CAPITALIZING ON HERITAGE STRUCTURES for a ZERO CARBON FUTURE

Lori Ferriss, AIA, PE and Nakita Reed, AIA,
October 28, 2021 | Getting to Zero Forum
Agenda

- Why existing and historic buildings are critical to an equitable net zero future
- How to reuse existing buildings to maximize climate benefits
- Resources for decarbonizing existing buildings
Paris Agreement 2015 – commit to cap global temperature rise to 1.5° to 2°C to avert catastrophic and irreversible impacts of climate change
Carbon Emission’s Effect on Future Global Warming

IPCC Global Temperature Projection Scenarios

Source: IPCC 2013, Representative Concentration Pathways (RCP); Stockholm Environment Institute (SEI), 2013; Climate Analytics and ECOFYS, 2014.

Note: Emissions peaks are for fossil fuel CO2-only emissions.
The Time Value of Carbon

- **65% Reduction** by 2030, Net Zero by 2040
- 67% chance of meeting 1.5°C

- **50% Reduction** by 2030, Net Zero by 2050
- 50% chance of meeting 1.5°C

**Linear Reduction, Net Zero by 2050**

>2°C

Global Emissions per year (GtCO₂)

- 340 Total GtCO₂
- 500
- 600

DATA SOURCE: ARCHITECTURE 2030

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Raw Material Use

Source: U.S. Geological Survey Fact Sheet 2017–3062
Loss of Cultural Heritage

The First Official Climate Refugees in the U.S. Race Against Time

A Native American tribe struggles to hold on to their culture in a Louisiana bayou while their land slips into the Gulf of Mexico.

source: Isle de Jean Charles Resettlement Program
Why Existing Buildings?
Why existing buildings?

- Most of what is here now will still be here in 2050
- Only about 2% of existing building stock gets renovated annually (blankets vs. mountains)
- ‘Historic’ building constructed prior to 1971
Global Carbon Emissions from Buildings

Global CO₂ Emissions by Sector

MOSTLY FROM EXISTING BUILDINGS
BUILDING OPERATIONS 28%
BUILDING MATERIALS & CONSTRUCTION 11%
MOSTLY FROM NEW CONSTRUCTION
INDUSTRY 30%
TRANSPORTATION 22%
OTHER 9%

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DATA SOURCE: ARCHITECTURE 2030
Building Sector Data

- **Residential**: 237 BSF
- **Commercial**: 65 BSF
- **Institutional**: 22 BSF

324 Billion Sq Ft

**RECS**
**CBECS**

US Energy Information Administration
2015 Residential Energy Consumption Survey
2012 Commercial Building Energy Consumption Survey
Building Sector Data

Category

- Residential
- Commercial
- Institutional

Segment

- Single family
- 2-4 Unit Building\(^{(1)}\)
- Mobile Home
- 5+ Unit Building\(^{(1)}\)
- Food Sales
- Food Service
- Lodging
- Education
- Health Care
- Mercantile
- Office
- Public Assembly
- Public Order & Safety
- Worship
- Service (other than retail & food)
- Warehouse/Storage
- Other

US Energy Information Administration
Building Sector Data

Single Family

Multi-family

Commercial

Institutional

201 BSF

36 BSF

65 BSF

22 BSF

123 Billion Sq Ft

US Energy Information Administration
2015 Residential Energy Consumption Survey
2012 Commercial Building Energy Consumption Survey
Modern-era buildings

66% 57.6 Billion Sq Ft

US Energy Information Administration
2015 Residential Energy Consumption Survey
2012 Commercial Building Energy Consumption Survey
Retrofits are Improving Energy Performance

• Post WWII through 80’s has highest energy use
• But the EUI of this era of buildings has improved

Leveraging the Existing Built Environment

Between now and 2060, the world is projected to add 2.5 trillion ft$^2$ of buildings, or an area equal to the entire current global building stock.

— UN ENVIRONMENT, GLOBAL STATUS REPORT 2017

Reusing and retrofiting an existing building can result in a 70%–85% reduction in embodied carbon emissions compared to new construction.

— ZERO NET CARBON COLLABORATION FOR EXISTING AND HISTORIC BUILDINGS, 2019
Equity in Preservation

City of Boston Social Vulnerability Mapping

City of Boston Historic Districts and Landmarks
Equity in Preservation

In NYC, historic districts contain:

- 8% of all private jobs
- 10.4% of all professional, scientific, and technical service jobs
- 13.3% of all information jobs
- 20.3% of all arts, entertainment, and recreation jobs

-Place Economics, Twenty-Four Reasons Historic Preservation is Good for Your Community
Equity in Preservation

-Millennials as Buyers of Houses 1912-1960
-Millennials as Buyers of Houses Pre-1960
-Millennials as Share of All Home Buyers

-Place Economics, Twenty-Four Reasons Historic Preservation is Good for Your Community
Equity in Preservation

Reuse/refurbishment produces **300 jobs** per 10,000 tons of waste compared to 1-6 jobs in the traditional landfilling/incineration process.

Source: “Treasure in the Walls: Reclaiming Value through material Reuse in San Antonio,” Place Economics, 2021

Image credit: Watertown Daily Times
Equity in Preservation

Total labor income (direct, indirect, and induced) from deconstruction is **nearly four times** that of demolition.

Source: “Treasure in the Walls: Reclaiming Value through material Reuse in San Antonio,” Place Economics, 2021

Image credit: Delta Institute
Equity in Preservation

Low-income communities are disproportionately impacted by hazardous environmental conditions created by demolition and landfill.

Source: “Treasure in the Walls: Reclaiming Value through material Reuse in San Antonio,” Place Economics, 2021

Image credit: The Keystone
Preservation & Gentrification

How: Existing Buildings?
Climate Action - The Tasks Ahead

1. **Mitigate** environmental impacts
2. **Adapt** to environmental changes
3. Do 1. and 2. in a way that is **equitable and just**
Building Reuse *is* Climate Action

1. Mitigate environmental impacts
   - Avoid embodied carbon emissions by reusing existing components
   - Reduce operational emissions through improved efficiency
   - Air sealing
   - Waterproofing
Building Reuse is Climate Action

1. Mitigate environmental impacts
   ➢ Avoid embodied carbon emissions by reusing existing components
   ➢ Reduce operational emissions through improved efficiency

2. Adapt to environmental changes
   ➢ Adapt to changing climatic conditions
   ➢ Leverage traditional resilience strategies
   ➢ Flood proofing
Building Reuse is Climate Action

1. Mitigate environmental impacts
   - Avoid embodied carbon emissions by reusing existing components
   - Reduce operational emissions through improved efficiency

2. Adapt to environmental changes
   - Adapt to changing climatic conditions
   - Leverage traditional resilience strategies

3. Do 1. and 2. in a way that is equitable and just
   - Improve access for all community members
   - Preserve cultural heritage while addressing past inequities
   - Maintain traditional building knowledge
   - Support local labor
Funding Options: Historic Tax Credits

Source: https://www.novoco.com/resource-centers/historic-tax-credits/state-htcs/state-htc-program-descriptions#md
Historic Tax Credits

Source: http://kronbergwall.com/portfolio-item/historic-tax-credits-portfolio/
Funding Options: Grants

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Won’t be able to finance a project on rebates but on multifamily projects rebates add up.

**Case Study Baltimore:**
Refrigerators $100 - $150 rebate  
Smart Thermostats: $100 rebate

$125 x 49 units = $6,125 (Refrigerators)  
$100 x 49 units = $4,900 (thermostats)  
$11,025 rebates
Lessons from the Past

- Local materials
- Natural/biogenic materials
- Skilled labor
- Passive building features
- Culture of repair versus replacement
- Salvage and Reuse
Carbon Reduction Strategies

Bringing embodied carbon upfront
Coordinated action for the building and construction sector to tackle embodied carbon

Carbon reduction potential

100%

Planning
Design
Construction
Operation and maintenance

Build nothing
Explore alternatives

Build less
Maximise use of existing assets

Build clever
Optimise material usage and design with low carbon materials

Build efficiently
Use low carbon construction technologies and eliminate waste
CHANGE OVER TIME

Stewart Brand

How Buildings Learn

<table>
<thead>
<tr>
<th>Component</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>stuff</td>
<td>5-15 yrs</td>
</tr>
<tr>
<td>space plan</td>
<td>5-20 yrs</td>
</tr>
<tr>
<td>services</td>
<td>5-30 yrs</td>
</tr>
<tr>
<td>skin</td>
<td>30-60 yrs</td>
</tr>
<tr>
<td>structure</td>
<td>60-200 yrs</td>
</tr>
<tr>
<td>site</td>
<td>&gt; bldg</td>
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</tbody>
</table>
Operational carbon can accumulate quickly
Renewable power

The Carbon Intensity of Electricity Generation

All figures in g CO2eq/kWh

Note: Data is the 50th percentile for each technology from a meta study of more than 50 papers.
Source: IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation

shrinkthatfootprint.com
Under-Occupied Buildings
El Centro de la Raza

- Seattle, WA
- Originally built as Beacon Hill School in 1904
- Abandoned by the Seattle School District by 1970s
El Centro de la Raza

- In 1972, peaceful, multiracial occupation for 3 months, led to permanent home for El Centro de la Raza
- Historic school listed on National Register of Historic Places
Resources for decarbonization of Existing Buildings
Mid-Century (Un) Modern

“Designed in an era when energy resources were cheap and plentiful, these first generation glass buildings were optimized to the standards and ideals of their day. Times have changed, however, and we are now acutely aware of the demands buildings place on energy and water infrastructure, as well as their impacts on global climate change.”
"Building Re-use almost always yields fewer environmental impacts than new construction when comparing buildings of similar size and functionality."
Zero Net Carbon Collaboration for Existing and Historic Buildings

The ZNCC is a strategic alliance committed to:

- Coordinating/monitoring technology development and integration for, and providing a unified resource for, the goal of responsibly bringing historic places to ZNC, and;

- Development of resources and best practices for accelerating the Zero Net Carbon (ZNC) rehabilitation of existing and historic buildings and places, accounting for both embodied carbon and operational carbon emissions.
# Carbon Assessment Toolbox

<table>
<thead>
<tr>
<th>Tool</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLF Carbon Leadership Forum</td>
<td>Database of &gt;1,000 buildings. Get a sense of what seems reasonable</td>
</tr>
<tr>
<td>buildcarbonneutral beta</td>
<td>Rough estimate for your building. Takes &lt;10 minutes</td>
</tr>
<tr>
<td>EC3</td>
<td>Material comparisons / EPD database</td>
</tr>
<tr>
<td>tally</td>
<td>Use the revit model to get a whole building embodied carbon number</td>
</tr>
</tbody>
</table>
A simple, high level tool for estimating total carbon emissions of existing building reuse compared to new construction.

- Excel dashboard with drop down menus
- A menu of renovation and upgrade options
- Four new building options
- Options for operational efficiency
- Embodied carbon modifiers
Carbon Accounting of Building Reuse: Case Study
High-Performance Design Approach

- **Scope of renovation included:**
  - Highly insulated walls and roof
  - High performance glazing
  - Reduced lighting power densities
  - Continuous daylight dimming controls
  - Variable-refrigerant-flow (VRF) units
  - Enthalpy wheels
  - Demand control ventilation (DCV)
  - High-efficiency condensing boilers

- Preserved 86% of structure and enclosure
Predicted Energy Reductions

**Figure 1: Annual Energy Consumption Comparison**

**Figure 2: Annual Energy Cost Comparison**
Operational Energy Reductions

Predicted Energy Use Intensity (kBtu/sf/yr)

- ASHRAE 90.1 Baseline: 87
- CBECs Baseline: 120
- Operational Energy Reduction: 58% to 36

- Baseline Comparison: 70% reduction
Calculating Embodied Impacts of the Renovation

Embodied Carbon Breakdown: Renovation vs. Average New Construction

- **Renovation**: 269,706 kgCO₂eq
- **Hypothetical Replacement**: ~900,000 kgCO₂eq

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**Divisions**
- 03 - Concrete
- 04 - Masonry
- 05 - Metals
- 06 - Wood/Plastics/Composites
- 07 - Thermal and Moisture Protection
- 08 - Openings and Glazing
- 09 - Finishes

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- 03 - Concrete: 14%
- 04 - Masonry: 3%
- 05 - Metals: 23%
- 06 - Wood/Plastics/Composites: 2%
- 07 - Thermal and Moisture Protection: 9%
- 08 - Openings and Glazing: 2%
- 09 - Finishes: 40%

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- Hypothetical Replacement: 59%

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Total Carbon Over Time

Carbon Payback Timeline

- **GWP (kgCO2eq)**
- **Years**
- **Millions**

Unrenovated Building
Total Carbon Over Time

Carbon Payback Timeline

- **Unrenovated Building**
- **Renovated Building**

**Carbon Payback of Renovation ~4 years**

GWP (kgCO2eq) vs. Years

- ** Millions**

- **2014**
- **2019**
- **2024**
- **2029**
- **2034**
- **2039**
Total Carbon Over Time

Carbon Payback Timeline

- Carbon Payback of Renovation ~ 9 years

*Assumes new building operates with additional 10% reduction in energy use.
Total Carbon with a Greening Grid

Carbon Payback Timeline

AVOIDED CARBON by 2030:
- REPLACEMENT 19%
- RENOVATION 45%

AVOIDED CARBON by 2050:
- REPLACEMENT 45%
- RENOVATION 57%
Take Aways

- Can’t build our way to Net Zero
- Too many existing and historic buildings to ignore
- Retrofit and weatherization
- Existing and Heritage buildings are part of the equity conversation
- This is not new & we need to learn from the Past