BUILDING LIFE CYCLE IMPACT

Understanding the impacts of building design

Presented by Kevin Harris, Director of Technical Services

VERDACITY

COURSE DESCRIPTION

Our course will address a critical factor in our planet's future: **the carbon impact of building materials**. This empowering session will show designers how to find viable alternatives to material selections and system assemblies and reduce negative impacts on our environment.

LEARNING OBJECTIVES

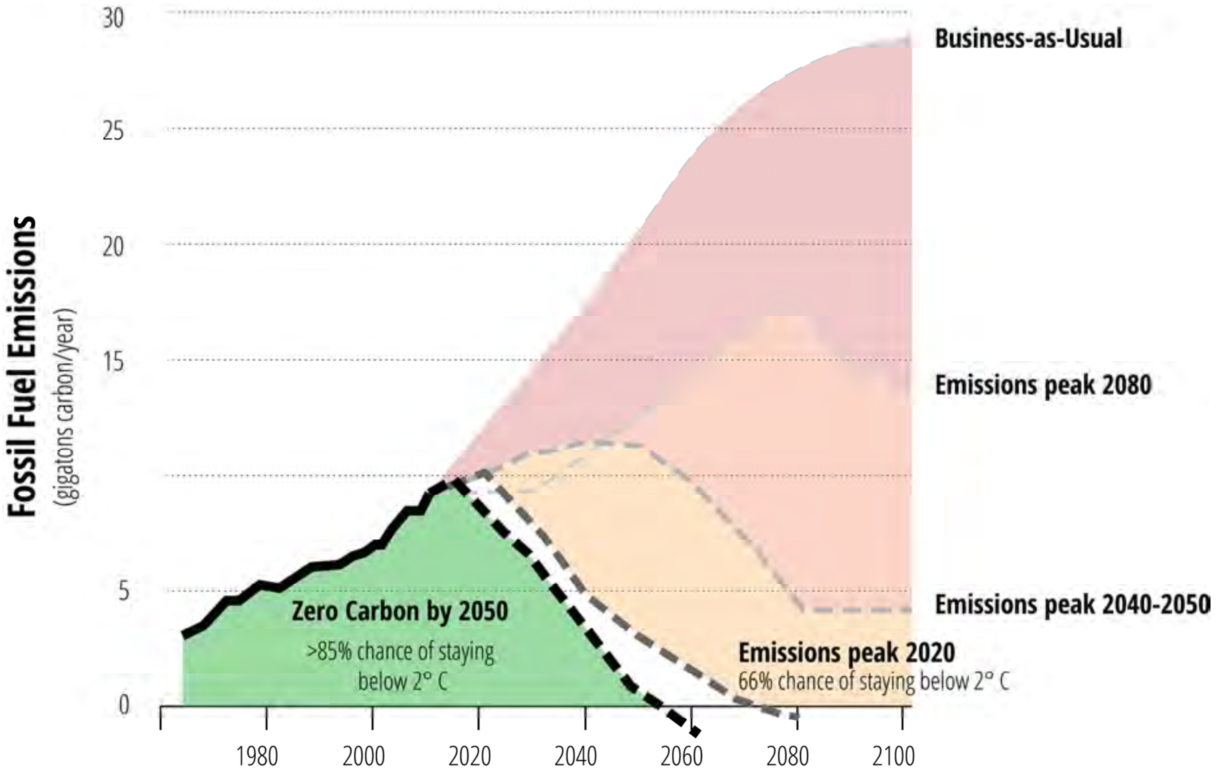
1. Learn the increasing importance of accounting for the life cycle impacts of building materials in order to achieve an environmentally sustainable carbon neutral future.
2. Become familiar with available and upcoming tools and methodologies for conducting a building life cycle assessment.
3. Identify the essential components of an accurate, informative, and useful assessment.
4. Discuss how life cycle assessments can benefit designers and manufacturers while achieving the goals of widely accepted environmental movements and standards.

Framing the Issue

Our Climate Deadline

The climate crisis the globe currently faces is time sensitive. The earlier we can address the issue of carbon emissions, the better our chances of not triggering an irreversible chain reaction in the global climate.

Key point: Decarbonization needs to happen as quickly as possible.



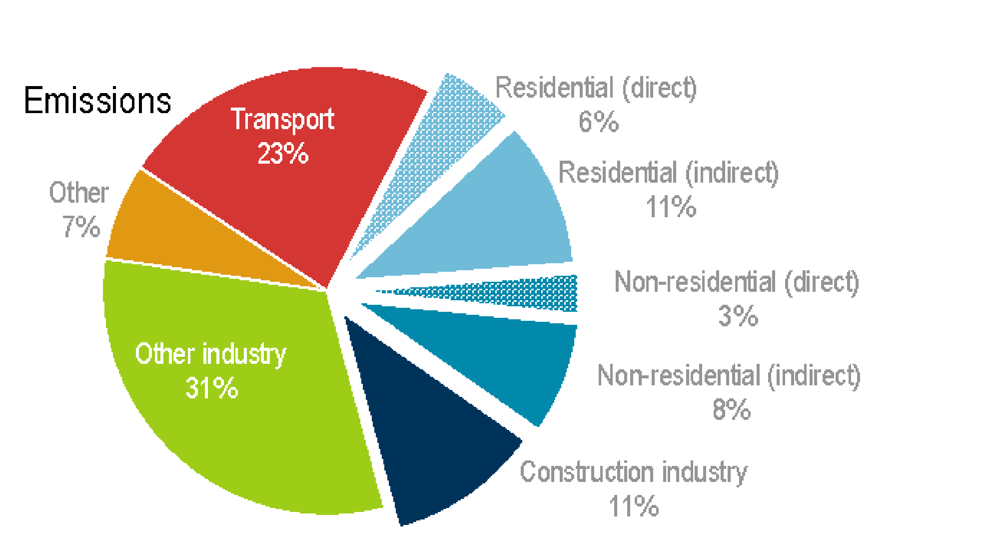
IPCC carbon emissions projection scenarios

Source: IPCC 2013, Representative Concentration Pathways (RCP): Stockhold Environment Institute (SEI), 2013, Climate Analytics and ECOFYS, 2014. Note: Emissions peaks are for fossil fuel CO2-only emissions.

Framing the Issue

Carbon Emissions – The current cost of the Human Habitat
The carbon emissions from the construction, operation, and maintenance of buildings represents a significant portion of global carbon emissions.

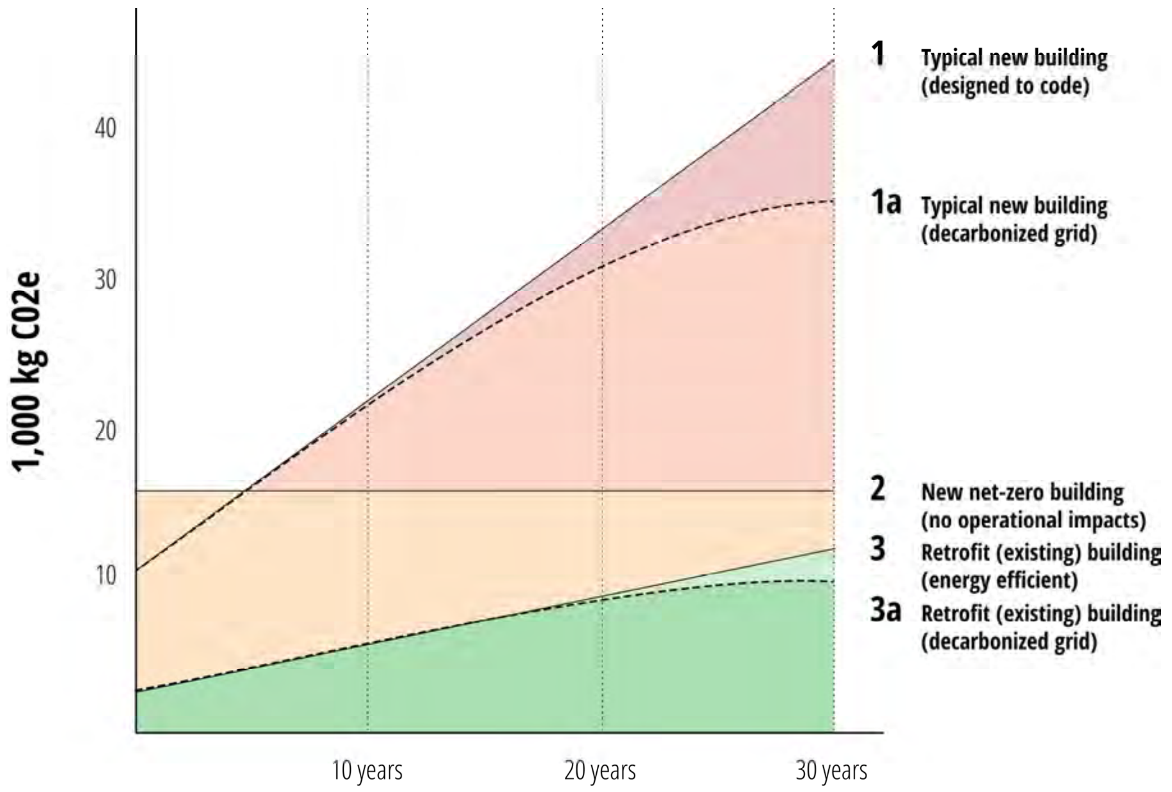
Key point: The building design industry must address its current way of operating.



Framing the Issue

Materials Emissions – Increasingly Time Weighted
Due to the goals set by climate scientists. emissions from material extraction, production, and transportation are becoming an increasing percentage of the total carbon (equivalent) emissions that need to be reduced or offset to avoid crossing the climate tipping point.

Key point: As energy is addressed, materials become more important to decarbonization.



Total Carbon Emission by Project Type

Source: Adapted from K. Simonen, *Testing Whole Building LCA*, 2015

Framing the Issue

Materials and Emissions – Once Ignored, Now Key to the Solution
Now that materials are coming to the forefront of the climate change movement, they represent an opportunity for significant carbon reductions, and perhaps even remediation.

Key point: Materials solutions are beginning to counteract existing energy emissions.

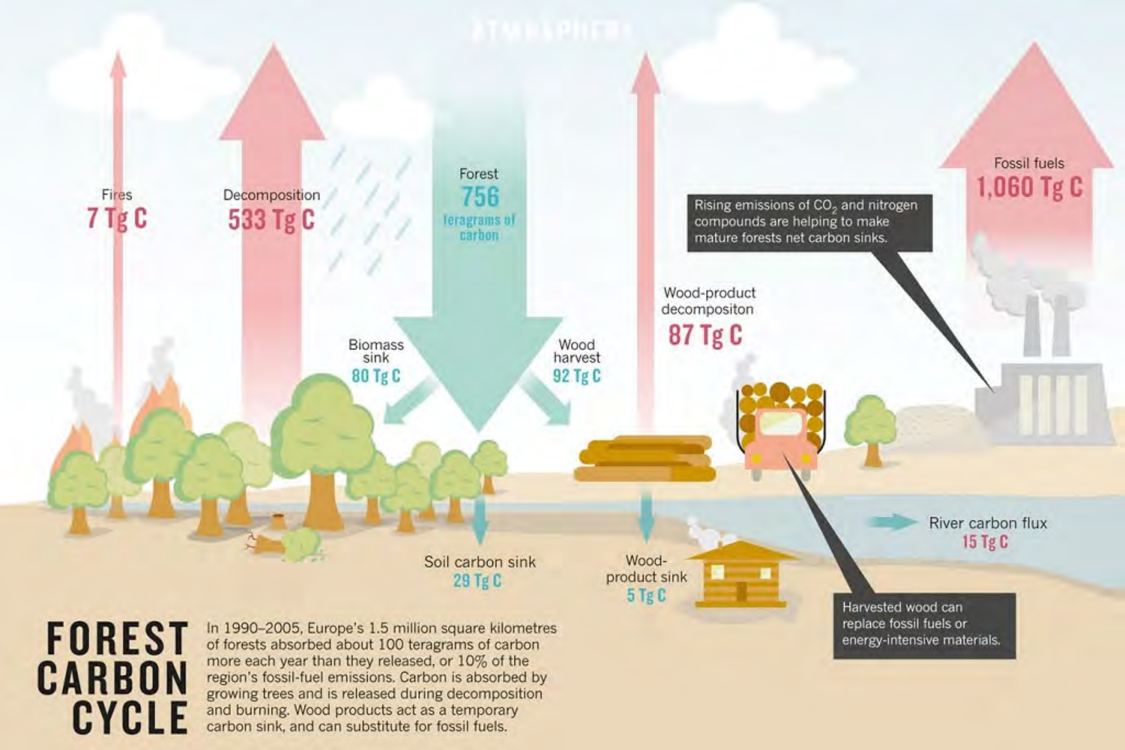


Image: https://www.nature.com/news/carbon-sequestration-managing-forests-in-uncertain-times-1.14687

Life Cycle Impact Assessment

A Materials LCIA is a science-based quantitative analysis of the potential impact building materials have on natural resources, ecosystems, and human health.

Impact assessments utilize ISO 14044-compliant data sets in order to ensure validity and accuracy.

Measuring Impact

LCIA – Looking Beyond the Construction Site
While life-cycle assessments have been a mainstay of consumer products and supply chain optimization, they are now being applied to materials on a scale that encompasses every portion of the buildings design.

Key point: Life cycle assessment on the building scale is a new development enabled by the progress of adjacent industries.

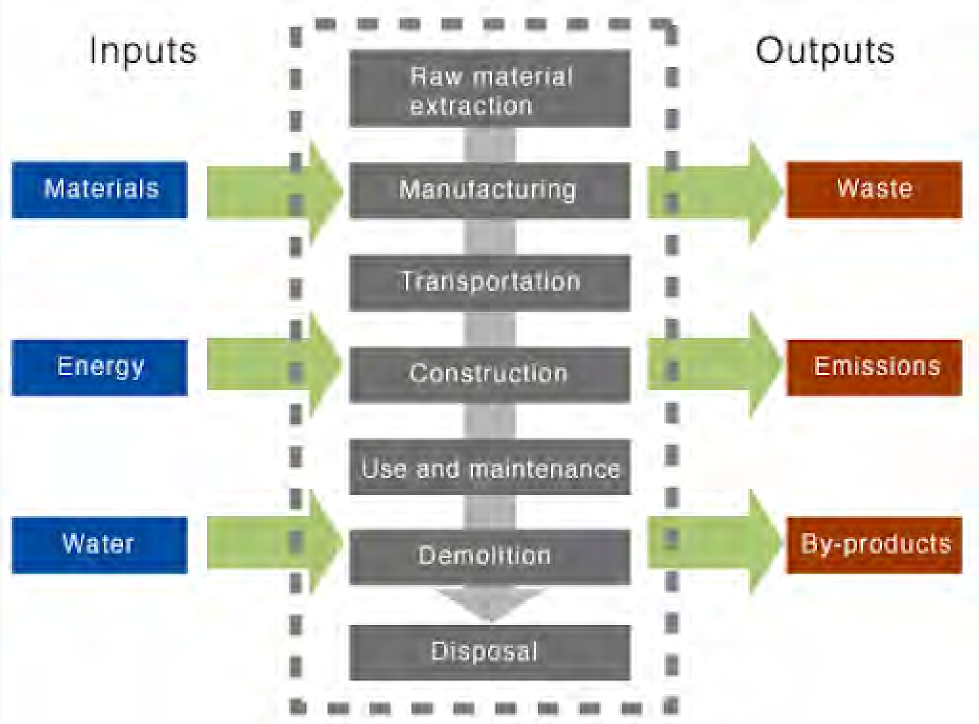


Image: https://www.researchgate.net/figure/LCA-relevant-parameters-Figure-2-Energy-efficiency-comparison_fig1_319667168

Measuring Impact

LCIA – Looking Forward

As more manufacturers begin to report the impact of their products and databases grow, designers will be equipped with more powerful tools to make decisions with a level of granularity that is necessary to being to truly balance the needs of the environment with the ever-growing human habitat.

Key point: Future assessments will include more detail and accuracy and allow for better decision making and greater impact reduction.

CERTIFIED
ENVIRONMENTAL PRODUCT DECLARATION
UL.COM/EPD

EPD Transparency Summary

COMPANY NAME	**CENTRIA**
PRODUCT TYPE	**Insulated Metal Panels**
PRODUCT NAME	Versapanel® Insulated Metal Panels
PRODUCT DEFINITION	Insulated metal panels are rigid foam sandwiched between two sheets of coated metal. The panels are molded in a variety of styles and sizes depending on application. Steel or aluminum panel facings create a vapor, air and moisture barrier and provide long term thermal stability. The metal skins offer long-term durability and come in a multitude of colors and finishes.
PRODUCT CATEGORY RULE (PCR)	Insulated Metal Panels & Metal Composite Panels, and Metal Cladding: Roof and Wall Panels (UL, October 2012)
CERTIFICATION PERIOD	**9/5/14 - 9/5/19**
DECLARATION NUMBER	**4786185203.104.1**

LIFECYCLE IMPACT CATEGORIES

The environmental impacts listed below were assessed throughout the product's lifecycle – including raw material extraction, transportation, manufacturing, packaging, use, and disposal at end of life

	ATMOSPHERE			WATER		EARTH	
	Global Warming Potential refers to long-term changes in global weather patterns – including temperature and precipitation that are caused by increased concentrations of greenhouse gases in the atmosphere.	**Ozone Depletion Potential** is the destruction of the stratospheric ozone layer, which shields the earth from ultraviolet radiation that's harmful to life, caused by human-made air pollution.	**Photochemical Ozone Creation Potential** happens when sunlight reacts with hydrocarbons, nitrogen oxides, and volatile organic compounds, to produce a type of air pollution known as smog.	**Acidification Potential** is the result of human made emissions and refers to the decrease in pH and increase in acidity of oceans, lakes, rivers, and streams – a phenomenon that pollutes groundwater and harms aquatic life.	**Eutrophication Potential** occurs when excessive nutrients cause increased algae growth in lakes, blocking the underwater penetration of sunlight needed to produce oxygen and resulting in the loss of aquatic life.	**Depletion of Abiotic Resources (Elements)** refers to the reduction of available non-renewable resources, such as metals and gases, that are found on the periodic table of elements, due to human activity.	**Depletion of Abiotic Resources (Fossil Fuels)** refers to the decreasing availability of non-renewable carbon-based compounds, such as oil and coal, due to human activity.
TRACI	**6.13E003** kg CO_2-Equiv.	**5.84E-005** kg CFC 11-Equiv.	**409** kg O_3-Equiv.	**1.19E003** H^+ moles-Equiv.	**0.984** kg N-Equiv.		
CML	**6.13E003** kg CO_2-Equiv.	**5.18E-005** kg R11-Equiv.	**5.53** kg Ethene-eq.	**23** kg SO_2-Equiv.	**2.33** kg Phosphate-Equiv.	**0.0729** kg Sb-Equiv.	**8.50E004** MJ

FUNCTIONAL UNIT: The functional unit for this study is defined as "coverage of 1,000 square feet with metal product". The coverage area refers to the projected flat area covered by the product as output by the final manufacturing process step, and does not account for losses due to overlap and scrap during installation.

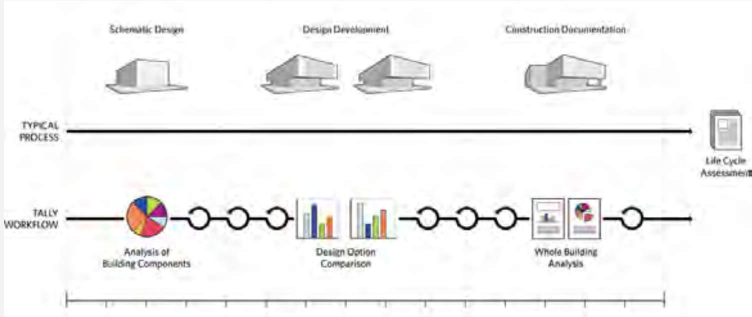
Environment

Measuring Impact

LCIA – Building Measurement Tools
As material information databases have grown in breadth and depth, new tools have been developed to begin to quantify the impacts of whole buildings and developments, giving designers and developers new information with which to make decisions and design solutions.

Key point: Emerging tools have made whole building LCIA's accessible enough to integrate into design.

https://choosetally.com/



http://www.athenasmi.org/

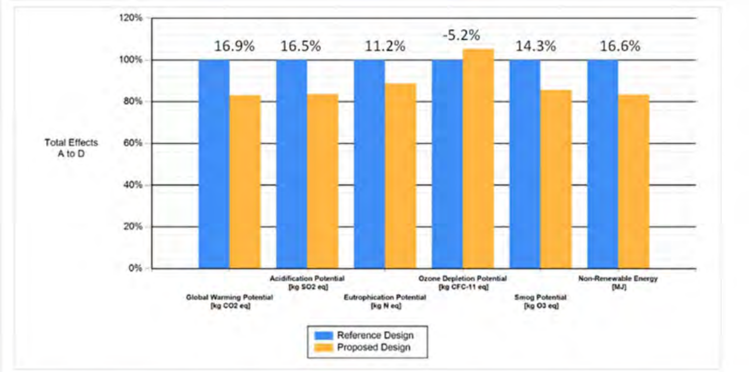


Figure 3: Example of LCA result provided by ATHENA tool comparing a proposed design against a reference (baseline) design

https://www.oneclicklca.com/

Measuring Impact

LCIA – Mainstream Acceptance
Increasingly, life cycle impact assessments are being incorporated into widely adopted rating systems and certifications. While each has their own requirements for how to conduct and report the findings of the assessment, all are built on ever increasing databases of material performance data.

Key point: Building Life Cycle Assessments are being integrated into most green building frameworks.

Measuring Impact

LCIA – Parameters and Methodology
Depending on the goals of the project, the assessment parameters can be adjusted to include all materials installed on site or limited to those known to be most impactful.

Key point: Project type and design goals can drastically change the type of assessment conducted.

Image: https://en.wikipedia.org/wiki/Construction

Example Methodology

LEED v4 Requirements
When conducting an LCA for LEED, the only included assemblies are foundations, structure, exterior walls, and roof assemblies. All interior partitions and finishes are excluded.

Key point: LEED only requires the most permanent of building assemblies to be included in the assessment.

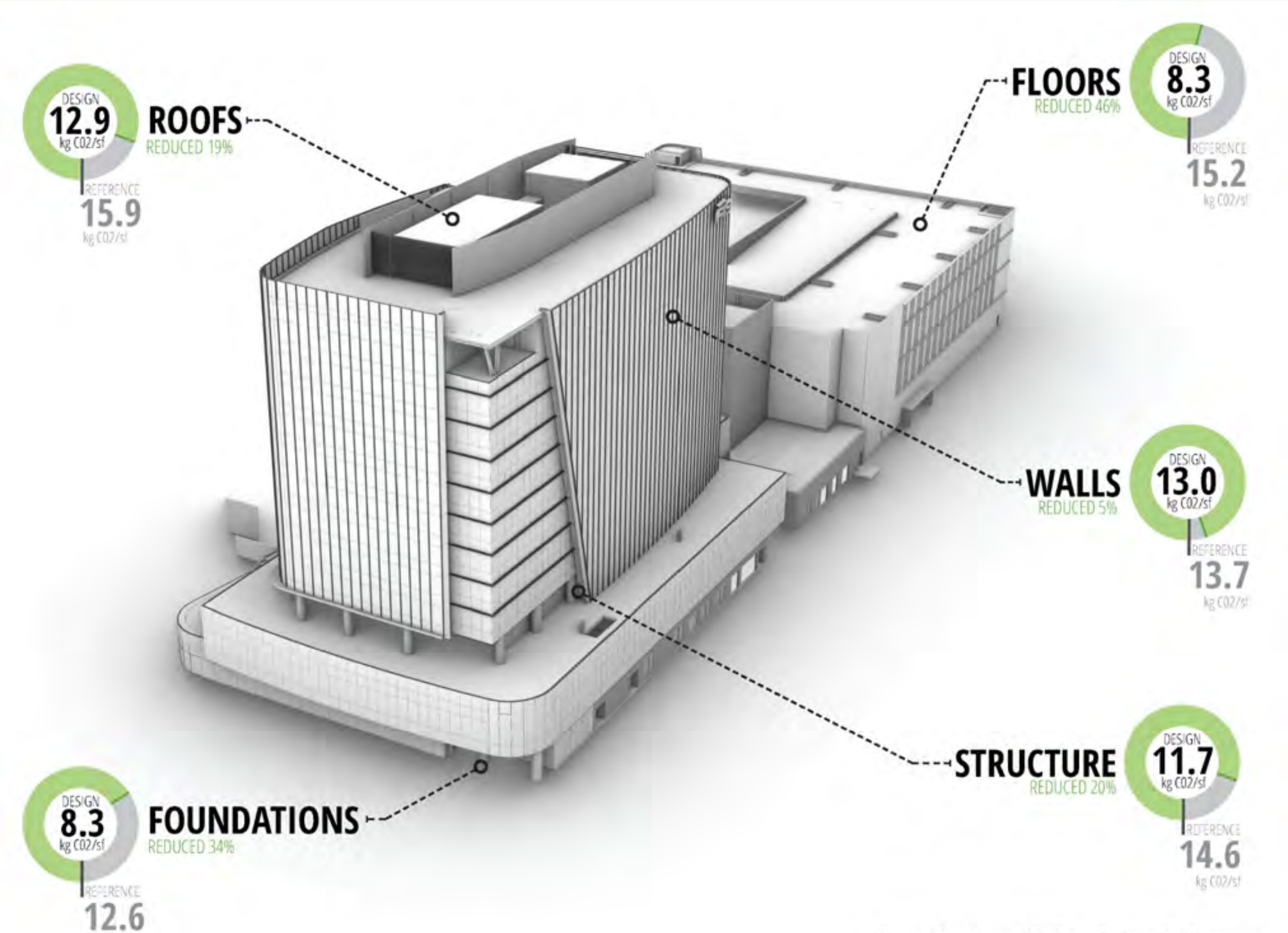


Figure 4 – Assembly Contribution Performance

Example Methodology

LEED v4 – Excluded Materials

LEED does not currently include interior finishes, partitions, or fixtures as part of the building assessment. As tools advance, more data is made available, and the impacts of other assemblies are reduced it will almost assuredly become important to include these assemblies in future iteration of LCIAs.

Key point: Interior elements are currently excluded but will likely be incorporated as the field progresses.

Image: http://www.casstudio.com/visualization-gallery/3d-floor-plan/

Example Methodology

LEED v4 - Structure

The impact of the structure of a building is highly dependent on the type of structure selected as well as the structural efficiency achieved with the chosen structure.

Key point: Building structure, while highly impactful, is generally optimized by the structural engineer for cost savings.

Image: https://www.spacesmith.com/blog/mass-timber

Image: https://www.on-sitemag.com/

Image: https://www.pinterest.com/

Example Methodology

Reducing Impact – Structural Analysis
Working with the project structural engineer to right-size the building structure is one of the best ways to realize impact reductions. In the right designs, utilizing prefabricated structural elements can yield impact reductions over traditional structural assemblies.

Key point: Structure requires significant collaboration with structural engineers to ensure safety while reducing impacts.

Image: http://www.understandconstruction.com/steel-frame-structures.html

Example Methodology

LEED v4 - Foundations

When assessing the impact of foundation assemblies, the primary impact indicators are almost always:

1. The amount of concrete used
2. The type of concrete used
3. Extent of steel reinforcement

Key point: Concrete is the key indicator of performance for foundation assemblies.

Image: https://theconstructor.org/concrete/uses-concrete-civil-engineering/35992/

Example Methodology

Reducing Impact – Concrete Mix
When looking at where to reduce impact, for most buildings, the key will be offsetting as much cementitious material as possible. Cement is an inherently high-impact material due to its production process. Replacing it with fly ash or slag cement can result in large impact reductions of C02 emissions for a whole building.

Key point: Offsetting cement is key to reducing the impact of a building.

Image: https://csengineermag.com/

Example Methodology

LEED v4 – Wall Assemblies
The exterior vertical envelope of a building is a category heavily impacted by the choices of the design team. Many times, aesthetic choices must be weighted against the impact of finish materials, while insulation must be right-sized to ensure high-performance.

Key point: The exterior envelope is one of the biggest opportunities for designers to make impactful choices about material selection and usage.

Image: https://gharpedia.com/blog/comparison-of-cladding-materials/

Example Methodology

Reducing Impact – Envelope Selection
Exterior walls provide some of the most variety in terms of available impact reduction strategies. One key strategy is the reduction of cementitious CMU blocks in favor of stud construction. The nature of block walls results in inherently more material and subsequent impacts.

Key point: Exterior envelope impact reduction requires balancing the design needs of the building with the realities of material impact.

20%-35% GLOBAL WARMING FOOTPRINT

- **High Impact Associations**: Aluminum windows and Curtain Wall
- **Recommendations**: Maximize usage of EIFS and Metal Panel over Curtain Wall or CMU; optimize window to wall area ratio

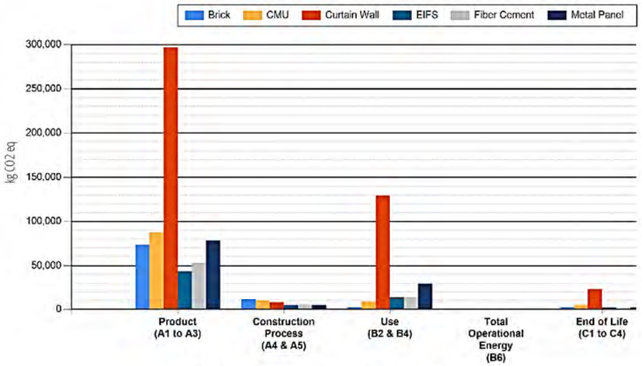


Figure 5 - Impact per life cycle stage- Global Warming Potential

MATERIAL	UNIT	RELATIVE IMPACT
EIFS	kg CO2 eq	100%
Fiber Cement	kg CO2 eq	115%
Brick	kg CO2 eq	138%
Metal Panel	kg CO2 eq	172%
CMU	kg CO2 eq	177%
Curtain Wall	kg CO2 eq	707%

Table 5

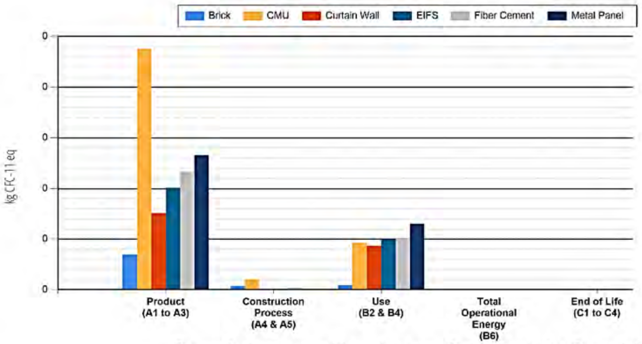


Figure 6 - Impact per life cycle stage -Ozone Depletion Potential

MATERIAL	UNIT	RELATIVE IMPACT
Brick	kg CFC-11 eq	100%
Curtain Wall	kg CFC-11 eq	282%
EIFS	kg CFC-11 eq	355%
Fiber Cement	kg CFC-11 eq	398%
Metal Panel	kg CFC-11 eq	467%
CMU	kg CFC-11 eq	691%

Table 6

Verdacity LCIA Report

Example Methodology

LEED v4 – Roofs

Roof assemblies, particularly those in commercial and industrial applications, represent one of the most difficult assemblies to assess. Roofs are an example of where we currently seek to do 'less harm' and look to mitigate their impacts elsewhere in a building.

Key point: Roof assemblies are inherently impactful, but design teams can still take steps to minimize them to the point that measures elsewhere can begin to mitigate.

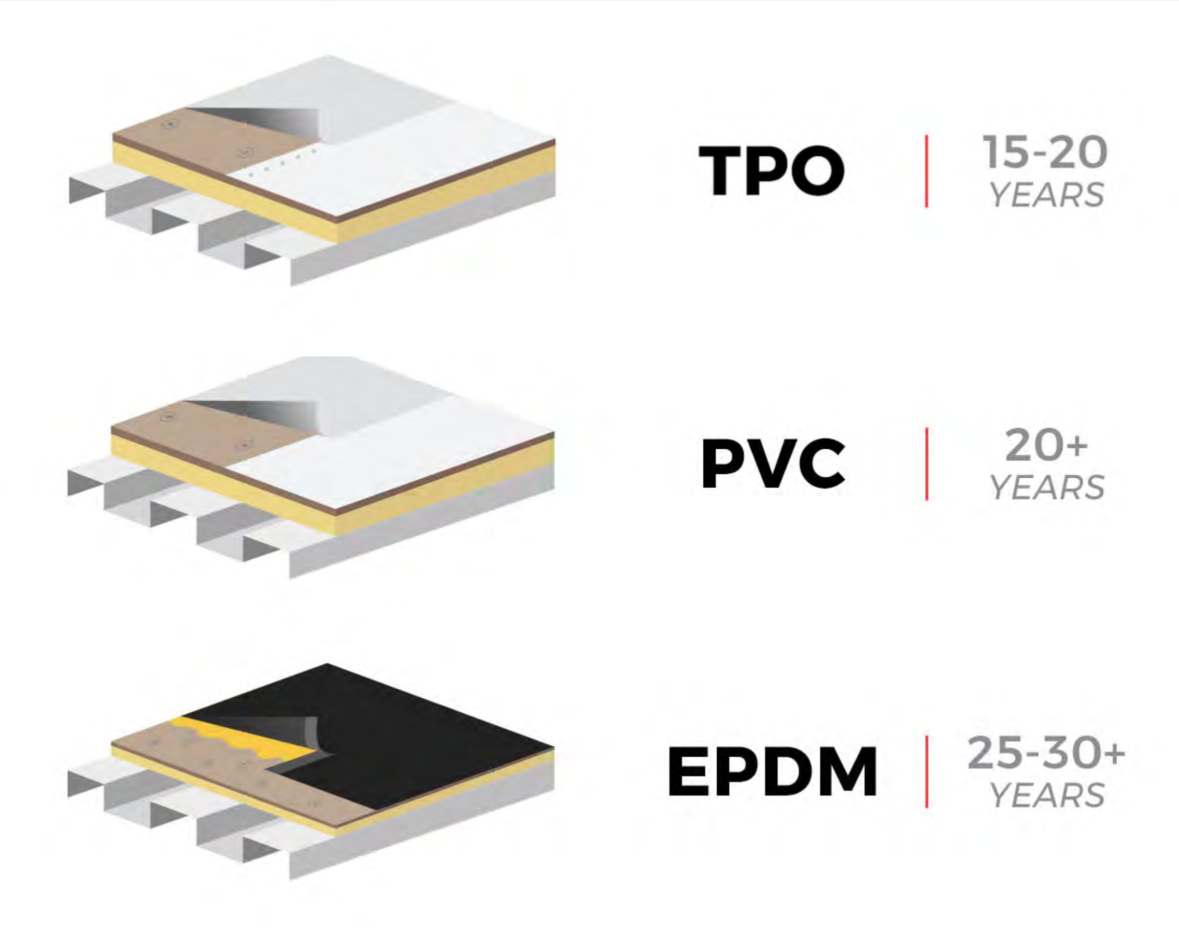


Image: https://roofslope.com/identify-types-roof-coating-membrane/

Example Methodology

Reducing Impact – Roofing Assemblies

It is important for project teams to establish their performance goals for the materials early in the design process, particularly those in the roof assemblies. Similar roof assemblies can have significantly different impacts depending on the membrane and insulation chosen.

Key point: Small changes in roofing materials can have significant effects on a buildings impact.

17% GLOBAL WARMING FOOTPRINT

- **High Impact Associations**: Production of materials
- **Recommendations**: Leverage efficiency of current design against other potential roof assemblies.

MATERIAL	UNIT	RELATIVE IMPACT
TPO	kg CO2 eq	100%
PVC	kg CO2 eq	109%
ASPHALT	kg CO2 eq	116%

Table 5 - Relative Assembly Impact

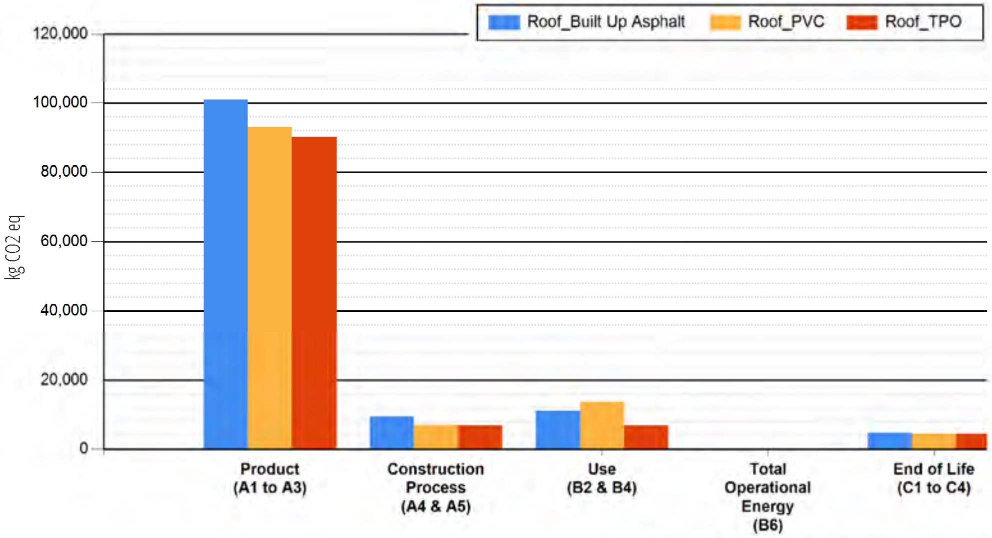


Figure 3 - Impact per life cycle stage- Global Warming Potential

Future Impact Reduction

Expanded Usage of Wood
Increasingly, wood as a material is being re-evaluated for future designs. Better understanding of the structural capabilities of this material has led to a resurgence of both application and research into how to utilize timber and framing on more projects. Methods in current development suggest wood can theoretically rival steel in some applications.

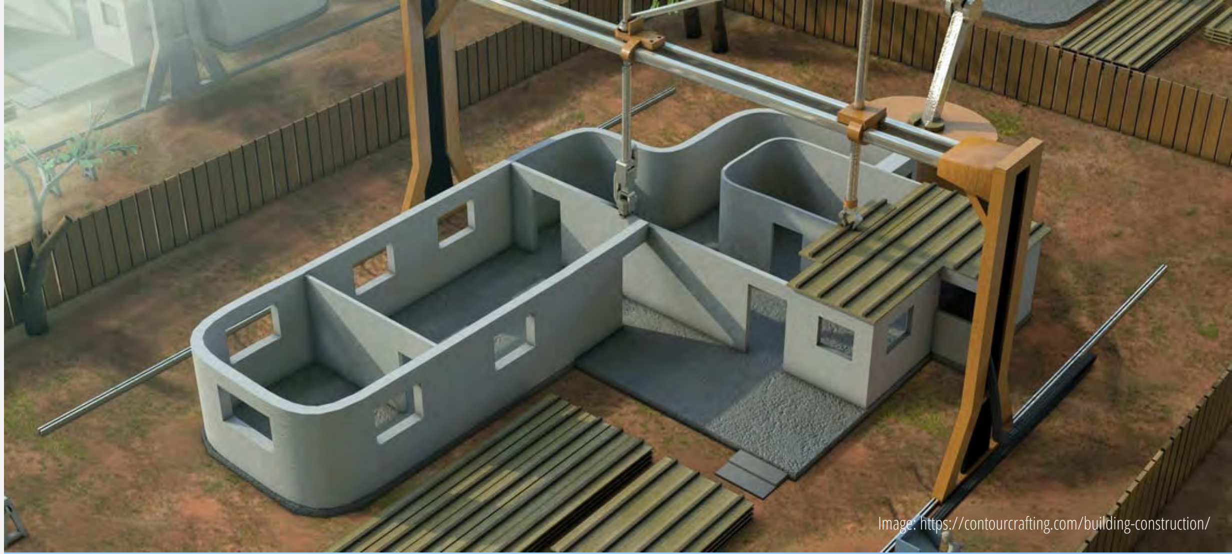
Key point: Wood offers a wide variety of possibilities for structure and finish while being a carbon sink material.

Image: https://www.designboom.com/architecture/manifesta-11-pavillon-of-reflections-studio-tom-emerson-eth-zurich-06-20-2016/

Future Impact Reduction

Expanded Material Palette
One of the keys of decarbonizing the building construction industry is going to be diversifying the material palette available to design teams by utilizing old materials in new ways and looking forward to newly developed materials.

Key point: Possibilities exist both in ancient building materials and newly developing, never-before utilized materials.



Future Impact Reduction

Redeveloping Concrete
Research and development of new concrete mixes is in the early stages, and while there are promising results from new developments like those being seen in geopolymers and recycled content, massive effort will be required to bring concrete into alignment with the requirements of the new building infrastructure.

Key point: Concrete's production process will need to be addressed before it can contribute to a carbon neutral future.

Image: https://www.watertechonline.com/industry/article/14073863/coal-ash-recycling-rate-declines-amid-shifting-production-and-use-patterns

Key Takeaways

The decisions we make now matter.
Designers can make an impact with decisions they make on their designs now.

Verdacity Corporate Office; Image: Verdacity, LLC/Jessica Roybal

Key Takeaways

Assessing impact is key to making better decisions.
Quantifying our impact is essential to understanding how to reduce it and to eventually mitigate it.

Image: http://www.prefabmarket.com/environmental-impact-of-construction/

Key Takeaways

Our ability to quantify and reduce impacts is quickly improving.

Tools and Databases are progressing quickly in their ability to identify the best options for designers to reduce impacts.

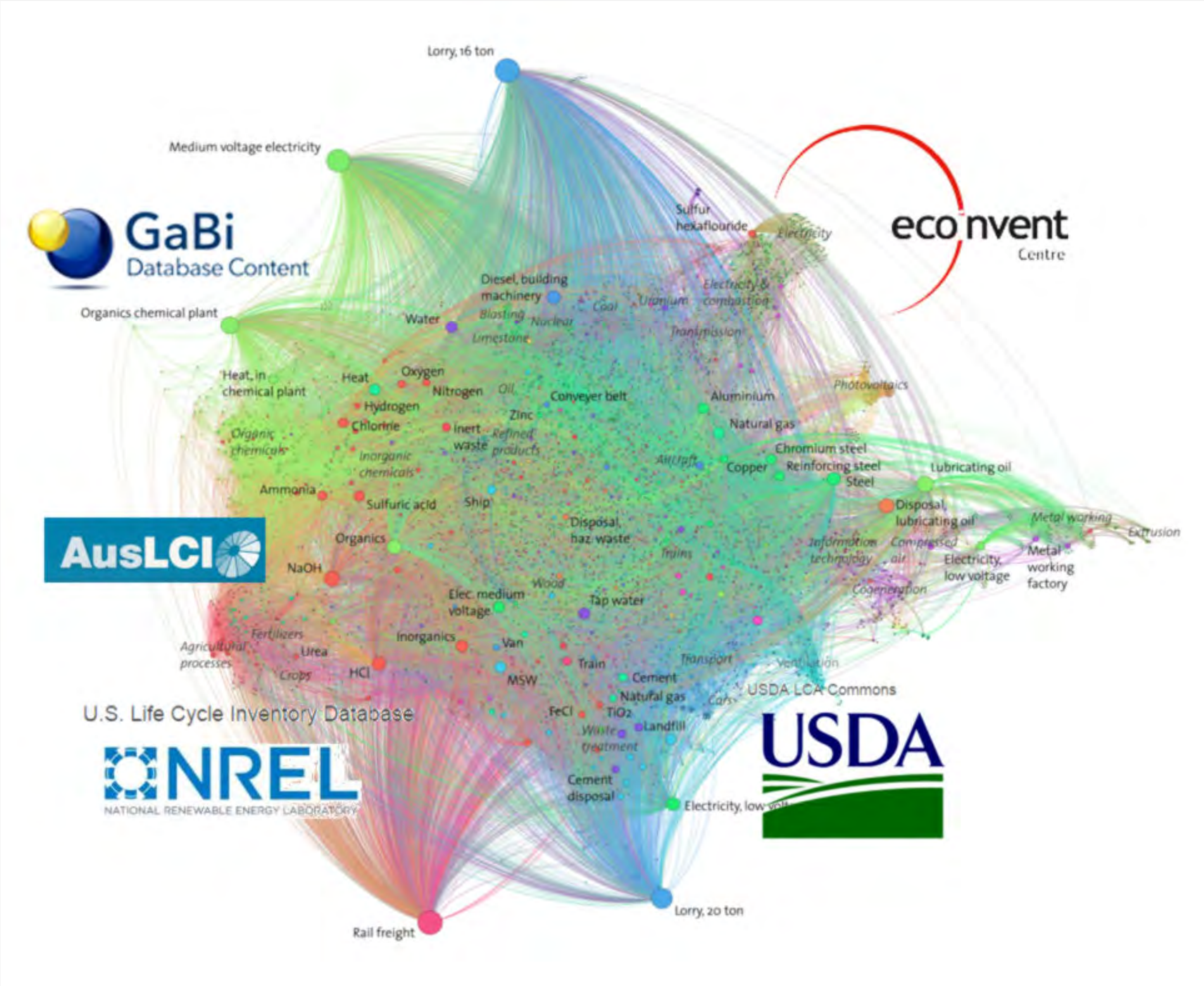


Image: https://www.ipoint-systems.com/blog/success-factors-for-life-cycle-assessment-data-data-data/

Key Takeaways

A *Carbon Neutral Future* is possible and can be enabled by how we design and build buildings.

The buildings of tomorrow will look and operate differently in a carbon neutral world.

"There is no ecological architecture, no intelligent architecture, and no sustainable architecture - there is only good architecture. There are always problems we must not neglect. For example, energy, resources, costs, social aspects - one must always pay attention to all these."

-EDUARDO SOUTO DE MOURA

Eduardo Souto de Moura - House in Moledo - Cristelo, Moledo, Portugal, 1991-1998; Image: Luis Seixas Ferreira Alves

QUESTIONS?

THANKS!

VERDACITY

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