U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Challenges of assessing life cycle impacts of buildings

Life-Cycle Energy & Related Impacts of Buildings Webinar Series

October 29, 2020

Agenda

I. **Opening Remarks**
   Karma Sawyer, Program Manager, U.S. DOE Building Technologies Office

II. **Introduction to Life Cycle Carbon Assessment (LCA)**
   Lyla Fadali - AAAS Policy Fellow, U.S. DOE Building Technologies Office

III. **Whole-Building Life Cycle Analysis**
   Jennifer O'Connor, President, Athena Institute

IV. **Building Life Cycle Analysis with GREET**
   Hao Cai, Principal Environmental Analyst, Argonne National Labs

V. **Metrics & Tools for Sustainable Buildings**
   Joshua Kneifel, Research Economist, National Institute of Standards and Technology

VI. **Q&A Session**
   Cedar Blazek - Management & Program Analyst, U.S. DOE Building Technologies Office

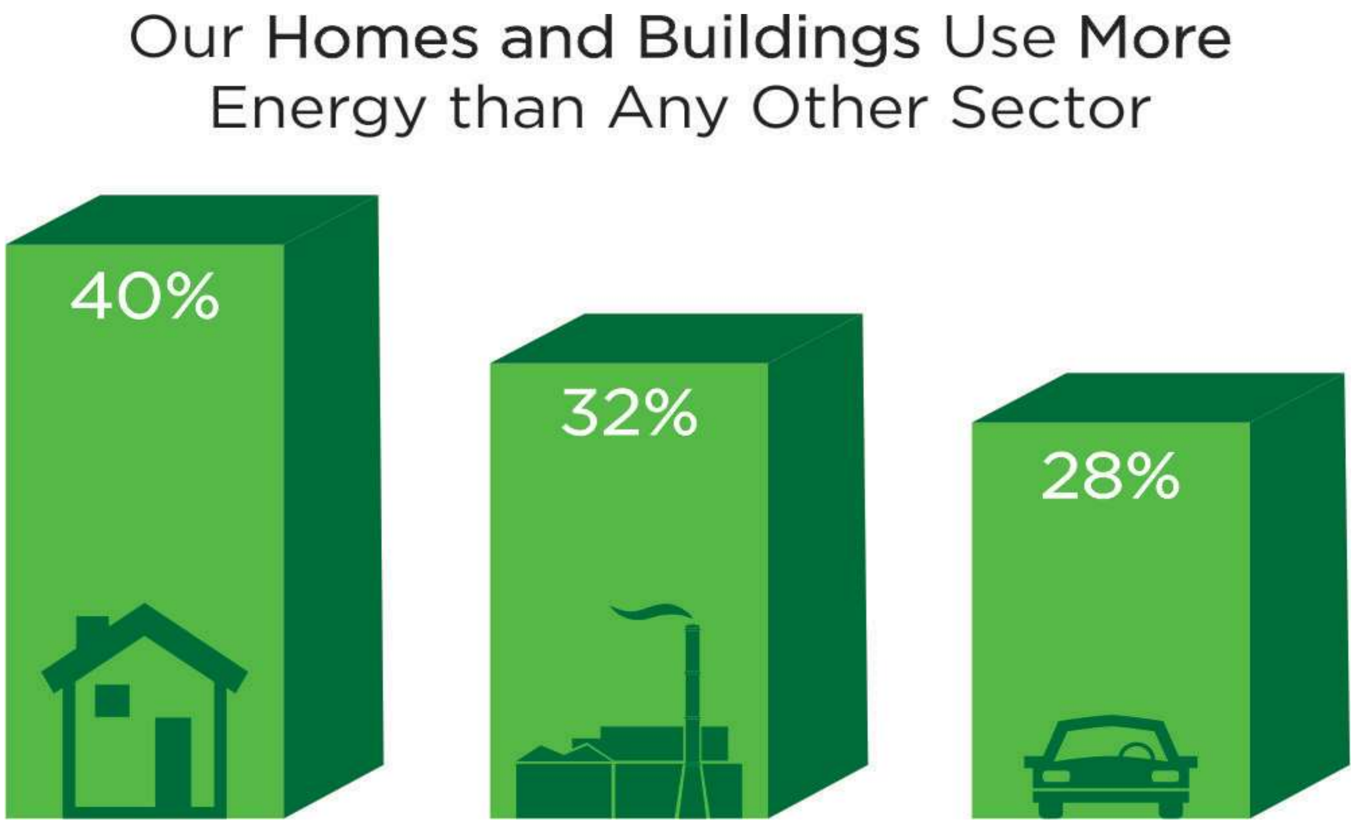
Building Life Cycle Impacts DOE Webinar Series

Topic	Date	Time
Overview of life cycle impacts of buildings	Oct. 16	12:00pm – 1:00pm ET
Challenges of assessing life cycle impacts of buildings	Oct. 29	12:00pm – 1:00pm ET
Innovative building materials	Nov. 12	12:00pm – 1:00pm ET
“Real Life” buildings striving to minimize life cycle impacts	Dec. 3	12:00pm – 1:00pm ET
Intersection of life cycle impacts & circular economy potential for the building sector	Dec. 17	12:00pm – 1:00pm ET

Poll Questions

- What industry are you from?
- How familiar are you with life cycle analysis tools?

Efficiency is key to meeting U.S. energy goals



Residential & Commercial

Industrial

Transportation

Source: EIA Monthly Energy Review

Building Technologies Office

BTO invests in energy efficiency & related technologies that make homes and buildings more affordable and comfortable, and make the US more sustainable, secure and prosperous.

Budget ~US$285M/year; activities include:

R&D
Pre-competitive, early-stage investment in next-generation technologies

Integration
Technology validation, field & lab testing, metrics, market integration

Codes & Standards
Whole building & equipment standards technical analysis, test procedures, regulations

DOE research has saved energy and saved consumers money

FOR EXAMPLE:

Past

Units **half** the price, almost 20% bigger, and **75% less energy** to operate – AND have more features!

Present

Future

- $550 purchase
- $50/year to operate
- 22 cubic feet

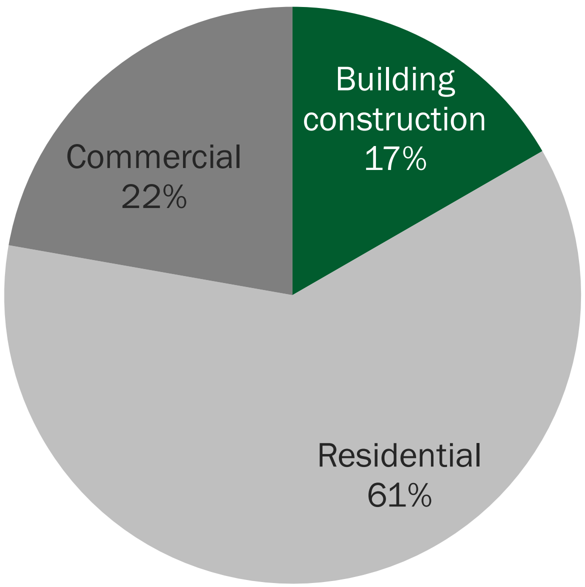
Our impact on a national scale

Energy efficiency standards completed through 2016 are expected to save **142 quadrillion Btu through 2030** — more energy than the entire nation consumes in one year.

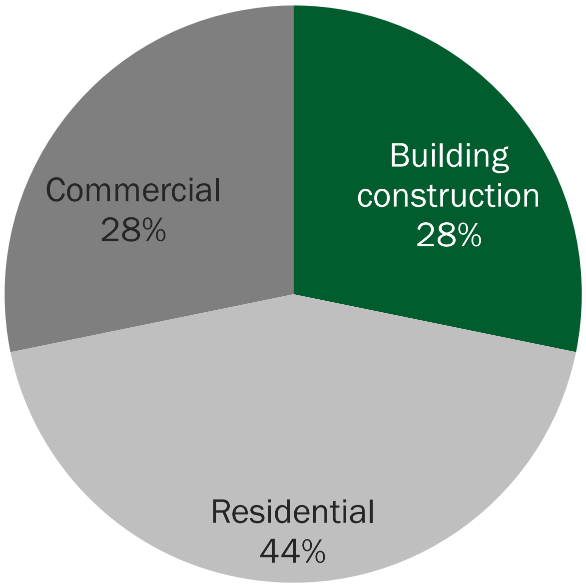
BTO’s work is making a difference, but we’re missing part of the picture.

Historically, BTO has focused on operating buildings.

Global energy use in buildings



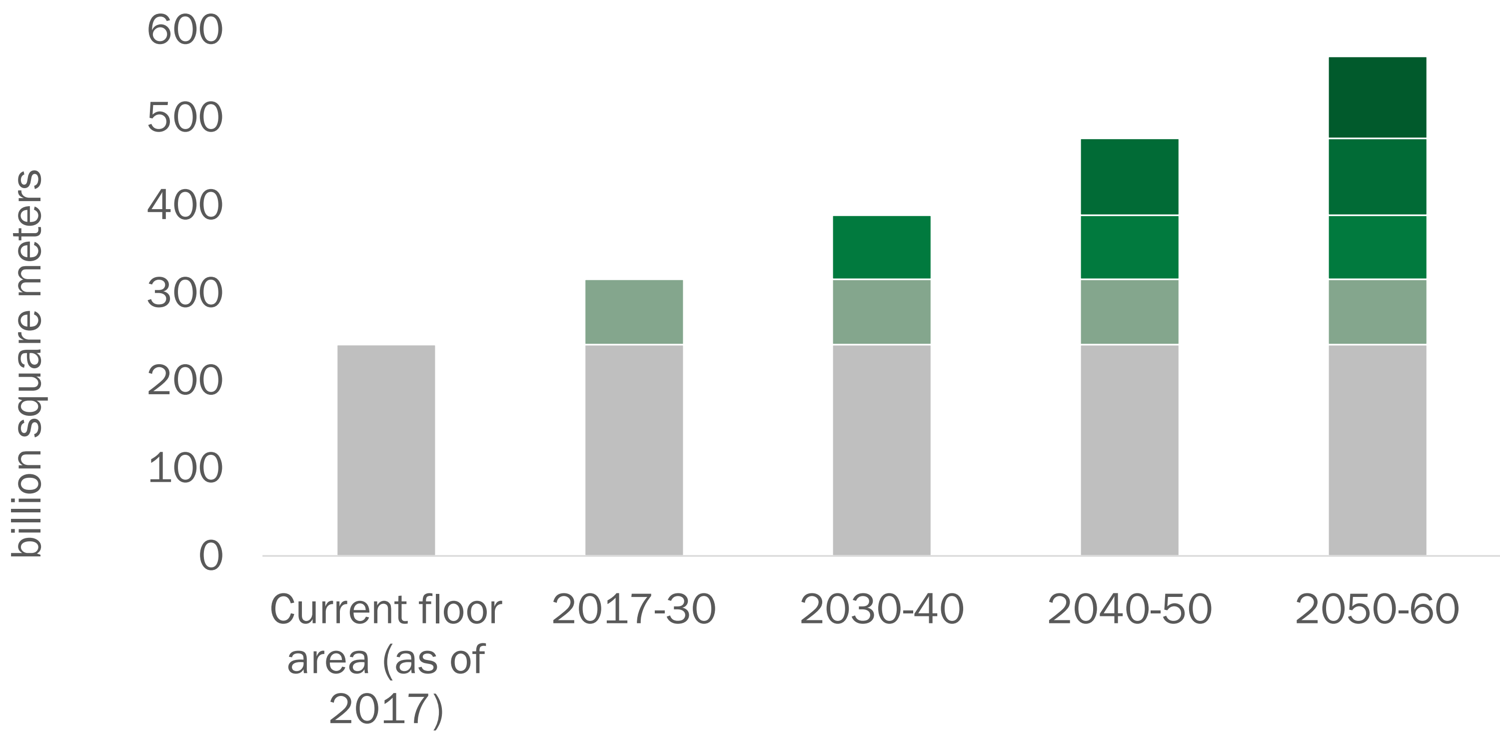
Global emissions from buildings



2018 Global Status Report. United Nations Environment Programme.
International Energy Agency for the Global Alliance for Building and Construction (GlobalABC)

Global building stock expected to more than double, making embodied carbon increasingly important.

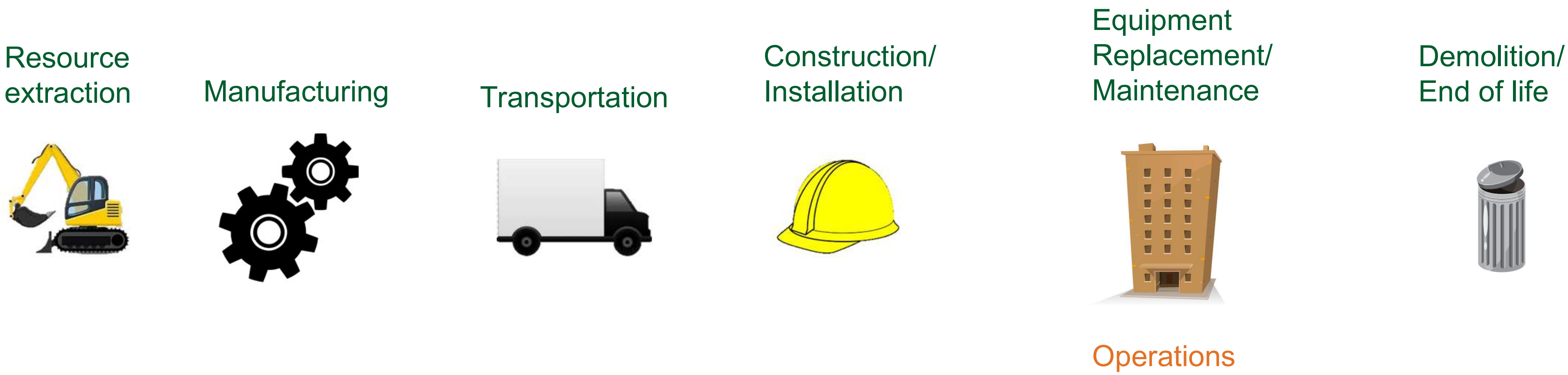
Global building stock through 2060



Source data from GlobalABC Status Report in 2017

Let’s look at the whole picture:

Lifecycle carbon refers to carbon emissions associated with all stages of a building’s life



Embodied carbon is the carbon associated with all stages of a building’s life cycle not including operating the building

Operational carbon is the carbon associated with operating the building

Reality is complicated.

Which mine?

Which manufacturer?

How much material is needed?

How is the product used?

Resource extraction

Manufacturing

Transportation

Construction/ Installation

Equipment Replacement/ Maintenance

Demolition/ End of life

Industry average?

How far?

Operations

How long does a building last?

Landfill or ?

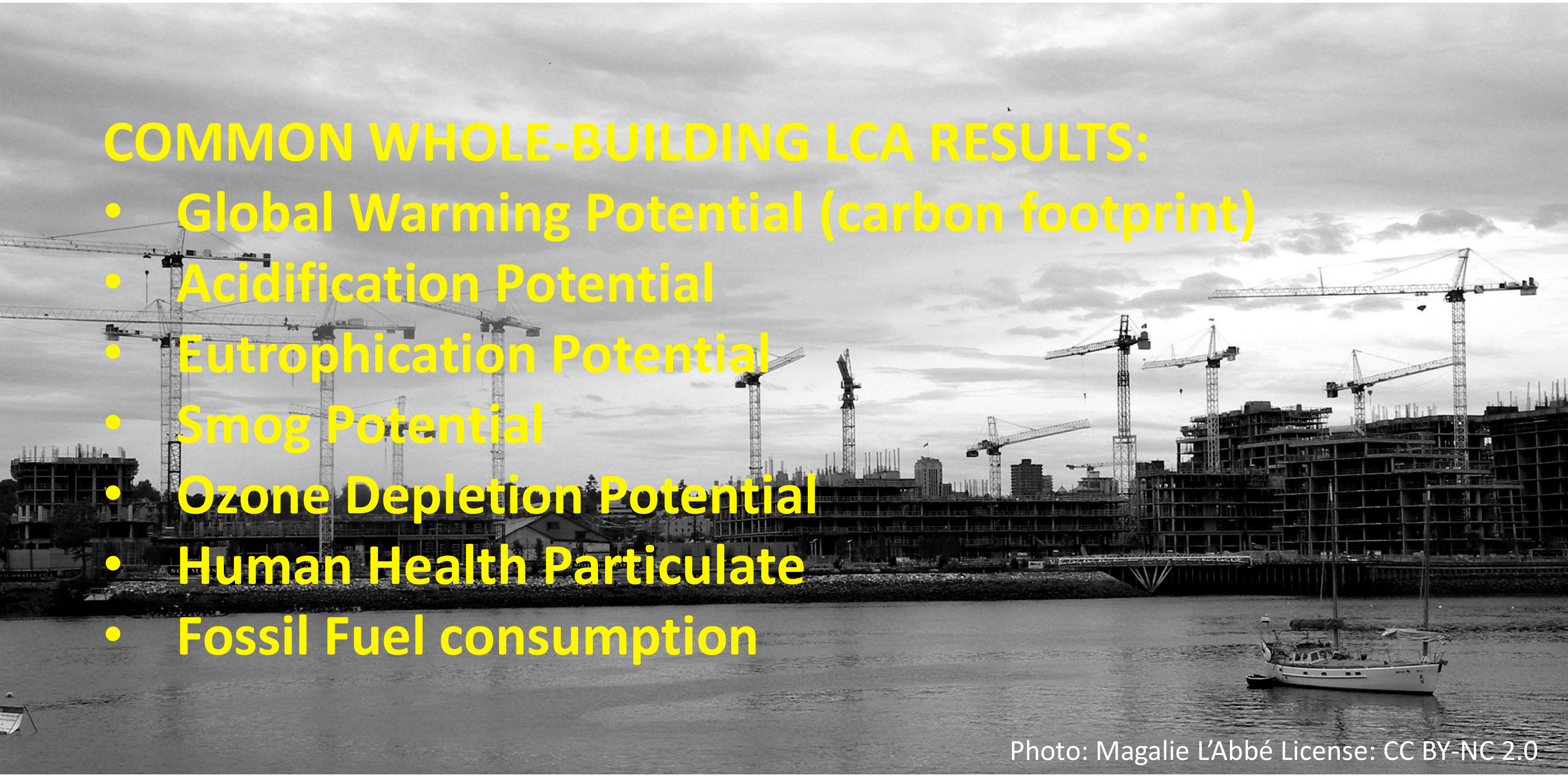
Whole-Building Life Cycle Assessment

Athena Impact Estimator for Buildings

Middlesex Centre Wellness and Recreation Complex

Reduced total environmental impacts by 20%

Cornerstone Architecture Incorporated



COMMON WHOLE-BUILDING LCA RESULTS:

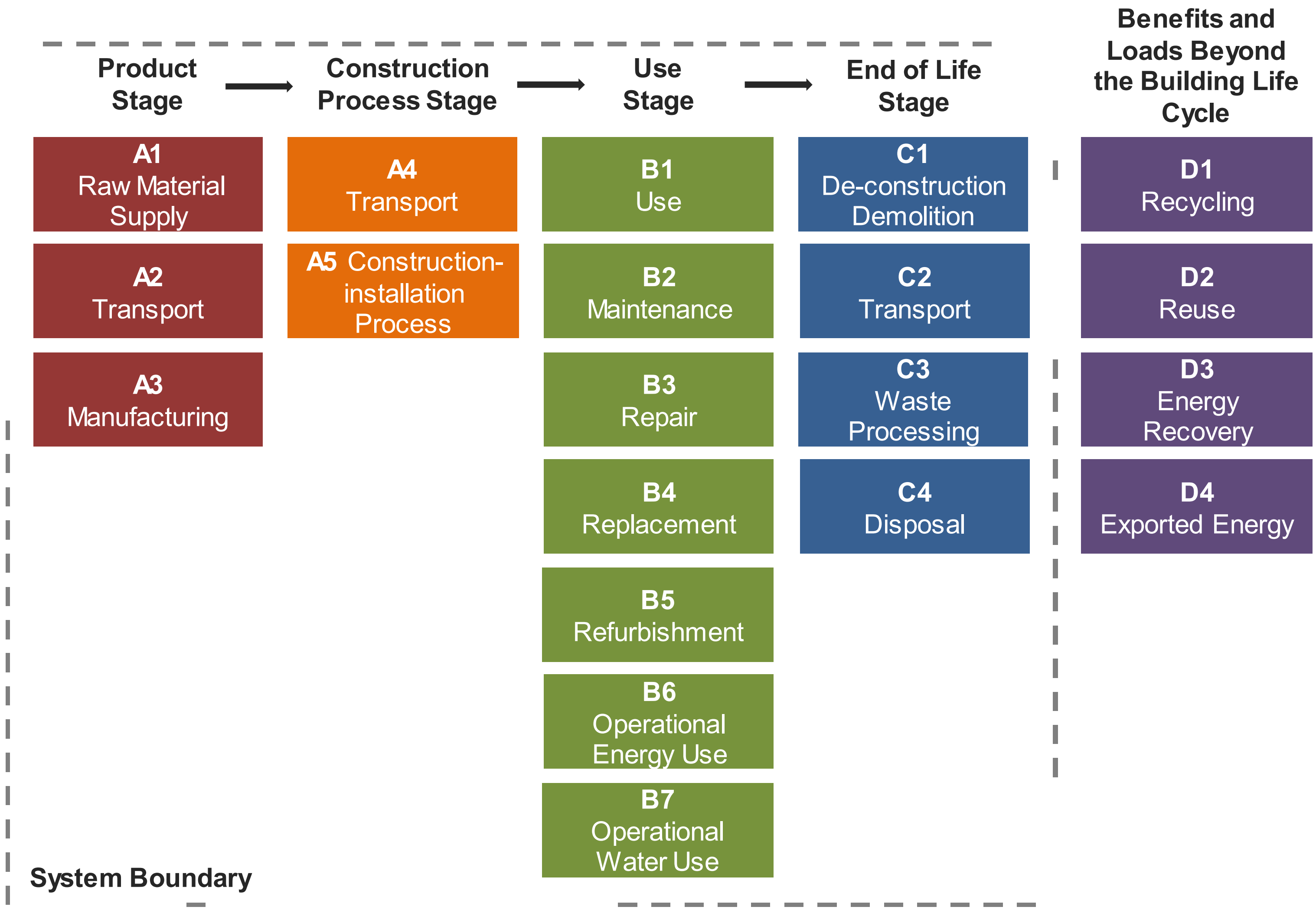
- Global Warming Potential (carbon footprint)
- Acidification Potential
- Eutrophication Potential
- Smog Potential
- Ozone Depletion Potential
- Human Health Particulate
- Fossil Fuel consumption


Rideau Valley
Conservation Centre

Reduced embodied
carbon impact by 100
metric tons CO_2.

Christopher Simmonds Architect Inc.

Life Cycle Stages for a Building



Life cycle stages per EN 15978:11 *Sustainability of construction works — Assessment of environmental performance of buildings —Calculation method.*

Athena databases

- LCI data on materials, products, energy, transportation
- Rolled up LCA data on some products
- Scenario data: transportation distances, construction energy and waste, repair and replacement schedules, end of life treatment
- TRACI characterization factors

User inputs

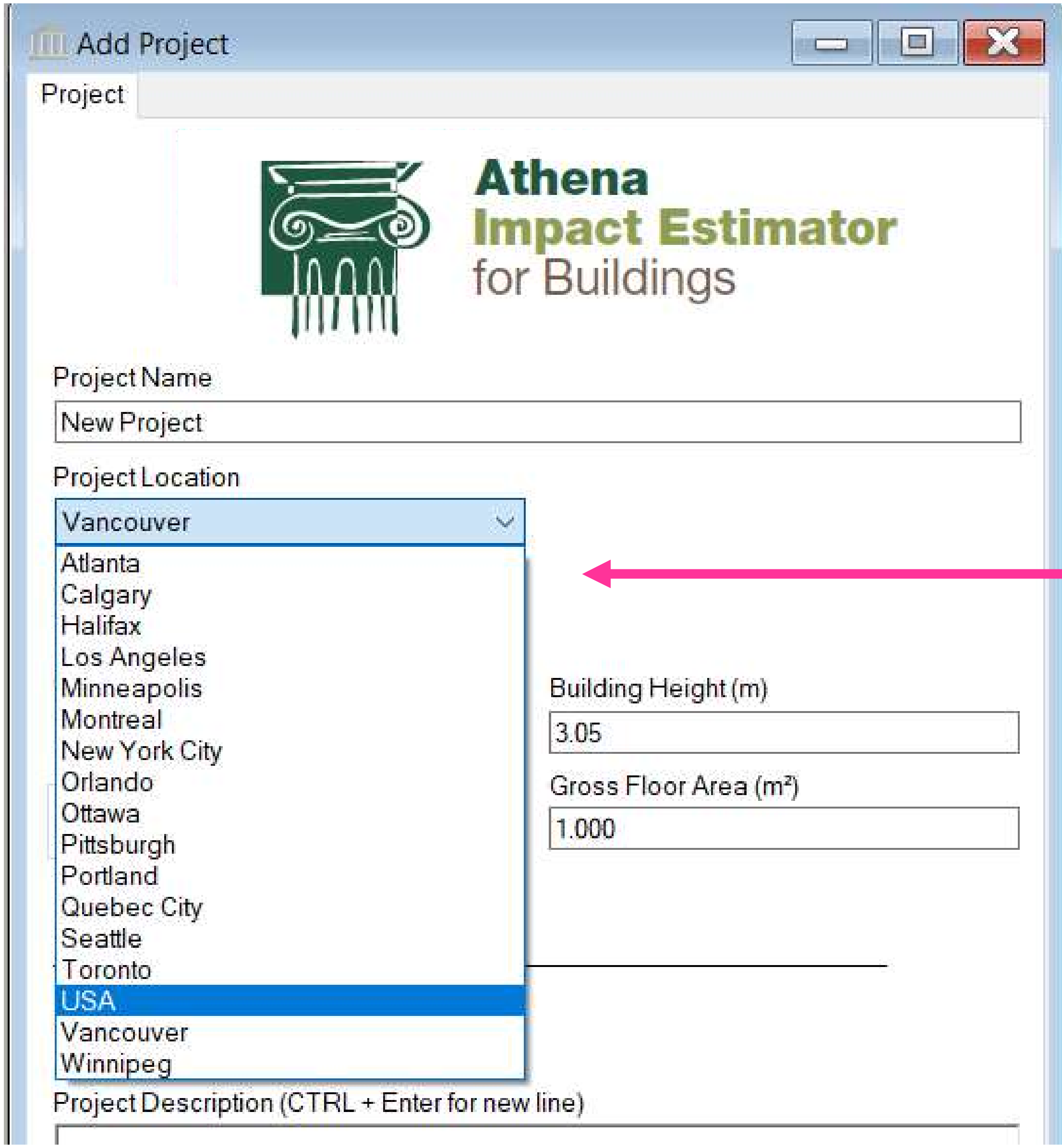
- Material quantities
- Location, etc.
- Operating energy

Athena
Impact Estimator
for Buildings

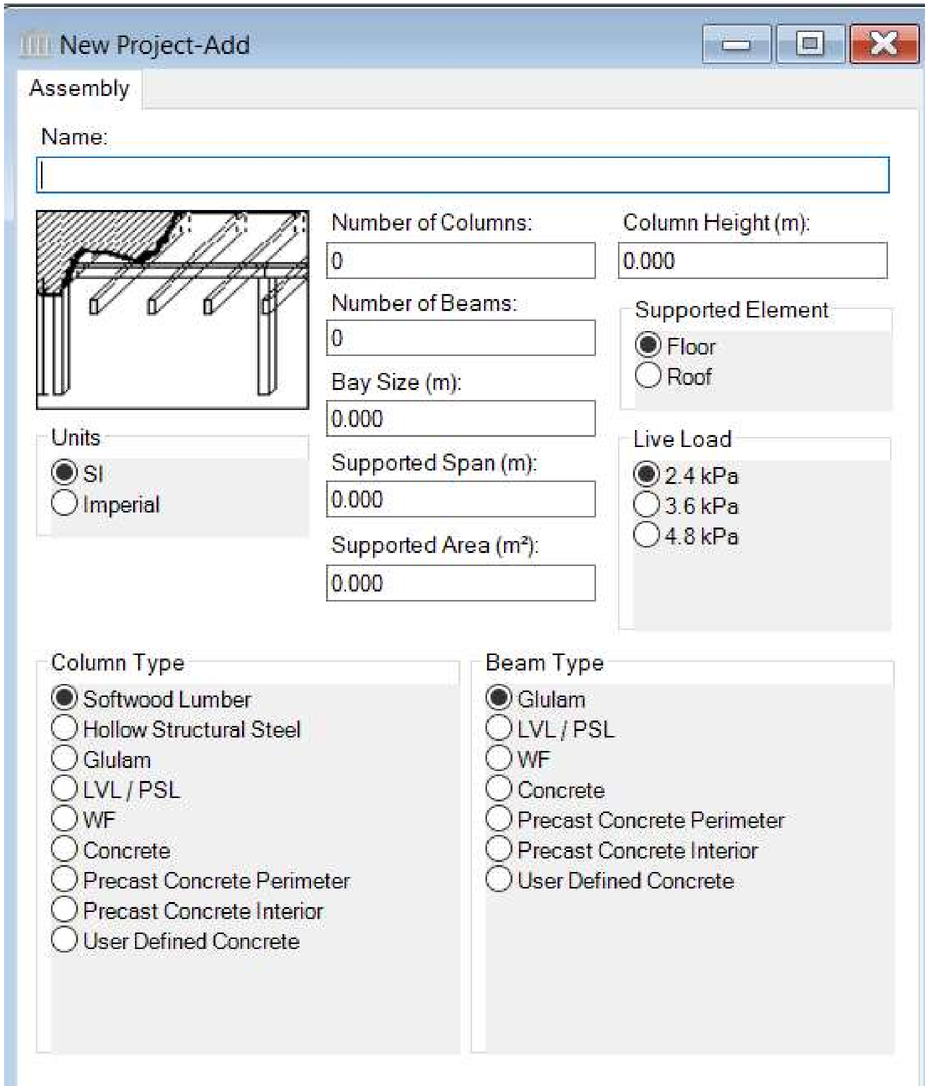
LCA results: global warming, acidification, smog, etc

LCI results: air emissions, water emissions, resource use, etc

Lifecycle bill of materials



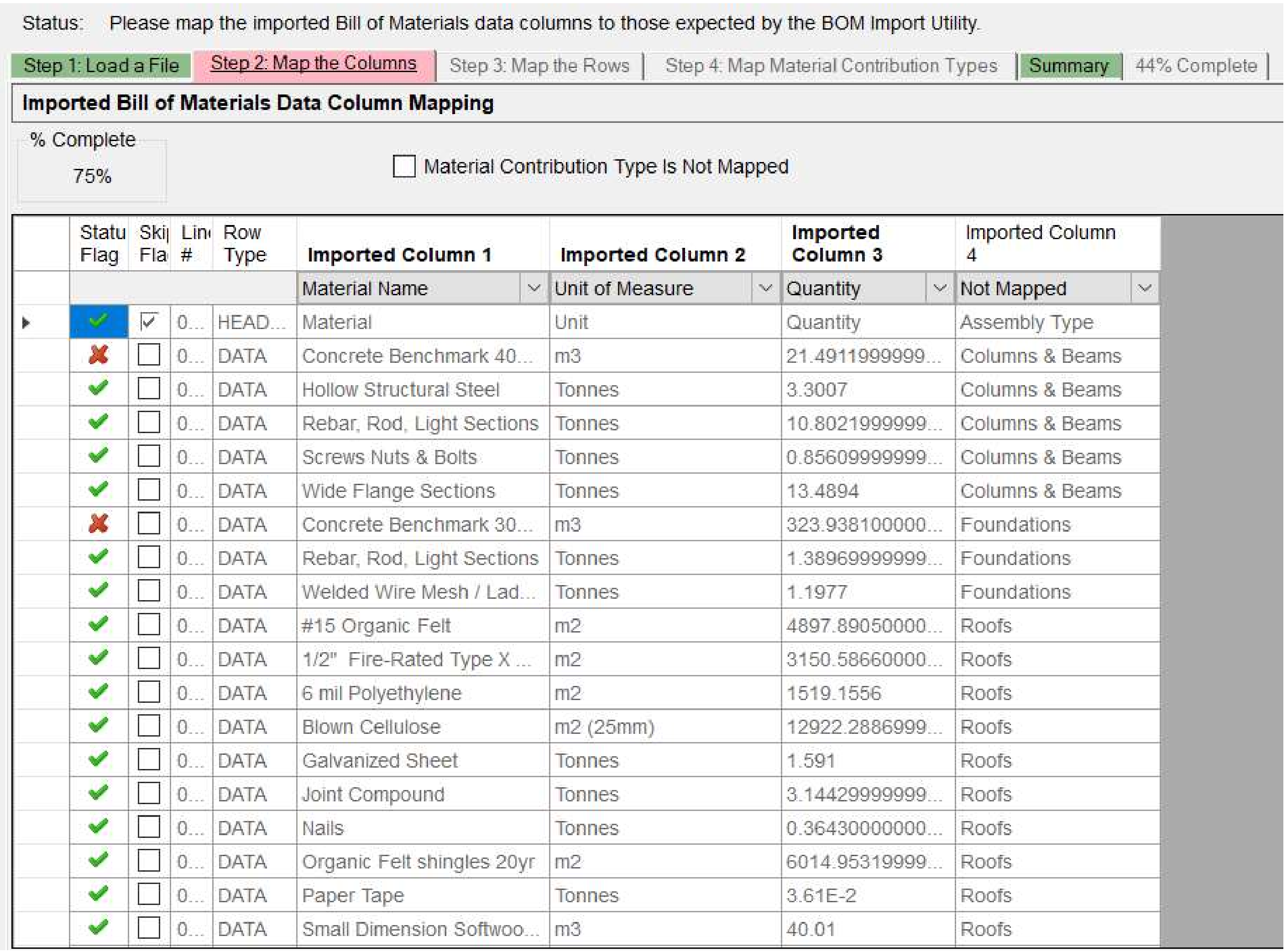
Choose closest city for regionally-accurate results.



Create a project

Option 1: Early design

Use dialogue boxes to quickly create assemblies. The software will calculate a bill of materials.



Status: Please map the imported Bill of Materials data columns to those expected by the BOM Import Utility.

Step 1: Load a File | Step 2: Map the Columns | Step 3: Map the Rows | Step 4: Map Material Contribution Types | Summary | 44% Complete

Imported Bill of Materials Data Column Mapping

% Complete
75%

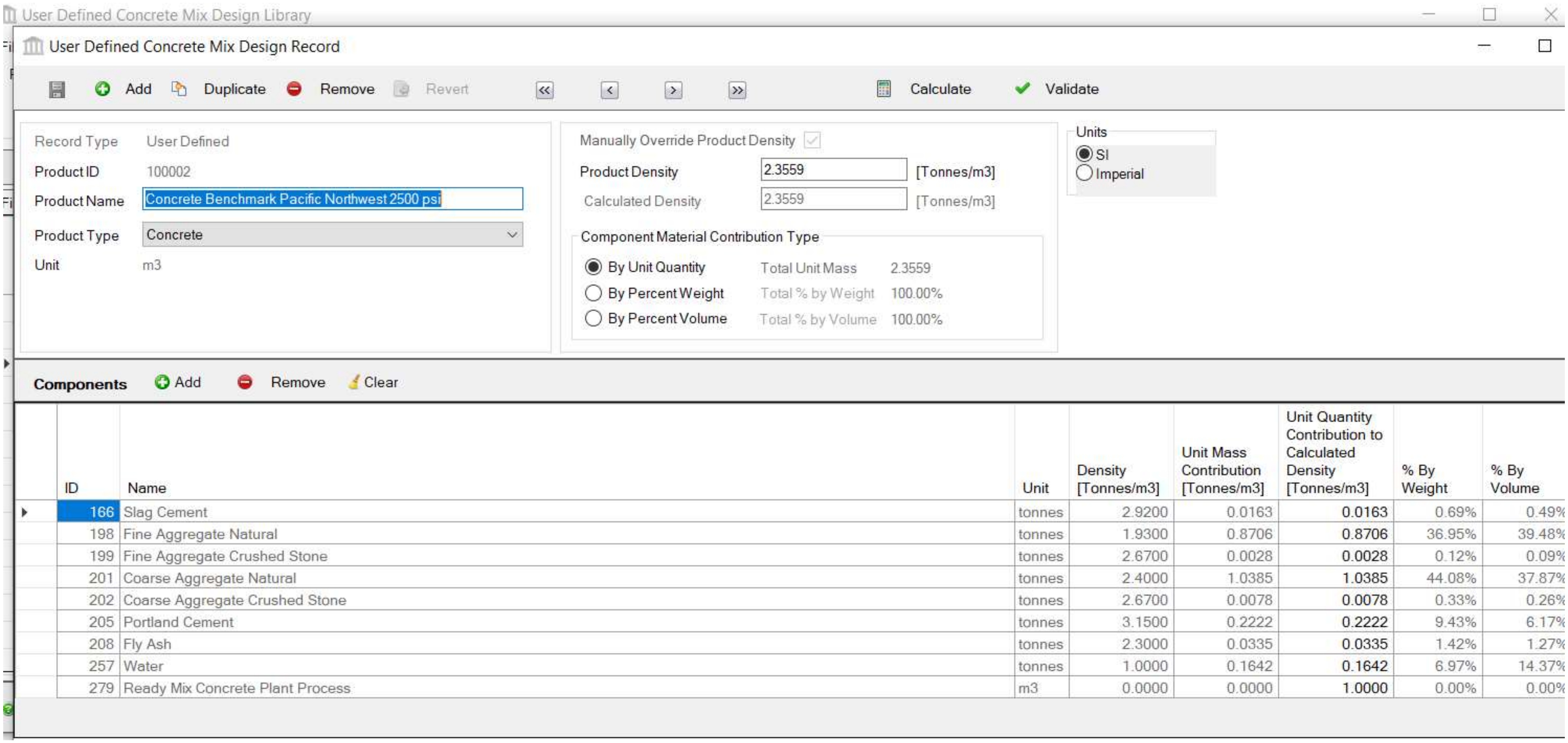
☐ Material Contribution Type Is Not Mapped

Statu Flag	Ski Fla	Lin #	Row Type	Imported Column 1	Imported Column 2	Imported Column 3	Imported Column 4
				Material Name	Unit of Measure	Quantity	Not Mapped
✓	☑	0...	HEAD...	Material	Unit	Quantity	Assembly Type
✗	☐	0...	DATA	Concrete Benchmark 40...	m3	21.4911999999...	Columns & Beams
✓	☐	0...	DATA	Hollow Structural Steel	Tonnes	3.3007	Columns & Beams
✓	☐	0...	DATA	Rebar, Rod, Light Sections	Tonnes	10.8021999999...	Columns & Beams
✓	☐	0...	DATA	Screws Nuts & Bolts	Tonnes	0.85609999999...	Columns & Beams
✓	☐	0...	DATA	Wide Flange Sections	Tonnes	13.4894	Columns & Beams
✗	☐	0...	DATA	Concrete Benchmark 30...	m3	323.938100000...	Foundations
✓	☐	0...	DATA	Rebar, Rod, Light Sections	Tonnes	1.38969999999...	Foundations
✓	☐	0...	DATA	Welded Wire Mesh / Lad...	Tonnes	1.1977	Foundations
✓	☐	0...	DATA	#15 Organic Felt	m2	4897.89050000...	Roofs
✓	☐	0...	DATA	1/2" Fire-Rated Type X ...	m2	3150.58660000...	Roofs
✓	☐	0...	DATA	6 mil Polyethylene	m2	1519.1556	Roofs
✓	☐	0...	DATA	Blown Cellulose	m2 (25mm)	12922.2886999...	Roofs
✓	☐	0...	DATA	Galvanized Sheet	Tonnes	1.591	Roofs
✓	☐	0...	DATA	Joint Compound	Tonnes	3.14429999999...	Roofs
✓	☐	0...	DATA	Nails	Tonnes	0.36430000000...	Roofs
✓	☐	0...	DATA	Organic Felt shingles 20yr	m2	6014.95319999...	Roofs
✓	☐	0...	DATA	Paper Tape	Tonnes	3.61E-2	Roofs
✓	☐	0...	DATA	Small Dimension Softwoo...	m3	40.01	Roofs

Create a project Option 2: Import a bill of materials

Load a file and map it. Save the map for future projects.

Make custom concrete mixes as needed



Condensed LCA Measure Table By Life Cycle Stages

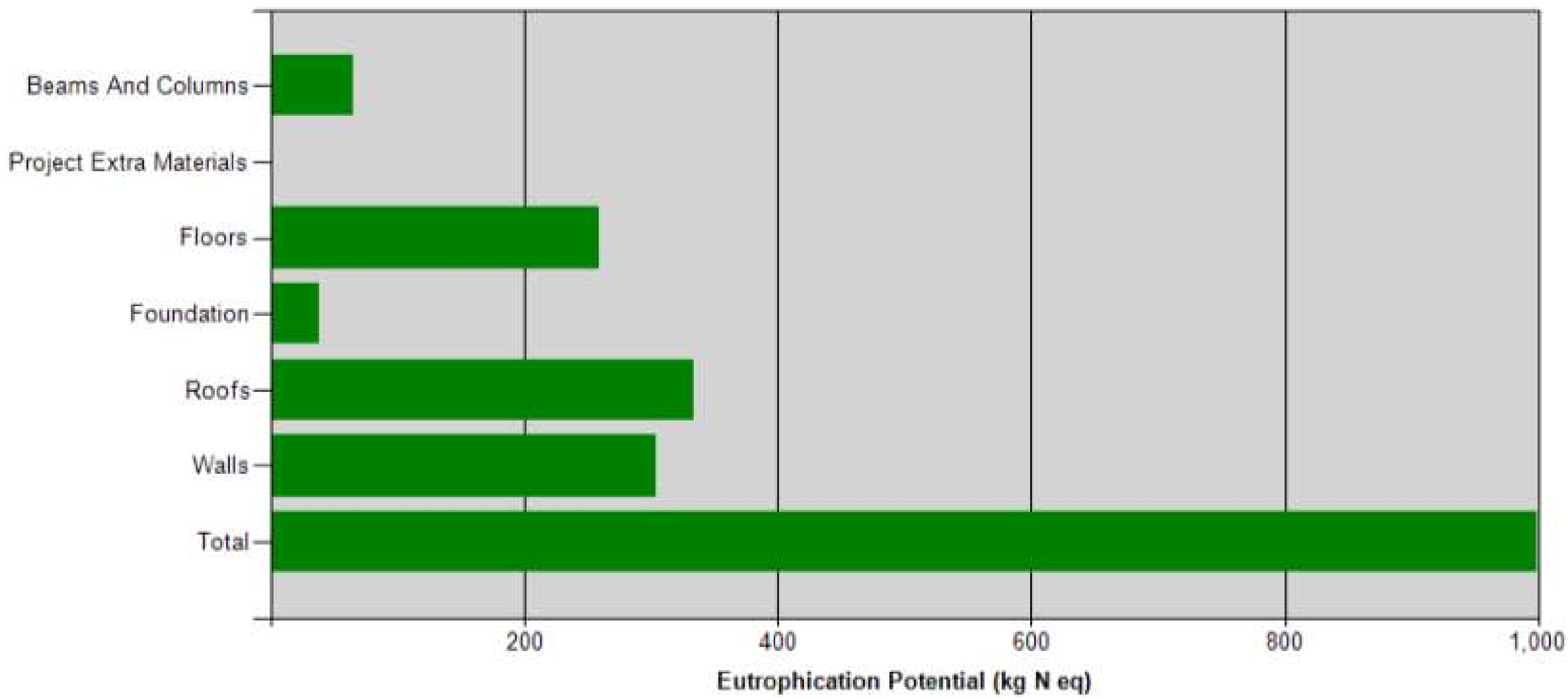
Project: Case Study - Condo

		PRODUCT (A1 to A3)	CONSTRUCTION PROCESS (A4 & A5)	USE (B2, B4 & B6)			END OF LIFE (C1 to C4)	BEYOND BUILDING LIFE (D)	TOTAL EFFECTS	
LCA Measures	Unit	Total	Total	Replacement Total	Operational Energy Use Total	Total	Total	Total	A to C	A to D
Global Warming Potential	kg CO2 eq	5.45E+05	6.31E+04	9.31E+03	0.00E+00	9.31E+03	4.01E+04	1.51E+04	6.57E+05	6.72E+05
Acidification Potential	kg SO2 eq	2.40E+03	5.02E+02	7.58E+01	0.00E+00	7.58E+01	5.05E+02	-1.22E+01	3.49E+03	3.47E+03
HH Particulate	kg PM2.5 eq	7.06E+02	3.36E+01	5.40E+00	0.00E+00	5.40E+00	2.38E+01	1.92E+01	7.69E+02	7.88E+02
Eutrophication Potential	kg N eq	2.04E+02	3.41E+01	2.61E+00	0.00E+00	2.61E+00	3.14E+01	1.87E+00	2.72E+02	2.74E+02
Ozone Depletion Potential	kg CFC-11 eq	5.00E-03	2.43E-04	2.98E-04	0.00E+00	2.98E-04	1.66E-06	-4.82E-07	5.55E-03	5.55E-03
Smog Potential	kg O3 eq	3.66E+04	1.44E+04	6.30E+02	0.00E+00	6.30E+02	1.65E+04	4.32E+01	6.81E+04	6.82E+04
Total Primary Energy	MJ	5.73E+06	7.95E+05	1.01E+05	0.00E+00	1.01E+05	5.93E+05	1.62E+04	7.22E+06	7.23E+06
Non-Renewable Energy	MJ	5.43E+06	7.80E+05	1.01E+05	0.00E+00	1.01E+05	5.92E+05	1.70E+04	6.90E+06	6.92E+06
Fossil Fuel Consumption	MJ	4.37E+06	7.58E+05	9.95E+04	0.00E+00	9.95E+04	5.91E+05	1.39E+05	5.82E+06	5.96E+06

Get detailed LCA and LCI results by life cycle stage and by assembly

Eutrophication Potential LCA Measure Chart By Assembly Groups (A to C)

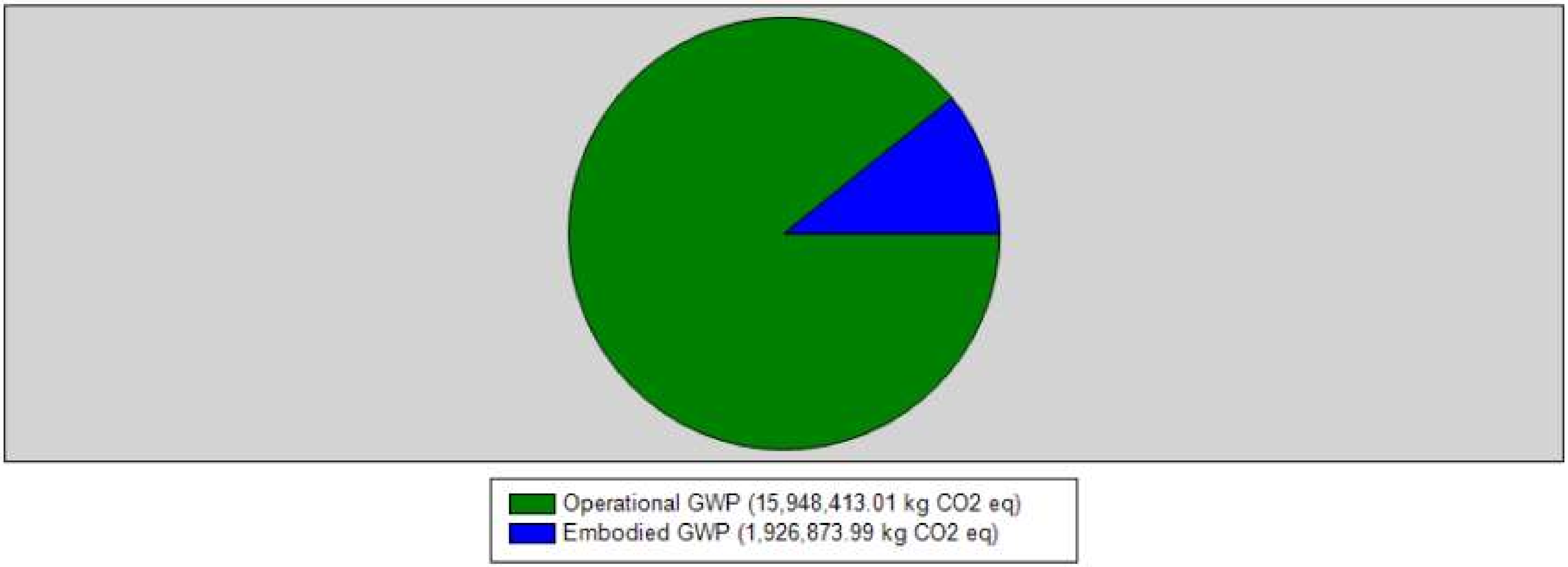
Project: Case Study - Condo Reference



Multiple graph options, or export all results to Excel

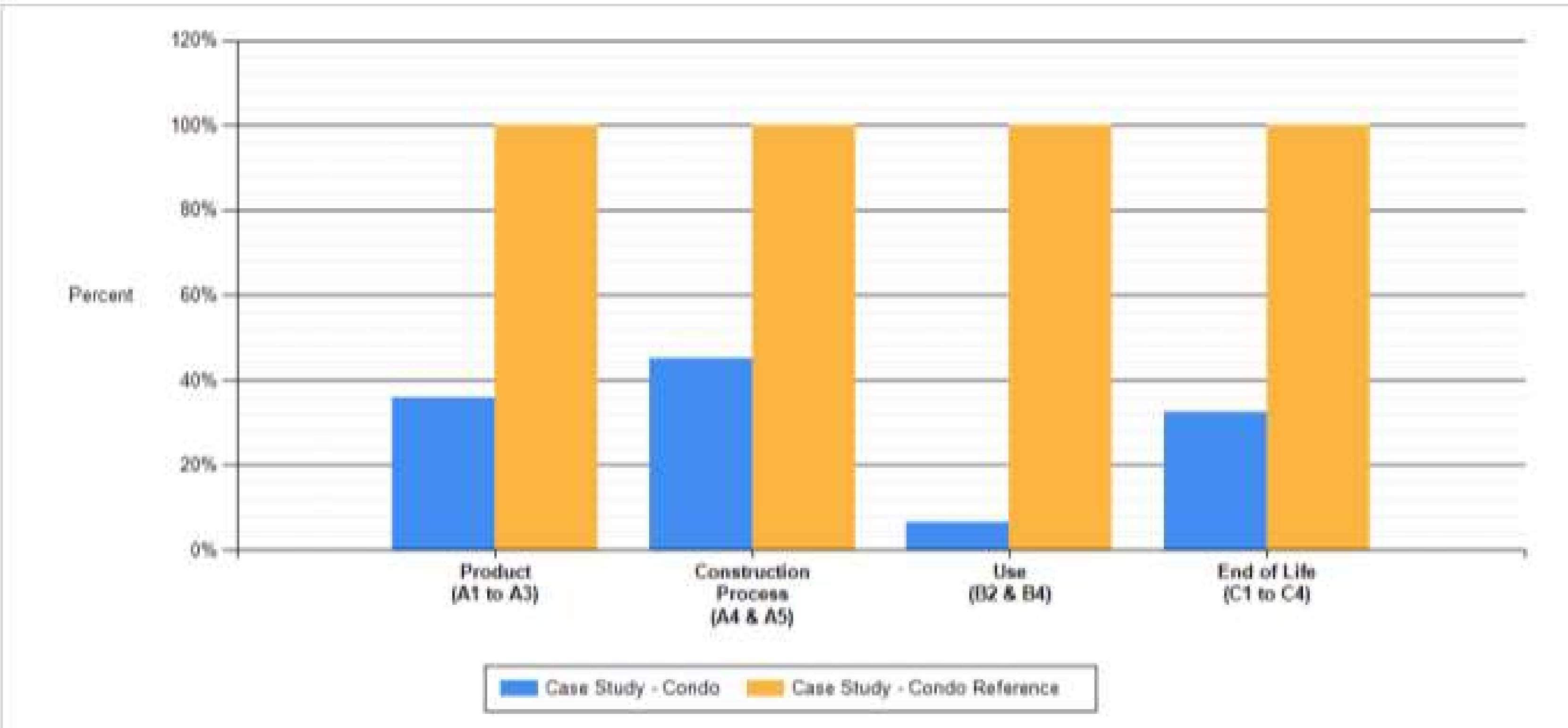
Operational vs Embodied Global Warming Potential (A to C)

Project Case Study - Condo Reference

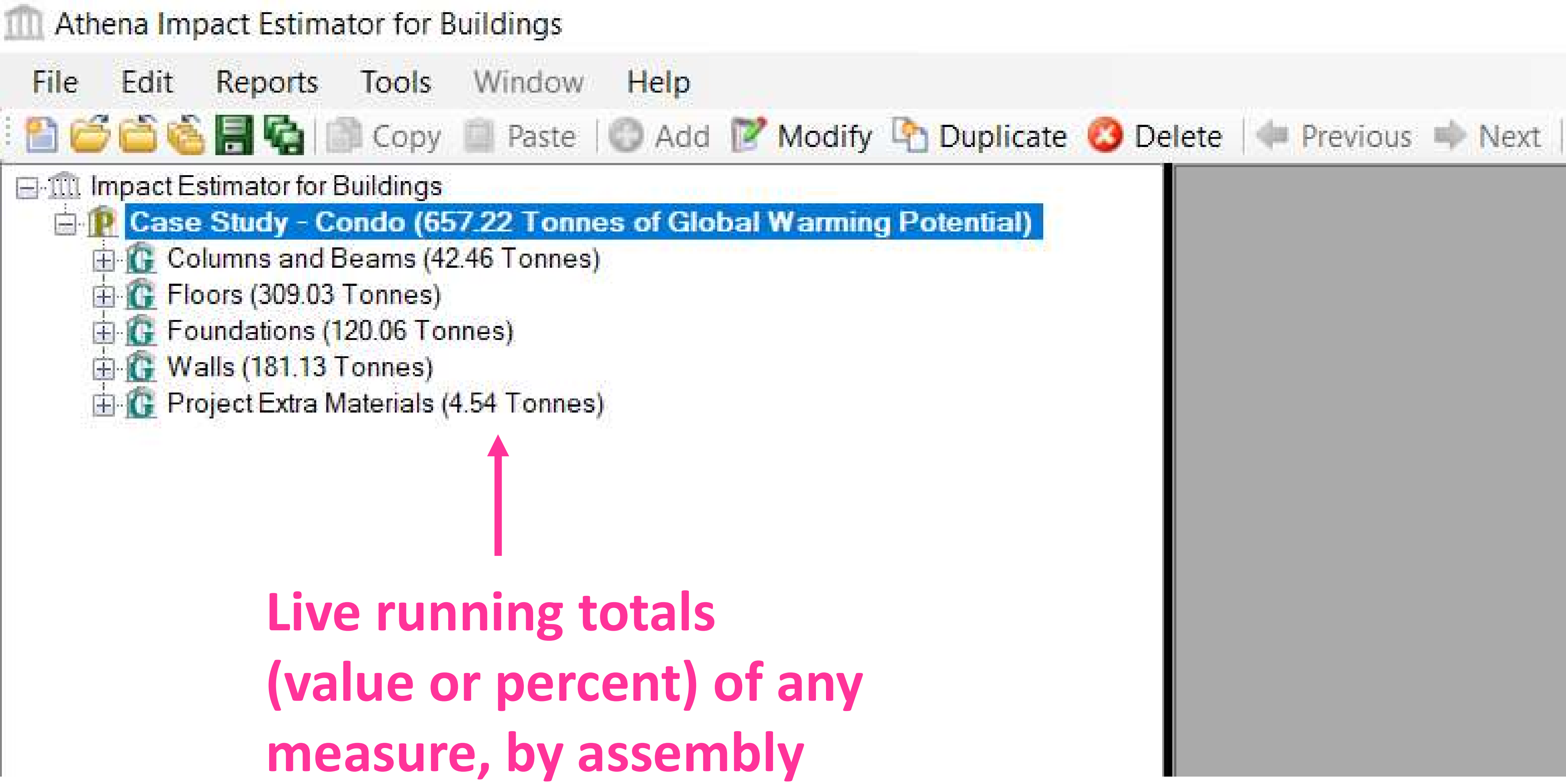


Compare operating and embodied energy and carbon

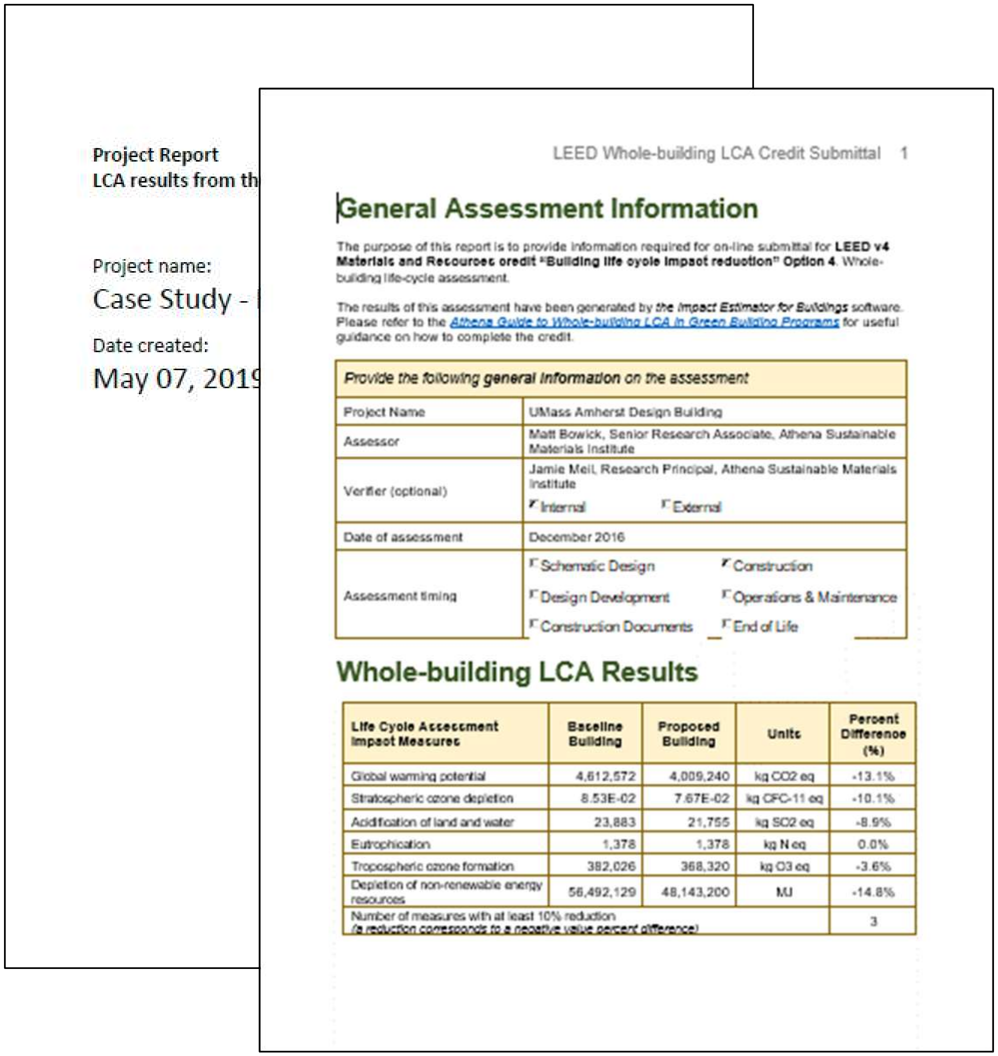
Comparison of Global Warming Potential By Life Cycle Stage (Embodied Effects) [With Case Study - Condo Reference as Project Baseline]



Easy side-by-side comparisons



Live running totals (value or percent) of any measure, by assembly


Project Report
LCA results from th

Project name:
Case Study -

Date created:
May 07, 201

LEED Whole-building LCA Credit Submittal 1

General Assessment Information

The purpose of this report is to provide information required for on-line submittal for **LEED v4 Materials and Resources credit "Building life cycle impact reduction" Option 4**. Whole-building life-cycle assessment.

The results of this assessment have been generated by *the Impact Estimator for Buildings* software. Please refer to the *Athena Guide to Whole-building LCA in Green Building Programs* for useful guidance on how to complete the credit.

*Provide the following **general information** on the assessment*	
Project Name	UMass Amherst Design Building
Assessor	Matt Bowick, Senior Research Associate, Athena Sustainable Materials Institute
Verifier (optional)	Jamie Meil, Research Principal, Athena Sustainable Materials Institute ☑ Internal ☐ External
Date of assessment	December 2016
Assessment timing	☐ Schematic Design ☑ Construction ☐ Design Development ☐ Operations & Maintenance ☐ Construction Documents ☐ End of Life

Whole-building LCA Results

Life Cycle Assessment Impact Measures	Baseline Building	Proposed Building	Units	Percent Difference (%)
Global warming potential	4,612,572	4,009,240	kg CO2 eq	-13.1%
Stratospheric ozone depletion	8.53E-02	7.67E-02	kg CFC-11 eq	-10.1%
Acidification of land and water	23,883	21,755	kg SO2 eq	-8.9%
Eutrophication	1,378	1,378	kg N eq	0.0%
Tropospheric ozone formation	382,026	368,320	kg O3 eq	-3.6%
Depletion of non-renewable energy resources	56,492,129	48,143,200	MJ	-14.8%
Number of measures with at least 10% reduction *(a reduction corresponds to a negative value percent difference)*				3

Instantly generate project reports and LEED submittals

Factors Affecting Reliability of Results for Any Whole-Building LCA study

- **Bill of materials:** Accuracy and comprehensiveness
- **Background material and process data:** Accuracy, consistency, comprehensiveness
- **Life cycle stages:** Comprehensiveness

The Whole-Building LCA technical infrastructure

Component	Purpose	Status
Standards	Guardrails	Good
Guidelines	Consistency	Inadequate
Data and methods	Accuracy	Lots of gaps
Software tools	Access	Needs improvement
Benchmarking	Comparison	Missing
Training	Interpretation	Inadequate

Athena
Sustainable Materials
Institute

www.athenasmi.org

- Free software download
- Case studies
- Research reports
- Learn more about LCA

- Join our mailing list!

BUILDING LIFE-CYCLE ANALYSIS WITH GREET

HAO CAI

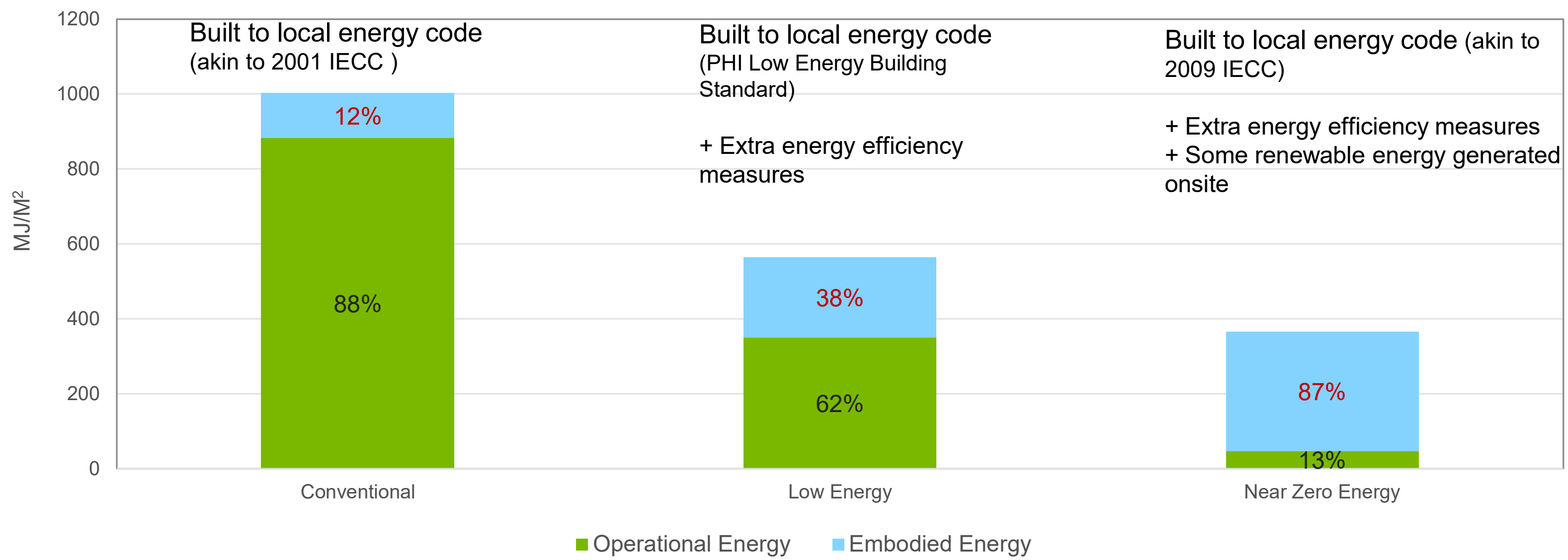
Principal Environmental Analyst
Systems Assessment Center
Argonne National Laboratory

10/29, BTO Building Life-cycle

LCA IS AN EFFECTIVE APPROACH TO ADDRESSING EMBODIED CARBON/ENERGY, WHICH BECOMES INCREASINGLY IMPORTANT FOR PROMOTING NEAR-ZERO ENERGY/EMISSIONS DESIGNS

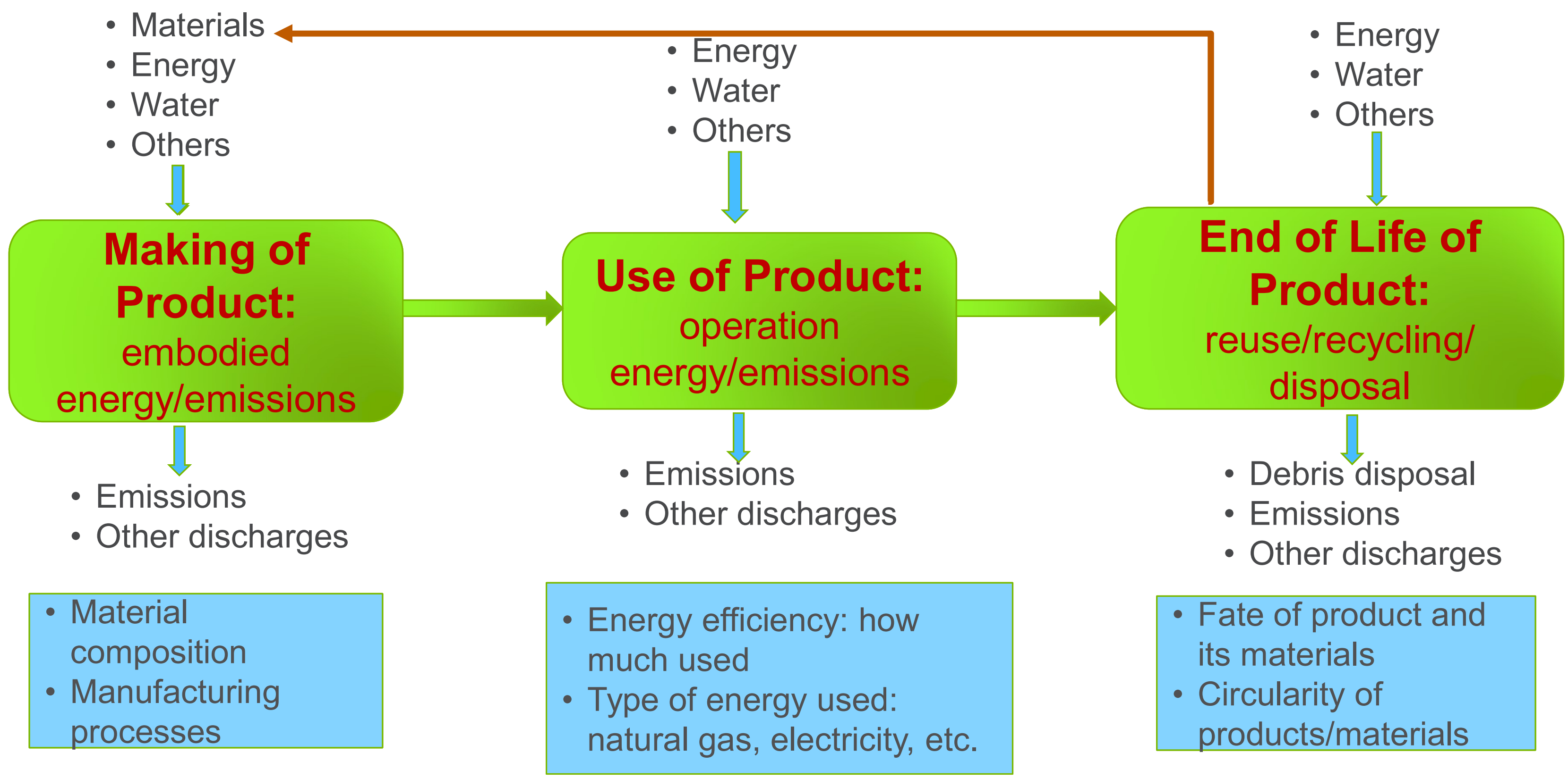
- As the building sector continues to improve energy efficiency to reach net zero energy buildings, embodied energy/GHGs become the integral part of consideration for pursuing sustainable building components/technologies and whole buildings

Illustrative Tradeoffs Between Embodied Energy and Operational Energy: MJ/M²



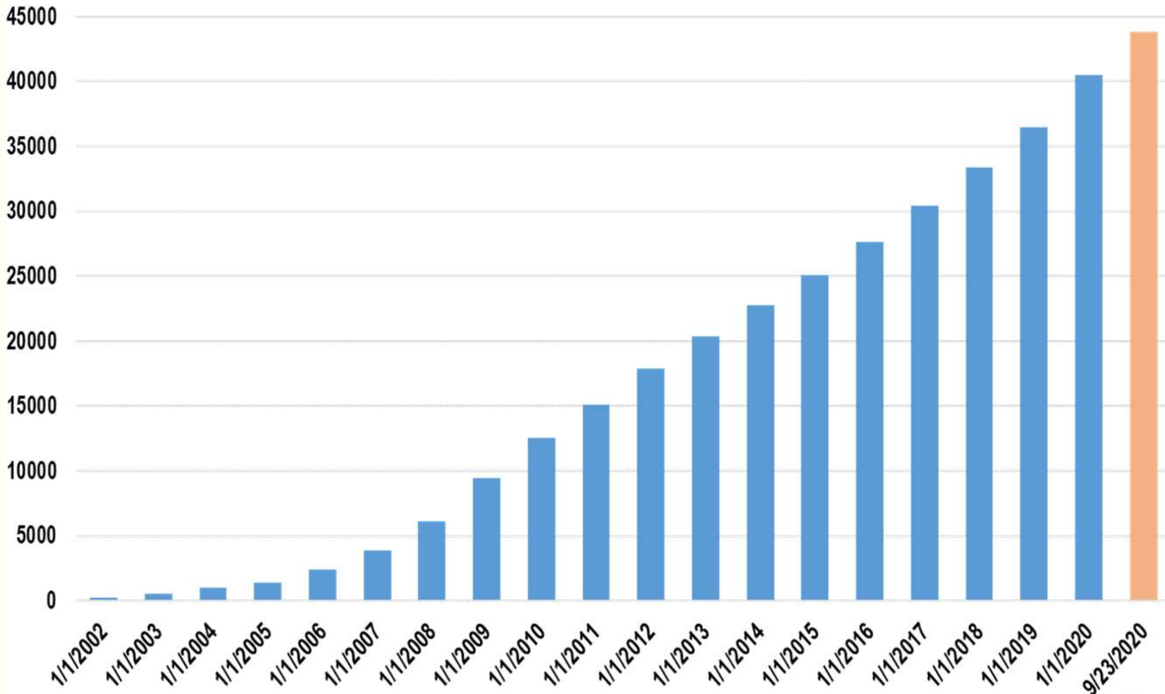
(From Goetsch 2020; Chastas et al, 2016)

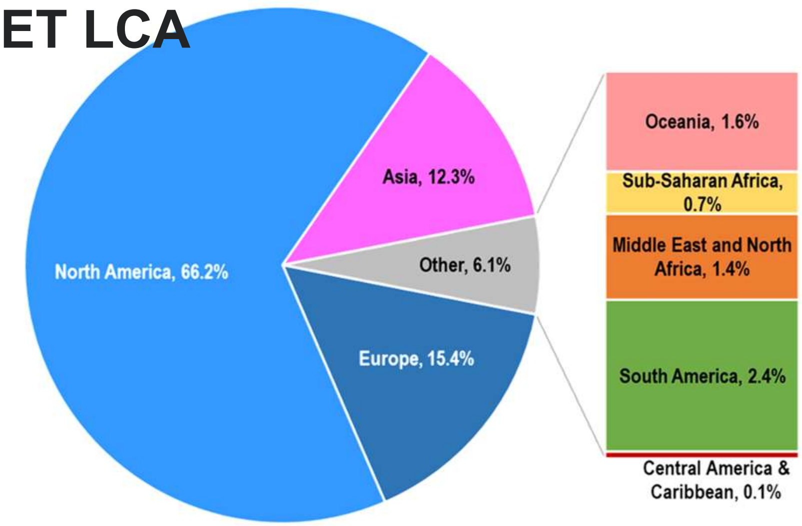
Building LCA: Cradle-to-grave consideration of a building product/technology to address its energy and environmental footprints

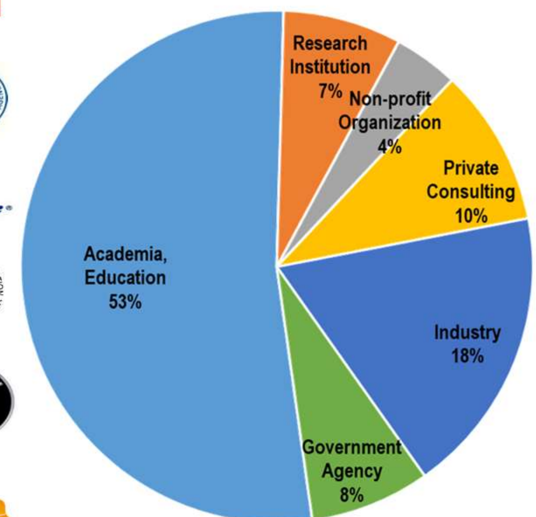


All inputs (materials, energy, and water) have their own life cycles and footprints!

With BTO support, Argonne is expanding its GREET LCA model for buildings and building technologies

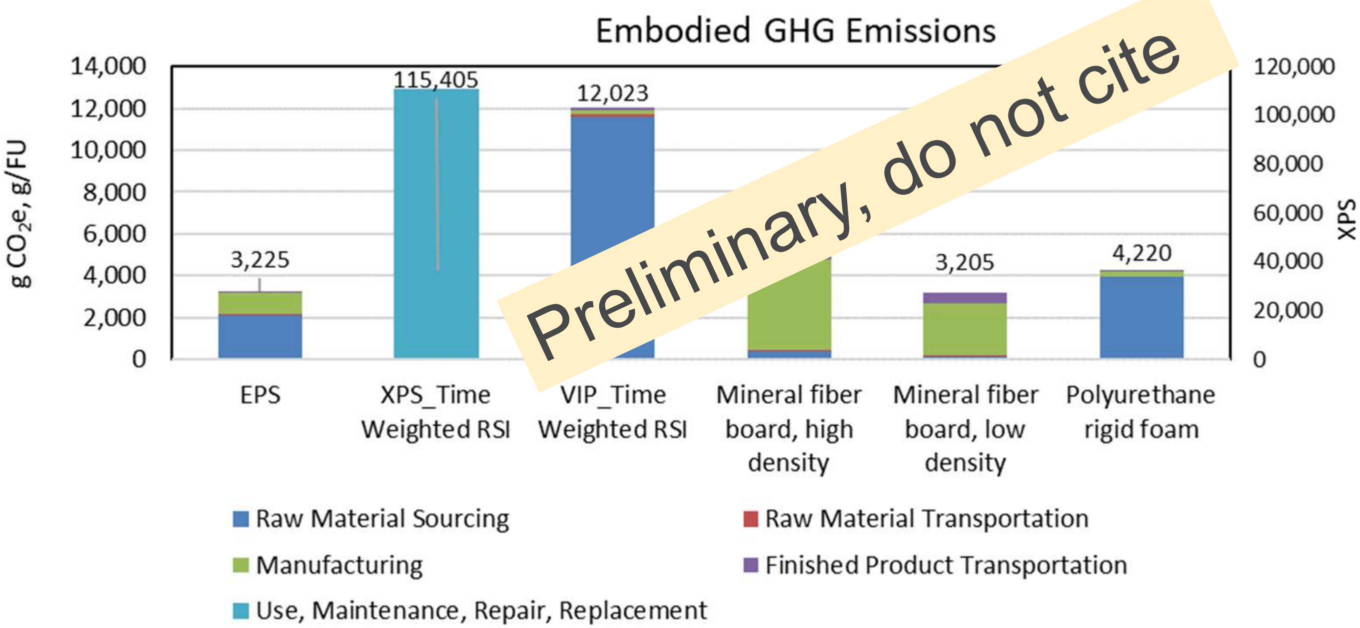






BUILDING LCA OFFERS INSIGHTS FOR PROMOTING SUSTAINABLE BUILDING TECHNOLOGIES AND DESIGNS

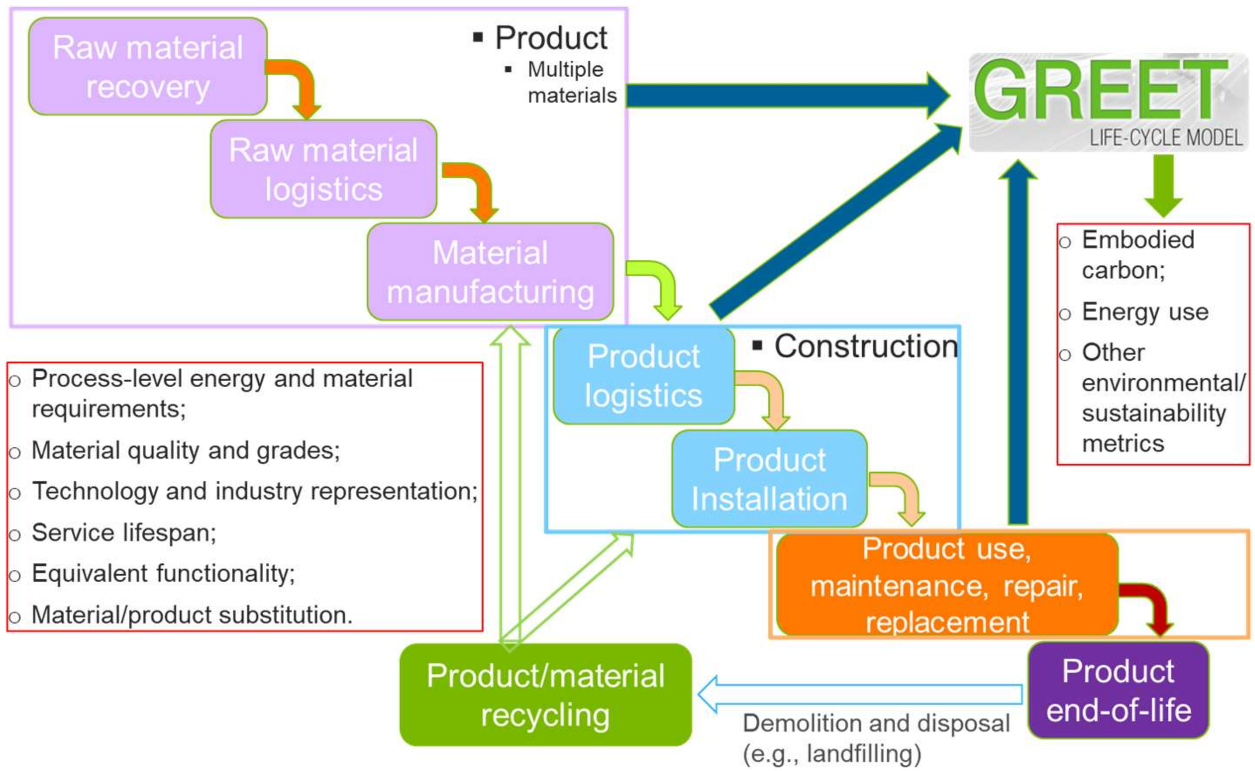
- LCA results can help answer numerous questions that arise during the design and construction of a green building. It can reinforce the decisions taken by architects, manufacturers, and engineering firms by providing a scientific justification (American Institute of Architects, 2020)



Example: holistic and comparable LCA results of insulation materials offer insight on material choices in architecture designs.

BUILDING LCA CHALLENGES: METHODOLOGIES

- ***Thorough, consistent LCA methodologies need to be agreed upon to***
  – Clearly defined and consistent system boundary
  – Defining and using a performance-equivalent functional unit is key to comparable LCA among building technologies



BUILDING LCA CHALLENGES: DATA

- ***Building LCA needs extensive, representative data***
  - Extensive and consistent background data
    - Energy supply systems:
      - ✓ Electricity, natural gas, etc.
      - ✓ Emissions of not only end use but also supply chain of energy systems (electricity generation, methane leakage of NG supply chain)
    - Material supply systems:
      - ✓ LCI data for raw materials to end-use materials
      - ✓ Commonality and uniqueness of materials specifications among different applications, e.g., automobile steel vs structural steel/rebar
  - Foreground data need to be developed for building components/technologies
    - Embodied energy/emissions as well as operational performance data are needed
    - Impacts of circular economy practices in the building sector as well as in other sectors need to be considered for dynamic evaluation

EPS Production

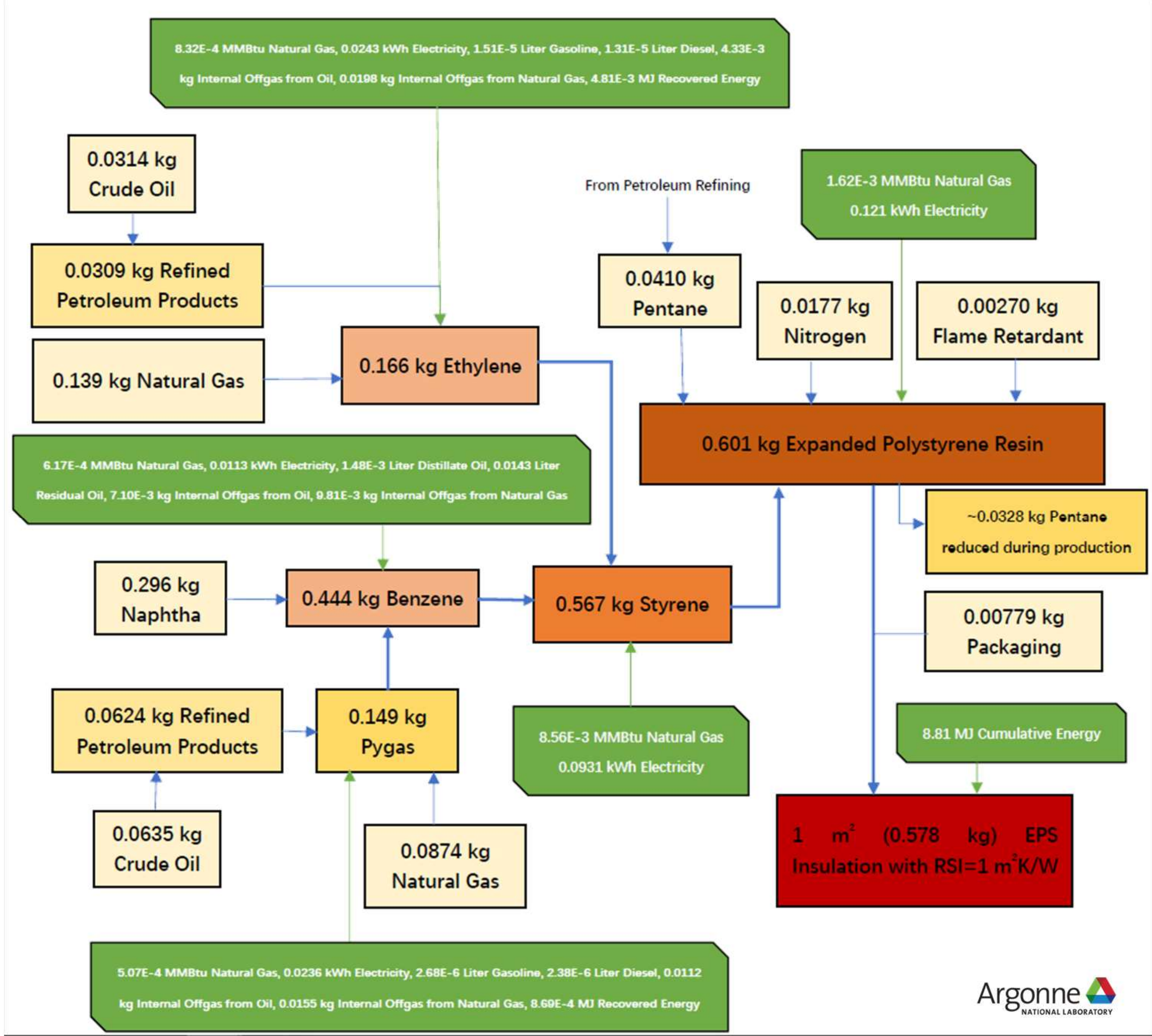
Process-level foreground data

Common background data for process materials and energy types

- **Functional Unit**

1 m² of EPS insulation with a thermal resistance RSI= 1 m²K/W and with a building service life of 60 years

Reference: Franklin Associates, 2017



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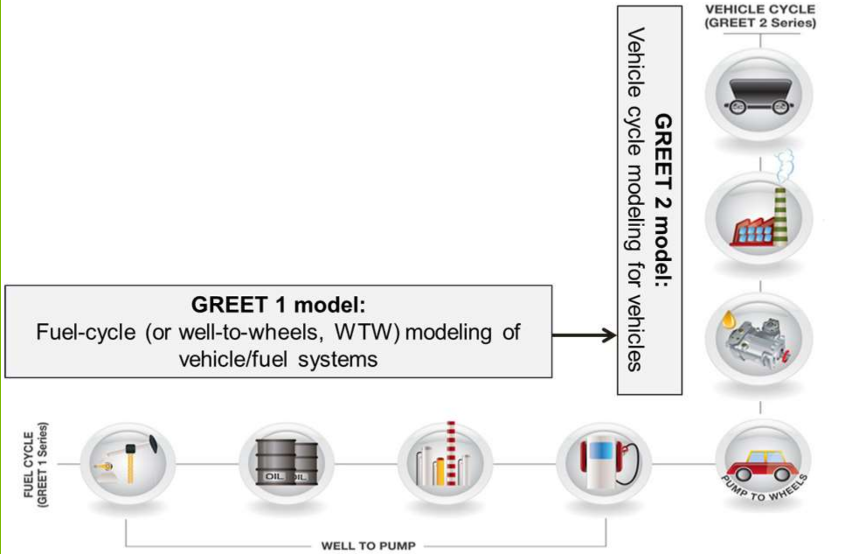
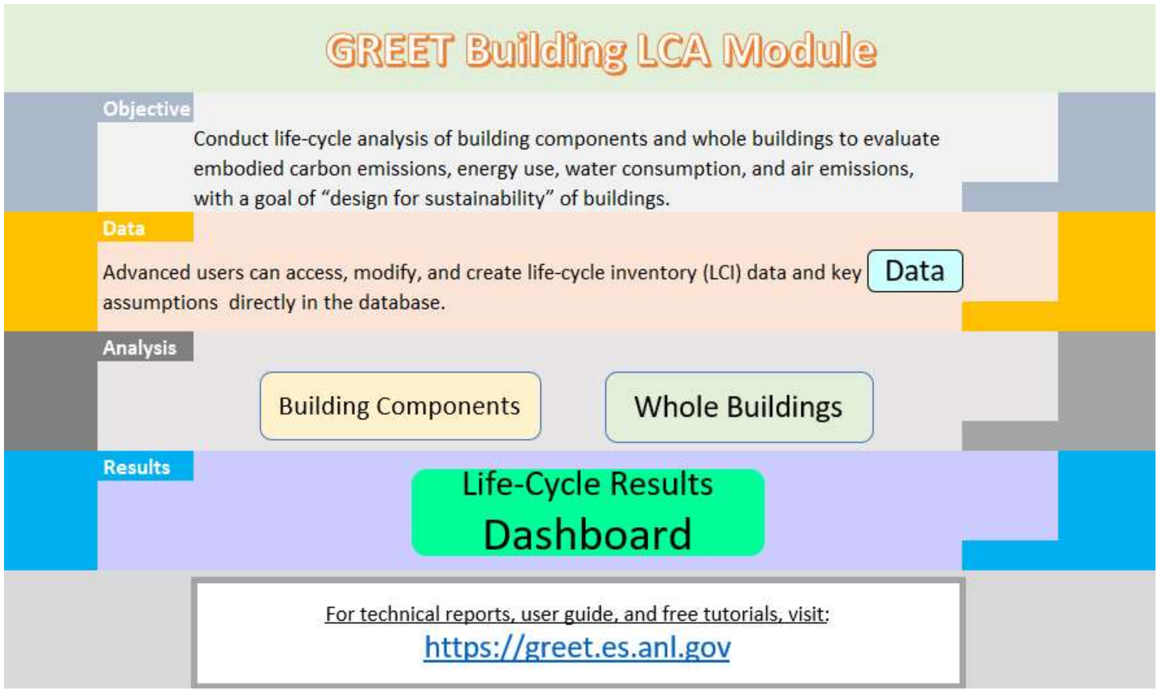
Building LCA challenges: LCA models for Transparent, detailed, and consistent modeling of building products and technologies

KEY MODEL FEATURES & ASPECTS	GREET
Modeling capability to address NEW building materials and technologies	✓
Transparent life-cycle inventory (LCI) data for user access and modification	✓
Consistent LCA methodology	✓
Consistent LCA system boundary	✓
Main data source	GREET background data and technology-specific foreground data from technology developers and modeling
Consistent background data	✓
Main users and applications	Building stakeholders needing LCA results for decision-making

ARGONNE GREET BUILDING LCA MODULE FOR DETAILED BUILDING LCA



- GREET: *Greenhouse gases, Regulated Emissions, and Energy use in Technologies*
- Argonne has been developing GREET since 1995 with DOE support
- It is publicly available at greet.es.anl.gov
- At present, there are >40,000 registered GREET users worldwide
- Users include governments, industries, R&D communities, universities, and NGOs



- Built in GREET2 platform to leverage existing data and analysis of materials
- Allow for detailed, transparent modeling of building components and whole buildings with consistent methodologies
- Beta Version is developed and ready for stakeholder inputs

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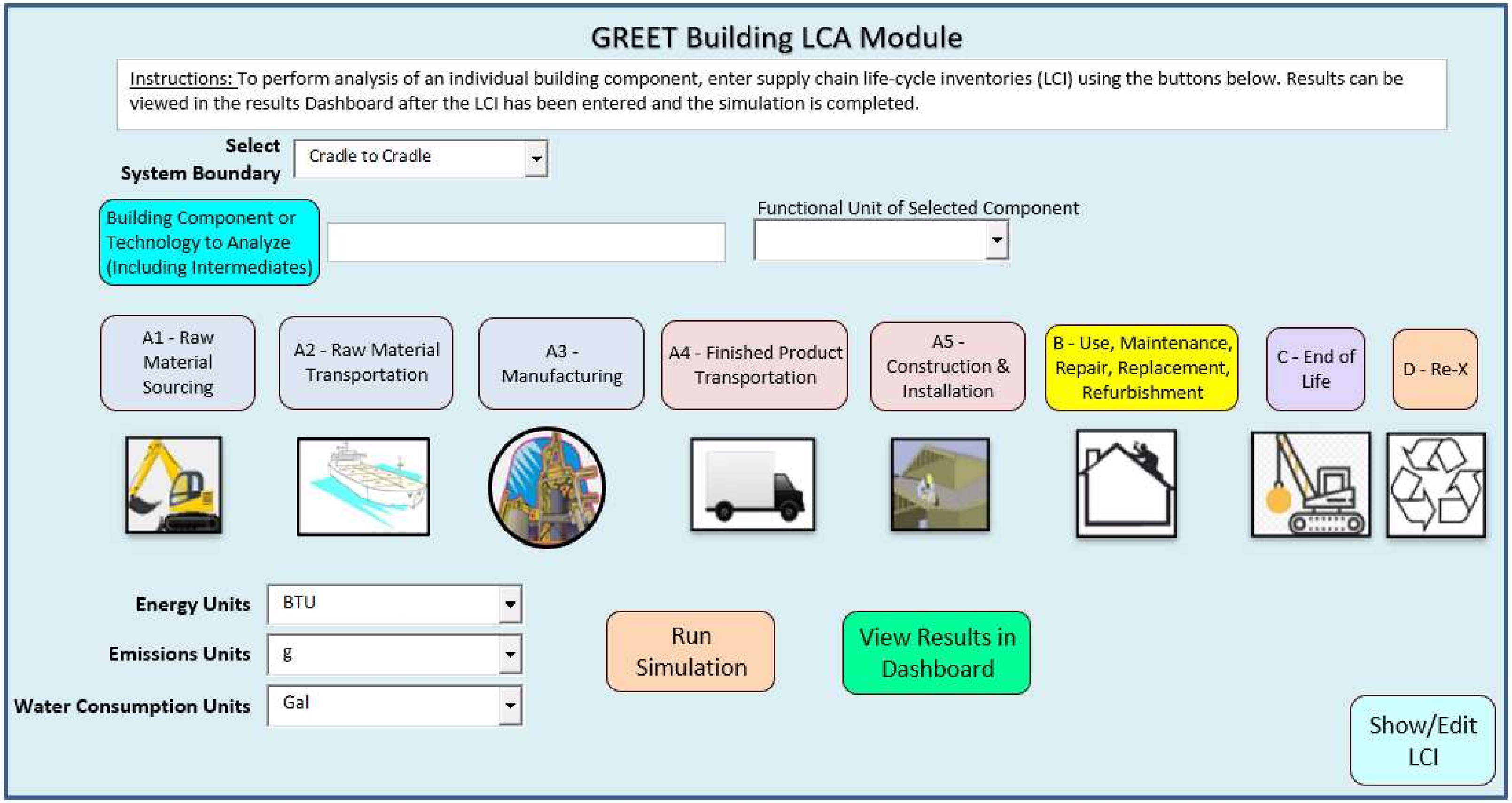
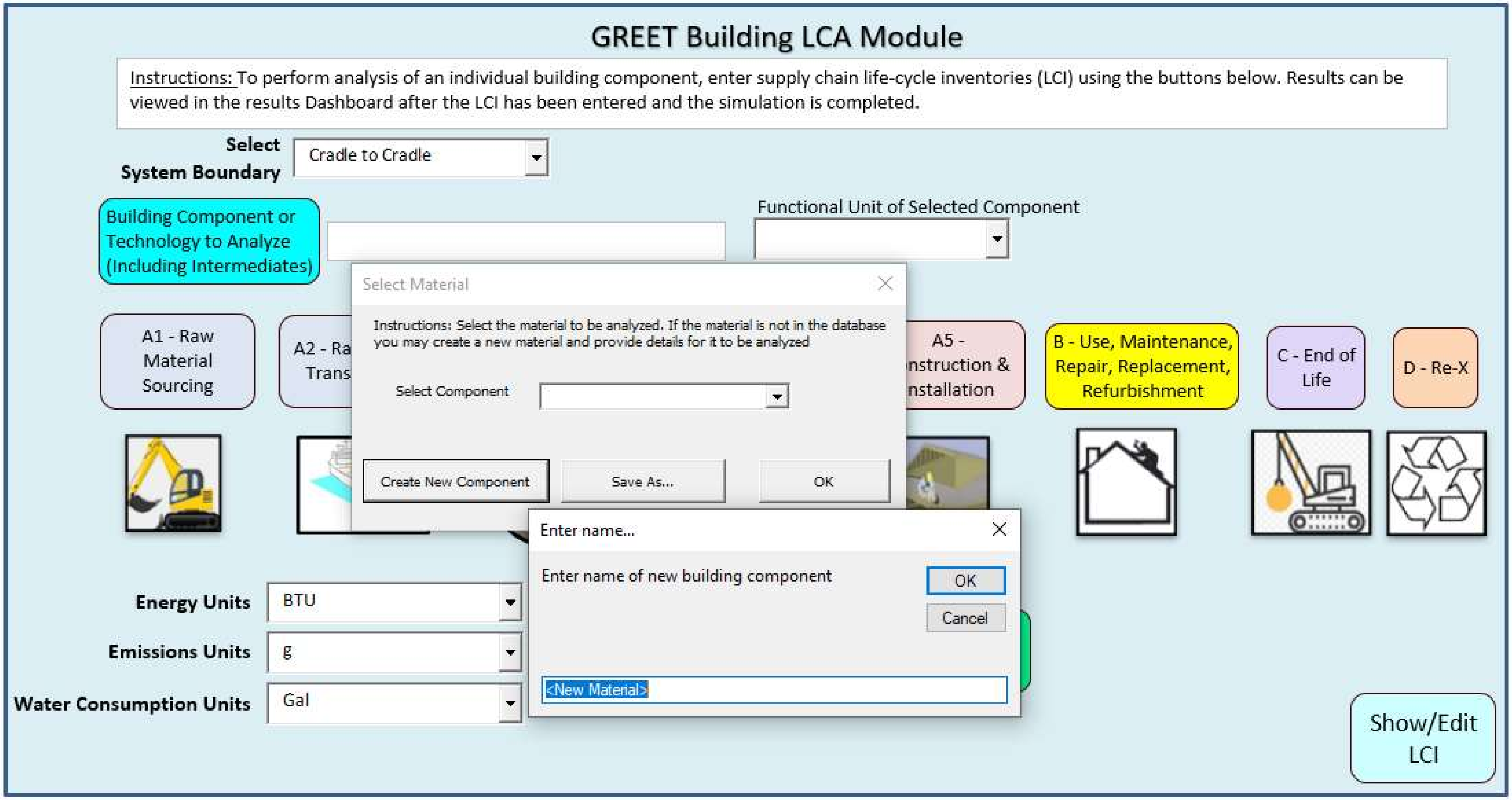
The GREET building LCA module: Overall User Graphical Interface (GUI)

- The building LCA module architecture was designed with interactive features



The GREET building LCA module: Addressing new building technologies



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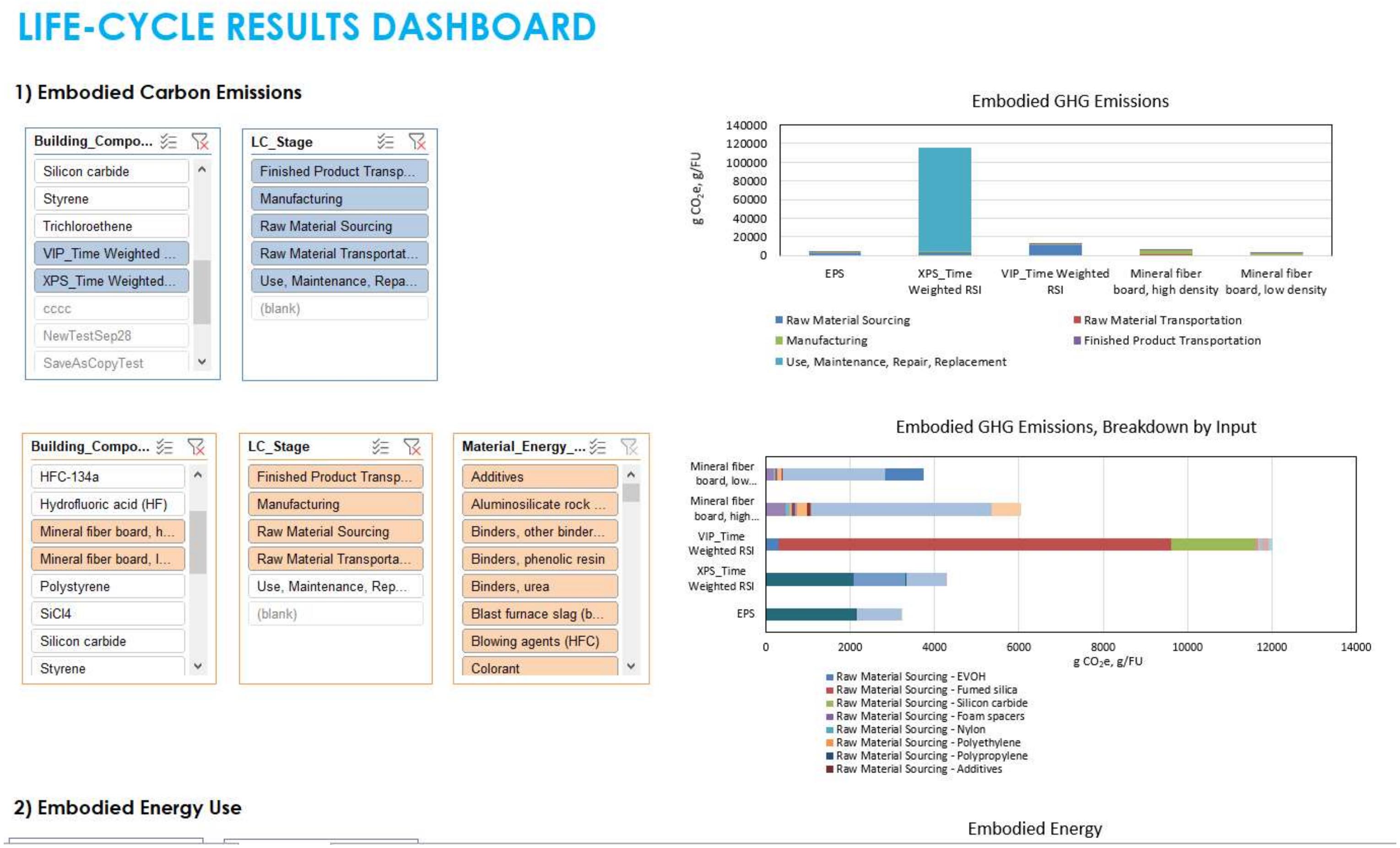
The GREET module provides an interactive Dashboard to quickly visualize, compare, and interpreting multiple metrics of LCA results of multiple modeled building materials/technologies



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National Institute of Standards and Technology
U.S. Department of Commerce

Metrics & Tools for Sustainable Buildings

Joshua Kneifel, PhD
Economist
Applied Economics Office
Engineering Laboratory

Metrics & Tools for Sustainable Buildings

NIST

Problem: **Difficult to Measure and Evaluate Building Sustainability**

Goal: **Assist stakeholders in making more sustainable building-related decisions using life cycle analysis**

Approach: **Develop (standards-based) information, metrics, data, and tools that are accessible in a form and function that can be incorporated into their decision-making process.**

Numerous Sustainability Criteria

NIST

Economics
Life Cycle Cost (LCC)

Environmental & Human Health Impacts
Life Cycle Impact Assessment (LCIA)

Energy, IAQ, and Comfort
Whole Building Simulation

Challenges Assessing Life Cycle Impacts

Hard to <u>Quantify</u> Environmental Impacts:

- **Consistent, transparent scope, methodologies, and data?**
- **Comparable?**
  - Building Product Selection (Interaction Effects?)
  - Whole Building Design (Comparable performance?)
  - Whole Building Life (Embodied and Operational?)

Hard to <u>Communicate</u> Environmental Impacts:

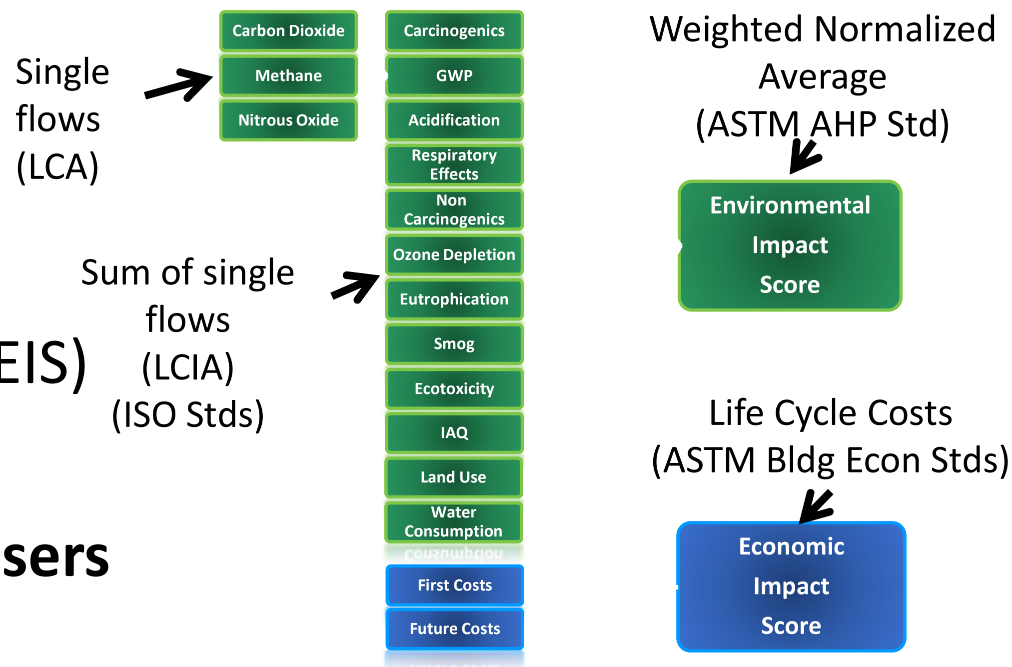
- **How to present results in a useful way?**
- **How do you use results in decision-making?**

<u>Changing</u> Demand and Technologies

- **How to design tools to provide useful, up-to-date information to decisionmakers?**
  - Relevant data, Flexibility to the user, Do not want to duplicate efforts

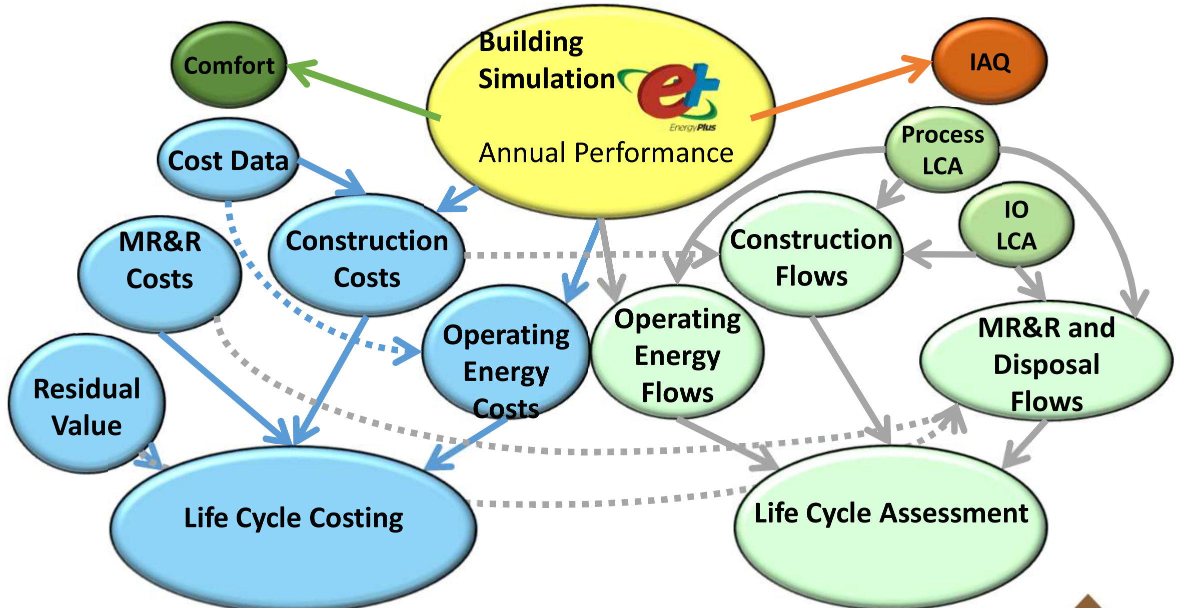
Building for Environmental and Economic Sustainability (BEES) Framework

- **Web Interface**
- **Individual Building Products**
- **Criteria**
  - LCIA Categories
  - Environmental Impact Score (EIS)
    - Weighted normalized average
  - Life Cycle Costs
- **Guidance and Default Values for Users**
  - Assumptions
  - Product selection
- **Visual Displays and CSV Access**



Building Industry Reporting & Design for Sustainability (BIRDS) Framework

- **Web Interface**
- **Whole Building Prototypes**
- **Building simulation results**
  - Standards/Codes
  - Incremental Design
- **Criteria**
  - LCIA categories & EIS
  - Life Cycle Costs
  - Operational Energy
  - Thermal Comfort
  - IAQ
- **Guidance and Defaults to assist Users**
  - Assumptions
  - Building Designs
- **Displays Key Results**
- **CSV Database available**



Trends in Sustainability Analysis

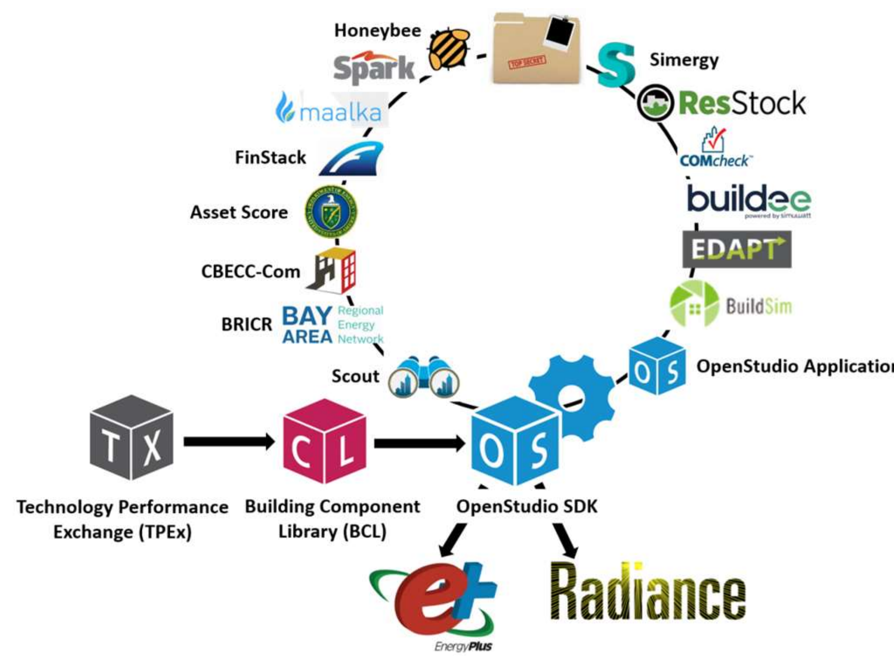
- Shifts in Technology to estimate building performance
  - Data and Computing power
    - Massive simulation and computational capabilities
  - Software development
    - Capabilities are ever expanding and increasingly open source
- Shift in Demand for “Green” Buildings
  - Product & Building Certification Programs
- Shift in Focus of Sustainability in Buildings
  - Product -> assembly -> “whole building” LCA
  - Credits in green certification programs

Needs in Sustainability Analysis

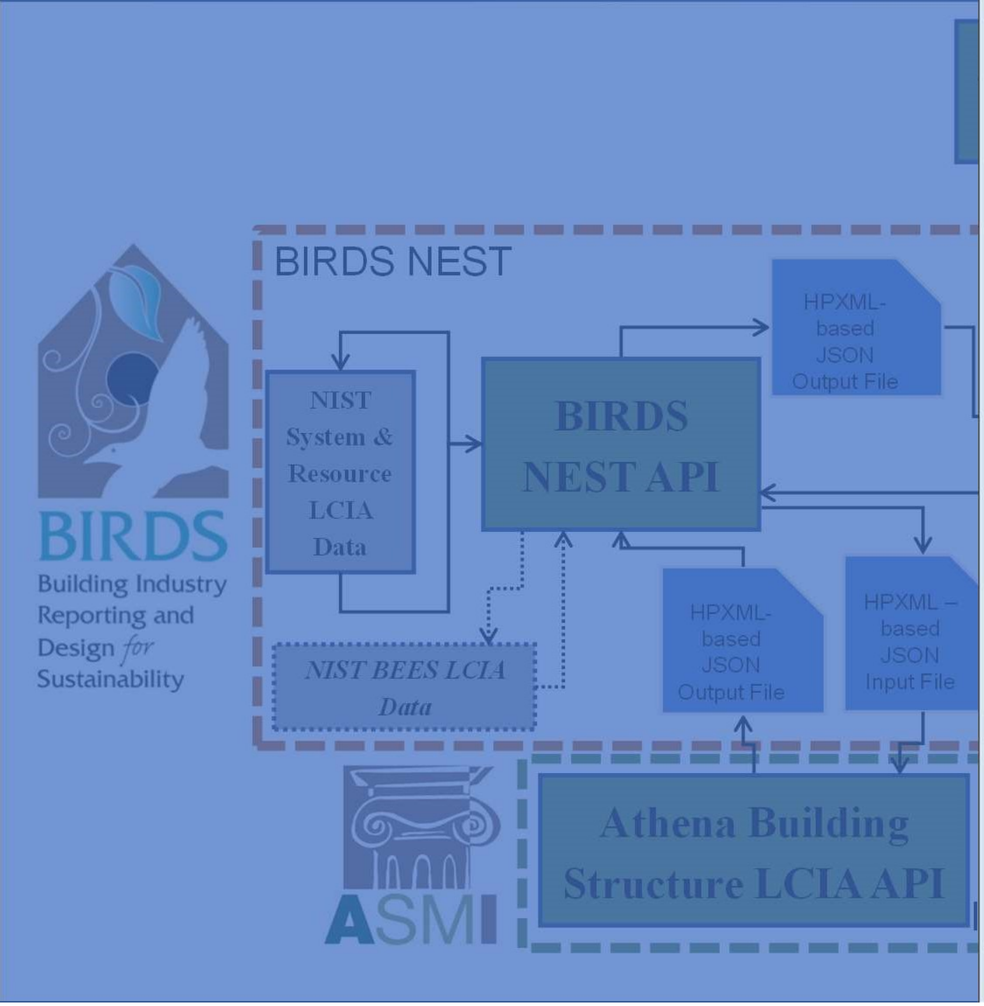
- Broader & Quantifiable Scope
  - How can you make quick, accurate evaluations to make informed decisions without a need for expertise in sustainability measurement science?
- Interoperable Software
  - Disaggregated and modularized tools
  - Ability to connect software tools and analyses
  - Leverage/Collaborate with other organizations to accelerate development
- Standards and Data
  - Standardization in data format
  - Reliable, transparent data is costly and difficult to create and maintain
  - Leverage existing data when feasible

BIRDS Neutral Environment Software Tool (NEST)

- Life Cycle Impact Assessment (LCIA) API
  - Custom, real-time LCIA calculations for single-family dwellings
  - Generic building products
- Audience
  - Builders and Architects
  - (Green) Code Compliance Software
    - NASEO Harmonizing HERS and Home Energy Score
- Interoperable with DOE's OpenStudio
  - 40,000+ users
  - Basis for building evaluation software
- BIRDS NEST API is Generic
  - Compatibility with other software tools



BIRDS NEST – IE4B – C



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File Preferences Components & Measures Help

Results Summary

Reports: NIST BIRDS NEST LCIA Results | Refresh | Set Path to DView in Preferences

Lifecycle Impact Analysis Results

Category	Subcategory	Global Warming (kg CO2 eq)	Acidification (kg SO2 eq)	Respiratory Effects (kg PM2.5 eq)
buildingComponentFlowsTotal	extraMaterialsFlows	0.108441487586	0.00053465388214	3.3014080599e-05
buildingComponentFlowsTotal	hvacSystemsFlows	7836.247790543017	13.895002792503217	-0.44075269230429
buildingComponentFlowsTotal	totalBuildingComponentFlows	0.0	0.0	0.0
buildingComponentFlowsTotal	totalStructureFlows	216.87157345235127	2.276310479480139	0.010612714744978
buildingComponentFlowsTotal	exteriorWallsFlows	22.363969232876563	0.259079800407959	0.000550805603883
buildingComponentFlowsTotal	interiorWallsFlows	0.0	0.0	0.0
buildingComponentFlowsTotal	fenestrationFlows	0.0	0.0	0.0
buildingComponentFlowsTotal	roofsatticsFlows	0.0	0.0	0.0
buildingComponentFlowsTotal	foundationsFlows	103.23078182821669	1.052130086967271	0.005585195051904
buildingComponentFlowsTotal	interiorFinishesFlows	0.0	0.0	0.0
buildingComponentFlowsTotal	columnsAndBeamsFlows	20.90939059873961	0.234119174898717	0.00071363593561
buildingComponentFlowsTotal	floorsFlows	70.3674317925184	0.730981417206192	0.003763078153581
buildingComponentFlowsTotal	extraMaterialsFlows	0.108441487586	0.00053465388214	3.3014080599e-05
buildingComponentFlowsTotal	totalSystemsFlows	0.0	0.0	0.0
buildingComponentFlowsTotal	hvacSystemsFlows	7836.247790543017	13.895002792503217	-0.44075269230429
buildingComponentFlowsTotal	dhwSystemsFlows	872.9164705038925	2.124067511277924	-1.377150092975781
buildingComponentFlowsTotal	solarPvSystemsFlows	27346888.62569215	134618.10397823752	33573.35440711035
buildingComponentFlowsTotal	solarThermalSystemsFlows	1411.2719014633997	6.448288859860001	-0.10595420315726
buildingComponentFlowsTotal	appliancesFlows	7403.516778500533	42.28039939021344	6.821274728669907
energyUseFlows	totalEnergy	355741724.6740436	908981.3223995004	61809.043697721325
energyUseFlows	electricity	355741724.6740436	908981.3223995004	61809.043697721325
energyUseFlows	naturalGas	0.0	0.0	0.0
energyUseFlows	propane	0.0	0.0	0.0
energyUseFlows	fuelOil	0.0	0.0	0.0

For further information…

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NIST EL Applied Economics Office

http://www.nist.gov/el/economics/

BEES Online

http://ws680.nist.gov/Bees/

BIRDS

http://ws680.nist.gov/Birds

IE4B

http://www.athenasmi.org/our-software-data/impact-estimator/

OpenStudio

https://www.openstudio.net/

Standardization and Data

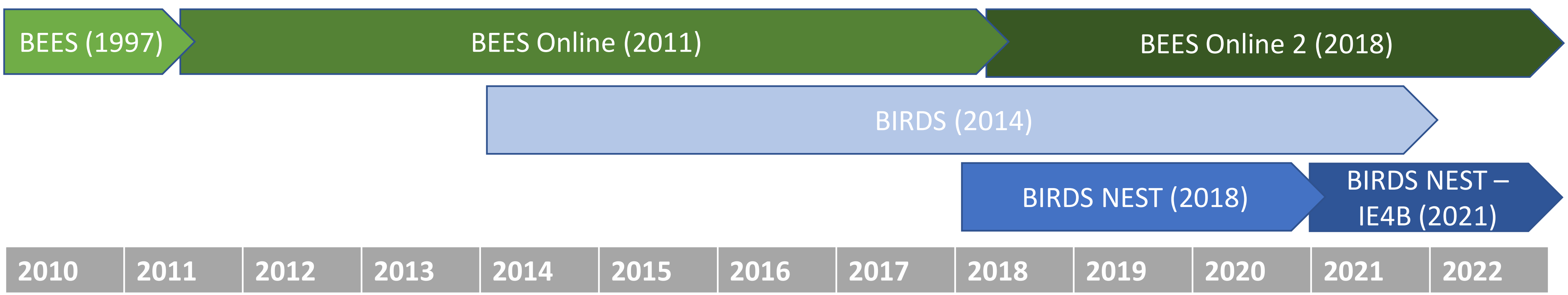
NIST

Highlighted Standardization and Data Efforts

- Detailed Documentation
  - Transparency on how the LCIA data was developed
  - BIRDS NEST code could be published on GitHub
  - Data will be published when feasible
- Standardized Component Dictionary and LCIA Results
  - LCIA Results using EN15978
  - Data Format using HPXML
- Operational Energy LCIA Data
  - Collaborating with NETL to develop publicly available on-site energy consumption LCIA data
  - Regionalized and published on a regular basis with most recent data
  - Electricity Baseline, Natural Gas Baseline, etc.
- Other Collaboration Efforts
  - Federal LCA Commons
    - Best Practices and consistent data across federal agencies
  - Building Transparency OpenLCI Project
    - North American LCI database

Easy to Use Software – LCA in Buildings

- **BEES (1997, 2011, 2018)**
  - Individual Products
- **BIRDS (2014)**
  - Whole Building Prototypes
- **BIRDS NEST (2018)**
  - User-Defined Buildings



Poll Question

A variety of tools and resources exist now to assist organizations making lifecycle impact decisions. What additional resources would be most helpful?

Enter answers in the question box!

Q&A Session

- **Use the Q&A feature to ask a question**
- **Panelists**
  - Hao Cai, Principal Environmental Analyst, Argonne National Labs
  - Jennifer O'Connor, President, Athena Institute
  - Joshua Kneifel, Research Economist, National Institute of Standards and Technology

Building Life Cycle Impacts DOE Webinar Series

Topic	Date	Time
Overview of life cycle impacts of buildings	Oct. 16	12:00pm – 1:00pm ET
Challenges of assessing life cycle impacts of buildings	Oct. 29	12:00pm – 1:00pm ET
Innovative building materials	Nov. 12	12:00pm – 1:00pm ET
"Real Life" buildings striving to minimize life cycle impacts	Dec. 3	12:00pm – 1:00pm ET
Intersection of life cycle impacts & circular economy potential for the building sector	Dec. 17	12:00pm – 1:00pm ET