

# ADVANCING SUSTAINABLE DESIGN WITH LIFE CYCLE ASSESSMENT

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MIDDLESEX CENTRE WELLNESS AND RECREATION COMPLEX  
PHOTO: CORNERSTONE ARCHITECTURE INCORPORATED

## INTRODUCTION

Life cycle thinking in construction is now more important than ever. Architects and engineers are becoming increasingly sophisticated in making buildings better by taking a holistic, long-range view – not just in costs and energy performance, but in environmental impacts as well. At the same time, the sustainability world is moving quickly to jettison “green” product labels in favour of providing consumers with quantified environmental performance data. Together, these trends are motivating adoption of life cycle assessment in the construction sector.

Life cycle assessment [LCA] is a powerful tool to help sustainable design move towards a performance basis. An analytical method for estimating lifetime environmental impacts due to a product or process, LCA can help building designers quantify and validate their sustainability decisions. LCA quantifies the resource consumption and emissions due to constructing, using and disposing of a building, and then estimates the resulting impacts to the environment. LCA can be a useful new skill set and a good match for existing skills in design offices or sustainability consultancies.

Plus, the recent release of LEED v4 with a new three-point credit for LCA and a new 33-point LCA credit in Green Globes are creating an incentive to learn LCA. And it's easier than it sounds.

## LCA 101

LCA is typically a cradle-to-grave quantification of potential environmental impacts of products or services; it is based on natural sciences and considers the entire value chain. LCA has long been used in the industrial sector to understand environmental “hotspots” in products so that improvements can most effectively be made.

Similarly, LCA can help building designers focus their efforts when a reduced footprint is desired. This application is called “whole-building LCA” when the entire building project is considered holistically in a LCA exercise – as opposed to LCA applied to parts of a building, such as only the floor assembly, or when selecting individual products.

Whole-building LCA allows maximum flexibility in trade-offs. For example, although the addition of more insulation will result in increased material impacts of a building, it will often result in a net life cycle benefit due to reduced operating energy consumption.

In a whole-building LCA, all of the flows between the building and nature are inventoried – that is, the resources consumed and the substances or wastes emitted to air, water and land are calculated for every stage of the building life cycle.

Next, those environmental flows are assessed for their likely consequential impact on the environment. For example, once we know the lifetime consumption of coal-fired electricity for constructing, operating, and disposing of a building, we can then estimate the greenhouse gas emissions attributable to this consumption and the subsequent increase in global warming potential.

It's important to look at LCA results in the right context and with the right expectations. LCA is a comprehensive assessment process, but it can't do everything on the sustainability agenda, and it is not intended to do so. Multiple tools are required for that.

In addition, there are uncertainties inherent in LCA, as with any complex modelling. This is why LCA is a science of best estimates and not a science of absolute measurement. Use LCA to help gauge relative performance across options, which then helps to refine the direction of further decisions.

### VALUE OF LCA TO A DESIGN PRACTICE

Traditional approaches to sustainable design are limited by incomplete information and a lack of a framework to assess decisions within a consistent, holistic context. By providing a rational and validated basis for decisions, LCA equips sustainable designers with a better toolkit.

Consider this scenario: a designer wants to select the best environmental choice between two competing products. Product One has high recycled content. Product Two is locally sourced. Which one is better? It's impossible to say given our limited data set here – all we have is a percent recycled content and a distance travelled, neither of which tells us anything about actual environmental performance. When we are forced to make a guess, there is a good chance that we end up with a greater environmental burden altogether, or the burden is unintentionally shifted to other life cycle stages or impacts of concern.

The alternative is to eliminate the guesswork by reviewing LCA data for both products. This allows objective comparison of quantified environmental performance for various metrics like kg CO<sub>2</sub>e global warming potential.

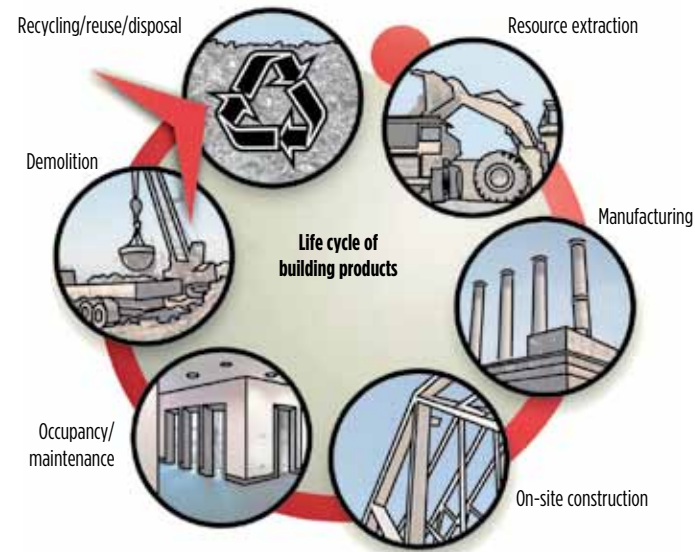
While useful in product comparisons, LCA is much more valuable to a designer when applied at the level of the whole building. Products with a heavy environmental burden can be balanced out by other building elements. In addition, the environmental performance of individual products is properly considered within the context of the whole building – this is an issue of scale.

Traditional sustainability metrics don't provide any indication of the relative scale of impact. Product One might have much lower environmental burdens than Product Two, yet choosing Product One could have a negligible impact on total building performance. If Product Two has other product advantages, it would likely be the better choice, and a designer would look elsewhere for environmental improvements in the building.

LCA is particularly useful for identifying hotspots, in other words, the biggest contributors to the environmental footprint of the building. By focussing attention on the hotspots, we can make meaningful and efficient improvements to the overall building footprint. Contribution analysis will indicate, for example, where in the building, or when in the building's life cycle, we are most likely to find opportunities for impact reduction.

LCA is critical for understanding the relative impacts of operating energy use and material use [i.e. "embodied" effects] in the total environmental equation of a building. Operating energy is usually seen as a dominant concern since it generally accounts for large shares of impacts such as primary energy use, global warming potential, and acidification potential over the total lifetime of the building. Design strategies that reduce operating energy are therefore often the most effective at reducing those impacts.

Yet, there are several reasons why the embodied impacts of a building should not be ignored. As buildings become more energy efficient and/or use cleaner fuels in operation, materials account for a greater share of the impacts that operating energy use typically dominates. Materials additionally always dominate certain types of impacts such as solid waste generation.



LIFE CYCLE OF BUILDING PRODUCTS: EACH STAGE IN THE LIFE CYCLE OF PRODUCTS [AND THE WHOLE BUILDING] IS ASSESSED FOR FLOWS TO AND FROM NATURE.

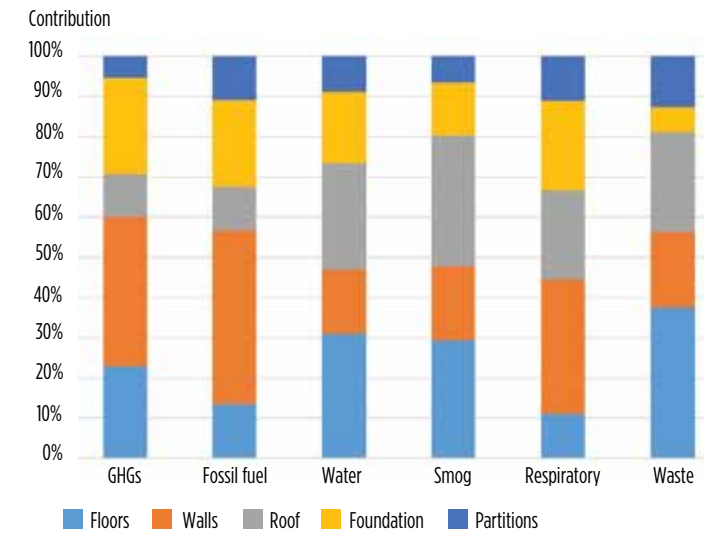
There is also an issue of urgency that only LCA can address. While operating energy consumption takes place slowly over time, architects and engineers make an immediate and significant debit in embodied impact during construction, due to their design choices. Consider that climate change mitigation requires that we drastically reduce emissions today – long term solutions are important too, but reductions have to start right now; in design, that means paying equal attention to embodied environmental impacts.

Four green building programs in North America now have incentives for designers to use LCA to minimize the environmental footprint of new construction. The whole-building LCA provisions in LEED®, Green Globes®, the International Green Construction Code and the California green code ask designers to show that the final design has lower LCA impacts than a "reference" building.

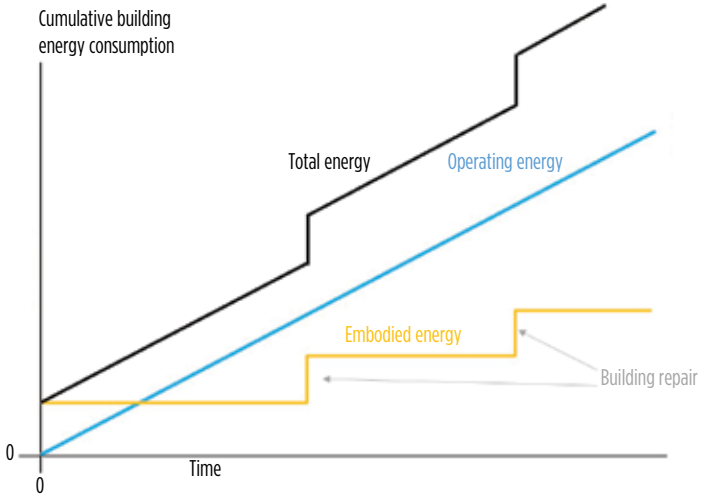
The intention here is that the reference building is an early iteration of the building design; performing LCA during early design creates a performance benchmark to beat, helping inform decisions as they evolve from conceptual design through design development. The green building programs want to reward design decisions that ultimately lead to lower LCA impacts.

Advanced sustainability designers won't stop with a LEED or Green Globes certification. Transparent and standardized communication of environmental performance metrics is a hot trend in product manufacturing and likely to migrate to building design. Manufacturers are rushing to publish environmental product declarations [EPDs] – think of these as the environmental equivalent of nutrition labelling on food packages.

Environmental performance of buildings should similarly be documented for validation and accountability. The best way to declare the performance of a building is by conducting and publishing whole-building LCA data for the building in accordance with the European standard EN 15978, which specifies a standardized methodology and reporting format.



WE CAN LOOK FOR HOTSPOTS IN A VARIETY OF WAYS. IN THIS EXAMPLE, SIX DIFFERENT LCA RESULTS ARE SHOWN WITH PROPORTIONAL CONTRIBUTION TO EACH ONE BY VARIOUS BUILDING ELEMENTS. IF WE ARE INTERESTED IN REDUCING EMBODIED ENERGY OF THIS EXAMPLE BUILDING, WE WILL NOTICE THAT THE WALLS ARE THE BIGGEST CONTRIBUTOR TO FOSSIL FUEL CONSUMPTION. WE CAN CONSIDER REDUCING THE TOTAL AREA OF WALLS, OR WE CAN DRILL DEEPER INTO THE WALL RESULTS IF WE WANT TO EXPLORE DIFFERENT WALL DESIGN AND MATERIAL OPTIONS.



THIS GRAPH SCHEMATICALLY SHOWS TOTAL ENERGY CONSUMED BY A BUILDING OVER TIME. FOR THE FIRST SEVERAL YEARS, TOTAL ENERGY IS VASTLY DOMINATED BY EMBODIED ENERGY, THAT IS, THE ENERGY USED TO MAKE THE CONSTRUCTION MATERIALS AND ERECT THE BUILDING. WE NEED LCA TO UNDERSTAND THIS INITIAL HIT TO THE BUILDING'S ENVIRONMENTAL FOOTPRINT. THERE'S NO SUCH THING AS A ZERO-CARBON BUILDING, UNLESS WE IGNORE THE INCONVENIENT EMBODIED CARBON.

### HOW TO BRING LCA INTO DESIGN

LCA is a complex science typically practised by experts. In order to make LCA accessible for architects and engineers, the Athena Institute developed a simplified LCA software tool specifically for them. The Athena Impact Estimator for Buildings [IE4B] was first released in 2002 and has been continuously updated. All of Athena's software and resources are provided free of charge.

The Impact Estimator has the complex life cycle databases and methodology in the background, meaning the user need only address inputs about the physical nature of the building. A bill of materials can be imported from any CAD program, or users can alternatively let the IE4B calculate building material volumes based on general geometry and loading parameters.

Although the IE4B doesn't include an operating energy simulation capability, it does allow users to enter the results of a simulation in order to compute the fuel cycle burdens, including pre-combustion effects, and factor them into the overall results.

Accommodating multiple comparisons at once, the IE4B allows users to change the design, substitute materials, and make side-by-side comparisons for any one or all of the environmental impact indicators. It also lets users compare similar projects with different floor areas on a unit floor area basis.

For those seeking to earn whole-building LCA credits in green buildings programs such as LEED and Green Globes, the Athena Institute recently published a document to make it easier: the Athena Guide to Whole-building LCA in Green Building Programs is available on our website. This guideline demystifies the credit requirements and provides help in achieving compliance using the IE4B, with extensive advice on how to approach the reference building.

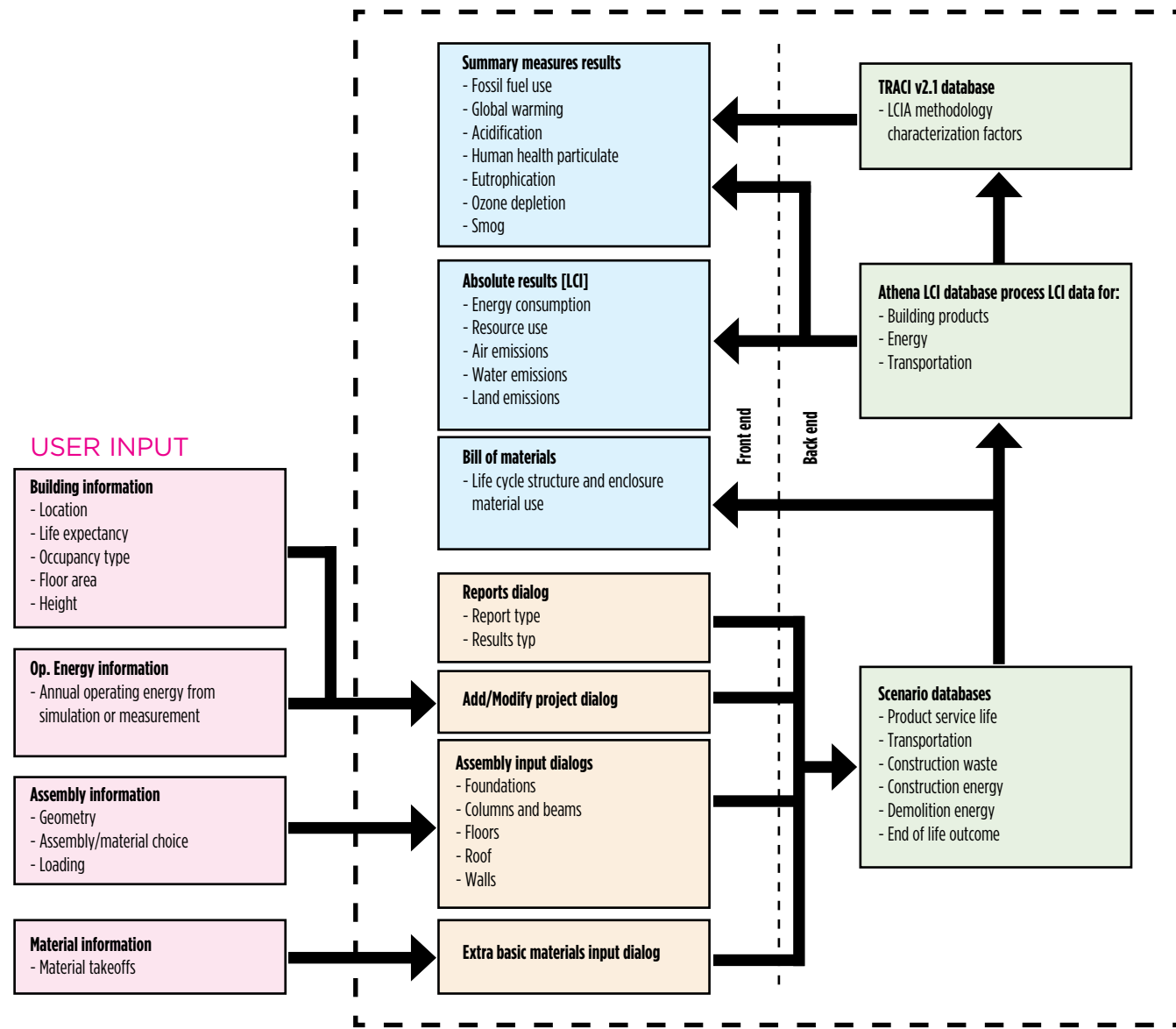
The Centennial Garage in Edmonton is a good example of LCA in the design process. Completed in April 2010, this massive building houses 250 buses and office space. As prime consultant, Morrison



CENTENNIAL GARAGE

Hershfield led a team targeting LEED silver and pursuing several different sustainability strategies. The IE4B software was used to explore several different approaches to structural design. The LCA results allowed the design team to bring environmental information into the equation as one of many sets of metrics used to decide on the final design.

## ATHENA IMPACT ESTIMATOR FOR BUILDINGS



Another project using LCA to include environmental data in design parameters is the Middlesex Centre Wellness and Recreation Complex in Komoka, Ontario. The London, Ontario firm Cornerstone Architecture achieved four Green Globes for this multi-use building, completed in 2011 and designed with a total life cycle approach to selection of materials and systems. The team used the Athena EcoCalculator to compare alternatives and to rationalize decisions with their client. They were able to quantify their environmental savings due to their decisions on roofing and cladding systems, and interior finishes..

### MORE INFORMATION ON LCA AND ADDITIONAL RESOURCES:

The Athena Institute [www.athenasmi.org] is a non-profit consultancy and think tank in life cycle assessment [LCA] for the built environment. The North American pioneer and only specialist in construction-sector LCA, the Athena Institute works with sustainability leaders in product manufacturing, building design, construction, and green rating programs to enable smaller footprints in the production and consumption of materials, buildings and infrastructure.

## THE COMPLETE VERSION OF THIS ARTICLE IS FOUND AT: [WWW.SABMAGAZINE-EDUCATION.INFO](http://WWW.SABMAGAZINE-EDUCATION.INFO)

### Also informaion on the following:

- The LEEDv4 LCA credit [option 4 of the MR credit "Building life-cycle impact reduction"]
- The Green Globes LCA provisions [Section 3.5.1.1: materials and resources - core and shell - performance path criteria]
- Free download of the Impact Estimator for Buildings software plus user manuals [including the Athena Guide to Whole-building LCA in Green Building Programs], video tutorials and FAQs: <http://calculatelca.com>

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