Counting Carb(on)s
Embodied vs. Operational Carbon

Dr. Kayla Natividad
Pilkington | NSG

glass.org/nga-glass-conference-chicago

Register TODAY!

glass.org/nga-glass-conference-chicago

Facility Tours | Taste of Chicago
Welcome Happy Hour | Get Stuff Done!
Answer “I Go to GlassBuild to...?!”
email to mdettmer@glass.org

Trade Show Registration FREE to NGA Members

Counting Carb(on)s
Embodied vs Operational

Dr. Kayla Natividad
Pilkington | NSG
What makes a building sustainable?

Sustainability

"Meeting the needs of the present without compromising the ability of future generations to meet their own needs."
- United Nations Brundtland Commission, 1987

Protecting the environment from human impacts to sustain livable conditions for future generations.

Resiliency

"The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions."
- United Nations Office for Disaster Risk Reduction

Protecting humans from environmental impacts to sustain livable conditions for future generations.

What makes a building sustainable?

More than half of U.S. commercial buildings were built before 2000 and do not meet today’s more efficient codes or have the most energy-saving products or technologies.
Where’s the Impact?

- Buildings account for almost 40% of global CO2 emissions
- 80% of buildings that will exist in 2050 already exist today.
- Existing buildings account for >65% of NYC emissions

Carbon Counting: Embodied vs Operational

Embodied Carbon 28%

Building Operations 72%

Annual Global Building Sector CO2 Emissions
Carbon Counting: Embodied Carbon

Long Term Solutions
• Hydrogen / Alternative Fuel
• Recycling / Increased Cullet
• Renewable Energy
• Carbon Reduction Targets

Façade Design Breakdown – Immediate Impacts

• Embodied Carbon
  • Structural Elements = body
  • Facade = shell of building
  • Reduce New Materials

• Operational Carbon
  • Improve operational performance by reducing energy use
Glass Performance

U-Factor & SHGC
- Improve occupant comfort
- Reduce HVAC load requirements
- Improve building resiliency

Visible light transmission:
- Improve quality views
- Reduce need for artificial lighting
- Improve occupant health and productivity

No “one size fits all”

Cold Climates – Better insulation
+ Less Solar Heat Gain (?)

Hot Climates – Less Solar Heat Gain
+ Better Insulation (!)
Design Approach

Reuse existing buildings/material

Reduce amount of new material

Rethink what glazing can do

Carbon Reduction – Reuse

Vacuum Insulating Glazing

- Reuse existing monolithic sash
  - Low embodied carbon impact
  - Maintain operability
- Improve glass performance
  - Monolithic ¼” Glass
  - IGU Performance
### Small Office Building Energy Impact

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>REPRESENTATIVE CITY</th>
<th>SO Heat</th>
<th>SO Cool</th>
<th>SHGC</th>
<th>U-factor</th>
<th>SO Heat</th>
<th>SO Cool</th>
<th>SHGC</th>
<th>U-factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>Miami, Florida</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
<td>3%</td>
<td>8%</td>
<td>11%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>2A</td>
<td>Houston, Texas</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
<td>3%</td>
<td>7%</td>
<td>11%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>2B</td>
<td>Phoenix, Arizona</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
<td>3%</td>
<td>7%</td>
<td>11%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>3A</td>
<td>Atlanta, Georgia</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
<td>3%</td>
<td>7%</td>
<td>11%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>3B</td>
<td>Los Angeles, California</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
<td>3%</td>
<td>7%</td>
<td>11%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>3C</td>
<td>Las Vegas, Nevada</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
<td>3%</td>
<td>7%</td>
<td>11%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>3D</td>
<td>San Francisco, California</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
<td>3%</td>
<td>7%</td>
<td>11%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>4A</td>
<td>Baltimore, Maryland</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
<td>3%</td>
<td>7%</td>
<td>11%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>4B</td>
<td>Albuquerque, New Mexico</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
<td>3%</td>
<td>7%</td>
<td>11%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>4C</td>
<td>Seattle, Washington</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
<td>3%</td>
<td>7%</td>
<td>11%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>4D</td>
<td>Chicago, Illinois</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
<td>3%</td>
<td>7%</td>
<td>11%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>4E</td>
<td>Boulder, Colorado</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
<td>3%</td>
<td>7%</td>
<td>11%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>4F</td>
<td>Minneapolis, Minnesota</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
<td>3%</td>
<td>7%</td>
<td>11%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>5A</td>
<td>Helena, Montana</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
<td>3%</td>
<td>7%</td>
<td>11%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>T</td>
<td>Duluth, Minnesota</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
<td>3%</td>
<td>7%</td>
<td>11%</td>
<td>5%</td>
<td>3%</td>
</tr>
</tbody>
</table>

Higher SHGC allows for more passive heat, reducing heating load. Low U-factor better insulates so reduces cooling load.

### Carbon Reduction – Reuse

**Secondary Window System**
- Addition to existing glazing
  - Reduce operational carbon by improving U-factor and SHGC
- Interior and Exterior Solutions
- Drawback
  - Lose operability
Using lightweight / thin high-performance materials as storm significantly improves performance.

Small Office Building Energy Impact

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>REPRESENTATIVE CITY</th>
<th>6mm Clear</th>
<th>6mm Interior Storm (Clean)</th>
<th>6mm Interior Storm (Partitive Low-e surface)</th>
<th>6mm Interior Storm (Partitive IGU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>Miami, Florida</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>7%</td>
</tr>
<tr>
<td>2A</td>
<td>Houston, Texas</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>2B</td>
<td>Phoenix, Arizona</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>3A</td>
<td>Atlanta, Georgia</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>3B</td>
<td>Los Angeles, California</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>3C</td>
<td>Las Vegas, Nevada</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>4A</td>
<td>San Francisco, California</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>4B</td>
<td>Boston, Massachusetts</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>4C</td>
<td>Washington, D.C.</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>4D</td>
<td>Dallas, Texas</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>5A</td>
<td>Chicago, Illinois</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>5B</td>
<td>Denver, Colorado</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>6A</td>
<td>Minneapolis, Minnesota</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>6B</td>
<td>Helena, Montana</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>7</td>
<td>Duluth, Minnesota</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
</tr>
</tbody>
</table>

Carbon Reduction – Reduce

Thin Triple IGU
- Improve operational performance
- Thin center lite reduces embodied carbon impacts
- Fits in standard double IGU system
- Reduce weight compared to traditional triple
Carbon Reduction – Rethink

Transparent Photovoltaics
• Rooftop area vs Façade area
• Passive IGU Benefits
• Dynamic Window Area
  • Embodied energy payback
  • Net zero building performance

Highly Insulating Glazing Solutions

NCI – Steven Selkowitz, LBNL
What about Resiliency?

![Graph showing interior temperature during NYC winter power outage]

Summary

**Existing Buildings**
- Minimize additional embodied carbon impacts
- Improve operational performance
  - Upgrade building envelope for passive building performance improvements + resiliency
  - Lead to smaller HVAC systems and cost savings.

**New Construction**
- Wide variety of available technologies.
  - R-20, double skins, VIG, TGU, 4x silver
- Carbon payback
  - Operational savings > embodied addition
- Design for the future
Counting Carb(on)s
Embodied vs Operational

Dr. Kayla Natividad
Pilkington | NSG
Kayla.Natividad@nsg.com