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Standard Practice for Minimum Criteria for Comparing Whole Building Life Cycle Assessments for Use with Building Codes, Standards, and Rating Systems[1]

This standard is issued under the fixed designation E2921; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice provides criteria to be applied irrespective of the assessment (LCA) tool that is used when LCA is undertaken at the whole building level to compare a final whole building design to a reference building design.

1.2 The purpose of this practice is to support the use of whole building Life Cycle Assessment (LCA) in building codes, standards, and building rating systems by ensuring that comparative assessments of final whole building designs relative to reference building designs take account of the relevant building features, life cycle stages, and related activities in similar fashion for both the reference and final building designs of the same building.

1.3 The criteria do not deal with building occupant behavior, possible future changes in building function, building rehabilitation or retrofit, or other matters that cannot be foreseen or reasonably estimated at the design or permitting stage, or both where this practice applies.

1.4 Only environmental impacts and aspects of sustainability are addressed in this practice. The social and economic impacts and aspects of sustainability are not addressed in this practice.

1.5 This practice does not deal with basic LCA methodology, calculation methods or related matters that are covered in cited international standards.

1.6 This practice does not supersede or modify existing ISO standards for the application of LCA at the product level, nor does it address any of the following related applications:

1.6.1 Aggregation of building products Environmental Product Declarations (EPD) at the whole building level;

1.6.2 Rules for applying EPDs in a building code, standard, or rating system; and

1.6.3 Comparability of building product EPDs.

NOTE 1—ISO 14025 and ISO 21930 provide guidance on use and comparability of building products EPDs.

1.7 This practice does not specify the impact categories or sustainability aspects to be addressed in building codes, standards, or building rating systems and users of this practice conform to the impact category requirements specified in the applicable code, standard, or rating system.

1.8 The text of this standard contains notes that provide explanatory material. These notes shall not be considered as requirements of the standard.

1.9 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.10 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E631 Terminology of Building Constructions

E2114 Terminology for Sustainability Relative to the Performance of Buildings

2.2 *Other Standards:*[3]

ISO 21930 Sustainability in building construction – Environmental declaration of building products

ISO 14025 Environmental labels and declarations – Type III environmental declarations – Principles and procedures

[1] This practice is under the jurisdiction of ASTM Committee E60 on Sustainability and is the direct responsibility of Subcommittee E60.01 on Buildings and Construction.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

ISO 14040:2006 Environmental Management – Life Cycle Assessment – Principles and Framework
ISO 14044:2006 Environmental Management – Life Cycle Assessment – Requirements and Guidelines
ISO 14050 Terminology

3. Terminology

3.1 For terms related to building construction, refer to Terminology E631.

3.2 For terms related to sustainability relative to the performance of buildings, refer to Terminology E2114.

3.3 For terms related to LCA (for example, product system, input, output) refer to ISO 14050 Terminology.

3.4 *Definitions of Terms Specific to This Standard:*

3.4.1 *building, n*—a shelter comprising a partially or totally enclosed space(s), erected by means of planned forces of forming and combining materials. **E631**

3.4.2 *building, v*—the act or process of construction. **E631**

3.4.3 *building product, n*—an item manufactured as an independent unit capable of being joined with or used with other elements for incorporation in buildings.

3.4.3.1 *Discussion*—Derived from definition of "building component" in Terminology E631.

3.4.4 *building service life, n*—the period of time after installation during which a building (or its parts) meet or exceed the performance requirement(s).

3.4.5 *characterization factor, n*—factor derived from a characterization model that is applied to convert an assigned life cycle inventory analysis result to the common unit of the category indicator.

3.4.5.1 *Discussion*—The common unit allows calculation of the category indicator result (ISO 14044).

3.4.6 *impact category, n*—a class representing environmental issue of concern to which life cycle inventory analysis results may be assigned.

3.4.7 *life cycle assessement (LCA), n*—compilation and evaluation of the inputs, outputs, and the potential environmental impacts of a product system throughout its life cycle.

3.4.8 *life cycle inventory analysis (LCI), n*—phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle.

3.4.9 *modular building, n*—a partially or completely assembled building that complies with applicable codes and regulations of the authority having jurisdiction at the time of construction and is constructed in a manufacturing facility using a modular construction process.

3.4.10 *operating energy, n*—energy loads that are related to building space conditioning, lighting, service water heating, or ventilation for human comfort.

3.4.11 *plug loads, n*—all energy use by devices, appliances, and equipment connected to convenience receptacle outlets during the building service life.

3.4.12 *process energy, n*—energy loads that are not directly related to building space conditioning, lighting, service water heating, or ventilation for human comfort, sometimes referred to as 'process loads.'

3.4.13 *reference building design, n*—a building design created to be used as a benchmark, or baseline, against which a final design is compared.

3.4.14 *reference service life, n*—service life of a building product that is known or expected under a particular set, that is, a reference set of in-use conditions and that shall form the basis of estimating the service life under other in-use conditions.

3.4.15 *whole building life cycle assessment (whole building LCA), n*—life cycle assessment of the complete building enclosure, structural systems, interior walls, and interior finishes and trim of a building, which may include operating energy, but excludes furniture and attached cabinetry.

3.4.15.1 *Discussion*—More information on study boundaries of the LCA is included in 6.3.

4. ISO Compliance

4.1 The procedures used for building product LCA shall be compliant with ISO 14040 and ISO 14044.

5. Significance and Use

5.1 This practice provides criteria that building design teams shall use to compare the environmental impacts associated with a reference building design and a final building design, including additions to existing buildings where applicable.

5.2 This practice deals specifically with material selection for initial construction, including associated maintenance and replacement cycles over an assumed service life, taking operating energy use into account if required or explicitly allowed under the applicable code, standard, or rating system.

6. Criteria

6.1 *Building and Product Service Lives:*

6.1.1 Unless otherwise specified by the applicable code, standard, or rating system, the building service life shall be no less than 75 years.

6.1.2 The same building service life shall be assumed for the reference building design and for the final design.

6.1.3 Product replacement schedules shall reflect the reference service lives for individual products or materials and the consequent number of replacements required over the assumed building service life.

6.1.4 When the reference service life of a product is less than the assumed building service life, the aggregate impacts associated with the number of product replacements necessary to equal the service life of the building shall be included. When the reference service life of the product is greater than the assumed building service life, the impacts associated with the product shall not be discounted to reflect the remaining product service life.

NOTE 2—If the expected life of a component is 20 years and the assumed building service life is 75 years, then the impacts would be multiplied by 3.75 to normalize the changeovers to be equivalent to the required 75-year life service. However, if the expected life of a component is greater than 75 years, then the impacts would not be scaled.

6.2 *Life Cycle Stages:*

6.2.1 All life cycle stages associated with the building shall be taken into account for the reference and final designs, including resource extraction or harvesting, building product manufacturing, all related transportation, on-site construction, operations including maintenance and replacement, and deconstruction or demolition and disposal.

6.2.2 The operations stage shall include operating energy use if required or explicitly allowed by the applicable code, standard, or rating system, in which case the results of energy simulations for the reference and final building designs shall be included in the LCAs and combined with embodied effects for the purpose of calculating impact measures.

6.2.3 Plug loads are permitted to be included in operating energy estimates. Process energy is excluded unless there is a clear and documented relationship to operating energy or unless process energy is required by the applicable code, standard, or rating system. The final building design shall include comparable plug loads and process loads if such loads are included in the operating energy estimates for the reference building design to which the final design is being compared.

6.2.4 If operating energy use is included, the reference and final building designs shall be in the same location, with identical temperature zones, and have the same orientation as per 6.4.1. The same energy simulation tool shall be used to estimate annual operating energy use on an hourly basis for both the reference and final building designs.

6.2.5 Maintenance and replacement schedules and actions for components during the operations stage shall be based on manufacturer recommendations, if available, or on documented common practice for similar materials used under similar conditions and exposure, and shall reflect building type and whether the building is intended to be owner occupied or rented.

6.2.6 The disposal stage shall assign comparable burdens to the reference and final building designs for all materials that are landfilled or incinerated as a means of disposal. All burdens associated with material reuse, recycling or incineration for the purposes of generating electricity or space conditioning shall be excluded as a charge to the next use after they leave the demolition/deconstruction site gate.

6.3 *Study Boundaries:*

6.3.1 Whole building LCA shall include the complete building envelope and structural elements, inclusive of the material components of footings and foundations, interior walls, floors and ceilings. Conduit, ductwork, piping, wiring and systems serving an equivalent function shall be included.

NOTE 3—Conduit, ductwork, piping, wiring and systems serving an equivalent function are essential elements in the systems identified in 6.3.3 below, but are fundamentally different from a practical LCA perspective in that they involve few materials and can be assessed at a representative instead of brand-specific level.

6.3.2 Underground parking shall be included in the final design if it is included in the reference design to which the final design is being compared.

6.3.3 Electrical and mechanical equipment and controls, plumbing fixtures, fire detection and alarm system fixtures, elevators and conveying systems shall not be included in the assessment.

NOTE 4—Life cycle inventory data or full LCAs for these equipment types and systems are limited and tend to be brand specific. Further, building LCAs have shown that, while these types of equipment and systems are critical to building operation, they have relatively insignificant embodied environmental impacts compared to the building structure and envelope.

6.3.4 Interior finishes shall be assessed to the extent that data is available, including through the use of a separate life cycle assessment tool, provided that comparable or similar function and performance of interior finishes are included in the reference building design to which the final design is being compared. All of the functions shall be represented in both the reference and final designs where interior finishes serve multiple functions.

6.3.5 Site development shall not be included.

NOTE 5—LCA in codes and rating systems is focused on the building materials, including the material components of footings and foundations. While excavation is an essential construction step, the associated environmental effects of that aspect of construction are highly site specific, which affects data availability. Further, the effects are unlikely to be significantly different for the reference versus final design given that both designs must reflect the building size, functions and orientation.

6.4 *Comparison to a Reference Building:*

6.4.1 A reference building design used as a benchmark shall meet the same criteria with regard to location, orientation, size, function and space conditioning as for the final design being compared to the reference design.

NOTE 6—Space conditioning is included in the above criteria to ensure that the final building design does not reflect a reduction in material use that would adversely affect space conditioning compared to the reference building design.

6.4.1.1 Materials assumed for use in a reference building design shall be based on design or construction practices for the area in which the site is located using similar material, erection, installation, and maintenance practices as buildings in the area that serve similar or related functions.

6.4.2 The same LCA tool(s) or software shall be used to complete the LCA for both the reference and final building designs including version numbers and updates for software based tools.

6.4.3 The same data sources for the same materials, components, systems and services, and the same impact categories and impact measure characterization factors shall be used for both the reference and final building designs.

6.4.4 If the selected tool does not have data for a material selected for use in the final design, the results of a critically reviewed LCA or a verified Environmental Product Declaration shall be separately used to provide the full set of required impact indicators and demonstrate the effect on building environmental impacts by substituting said material for another material, taking account of all ancillary product effects.