the level of circularity of a product. It is the core output of the Ellen

MacArthur Foundation's work on circular economy metrics in conjunction with Granta Design. It takes the Linear Flow Index and applies a measure of the Utility of the product, which has a significant impact on the level of circularity for that product. For example, a product that has a long life-span and has a high level of operational performance represents a more efficient use of materials than a product with a very short life span that can only be used a few times before it is disposed of. The metrics required for calculating the MCI can either be focused on product lifetime vs. industry average lifetime, or alternatively, how much product is used, for example number of operations over its average life span vs industry average. If this is not appropriate (for example, for products and infrastructure projects with extremely long or indeterminate lifetimes), then the LFI should be used as a standalone indicator.

The MCI has a value between 1 and 0. An MCI of 1 represents a completely 'circular' product where all materials are from recycled or reused sources or feedstocks and no material is disposed of at the end of life. An MCI of 0 represents a product which only uses virgin materials, all of which is disposed of at the end of life, and which has a low level of utility. See Appendix B for the calculation method for the MCI indicator.

Please see the 'Instructions' tab on the indicators tool spreadsheet for more detailed information on data entry.

SUPPLEMENTARY INDICATORS

These are not calculated by the tool but can be entered by the user as supplementary information. The LFI and MCI specifically measure material use, so it is important to also consider other sustainability indicators when making decisions, so circularity isn't viewed in isolation. For example, there is a common misconception that recycling should be maximised for every product and material. However, for some products, other avenues of disposal (for example, reuse, repair, or remanufacture) may be more beneficial to the environment, because recycling processes for some products can be very energy and carbon intensive.

Carbon footprint *(see cell C13 in 'Indicators' tab in Spreadsheet Tool)* Energy usage and transportation involved in the material production and manufacture of products is an important factor in the carbon footprint. The Carbon Trust has more information on how to calculate carbon footprints, otherwise, Life Cycle Assessments (LCA) and Environmental Product Declarations (EPD) will contain carbon footprint data. Carbon footprints usually estimate the emissions of all common greenhouse gasses, including the most common, which is CO_2. The results are usually expressed as the equivalent mass of CO_2 that would have the same global warming potential as all the emissions ($kgCO_2eq$).

Definition: A Life Cycle Assessment considers the environmental impacts associated with all the stages of a product's life.

Definition: An Environmental Product Declaration is an independently verified document that communicates the results of a Life Cycle Assessment.

Water footprint *(see cell C14 in 'Indicators' tab in Spreadsheet Tool).* Potable and non-potable water use can be calculated as part of LCA and reported in EPDs and is usually reported as total litres used. The Supply Chain Sustainability School has more information on how to calculate water footprints.

Material scarcity *(see cell C15 in 'Indicators' tab in Spreadsheet Tool).* This assesses the relative abundance or availability of the materials within a product, and how much of those materials are used. It is more important to preserve scarce materials and take a circular approach to their use. Furthermore, the use of scarce materials may pose a business risk if their scarcity implies an unreliable supply in the future. Material scarcity is most commonly calculated as part of LCA and is usually reported within an EPD as the 'abiotic depletion potential' (ADP). The ADP is an estimate of the use of all scarce materials, in amounts relative to the scarcity of the element antimony (chemical symbol Sb) and reported in units of kgSbeq. The geological survey's research on critical raw materials can be used for more information on material scarcity and a summary of the critical raw materials at risk of overexploitation. This information could be used to identify scarce materials used in products if a full LCA has not been undertaken.

Please see the '*Instructions*' tab on the indicators tool spreadsheet for more detailed information on data entry.

COMMERCIAL INFORMATION

This section lists some additional information that frames the material circularity indicators. It is suggested that organisations gather data on the following areas relating to the sustainability of materials supply. These can be considered alongside circularity opportunities but due to their commercial nature are not included in the tool.

Material toxicity: The level of toxicity of materials within a product is key to understanding how easily and safely the product can be recycled or reused. This is a vital consideration in Cradle to Cradle certification (C2C), as material health can significantly influence the feasibility of circular designs and business models. Information on material toxicity is likely to be collected for regulatory purposes.

Price variability: This is an important factor for understanding how commodity prices for the materials within a product affect your organisation. Improving circularity and reuse of materials will bring the most benefits for materials with extremely volatile material costs, as using more secondary material could avoid volatility of virgin material prices. It is suggested by Ellen MacArthur Foundation to consider price data for the past five years.

Supply chain risk: It is suggested that monopoly of supply, considering the structure of suppliers and the reliance on each one, for the supply of certain materials, is used to assess the reliability of supply, along with publicly available information such as the Global Slavery Index, which ranks countries according to their Modern Slavery risk. Each of these factors may represent a risk to the continued supply of these materials. Product certifications and organisational standards are important to consider as these may reduce social or environmental supply chain risk. The reuse and recycling of these materials will reduce the risks associated with the sustainability of supply of the virgin materials.

Whole life value: A key concept of the Circular Economy is the maximisation of resource value. Therefore, an important consideration when manufacturing and procuring products, and carrying out construction projects, is the whole life value of the asset. This takes into account predicted residual value at the end of a product's functional life and the total cost of materials. This is inherently difficult to calculate due to uncertainty in future product prices, however, beginning to have collaborative discussions throughout the supply chain on whole life value could positively influence decisions that are made around circularity. For instance, this might highlight the potential benefits of take-back schemes with planned recycling or reuse, or leasing arrangements, where the product and the materials in it remain in the ownership of the manufacturer.

SUPPLY CHAIN COLLABORATION AND CONTINUAL IMPROVEMENT

One of the main challenges with developing and embedding indicators for the Circular Economy lies in accommodating the different stages that organisations are at along the journey to circularity. For example, collecting all the primary data needed to calculate MCI and LFI will be too advanced for some organisations that are just beginning to understand what circularity means for them; to get started they may need to rely on industry average data, where available. We therefore suggest a hierarchical approach is applied to the suggested metrics and indicators, for example, the illustrated outlined in Figure 3 for a product manufacturer scenario. Many product manufacturers will currently be at the lower levels of this hierarchy and have the opportunity to improve their measurements and reporting.

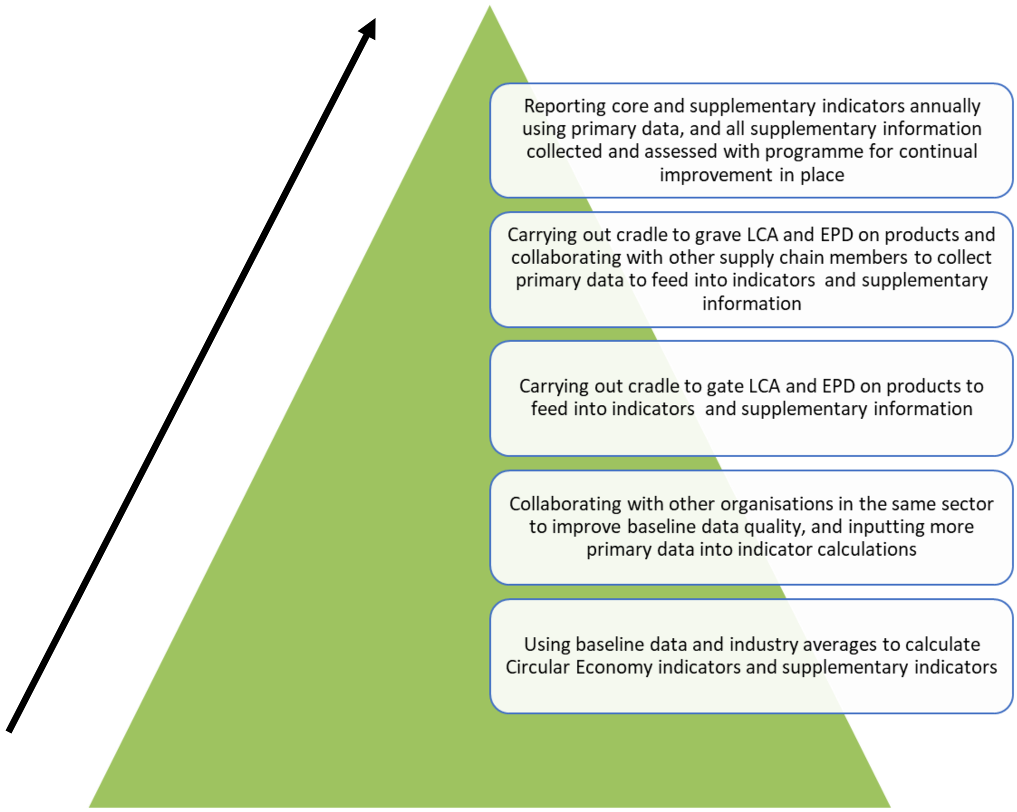

Figure 3: Example of a hierarchy approach to measuring circularity

It is suggested that industry average data are used as a baseline when calculating the indicators without available primary data. A small selection of industry average baseline data to demonstrate the suggested approach can be found in Appendix C.

A commonly undervalued characteristic of the Circular Economy is its inherently inter-connected and collaborative nature. At the core of improving circularity and its measurement and reporting, is the collection and sharing of data throughout the supply chain. The indicators and metrics could also support other initiatives, for example, the EU BAMB project, encouraging the use of Materials Passports. These passports will include material and product data necessary to promote reuse and recycling and could include the necessary information to make estimates of the circularity indicator values. The indicators could also improve relationships between building and infrastructure contractors and their suppliers, for example, collaborating with manufacturers with take-back schemes (see British Gypsum and Armstrong Ceilings Case Studies, and starting conversations with waste recyclers to understand their challenges and potential opportunities for improvement. This type of activity, and the use of the suggested indicators and metrics therefore holds the potential to create much larger scale positive benefits for sustainability and the Circular Economy by raising the bar for the industry as a whole.

APPENDICES

Appendix A

Linear Flow Index (LFI) *(see 'Indicators' tab in Spreadsheet Tool)*

LFI = (V + W) / (2M + ((Wf – Wc)/2)); and

V = mass of virgin material going into the product manufacture = M(1 – Fr – Fu):

M = mass of product

Fr = % mass of recycled material

Fu = % of mass of reused materials

W = unrecoverable waste = Wo + ((Wf + Wc)/2);

Wo = waste to disposal (landfill or burning) = M (1 – Cr – Cu);

Cr = % of product sent for recycling at end of life

Cu = % of product sent for reuse at end of life

Wf = waste generated to produce recycled material = M ((1-Ef)Fr/Ef)); and

Ef = % efficiency of recycling process to produce new feedstock

Wc = waste generated during collecting recycled materials = M (1 – Ec) Cr;

Ec = % efficiency of process of sending materials recovered for recycling into the recycling process (for instance if a coating needs to be removed from a material before recycling then there will be a mass loss and waste generation)

Appendix B

Material Circularity Indicator (MCI) *(see 'Indicators' tab in Spreadsheet Tool)*

MCI = (1 – LFI (0.9/X))

X = Utility, where;

X = (L/Lav) *OR* (U/Uav)

L = product lifetime or design life (and industry average lifetime or design life = Lav), and

U = use (and industry average = Uav); where use is defined as number of operations during the product life (e.g. projected hours use of an electrical product).

Appendix C

To get you started, typical or average data for a small selection of construction products is shown in the table below (with data source references in brackets). Please be cautioned that these figures may vary considerably for individual materials or products and actual product data should be sought where possible.

Product/Material	Recycled material content	CO_2 emissions (Supplementary Information)	Water usage (Supplementary Information)	Recycling rates
Precast concrete	45% (1)	0.11 $kgCO_2eq/kg$ (2)	0.084 litres/kg (1)	94% (1)
Clay bricks and blocks	9.3% (3)	0.24 $kgCO_2eq/kg$ (2)	0.027 litres/kg (3)	98% (3)
Bitumen				84% (4)
Tiles and ceramics				54% (4)
Glass		0.91 $kgCO_2eq/kg$ (2)		96% (4)
Plastic		3.31 $kgCO_2eq/kg$ (2)		82% (4)
Iron and Steel				94% (4)
Construction Steel		1.46 $kgCO_2eq/kg$ (2)		71 - 98% (5)
Aluminium	75% (6)	9.16 $kgCO_2eq/kg$ (2)		92 – 98% (6)
Wood				42% (7)

Trade bodies and associations, along with private and public-sector initiatives looking into waste and recycling, have a wealth of information and potential baseline data to use. Here is a selection of some examples for the construction industry:

- WRAP Resource Efficiency Action Plans (REAPs) for construction products: http://www.wrap.org.uk/)
- Trade bodies, e.g.:
  - Construction Products Association (https://www.constructionproducts.org.uk/),
  - Mineral Products Association (http://www.mineralproducts.org/),
  - Plasterboard Sustainability Partnership (https://www.plasterboardpartnership.org/)

- EA Waste Interrogator data for recycling rates (https://data.gov.uk/dataset/waste-data-interrogator-2016)
- BRE SmartWaste database (http://www.smartwaste.co.uk/)

Sources:

(1) WRAP 2013 Precast Concrete REAP
(2) Embodied Carbon. The Inventory of Carbon and Energy (ICE). BSRIA 2011 (https://www.bsria.co.uk/.../embodied-carbon-the-inventory-of-carbon-and-energy-ice/)
(3) WRAP 2013 Clay bricks and clay blocks REAP
(4) EA Waste Interrogator 2016 (https://data.gov.uk/dataset/waste-data-interrogator-2016)
(5) Steelconstruction.info (https://www.steelconstruction.info/Sustainability#Recycling_and_reuse)
(6) Aluminium Federation (http://www.alfed.org.uk/files/Fact%20sheets/5-aluminium-recycling.pdf)
(7) DEFRA (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/82571/consult-wood-waste-researchreview-20120731.pdf)