

Life Cycle Assessment of Buildings: *Technical Guidance*

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Introduction

The purpose of this *Technical Guidance* is to provide detailed recommendations for conducting life cycle assessments (LCAs) of buildings and to increase the standardization of practice in North America. This *Technical Guidance* supplements [Life Cycle Assessment of Buildings: A Practice Guide](#) (referred to as the *Practice Guide* from this point forward) with technical details, and is directed towards seasoned LCA practitioners and LCA tool developers. The *Technical Guidance* follows the structure of the European Standard EN 15978, *Sustainability of construction works – Assessment of environmental performance of buildings – Calculation Method*, and recommends aligning with much of its content. Note that this document references sections of EN 15978 directly so as not to a) infringe upon the copyrights of EN 15978, or b) obscure clarity by rephrasing, though summaries for each major section are provided. The reader will require access to an official copy of EN 15978 in order to make a full and detailed interpretation.

This *Technical Guidance* provides additional guidance in places where EN 15978 needs adjustment for use in North America and where additional standardization or clarification is needed, as identified during the development of the *Practice Guide*. Significant additions to EN 15978 addressed by this *Technical Guidance* include:

- A. **Minimum Criteria:** Defines a minimum criteria for reporting the results of an LCA for: general information, goal and scope, system boundary, inventory of materials and energy, and environmental impact results.
- B. **North American Impact Categories:** Recommends aligning with ISO 21930:2017 for environmental impact categories for use in North America, based on TRACI.
- C. **Taxonomy for WBLCA:** Outlines a proposed *taxonomy*¹ for building LCA data and documentation (referred to as the *Taxonomy* from this point forward). The final taxonomy is presented in a separate document, which can be accessed in the [Online Resources](#).

Note that this document should be used as guidance to encourage the quality of whole building LCA practice. Additional standardization is needed in order to enable comparisons between LCA results created using different LCA tools. Additionally, more specific guidance is needed for North American LCA practitioners, similar to those developed for European programs such as:

- 1) [HQE Performance Life Cycle Assessment](#): *Specific rules for new buildings in line with EN 15978 standard 2012/06/12 version for the HQE Performance 2012 experiment.*
- 2) [Whole life carbon measurement: implementation in the built environment](#). RICS professional statement. 1st edition 2017.

The text in the document contains four distinct text formats to indicate the following:

- **# Headings:** Numbered headings match corresponding headings from EN 15978
- Text in gray box: summarizes section from EN 15978
- **Bold text:** provides general direction regarding EN 15978
- Plain text: provides detailed instruction or clarification regarding EN 15978.

¹ A *taxonomy* is a system of organizing information. The term is often used to describe the classification of biological organisms, but the term is used in this context to establish a structure to facilitate consistent communication of LCA in the North American building industry.

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The members of the advisory committee are listed below. Their contributions were critical to the development of this document and are greatly appreciated. Individuals who went above and beyond are recognized in bold text.

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1 Scope

This section in EN 15978 discusses the scope of the EN standard, which includes providing LCA calculation methods and reporting requirements for new, existing, and refurbished buildings across all life cycle stages. Interpretation and value judgments are not covered.

Recommend following EN 15978 Section 1.

This technical guidance outlines the best practice calculation methods for assessing the environmental performance of a building based on life cycle assessment (LCA) principles in North America, adapts EN 15978 to the North American context, and provides additional guidance regarding reporting classification terminology, building use scenarios and other clarifications.

2 Normative references

This section in EN 15978 provides a list of EN and ISO standards that are “indispensable for the application of this document.”

Recommend that all specifications within EN 15978 that reference prEN 15804 be replaced with ISO 21930:2017 Sustainability in building construction – Environmental declaration of building products.

Additional references that informed the details of this technical guidance include:

Critical Issues When Comparing Whole Building & Building Product Environmental Performance, Miller, T. Reed; Gregory, Jeremy; Kirchain, Randolph, 2016-10-17.

<https://dspace.mit.edu/handle/1721.1/104838>

3 Terms and definitions

This section in EN 15978 contains five and a half pages of terms, their definitions, and reference standards.

Recommend following EN 15978 Section 3 definitions.

4 Abbreviations

This section in EN 15978 contains half a page of abbreviations.

Recommend using abbreviations noted in EN 15978 Section 4, as well as:

EPD	Environmental Product Declaration
ESL	Estimated Service Life
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory

LCIA	Life Cycle Impact Assessment
PCR	Product Category Rules
RSP	Reference Study Period
RSL	Reference Service Life
ReqSL	Required Service Life

5 Overview of the LCA Process

This section in EN 15978 provides an overview of calculation steps in a flowchart.

The processes outlined in Figure 3 of EN 15978 have been refined into five steps in the *Practice Guide*. The alignment between EN 15978, the *Technical Guidance*, and the *Practice Guide* is shown in Table A1.

Table A1. Alignment of EN 15978 and LCA Practice Guide

Process (EN 15978)	Information required (EN 15978)	Section number in EN 15978 & Technical Guidance	Step in Practice Guide
Identify purpose of assessment	Goal Intended use	6	Step 1
Specification of the object of assessment	Functional equivalent Reference study period System boundary Building model - physical	7	Step 1
Scenarios for the building life cycle	Building model – time Life cycle stages Scenarios	8	Step 2
Quantification of the building and its life cycle	Net amount (material, energy etc) Gross amount Types of data	9	Step 2
Selection of environmental data and other information	Use of EPDs Use of other information Data quality Consistency	10	Step 3
Calculation of the environmental indicators	Environmental impacts Calculation method(s) Aggregation	11	Step 3
<i>Not included in EN 15978</i>	<i>Not included in EN 15978</i>	N/A	Step 4 (Interpret Results)
Reporting and communication	General information The assessment result Data sources	12	Step 5
Verification	Verification	13	Step 5

6 Purpose of the assessment

This section in EN 15978 discusses how to describe the purpose of assessment (goal, scope, and intended use), and lists possible intended uses.

Recommend following EN 15978 Section 6.

See “Step 1: Define Goal and Scope” from the *Practice Guide* for additional details. See the *Taxonomy* for a list of parameters.

7 Specification of the object of assessment

This section in EN 15978 discusses how to describe the object of assessment (the building), using terms such as *functional equivalent*, *reference study period*, *system boundary*, and the *building model*. Section 7.2 defines the term *functional equivalent*, discusses how to define it for an assessment, and how functional equivalents can be used to make comparisons. Section 7.3 discusses the *reference study period* (RSP), how to base it on the *required service life* (ReqSL), and how to convert assessment results if RSP and ReqSL are not equal. Section 7.4 covers the *system boundary*, with each subsection focusing on a life cycle stage and listing the items that individual life cycle modules shall include. Section 7.5 discusses how to describe the building model and provides a list of physical characteristics to include.

Recommend referencing EN 15978 Section 7 with the following clarification:

See “Step 1: Define Goal and Scope” from the *Practice Guide* for additional clarification and the *Taxonomy* for recommendations on how to characterize the system boundary of the LCA.

8 Scenarios for defining the building life cycle

This section in EN 15978 discusses the use of scenarios. Section 8.1 defines scenarios as having time-related characteristics. Section 8.2 states that scenarios shall be thoroughly documented and be as specific as possible. Section 8.3 provides examples of scenario characteristics, such as maintenance, replacement, cleaning, and other periodic operations (must describe these), and also briefly mentions climate conditions and some performance requirements (e.g. energy efficiency, fire safety, seismic). Section 8.4 states that scenarios for the product stage shall be based on EPDs, and if EPDs are not available, the results shall be based on cradle-to-gate data. Section 8.5 specifies that scenarios for the construction process stage shall include transportation and on-site activities. Section 8.6 covers scenarios for the use stage (Stage B), and generally describes activities associated with the building, e.g. maintenance, operational energy/water use, with each subsection further detailing requirements for each module. Section 8.7 covers scenarios for the end-of-life stage (Stage C), again with subsections detailing each module. Section 8.8 discusses scenarios for benefits and loads beyond the system boundary (Stage D).

Recommend following EN 15978 Section 8 with following clarifications:

LCA tools should report all default scenarios to comply with EN 15978. Additional research is needed to provide guidance and align scenarios.

Of note:

- a. Life cycle stages A, B, C & D should be calculated and reported separately (not aggregated) and scenarios for estimating future impacts reported.
- b. In current whole building LCA practice, stages B1, B3, B5 and B7 are rarely included in LCA tools.
- c. Best practice should include the impact of site preparation (excavation, site paving, landscaping etc.) but it should be noted that current LCA tools do not have standardized data or methodology to implement this. Methods to standardize the collection of data from practice such as requesting the data as part of construction specifications or developing estimates of construction impacts in collaboration with general contractor needs development.
- d. Standardized methods to integrate the repair of damage due to hazards needs development.

9 Quantification of the building and its life cycle

This section in EN 15978 specifies how the building shall be quantified in terms of its material quantity estimates and scenarios. Section 9.2 discusses the term *net amount*, and Section 9.3 discusses quantification of the *gross amount*, which also covers component replacement. Section 9.4 discusses the appropriate types of data (generic, aggregated, product specific or average, etc.) that can be used based on the life cycle stage during which the assessment is conducted. Sections 9.5 and 9.6 describe how operational energy and operational water use are to be quantified, respectively.

Recommend following EN 15978 Section 9 with the following clarifications:

Report all default scenarios to comply with EN 15978. The following guidance is provided to assist in developing scenarios:

- 9.3 Report scenarios to account for the difference between gross amount and net installed amount accounting for ‘losses’ that occur in transit, construction etc. At a minimum, material losses during manufacturing and the difference between installed material quantities and purchased construction should be accounted for.

Scenarios for replacement rates of materials and components should be published. Sources for replacement rates include:

- Commercial building component lifespans can be estimated from BOMA.
- Multi-family residential building component lifespans can be estimated from Fannie Mae.
- Single family residential building component lifespans can be estimated from InterNACHI.

9.4 With regards to the type of data appropriate for the assessment, refer to Table A2, which is a simplified table adapted from EN 15978.

Table A2. Preferred types of data at various points during the assessment process adapted from EN 15978.

Type of data	Point of assessment during building life cycle stage				
	Concept design	Detailed design	Construction phase	Use phase	End-of-life phase
Generic data	✓	✓	○	○	✓
Industry average data	✓	✓	○	○	✓
Product specific data	○	✓	✓	✓	✓
Model scenarios for use stage	✓	✓	✓	○	
Measured data (e.g. energy used to construct and operate building)			✓	✓	✓

✓ represents preferred data type, ○ represents alternative option.

10 Selection of environmental data and other information - use of Environmental Product Declaration(s)

This section in EN 15978 discusses environmental product declarations (EPDs) – what they are, what they shall specify, and how to use them. If the underlying assumptions of an EPD do not match the scenarios of the building, then the EPD impacts shall be modified accordingly. This section also discusses requirements for general environmental data.

Recommend following EN 15978 Section 10 with the following additional additions:

- a. Recognize that attributional LCA (tracking environmental impacts attributed to each process rather than measuring the consequences to the environment of specific changes) is the most common method of LCA used today in construction practice.
- b. The data used in whole building life cycle assessment should be developed using consistent ISO 14044 compliant life cycle inventory datasets. Different LCI datasets may not be comparable.
- c. The LCI should use internally consistent allocation methodology both in calculation methods and in how the results are reported. Allocation of impacts between co-products, methods to report biogenic carbon and assumptions about end-of-life treatment can significantly alter results. The allocation methodology and assumptions should be included in the LCA report and/or referenced in documentation provided by the LCA tool and data supplier.
- d. Use and end-of-life scenarios should be included in the LCA report and/or referenced in the documentation provided by the LCA tool and data supplier.
- e. While ideally LCAs would capture the underlying data uncertainty, at present LCA datasets present a single ‘representative’ value to represent either industry average results or

estimated impacts using generic assumptions. LCA tools and data should be refined to include statistical representation of uncertainty such as mean and standard deviation or confidence intervals.

11 Calculation of the environmental indicators

This section in EN 15978 presents a selection of recommended environmental indicators, which were selected because they have agreed-upon calculation methods. This section also describes the matrix calculation method of calculating environmental impacts.

Recommend reporting indicators per ISO 21930 with TRACI characterization factors summarized in a table with the following additions/clarifications:

- a. Fewer environmental indicators may be reported if this is in alignment with the project goal and scope.
- b. Land use change may have significant impact on LCA results and is not currently included in most LCA datasets. The lack of inclusion of land use change impacts should be noted in the project report along with a statement:

“Land use change may have a significant environmental impact and is not yet well integrated into LCA data. Examples of some conditions when land use change may be expected are listed below:

- When old growth/original forests are logged and converted to production forests (even if forests are replanted).
- When forests are cut for logging and not maintained using sustainable forestry practices.
- When agricultural or forest land is converted to building occupied land.
- When land use is changed to land used for agricultural or material extraction purposes.”

12 Reporting of the assessment of results

This section in EN 15978 describes what the assessment shall report – information about the building, the LCA assessment, and the supporting environmental and building data – and how to communicate the results.

Recommend following EN 15978 Section 12 but with Tables 7, 8, 9 & 10 (in EN 15978) superseded by the corresponding tables in Appendix E of ISO 21930:2017, and with guidance provided by the Taxonomy with the following clarifications:

- a. Results from life cycle stages A, B and C may be aggregated but should also be reported separately by module (e.g. A1, A2, etc.). If certain impacts or modules are not assessed, modules should be explicitly identified as such, using “INA” (indicator not assessed) or “MNA” (module not assessed).
- b. Life cycle stage D should not be aggregated with stages A, B and C.

13 Verification of results

This section in EN 15978 lists requirements for verification of the assessment.

Recommend adopting EN 15978 Section 13 with the following additions:

Verification should occur whenever the results are shared outside of the organization creating the LCA (e.g. with a green building rating system). Verification can be either internal to the organization (performed by individuals who did not conduct the analysis) or external to the organization. The verification should include:

- a. Name, title and affiliation of the person performing the LCA
- b. Name, title and affiliation of the person performing the verification
- c. A statement asserting that the verification is 'internal' or 'external'
- d. A statement categorizing the competence of the verifier (to identify verifiers experience in both LCA and the building industry)
- e. Date of the verification
- f. Signature of the verifier
- g. Statement of what items were verified, which shall include at a minimum the criteria from EN 15978:
 - i. Consistency between the purpose of assessment and boundaries and scenarios used;
 - ii. Traceability of data used for the products (can be met by using a tool that confirms and reports that the data meet this requirement);
 - iii. Conformity of data with requirements of ISO 21930 (can be met by using a tool that confirms and reports that the data meet this requirement);
 - iv. Consistency between the scenarios that apply at building level with those used for the product (can be met by using a tool that confirms and reports that the data meet this requirement);
 - v. Completeness and justification of completeness for the quantification at the building level.

14 Comparison of LCA results

No corresponding section in EN 15978.

Results of LCA studies are often used to compare between materials, products or design options. ISO 14044 Section 5.3 has specific requirements for the use of LCA for comparative assertions. Using LCA data to make design decisions or to support certification in green building rating systems should not constitute a public comparative assertion. Publicly disclosed comparative assertions require third party critical review per ISO 14044 which requires the following:

- a. In all cases when comparing between materials, products or systems, the comparison shall be done in the context of the whole building including all life cycle stages with functional equivalence defined and justified.
- b. Comparisons of buildings and building products must be conducted in the context of a building using the same location, unless the purpose of the study is to compare the results with respect to location.
- c. Products with different supply chain geographies may be compared.

- d. When making comparative assertions, the report should characterize the uncertainty and results of the sensitivity analysis.
- e. The same RSP shall be used when making comparisons, as shall other LCA scope definitions such as system boundary, functional unit etc.