Whole-building LCA Guidelines and Benchmarking Initiative

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The Athena Institute is working to harmonize the practice of whole-building life cycle assessment (WB-LCA) and develop robust WB-LCA benchmarks. We are creating North America’s first set of comprehensive WB-LCA technical guidelines, and the first WB-LCA benchmarking system.

DELIVERABLES
This is a complex initiative with multiple tasks. We will produce:

- Guidelines to perform standardized WB-LCA per EN 15978 and ISO 21930, with an emphasis on collection and characterization of bill of material data per the OmniClass classification system.
- A software tool to help collect and characterize bills of materials, per the guidelines.
- A database of records for multiple real buildings (bills of materials).
- Guidelines on use of the database for creating benchmarks with whole-building LCA tools.
- Recommendations for growth and maintenance of the database, and for use of the benchmarking system in green building policy and programs.

INTENDED OUTCOMES

- Standardize the practice of whole-building LCA in order to assure quality and comparability of results across different building projects. This is currently a problem impeding policy.
- Enable the calculation of reliable baselines, or benchmarks. A system for this does not yet exist.
- Support improved WB-LCA compliance schemes in green building programs and policy. Benchmarks are key for programs and policy to establish valid performance targets.
- Facilitate measurement of policy impacts. A statistically based benchmark system provides assurance that presumed benefits against business-as-usual are real.
- Increase the use of LCA in decision-making to reduce environmental impacts in the built environment, because WB-LCA results will be more comparable, meaningful and actionable.

FUNDERS
National Research Council of Canada (LCA² program) – current funder
US Endowment for Forestry and Communities – current funder
BC Housing – past funder (pilot test)
Athena Institute members – current and past funders
OVERVIEW OF THE INITIATIVE

This work is addressing two missing components in the technical infrastructure that supports whole-building life cycle assessment (WB-LCA): a benchmark database and a set of WB-LCA guidelines. These components are essential for more effective WB-LCA practice and to support green building policy like embodied carbon legislation.

The applicability of WB-LCA results will expand when the technical ecosystem becomes more robust. In our benchmarking initiative, we are addressing gaps that impede comparability. See Figure 1 for our interpretation of the optimal technical ecosystem.

Figure 1  Required technical infrastructure to support effective use of whole-building LCA
Comparability of results across WB-LCA studies is key to the development of performance targets, whether internal to a design practice or broadly implemented in green building programs and policy. We are addressing comparability by developing two new components in the technical infrastructure. **Guidelines** will improve quality and consistency of WB-LCA practice (to improve comparability), and **benchmarking** will deliver a valid performance comparative basis.

Our whole-building LCA **guidelines** will provide definitive and comprehensive instruction for the practice of WB-LCA, based on relevant standards and keyed to various intentions for the study. The purpose of the guidelines is to harmonize the practice of WB-LCA across different studies and to assist in interpretation of and compliance with relevant standards. This is not a high-level introductory document; the guidelines are detailed and technical. The guidelines will be periodically updated, as methods and standards evolve.

As shown in Figure 1, the guidelines draw on standards, and then:

- Inform the process of compiling data (model inputs) for a WB-LCA, with consideration of the various end-use applications for the results.
- Provide the framework and standardization necessary for compiling building material use to produce benchmarks (building database).
- Inform the use of WB-LCA software and influence how software is updated or developed.

Guidelines are a precursor to a robust **benchmarking** system. Whole-building LCA results are most useful when they can be compared to something – a baseline or a benchmark. For reliable WB-LCA policy results against business-as-usual, statistically valid benchmarks are needed.

In this initiative, we are creating a system for generating statistically valid performance targets for buildings (benchmarks) and a set of rules to ensure that comparison to a benchmark is fair (guidelines).

Our approach in this initiative has been developed over several years, with stakeholder input and guidance. We conducted a pilot test\(^1\) as a proof-of-concept exercise for an early version of our methodology. We used lessons from that study to refine our method, which we extensively documented for stakeholder input in a white paper\(^2\), in which we highlighted the need for detailed guidance in the practice of WB-LCA, particularly in the collection and identification of bill of material data. We developed a framework for a comprehensive guidance document\(^3\), with funding from the National Research Council of Canada (NRC) under the LCA\(^2\) initiative\(^4\). Our current workplan is overseen by multiple stakeholders and advisors.

See the following pages for technical details about this work.

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**WB-LCA GUIDELINES — DETAILED PROJECT DESCRIPTION**

The guidelines will provide comprehensive instruction for the practice of life cycle assessment applied to buildings, based on relevant standards and keyed to various intentions. The guidelines will be periodically updated, as methods and standards evolve. The purpose of the Guidelines is to:

- Instruct WB-LCA practitioners to assure quality and comparability of their results.
- Enable the calculation of reliable baselines or benchmarks.
- Support LCA-based compliance schemes in green building programs and policy.
- Assist in the development and use of WB-LCA software.

The guidelines are intended to harmonize the practice of WB-LCA in compliance with the leading relevant standard, EN 15978⁵, and ISO 21930⁶ where it supersedes. The guidelines will be applicable to new and existing buildings in North America.

The guidelines will be robust enough to serve as a reference in policy and programs and simple enough for use by the community of designers and sustainability consultants that will rely on it in order to comply with policy.

The sequence of the guidelines will generally follow the assessment process described in EN 15978 — see Figure 2. We will additionally provide guidance on 1) specific uses of WB-LCA practice (e.g. informing building design vs. meeting WB-LCA compliance schemes), and 2) evaluating performance datums such as baselines and benchmarks.

This work is substantially funded by the National Research Council Canada, under the LCA² initiative.

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**Figure 2  Structure of the guidelines**

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⁵ EN 15978:11 *Sustainability of construction works — Assessment of environmental performance of buildings — Calculation method.* This is a European document that is the most commonly used standard for performing WB-LCA worldwide.

⁶ ISO 21930:17 *Sustainability in buildings and civil engineering works — Core rules for environmental product declarations of construction products and services.* This is the most current international-consensus core product category rules standard on product LCA and publication of EPDs. While ISO 21930:17 is in general conformance with EN 15978:11, it naturally supersedes the older European standard, where applicable.
The guidelines will focus on the **standardization and data quality of bills of materials**, which is a key gap in existing documents that provide high-level WB-LCA guidance. Accurately identifying and quantifying materials for a WB-LCA model is the key task for the WB-LCA practitioner and a prime factor in quality and consistency of results. The guidelines aim to improve the quality and consistency of bills of materials.

Based on previous research and general consensus, we are applying the OmniClass building classification system to standardize the way material takeoff quantities are defined. See Figure 3.

Standardizing the scope of bills of materials also allows for collection of material use for many buildings in a database, which could be used to derive a “benchmark” (or “average performance”) bill of material. Benchmarks provide a performance datum from which the results of a proposed building can be evaluated. The guidelines will address benchmarking.

The guidelines will be applicable for use with any WB-LCA software tool.

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**Figure 3**  *OmniClass system used (left) with an example (right)*

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7 OmniClass is a system for organizing construction information in a standardized way. It draws from existing well-established classification systems for a comprehensive approach: it uses UniFormat to define building elements and MasterFormat to define building products.
**BENCHMARKING – DETAILED PROJECT DESCRIPTION**

The key to using LCA as a lever in green building policy is an ability to measure performance against benchmarks: for example, how much better a building is against business-as-usual.

To ensure that policy is effectively delivering real results, the benchmark system must be methodologically sound. In other words, if the green building design community is given a performance target for WB-LCA results, then the target needs to have been derived in a defensible manner.

This is a challenging task, requiring a careful and rigorous technical approach. We have pilot tested and thoroughly documented our methodology, which we have been developing over several years.

In our approach, a robust performance benchmark is based on a statistically-derived peer building – that is, a building that represents an average comparative basis for the project at hand. The system we are developing will provide a standardized and universal mechanism for benchmarking.

The benchmarking system will enable next-generation evolution of WB-LCA schemes in green building programs and policy. Specifically, benchmarks can replace the current vaguely defined “reference building” used as a baseline for performance improvements. Instead of instructing users to determine their own baseline and then strive to beat it, green building programs could instruct users to beat a statistically valid benchmark.

The use of a benchmark is illustrated in Figure 4. Here, benchmark LCA results for a peer building were calculated and are indicated in the horizontal “benchmark” line. The LCA results for the building of study (a proposed building design) are shown against the benchmark. The proposed building is substantially beating the benchmark in four of the six LCA measures shown in the graph.

![Figure 4 LCA results for a building of study compared to a benchmark](image-url)
Creating a valid benchmark is difficult. It’s tempting to shortcut this process, simply by gathering up LCA results for a group of buildings and taking an average, as shown in Figure 5. That won’t work. Whole-building LCA studies typically have major differences in scope, boundary, data and method, which means they aren’t comparable and therefore cannot be reliably averaged. Even if all of those conditions were tightly prescribed, other variables that affect comparability will still come into play: for example, building type, building location, and WB-LCA software tool (or even different versions of the same tool).

![Figure 5](image)

*Figure 5  Averaging global warming potential (GWP) results from WB-LCA studies will not produce a reliable benchmark*

Instead, WB-LCA performance benchmarks are created on a custom basis, in a two-step process. The benchmark LCA results (step two) come from running a benchmark bill of materials (step one) through WB-LCA software.

The “bill of materials benchmark” is the starting point. This is a list of material quantities for a statistically derived object (i.e., a building or part of a building) that is a peer for the proposed project being studied. Material quantities would be calculated by collecting data from a selection of relevant real buildings, determining material use intensity, averaging it, and then scaling it to the size of the building being studied. See Figure 6.

![Figure 6](image)

*Figure 6  Creating a bill of materials benchmark, which then becomes the data input for valid benchmark WB-LCA results*

*Note: GFA is gross floor area.*
This approach to benchmarking makes use of a large database of buildings. In this project, we are developing the database and associated elements to assist in its use. This work is substantially funded by the US Endowment for Forestry and Communities.

The database will house “bill of work” (i.e., bill of material) records for potentially hundreds or thousands of buildings. Users will query the database to assemble a bill of materials that represents a peer model for the building of study. This is a sophisticated, flexible, dynamic and self-updating approach to identifying a peer model compared to, for example, trying to establish a static and generic “archetype” baseline building. As the database grows, regional and building-type specificity will increase. See Figure 7 for a representation of how the system will work.

Figure 7  Sampling the database to create a benchmark model
Methodically compiling the bills of work of constructed buildings requires significant time and resources; this represents the core work of the benchmarking Initiative, and includes the following tasks:

1. **Procure data sources**: building designs from various sources will be sought from the building sector. It is anticipated that most source material will be either from building information models (BIM) or from cost reports produced by Quantity Surveyors.

2. **Evaluate and compile bills of work per guidelines**: the data sources will be evaluated for their applicability and data quality. If the source is usable, a bill of work will be produced.

3. **Import bills of work into the building database and troubleshoot**: the completed bills of work will be imported into the database. Queries and other tests will be employed to identify potential issues with the underlying data. Updates to the data will be performed, as required.

To assist in effective use of the database for creating bill of work benchmarks that are consistent in scope and method with buildings of study, we are developing two companion elements: guidelines for creating and cataloguing bills of work, and an associated Excel-based “compiler” tool. These pieces will be developed in accordance with the WB-LCA Guidelines underway within this initiative.

In the big picture, this work will complete the map for life cycle building performance measurement. Fundamentally, life cycle benchmarking sits on proper quantification of resource consumption: materials, energy and water. The sustainable design community already knows how to quantify energy and water resources. The missing piece is standardized quantification and identification of material consumption. See Figure 8 on the next page for an illustration of the three resource streams and their combined use in creating a complete WB-LCA benchmark.
Figure 8  How a material-use database fills out the total building performance picture

Note: The WB-LCA nomenclature (A1, etc.) refers to life cycle stages as defined in the standards EN 15804 and EN 15978.