Overview of life cycle impacts of buildings

Where do buildings come from and where do they go when they die?

Life-Cycle Energy & Related Impacts of Buildings Webinar Series

October 16, 2020
Agenda

I. Opening Remarks
   David Nemtzow - Director, U.S. DOE Building Technologies Office

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

III. Embodied Carbon Overview
   Ed Mazria - CEO, Architecture 2030

IV. Life Cycle Assessment
   Kate Simonen - Professor and Chair of Architecture, University of Washington

V. Building Life Cycle Impacts: Challenges and Opportunities
   Michael Deru - Engineering Manager, National Renewable Energy Laboratory

VI. Q&A Session
   Cedar Blazek - Management & Program Analyst, U.S. DOE Building Technologies Office
# Building Life Cycle Impacts DOE Webinar Series

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Poll Questions

• What industry are you from?
• How familiar are you with life cycle analysis?
David Nemtzow
Building Technologies Office Director
Efficiency is key to meeting U.S. energy goals

Our Homes and Buildings Use More Energy than Any Other Sector

- Residential & Commercial: 40%
- Industrial: 32%
- Transportation: 28%

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!

**Efficient**

- $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
- Commercial: 22%
- Building construction: 17%
- Residential: 61%

Global emissions from buildings
- Commercial: 28%
- Building construction: 28%
- Residential: 44%

International Energy Agency for the Global Alliance for Building and Construction (GlobalABC)
Let’s look at the whole picture:

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

- Resource extraction
- Manufacturing
- Transportation
- Construction/Installation
- Equipment Replacement/Maintenance
- Demolition/End of life
- Operations

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

Source data from GlobalABC Status Report in 2017
Where are the biggest opportunities? Where is BTO needed?

What types of buildings?
   Residential or commercial?
   New construction or retrofits?

What types of materials in the building?
   Envelope? Lighting? HVAC?

What parts of the life cycle?
   Transportation?
   Material extraction?
   End of life?
Poll Question

• What aspect of lifecycle carbon should BTO focus on? Include alternate answers in the question box!
Ed Mazria

Architecture 2030
Life Cycle Assessment

Kate Simonen, AIA SE
Director Carbon Leadership Forum
University of Washington
www.carbonleadershipforum.org
Life Cycle Thinking

Life Cycle Costing (LCC)
FINANCIAL Impacts

Life Cycle Assessment (LCA)
ENVIRONMENTAL Impacts

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Building Sector Decarbonization

Embodied Carbon
Manufacture, transport and installation of construction materials

Operational Carbon
Building Energy Consumption

Total Carbon = Embodied Carbon + Operational Carbon

$TC = EC + OC$

Image: S. Smedley Skanska

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Carbon Smart Building

• **New Buildings – Operations and Embodied Emissions.** All new buildings and developments are net zero carbon by 2030, with increase in carbon-storing material use.

• **Existing Buildings – Operations and Embodied Emissions.** Extend building lifespan to 100 + years and retrofit existing buildings to net zero carbon operations by 2050.

• **All new building (material production, construction, and use) is healthy, equitable and just.**
What about the ‘Carbon Loophole’?

Emissions from purchased goods emissions—when they are manufactured out of state?
Embodied Carbon Reduction Strategies

**Optimize Project**
- New vs Retrofit
- Smaller footprint
- Design for Disassembly

**Optimize System**
- Alternate materials
- Building shape
- Life cycle thinking

**Optimize Procurement**
- Transparency
- EC limits/incentives
- Low carbon specs

**Rules of Thumb/LCAs**

**Life Cycle Assessment**

**EPDs, EC3**
Buy Clean
CLF Embodied Carbon Benchmark Study
www.carbonleadershipforum.org
Embodied Carbon Estimates: Use Life Cycle Assessment

MATERIAL QUANTITY ESTIMATE \times EMBODIED CARBON PER UNIT MATERIAL = BUILDING EMBODIED CARBON (EC) ESTIMATE
Embodied Carbon Solution Strategies
Embodied Carbon Solution Strategies
Innovative Carbon Storing Materials

Environmental Impacts

Concrete Innovations
- Grow concrete with algae
- Store carbon in rocks
- Cure concrete with CO2

Bio Based Materials
- Long life wood products from sustainably managed forests
- Agricultural waste to building products
- Bio based insulations

Steel Innovations
- Hydrogen Steel Production
EPDs Enable Embodied Carbon Transparency

Environmental Product Declarations

EPD Results are like MPG
- Estimates based on standard assumptions (PCR)
- Known variability
- Directionally accurate
EC3: Embodied Carbon in Construction Calculator
www.buildingtransparency.org

CLF Conservative Baseline:
If you don’t know the supplier, don’t assume ‘average’

Target:
At least 20% of products in EC3 are below this
Embodied Carbon Reduction Strategies

**Optimize Project**
- Strategies
  - New vs Retrofit
  - Smaller footprint
  - Program efficiency

**Optimize System**
- Strategies
  - Alternate materials
  - Building shape
  - Life cycle thinking

**Optimize Procurement**
- Strategies
  - Transparency
  - EC limits/incentives
  - Low carbon specs

Rules of Thumb

Life Cycle Assessment

EPDs, EC3
Buy Clean
Carbon Leadership Forum Network

12 Regional Hubs, 12 more under development!

www.carbonleadershipforum.org
Building Life Cycle Impacts: Challenges and Opportunities

Michael Deru
October 16, 2020
Challenge and Opportunity #1

Challenge: Massive new construction and retrofits of existing buildings are needed to meet the demands of growing and shifting populations and energy and climate goals.

Opportunity: Transform the construction of our buildings to be more sustainable, economical, and equitable.
Challenge and Opportunity #2

**Challenge:** Growing environmental and economic impact of energy consumption, resource constraints, and aging infrastructure

**Opportunity:** Transform our energy generation, distribution, and consumption systems to be low carbon, efficient, resilient, and reliable
Solutions
Advanced Building Construction Initiative
https://www.energy.gov/eere/buildings/advanced-building-construction-initiative

Transform the construction industry:
- Improve energy performance
- Increase labor productivity
- Improve circularity
- Address social and economic inequities
Circular Economy for Buildings and Building Materials

Minimize embodied carbon
Minimize waste
Reduce material consumption
Reduce toxic materials
Improved end-of-life actions

Why CE thinking is important
Global construction expected to double building stock by 2060 = NYC every month for 40 years

Why the world is running out of sand

**2015 U.S. C&D Waste**

- 169 million tons (9% growth from 2012)

- Buildings
- Roads & Bridges
- Other

- Concrete
- Wood Products
- Drywall and Plasters
- Steel
- Brick and Clay Tile
- Asphalt Shingles
- Asphalt
Operational Carbon Decision Making

Framework and data to help facility operators make smart low-carbon decisions

Operational consumption emissions (energy, water)

- New furniture
- Equipment replacement
- Refrigerant recovery and destruction
- Major renovation
- End of Life emissions

Event-based emissions

- End of Life emission credits

Annual Carbon Emissions

Time Years
Transformation of our energy systems

- Decarbonization
- Efficient
- Resilient
- Secure
Grid-Interactive Efficient Buildings – GEB
(https://www.energy.gov/eere/buildings/grid-interactive-efficient-buildings)

Grid and buildings operating as one large system

Distributed energy resources
- Generation
- Storage
- Flexible loads
Los Angeles 100% Renewable Energy Study

LADWP
$6 billion annual budget
9,400 employees
4 million residents

Advisory Group
Diverse energy backgrounds
Quarterly meetings
Policy oriented

Integrated Electricity Modeling
Full range power system modeling
Integrated transmission and distribution analysis

Environmental Analysis
Air quality
Environmental Impact

Economic Analysis
Job creation
Job migration
Economic development
Thank You

www.nrel.gov

michael.derus@nrel.gov
Q&A Session

• Use the Q&A feature to ask a question
• Panelists
  – Ed Mazria - CEO, Architecture 2030
  – Kate Simonen - Professor and Chair of Architecture, University of Washington
  – Michael Deru - Engineering Manager, National Renewable Energy Laboratory
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