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Briefing Paper

Assessing the environmental impacts of construction – understanding European Standards and their implications

BRE Centre for Sustainable Products

Summary

The context for environmental assessment in the construction sector is undergoing considerable change. This is largely due to the publication of the long-awaited suite of standards from CEN TC 350, which interlink with those from International Standards Organisation (ISO) relating to life cycle assessment (LCA) and Type III environmental labelling.

This paper, funded by the BRE Trust, is provided as an aid to understanding the implications of CEN TC 350's emerging standards for assessing the environmental performance of construction products (materials) and buildings.

The document presents an overview of the TC 350 standards relating to the environmental performance of materials and buildings and identifies the key aspects of the standards and their implications for modelling the environmental impacts of construction.

This paper will be of interest to manufacturers of construction products and services, architects and specifiers using these products and services, and LCA practitioners engaged in assessing them. It will help you understand the standards emerging in Europe and the challenges faced in implementing them.

BRE Trust

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Contents

1 Introduction to the standards

The European Committee for Standardisation (CEN) set up Technical Committee 350 "Sustainability of construction works" to be responsible for the development of a voluntary harmonized methodology for the assessment of the sustainability aspects of new and existing construction works and for standards for the environmental product declaration (EPD) of construction products.

The TC 350 environmental standards are intended to provide a harmonised approach to the measurement of embodied and operational environmental impacts and their aggregation (particularly for materials from construction product data EPD) into models for whole buildings across the entire lifecycle.

Under the TC 350 work mandate, a suite of standards has been, or is in the process of, being published. At the highest level is a standard that describes the means for the integration of all three sustainability aspects (EN 15643-1:2010).

To date, the greatest progress has been in the area of environmental impacts, since this is the area where knowledge and experience are most developed. These standards are the focus of this paper; they cover both the product-level and the building-level, with the product-level providing a means of support for the building-level.

The following sections of this paper outline the European standards at the product-level and then at the building level. The paper then goes on to explore the implications of these standards for the assessment of the environmental impacts of construction.

2 Product-level (environmental) standards and reports

Under the environmental strand of the CEN TC 350 mandate, two standards and a technical report have been published at the product level and are summarised in Table 1.

The production and listing of EN 15804 compliant EPD is only possible within an EPD programme (scheme). BRE Global has established an EN 15804 EPD scheme with its PCR 'BRE Environmental Profiles 2013: Product Category Rules for Type III environmental product declaration of construction products to EN 15804:2012' applicable to all construction products.

Other EPD Programme Operators have PCR that comply with EN 15804 but make different choices from those of the BRE programme; for example the German EPD programme operated by the Institut Bauen und Umwelt e.V. (IBU) allows the use of green tariffs whereas BRE's scheme does not, due to indications that, in the UK at least, they are unsuccessful in achieving the aim of providing increased amounts of renewable energy. This has considerable implications for the portability of EN 15804 compliant EPD and for their usage within building models and building-level assessment schemes.

A pan-European initiative between EPD Programme Operators called ECO Platform is endeavouring to work towards mutual recognition of EN 15804 EPD, and progress has so far been made in recognising the quality of the EPD via a consistent approach to verification rather than the automatic import of the numerical values contained within EPD.

Table 1: CEN TC 350 Product Level (Environmental)

Standard/Report	Scope
EN 15804:2012 Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products.	This standard provides core Product Category Rules (PCR) for all construction products and services. It provides a structure to ensure that all Environmental Product Declarations (EPD) of construction products, construction services and construction processes are derived, verified and presented in a harmonised way.
CEN/TR 15941:2010 Sustainability of construction works – Environmental product declarations – Methodology for selection and use of generic data	This Technical Report supports the development of EPD. It assists in using generic data according to the core product category rules (EN 15804) during the preparation of EPD of construction products, processes and services in a consistent way, and also in the application of generic data in the environmental performance assessment of buildings according to EN 15978.
EN 15942:2011 Sustainability of construction works – Environmental product declarations – Communication format business-to-business.	This standard specifies and describes the communication format for the information defined in EN 15804 for business-to-business communication to ensure a common understanding through consistent communication of information.

3 Building-level (environmental) and framework standards

Under the environmental strand of the CEN TC 350 mandate, three standards have been published at the building level and these are summarised in Table 2.

Table 2: CEN TC 350 Building Level (Environmental) and Framework Standards

Standard	Scope
EN 15643-1:2010 Sustainability of construction works – Sustainability assessment of buildings – Part 1: General framework.	This standard provides the general framework for the assessment of buildings in terms of environmental, social and economic performance. The framework applies to all types of buildings over their entire life cycle. The standards developed under this framework do prescribe levels, classes or benchmarks for measuring performance.
EN 15643-2:2011 Sustainability of construction works – Assessment of buildings – Part 2: Framework for the assessment of environmental performance.	This standard provides the specific principles and requirements for the assessment of environmental performance of a building.
EN 15978:2011 Sustainability of construction works – Assessment of environmental performance of buildings - Calculation method	This standard provides the calculation rules for the assessment of the environmental performance of new and existing buildings.

4 Overview of interactions between standards

The complex interactions between the standards in Figure 1 (along with other key standards that feed into them) are illustrated in Figure 2.

The complicated network in Figure 1 highlights the need to be aware of a raft of standards to ensure that the implementation of the building-level and product-level standards is compliant with the underpinning standards. This is a considerable undertaking and investigation of the standards reveals that there are some areas where different interpretations are possible. This presents potential difficulties when seeking to model at the building-level, particularly with the aim of producing benchmarks. A further challenge to modelling at the building-level is the fragmentation between product-level data providers and building-level assessment schemes – it is crucial that both parties understand the needs of the others to ensure that data compatibility and the building-level modelling are as accurate as possible.

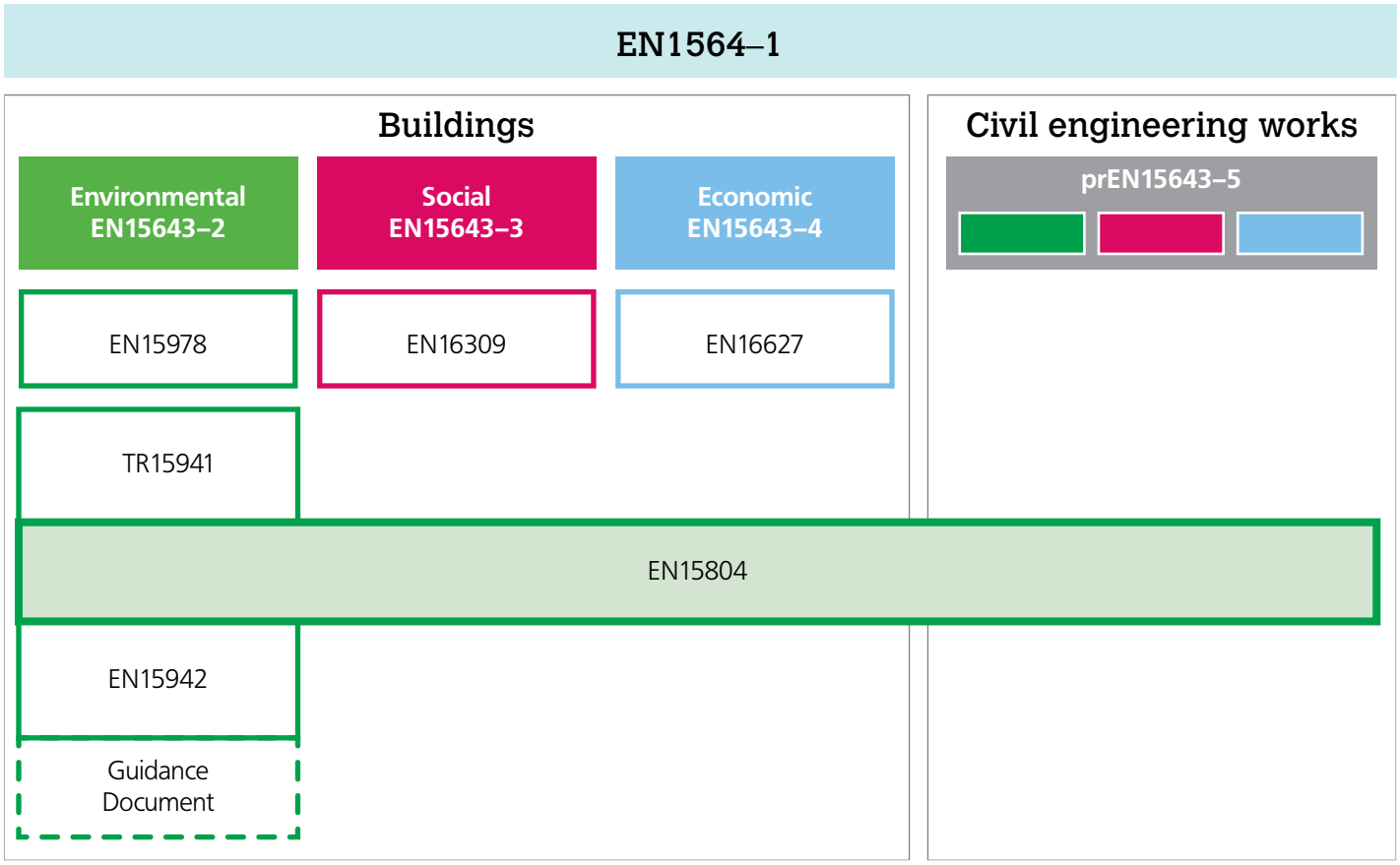

Figure 1: Technical Committee 350 'Sustainability of construction works' standards

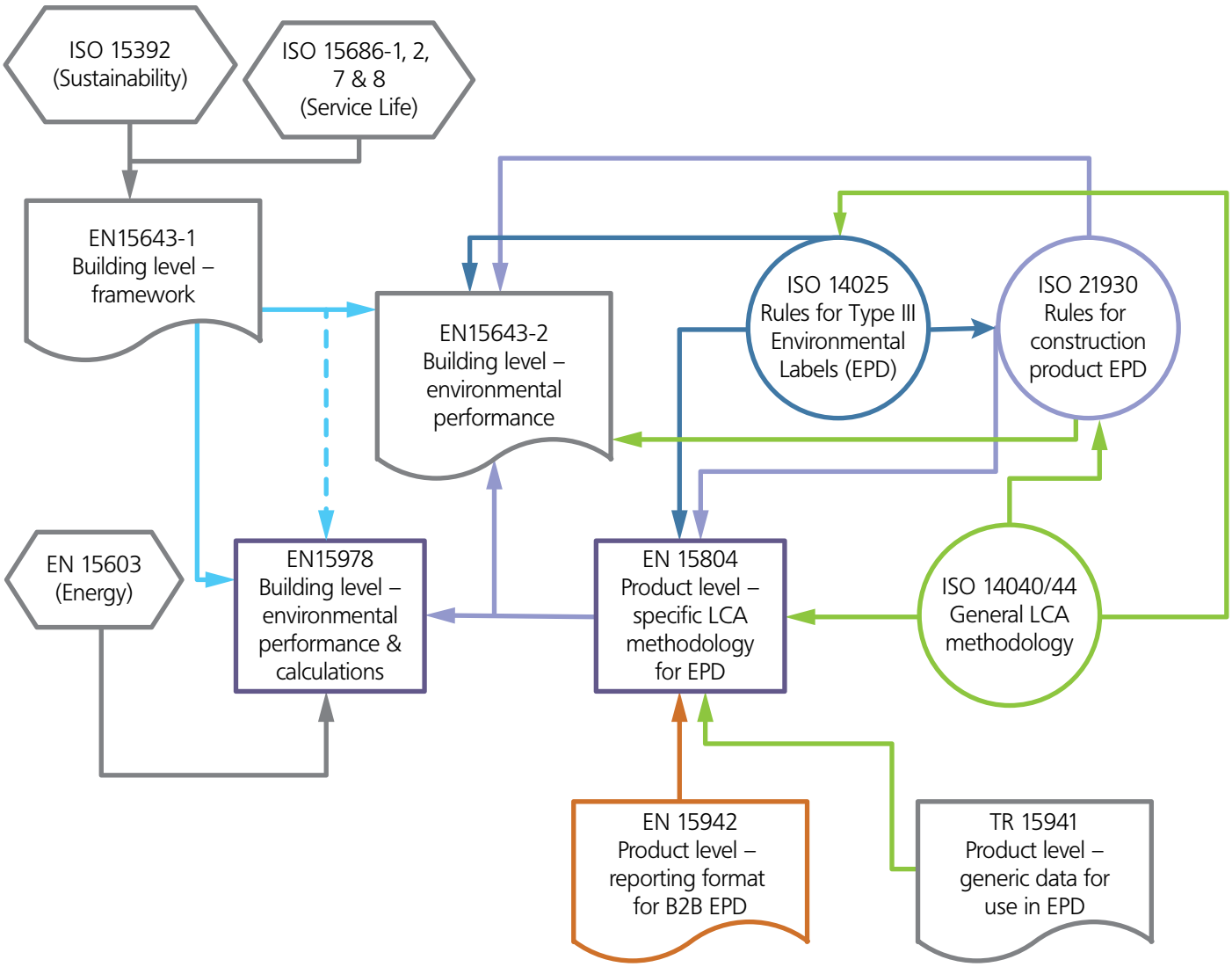

Figure 2: Interactions between TC 350 environmental assessment EN and ISO standards

The modular approach employed by both EN 15978 and EN 15804 is a useful means of building flexibility into the provision and use of data. The modules used are shown in Figure 3.

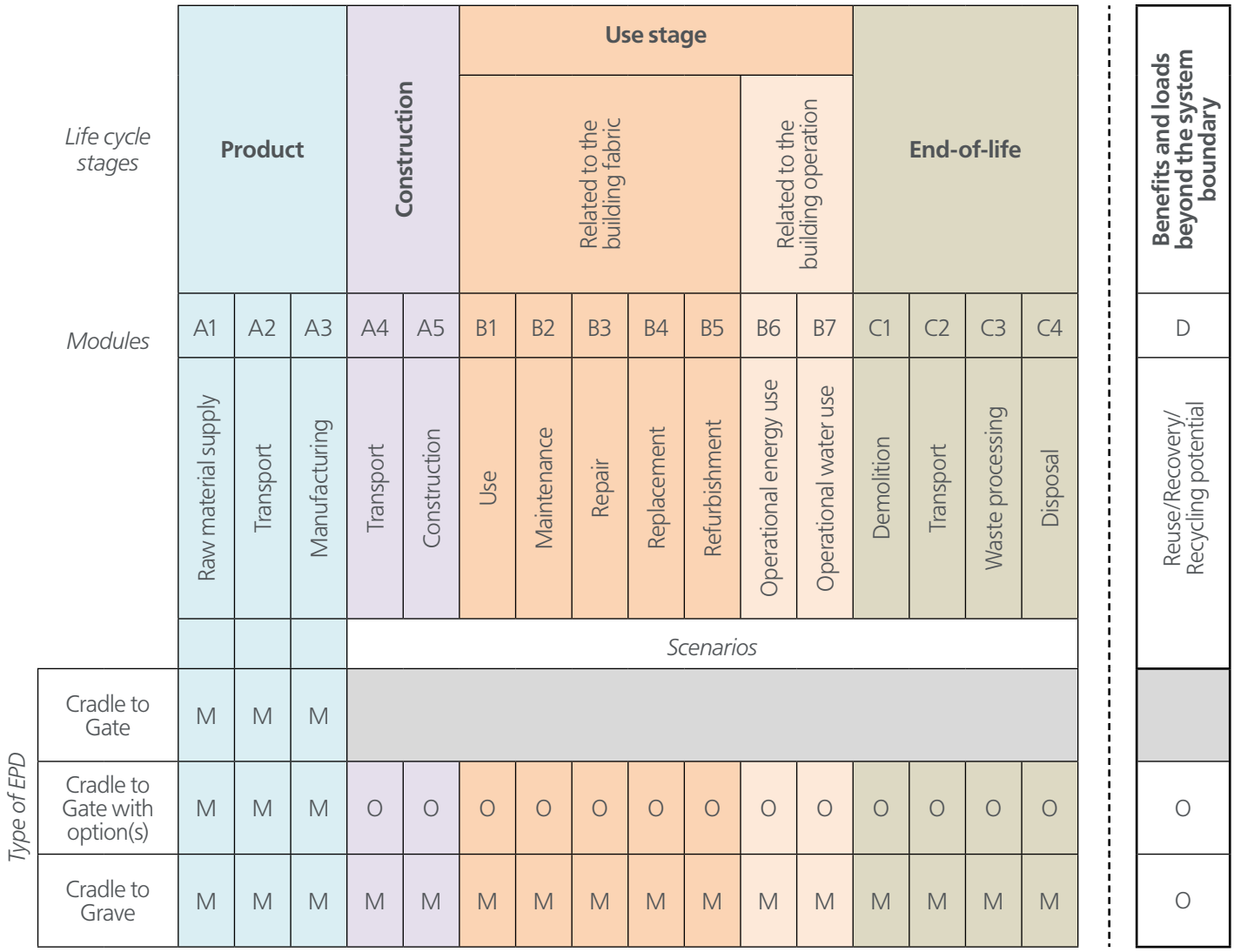

Figure 3: Mandatory and optional elements and information modules for construction products, adapted from EN 15804:2012.

5 Implications of European standards for assessing the environmental sustainability of construction.

As outlined earlier, EN 15804:2012 describes the methodology for producing EPD at the product-level while EN 15978:2011 describes the assessment of environmental performance at the building-level. There must, therefore, be consideration given to the building level when working at the product-level. This is because any scenario choices that are made during the assessment at the product-level have implications for when this information is taken forward for the assessment at the building-level.

This interdependency is demonstrated by the information provided in Table 4, which lists the life cycle stages described by 15804:2012 and 15978:2011 and shows whether the results for a stage are dictated at the product-level or at the building-level or, in the case of future use scenarios, by both. For example, it is the product that dictates the environmental impacts of A1 to A3 and the product's end of life disposal, but it is the building that will influence the environmental consequences of stages A4 to C3.

Table 3: Life Cycle Stages and their Relationship to the Product and Building Contexts

Life Cycle Stage			**Influenced by**	
Life cycle stage (module)		**Description**	**Product**	**Building**
Product stage	A1	Raw material supply	✓	
	A2	Transport of the materials	✓	
	A3	Manufacturing	✓	
Construction stage	A4	Transport to construction site		✓
	A5	Construction, Installation		✓
Use stage	B1	Use		✓
	B2	Maintenance		✓
	B3	Repair		✓
	B4	Replacement		✓
	B5	Refurbishment		✓
	B6	Operational energy		✓
	B7	Operational water		✓
End of Life stage	C1	Deconstruction, demolition		✓
	C2	Transport of wastes/ demolition material		✓
	C3	Waste processing		✓
	C4	Disposal	✓	
Benefits and loads beyond the system boundary	D	Reuse, recovery, recycling	✓	✓

The key areas of influence are:

1. System Boundary
2. Scenarios/Models
3. Quantities (net and gross)
4. Data Quality
5. Cut off Rules (criteria for exclusion of inputs and outputs)
6. Environmental Indicators
7. Allocation
8. Reporting
9. Service Life
10. Infrastructure
11. Comparability of EPD

A comparison of the standards found that there are many areas where the approach was not quite the same across all standards. The majority were similar to each other, but there were some instances of potential conflict and many more of potential differences in interpretation. These will only truly be revealed once a large body of EPD from different schemes become available and are applied to the assessment of the impacts of buildings.

The concept of TC 350 is to provide data for modelling at the building level. The data can be derived from a range of sources including, but not restricted to, EN 15804 EPD (hence the modular approach of EN 15804). This implies a patchwork of datasets can be assembled to provide a building model as long as the criteria for EPD comparability are met. These criteria are set out in EN 15804 and ISO 14025 and presented below:

EN 15804, clause 5.3 Comparability of EPD for construction products

In this clause, the contribution of construction products to the environmental performance of the building defines the basis of the comparison of the EPD of such products. In other words, according to EN 15804 this comparison is essentially based on the use of the products in the building and therefore requires the consideration of the complete life cycle of the products (cradle to grave).

Comparisons are also possible 'at the sub-building level, e.g. for assembled systems, components, products for one or more life cycle stages'. Clause 5.3 of EN 15804 lists conditions for this, along with the proviso that the information used is transparent to ensure that the limitations of this comparability are taken into account. There are requirements for further investigation in situations where the EPD does not cover all life cycle stages or where assumptions used in the underlying scenarios are not applicable in or appropriate to the particular building context.

ISO 14025, clause 5.6 Comparability

According to this clause, EPD are intended to allow the comparison of the environmental performance of construction products on the basis of their life cycle using transparent information. The transparency ensures that whomever is making such comparison is aware and understands the inherent limitations which are detailed in a separate clause of the standard (clause 6.7.2) described below. Examples of such limited comparability are EPD based on LCA studies not covering all life cycle stages or that have been derived using different PCR documents.

ISO 14025, clause 6.7.2 Requirements for comparability

This clause in ISO 14025 elaborates further the specific requirements for comparability. These include requirements that the product category definition and descriptions are identical; the functional unit used in the product LCA are identical and other aspects of the goal and scope of the study are equivalent; the use of equivalent methods of data collection and identical calculation procedures; the use of identical rules for and selection of impact categories, etc.

In all there are 11 specific aspects itemised, as well as requirements on the omission of life cycle stages only if the environmental impacts of these stages are insignificant or that the data of the stages are identical within the boundaries of data uncertainty.

It is extremely difficult to achieve all the requirements in this list in clause 6.72 of ISO 14025 or in the criteria as described by both EN 15804 and ISO 14025. This means that it is virtually impossible to create a database of construction products that can be said to be comparable according to the standards. This has considerable implications for the assessment of buildings from EPD data.

However, exhaustive though the comparability requirements in the standards are, there are no requirements around the source of the datasets underpinning the EPD. After examining two building models that were each assessed twice, using two different commercial databases, the conclusion was that database choice will strongly affect the results obtained and, consequently, any decisions based on them.

A further issue to consider is the volume of data and its potential usefulness in modelling at the building level. The modular approach described in Product-level standards shows that, for a cradle-to-grave EPD, there could be 17 life cycle stages reported for each of the 24 parameters (or 25 parameters for BRE's PCR where High Level Nuclear waste is reported separately as well as being included in the total nuclear waste – High Level Nuclear waste accounts for a small proportion of the nuclear waste but nearly all of the problem). This means that a total of 408 values could be contained in the EPD (425 for EPD based on BRE's PCR). This total could be even higher if several Module D scenarios are presented and C4 Disposal modelled as both 100% to landfill and 100% to incineration.

When using EPD to select the product with the lowest environmental impacts, the question then is: How feasible is it to compare over 400 numbers with each other, even for just two EPD? Even for this simplest case, it is also necessary to consider two further questions: How likely is it that all values will be bigger in one EPD than in the other, so that the choice will be clear? and How likely is it that the EPD will achieve all the comparability requirements of ISO 14025, which doesn't even consider database choice?

Achieving comparability between EPD at the product level is, therefore, very difficult, but it is extremely important if comparability at the building level is to be achieved.

The TC 350 standards place the emphasis on comparative assessment at the building level requiring 'functional equivalent'[1] specifications, as set out in the Introduction to EN 15643-1, and echoed in EN 15643-2, EN 15978 and EN 15804:

1 Functional equivalent: quantified functional requirements and/or technical requirements for a building or an assembled system (part of works) for use as a basis for comparison. EN15978:2011

EN 15643-1: Introduction

In carrying out assessments, scenarios and a functional equivalent are determined at the building level.

Assessment at the building level means that the descriptive model of the building with the major technical and functional requirements has been defined in the client's brief or in the regulations as illustrated in Figure 1. Assessments can be undertaken for the whole building, for parts of the building which can be used separately or for elements of the building. Although the evaluation of technical and functional performance is beyond the scope of this series of standards, the technical and functional characteristics are considered within this framework by reference to the functional equivalent. The functional equivalent takes into account the technical and functional requirements and forms the basis for comparisons of the results of the assessment.

Any particular demands for, or related to, the environmental, social and economic performance defined in the client's brief or in the regulations, may be declared and communicated.

It is, therefore, imperative that any comparisons of performance must be based on buildings that have the same technical properties. While functional requirements can be presented in terms such as 'support the primary education of 450 pupils', the technical performance requirements in the UK will have to satisfy as a minimum the relevant levels embedded within the Building Regulations/Standards and supported by the sets of Approved Documents/Technical Handbooks. For example: Approved Document Part L (conservation of fuel and power) sets CO_2 targets for the building (as kg CO_2/(m^2.year), but also requires that the performance of the building fabric and the fixed building services achieve reasonable overall standards of energy efficiency. The aim of Part L is to place limits on design flexibility to discourage inappropriate trade-offs by practices such as using low levels of insulation and offsetting this with renewable energy systems of unknown service life.

There are many factors that can influence the accuracy of modelling at the building level. These include the following potential sources of error:

a) in the data itself
b) in rounding the data once analysed[2]
c) in calculating masses required to assess a whole building + wastage rates + wastage routes.

The TC 350 standards provide a useful framework for the measurement of the environmental impact of specific buildings; what they do not do is provide a means of applying that measurement to a comparative system that enables judgements to be made on how the performance of buildings compares to that of generics (i.e. benchmarks).

To be able to compare buildings and reward performance appropriately, therefore, requires considerable work to establish the basis of comparison, and what levels of differentiation are possible and worth rewarding. The essence of the TC 350 standards is to measure everything and compare on the basis of functional equivalence.

However, for BREEAM (BRE's environmental assessment method for buildings), it is worth considering whether it would be more useful to carry out an initial set of assessments that do measure everything but then to focus on the important aspects where significant improvements can be made. For example, a project funded by the BRE Trust has shown that a building's fixed services can cause almost as much environmental impact as the building's fabric, but there are very few options available for selecting the most sustainable services for a building. Building-level assessment schemes need to include tools to assist this.

If building-level assessment schemes wish to influence design (rather than measure the results of a finished design), then it is important that the design process is clearly understood and the approach developed, including supporting tools, reflects the needs and abilities of the scheme's users.

Meeting the requirements of the suite of TC 350 standards will be difficult: the standards seem to be aimed at measurement of the environmental impacts occurring at a specific site where many of the necessary criteria are already known, e.g. the curtilage and any arising infrastructure within it, the foundations needed, the climatic conditions, and the technical requirements for the building.

If a building-level scheme wishes to assess how well a development performs against preset levels, then the key implication of the TC 350 standards is that energy, water and materials will need to be drawn together into an integrated whole that is modelled at the complete building level. The determination of how to set the different performance levels required to achieve specific credits will, therefore, necessitate the production of a sophisticated set of benchmark buildings. A further challenge is that the tools to support the assessment of individual developments will need to reflect the abilities of the users along with the status of LCA knowledge and data in the region where the scheme is operating.

Achieving suitable benchmarks when considering the main life cycle (stages A, B and C[3]) is challenging but attainable. Module D (Reuse/Recovery/Recycling potential), however, presents a perplexing issue: it is scenario-based and the scenario should be according to the most probable and technically viable option, but it is inherently beyond the boundary of the system considered; the standards are explicit that Module D is separate from A to C and cannot be directly combined with them. There are many complications associated with assessing it at the whole building level and converting this into meaningful comparative performance measures. For example, for a highly recycled material such as a metal, if 1 kg of the original product contains 0.2 kg of recycled material and 0.8 kg of virgin material and the 'product' leaving the system is 0.95 kg of material that can go back into the originating system, this would mean that the 'exit product' could replace both the 0.2 kg or recycled material and 0.75 kg of the virgin material so that only 0.05 kg of virgin material would be required. The Module D declaration would be for the consequences of providing the 0.95 kg of the 'exit product' and avoiding the manufacture of 0.75 kg of virgin material.

2 EN15942:2011, clause 6 Requirements for EPD communication format, 'numerical reporting of no more than three significant figures shall be applied'. Reporting 3 significant figures at EPD level has implications for error at building level but these are likely to be small (calculations using such data indicate less than ±0.5% on the final rounded result).

3 EN15978:2011, clause 12.6 Communication of assessment results, states 'within each of the building life cycle stages … the results per indicator may be summed provided that values for the indicator are determined for each module within that stage'.

A visual representation of this example is given in Figure 4 below.

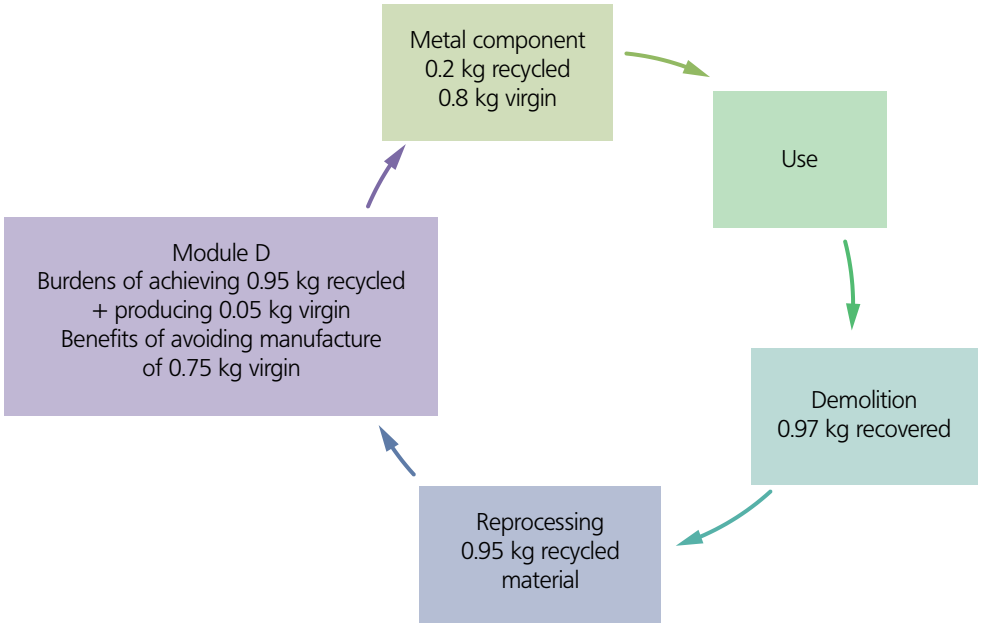

Figure 4: Diagram of example Module D scenario

The main problem with this approach is that it does not address the issue of time passing. This has two important implications: a) if the building has a life of 60 years then the original material production system operated 60 years ago and is not likely to have remained the same; b) the amount of material available for recycling is likely to change. A further issue is that, in considering only 1 kg, the approach does not address the relative sizes of the originating system and the building system: the metal production system will be much larger than the construction system and the producing system is likely to be operating at the highest level of recycled content that represents a balance of availability and technical properties.

6 Conclusion

In conclusion, whereas the TC 350 suite of standards are aimed at producing detailed measurement of the environmental performance of a product, service or building; they are not well set up to provide a mechanism for applying that information. However, the building level standard (EN 15978) does allow for a selective approach in the communication of results. This indicates it is possible for a building-level scheme to work with a reduced set of parameters and sum data within the main lifecycle stages.

Glossary

Building product/Construction product: Goods or services used during the life cycle of a building or other construction works.

Environmental impact category: environmental impact issue being examined, e.g. Global Warming, being measured by global warming potential (GWP), and Ozone Depletion being measured by the depletion potential of the stratospheric ozone layer (ODP).

Inventory data: table of amounts of resources used, and products and emissions produced to achieve the product or function being studied.

Life cycle: consecutive and interlinked stages of a product from raw material acquisition or generation of natural resources to the final disposal.

Life cycle assessment (LCA): compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product throughout its life cycle.

Life cycle inventory (LCI): conversion of process inputs and outputs into environmental burdens contributing to the environmental impact categories being assessed.

Life cycle impact assessment (LCIA): phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product. LCIA attributes the LCI results to all relevant environmental impact categories.

Product category: group of products that can fulfil equivalent functions.

Product category rules (PCR): set of specific rules, requirements and guidelines for developing Type III environmental declarations for one or more product categories. This BRE PCR applies to the product category 'construction products'.

System boundary: describes what is being assessed within the life cycle of the system studied. The boundaries must address the geographical area and time horizon considered as well as covering the boundaries between: the technological system and nature; production of the product and production of capital equipment, and the life cycle of the product studied and related life cycles of other products.

Type III environmental declaration: (Environmental product declaration, EPD) – a third party verified report providing quantified environmental data (impacts) using predetermined parameters and, where relevant, additional environmental information for the product being studied.

References

EN 15804:2012, Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products.

EN 15643-1:2010, Sustainability of construction works – Sustainability assessment of buildings – Part 1: General framework

EN 15643-2:2011, Sustainability of construction works – Assessment of buildings – Part 2: Framework for the assessment of environmental performance

EN 15978:2011, Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method

CEN/TR 15941:2010, Sustainability of construction works – Environmental product declarations – Methodology for selection and use of generic data

EN 15942:2011, Sustainability of construction works – Environmental product declarations – Communication formats: business to business.

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

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