Proposal for the Development of a Decision Making Framework for Minimizing the Life Cycle Impacts of Buildings at Michigan State University

White Paper

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Overview

Among all industries, the building construction sector in the U.S., creates a substantial amount of waste and pollution. It is reported that 39% of energy is primarily consumed by buildings. Moreover, in the U.S. 38% of all CO_2 emissions, and 136 million tons of debris in a year are generated by buildings (USGBC, 2008). Due to the diverse character of the construction industry, construction processes require segregation and expansion in order to understand their true environmental implications. Examples of these implications include energy use; emissions to air, water, and land; and resource depletion for the manufacturing and transportation processes of materials. The effects of these implications increase as a result of poor choices made by project teams which are mostly associated with limited criteria, such as low first cost.

Most of the green building assessment systems suggest the reduction of environmental impacts through better material choices. The Leadership in Energy and Environmental Design, the most widely adopted green building assessment system in the US which guides building professionals through design and construction processes, suggests the use of recycled materials, rapidly renewable resources, and the purchase of local materials to reduce environmental impacts (USGBC, 2005). However, these choices do not underline the life cycle impacts of materials used in buildings. The current literature points out that this goal can be best achieved with the life cycle assessment (LCA) model framework and approach (Sharrard and Mathews, 2007).

According to the Environmental Literacy Council (ELC, 2006), LCA examines the impact of a product on the environment by detailing all the inputs and outputs through the life of the product as a cradle to grave process it includes birth of the product (i.e., design, raw material extraction, material production, part production, and assembly), occupancy and maintenance, and finally, demolition and disposal. While, the LCA approach accounts for the environmental, economic, and social impacts of materials during their life cycle, this proposal focuses on the environmental impacts, specifically emissions and wastes.

The literature points to various LCA tools to calculate these impacts. Examples include: Eco-Calculator (Athena), BEES 4.0 (Building for Environmental and Economic Sustainability), ECOBILAN, and Eco-Quantum. Calculation of various impacts are based on criteria such as global warming potential, indoor air quality, embodied energy, acidification, air and water pollution index, and fossil fuel depletion. These tools commonly follow an Excel sheet format to present the computed impacts under each of the above mentioned criteria. The results are represented with a unit of measurement (e.g., BTU, ton) or as ratios against scientifically determined thresholds. The table below illustrates a comparison of the selected three LCA tools.

Table: Comparisons of the Selected LCA Tools

	Athena	Carbon Calculator	BEES
Base	Only Assembly	Assembly and Materials	Only Material
Strength	-- Due to the broad nature of the assumptions, (e.g., region, type of building, assemblies), it provides the user with an overview of the impact. -- Predefined options enable ease of use. -- Simplified interface and input format allows users with limited background knowledge to easily use the tool and understand the outputs.	-- Presents a detailed analysis of the assemblies' impact. --The user can create assemblies and eventually the environmental impact of the entire building can be calculated. -- A final report of each calculation helps the user to understand the environmental implications of the choices made. -- Visual representation of outputs strengthens the understanding of material impacts under various categories.	-- Presents a detailed analysis of the materials' impact. -- Detailed list of materials are available to select from. -- Allows user to compare the impact of materials. -- A final report of each calculation helps the user to understand the environmental implications of the choices made. -- Visual representation of outputs strengthens the understanding of material impacts under various categories.
Weaknesses	-- The user needs to be specialized to understand the root database of the system. -- The root database and the assemblies cannot be edited to suit the user requirements. It needs to be expanded to suit broader audience needs. -- The assumptions are very broad and do not account for criteria such as the distance that material has to travel. -- Outputs do not give a detailed analysis or the visual representation of the impacts. -- The basis of the calculations and background equations are not presented within the system.	-- The root database is not available for review. -- The materials are predefined and cannot be edited to suit user requirements. -- The list of materials needs to be expanded to suit needs of broader audiences. --The basis of carbon values is not justified. -- The carbon values cannot be edited according to the region, location, and building type. -- The basis of the calculations and background equations are not presented within the system.	-- The root database is not available for review. -- The materials are predefined and cannot be edited to suit user requirements. -- The list of materials needs to be expanded to suit needs of broader audiences. -- As each material has to be chosen, an analysis for an entire building becomes very difficult. -- Due to the wide variety of materials the system requires as input, the system needs the user to be very precise. -- The carbon values cannot be edited according to the region, location, and building type. -- The basis of the calculations and background equations are not presented within the system.

The preliminary literature review and the LCA tool comparisons show that none of these devices account for critical factors, such as customized location, climate, materials, and usage, of which are required for analyzing the environmental impacts of institutional buildings at Michigan State University (MSU). Therefore, despite the comprehensive tools noted in the literature, a unique decision making framework should be developed for the use of project teams at MSU. To fill this gap in the text and to fulfill MSU's needs in this area, this proposal suggests exploring the existing LCA tools further and develop a decision-making framework for MSU projects.

Preliminary Work Completed to Date

- Preliminary literature review of embodied energy and LCA concepts;
- Overview of existing LCA tools;
- Critical analysis of selected LCA tools from the usability perspective at MSU;
- Recommendations for future areas of research.

Expected Deliverables

Based on the preliminary work completed the following are the expected deliverables of this study:

1. Comprehensive literature review of existing LCA tools
2. Demonstration of practical examples of LCA applications. For example: selection of a subsystem of an MSU project and the performance of an LCA comparison based on different material choices, content, location, weight etc.;
3. Raising awareness amongst Engineering and Architectural Services (EAS) personnel on the issues of life cycle impacts of products and systems selected;
4. Develop a decision making framework to help account for life cycle impacts of material choices for buildings at MSU.
5. Presentation of findings at MSU staff training as appropriate

Project Oversight

Members of EAS, CMID, Physical Plant, CPA and OVPFO as appropriate

Project Methodology

To generate the expected deliverables, the following methodology steps will be executed for the project in the given order:

1. Conduct historical background review on concepts of Life Cycle Assessment (LCA);
2. Overview of existing LCA calculators;
3. Assemble and develop metrics to measure life cycle impact of building construction materials;
4. Identify the materials and systems with high life cycle impact to be included in the project analysis;
5. Apply of LCA of the selected materials and systems with selected LCA tools on an MSU project;
6. Develop of a decision making framework for minimizing the life cycle impacts of buildings at MSU;
7. Prepare a final report of the project findings, conclusions, and recommendations for future areas of research.

Personnel

Investigators: Timothy Mrozowski A.I.A., Professor, Construction Management Program
Sinem Korkmaz, Assistant Professor, Construction Management Program
Graduate Students in the Construction Management Program
Undergraduate Students in the Construction Management Program

The undergraduate students that will take part in this project have the skills to perform take offs from project construction documents and, are familiar with specification standards as organized by the Construction Specification Institute (CSI) division and the technical section set forth by Michigan State University.

Proposed Project Funding

Total funding request of $25,000 is made to CCPPAI, which includes the following:

- Graduate student support for two semesters;
- Undergraduate or graduate student labor;
- Faculty participation is in-kind project contribution.

Schedule

Project schedule is anticipated as <u>one year</u> from start of project and has the following activities:

- Project Funding to Begin (TBA)
- Appointment of Oversight Group
- Literature Review
  - Historical Background
  - Overview of Existing LCA Calculators
- Assembly and development of LCA metrics
- Identification of the Focus Construction
- Materials
- Calculator Application on the MSU Project
- Development of an LCA Decision Making Framework
- Project Completion and Submission of the Final Report

References

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