BTO’s Integrated Approach

Research & Development
- Develop technology roadmaps
- Prioritize opportunities
- Solicit and select innovative technology solutions
- Collaborate with researchers
- Solve technical barriers and test innovations to prove effectiveness
- Measure and validate energy savings

Market Stimulation
- Identify barriers to speed and scale adoption
- Collaborate with industry partners to improve market adoption
- Increase usage of products & services
- Work through policy, adoption, and financial barriers
- Communicate the importance and value of energy efficiency
- Provide technical assistance and training

Codes and Standards
- Establish minimum energy use in a transparent public process
- Protect consumer interests
- Reduce market confusion
- Enhance industry competitiveness & profitability
- Expand portfolio of EE appliances & equipment
- Raise the efficiency bar
Priority areas for envelope R&D based on the roadmap

<table>
<thead>
<tr>
<th>Technology</th>
<th>2025 Installed Cost Premium Target</th>
<th>2025 Performance Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Highest Priority R&amp;D Areas</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building envelope insulation</td>
<td>≤ $0.25/ft²</td>
<td>• ≥ R-12/inch thermal insulation material for retrofitting walls</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Meets durability requirements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Minimizes occupant disturbance</td>
</tr>
<tr>
<td>Air-sealing technologies</td>
<td>≤ $0.5/ft² finished floor</td>
<td>• Residential &lt; 1 ACH50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Commercial: &lt; 0.25 CFM75/ft²</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Concurrently regulates heat, air, and moisture</td>
</tr>
<tr>
<td><strong>High Priority R&amp;D Area</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highly insulating roofs</td>
<td>≤ $1/ft² over standard roof costs</td>
<td>Energy use reduction equivalent to doubling current ASHRAE R-values</td>
</tr>
<tr>
<td>(commercial)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Priority areas for windows R&D based on the roadmap

<table>
<thead>
<tr>
<th>Technology</th>
<th>2025 Installed Cost Premium Target</th>
<th>2025 Performance Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Highest Priority R&amp;D Area</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-10 Windows</td>
<td>Residential: ≤ $6/ft²</td>
<td>• Residential: R-10, $T &gt; 0.6</td>
</tr>
<tr>
<td></td>
<td>Commercial: ≤ $3/ft²</td>
<td>• Commercial: R-7, $T &gt; 0.4</td>
</tr>
<tr>
<td></td>
<td>over typical 2010 windows</td>
<td>• Comparable weight and thickness to currently installed base</td>
</tr>
<tr>
<td><strong>High Priority R&amp;D Areas</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dynamic Windows</td>
<td>Windows: ≤ $8/ft²</td>
<td>• $\Delta$SHGC &gt; 0.4</td>
</tr>
<tr>
<td></td>
<td>Window Films: ≤ $2/ft²</td>
<td>• $T$ bleached state &gt; 0.6 (residential) and &gt; 0.4 (commercial)</td>
</tr>
<tr>
<td></td>
<td>over a standard IGU</td>
<td></td>
</tr>
<tr>
<td>Visible light</td>
<td>≤ $5/ft²</td>
<td>50% reduction in lighting energy use over a 50-ft floor plate</td>
</tr>
<tr>
<td>redirection</td>
<td>over standard window or shade</td>
<td></td>
</tr>
<tr>
<td>(commercial)</td>
<td>including lighting and controls costs</td>
<td></td>
</tr>
</tbody>
</table>
Cross-cutting challenges for windows and envelope

• “Seamless” interfaces/transitions between functional areas (e.g., roof-walls, walls-windows)
  – Air and moisture infiltration, installation cost, construction errors
• Simple, accurate, low cost methods for evaluating envelope air sealing
• “Soft” costs as a fraction of total installed costs
• Advanced manufacturing methods for windows
  – Reduce costs, increase quality, reduce lead times
• Products and methods that reduce retrofit cost and complexity
QTR results reflect the potential benefits of envelope R&D

Residential Energy (Single Family, All Regions)

Primary EUI (kBtu/sq. ft.)

End Use
- Heating
- Secondary Heating
- Cooling
- Lighting
- Water Heating
- Refrigeration
- Drying
- Other

Efficiency Scenario

ET 2020 – ET Multi-year Program Plan Targets for 2020

*Energy Savings %
QTR results include cost-effective envelope technologies

- 6: Air sealing (R)
- 8: Insulation (C)
- 19: Air sealing (C)
- 23: Roof insulation (C)
- 24: Insulation (R)
- 25: Dynamic window films
- 26: Dynamic windows
R&D is needed to successfully reach program targets

MYPP Target: Highly Insulating Windows

- Residential R-5.6
- Residential R-5.2
- Residential (North)
- Residential (South)

MYPP Target: Envelope Retrofit

- Residential Wall Insulation
- ORNL Modified Atmospheric Insulation

- EnergyStar
- EnergyStar (Most)
- Current Best
- ET 2020 Targets
- Other

Installed Cost ($/sq.ft.)

R–Value

Installed Cost ($/sq.ft.)

R–Value/in.
Projects to be reviewed today

• Windows
  – **ORNL**: Low-cost Haziness-free Transparent Insulation
  – **WCMA**: Attachments Energy Rating Council (AERC)
  – **LBNL**: Fenestration Attachments Quantitative Evaluation
  – **PPG**: Fabricate-on-demand Vacuum Insulated Glazings
  – **Alcoa**: Novel Thermal Break with Simplified Manufacturing for R-7 Commercial Windows

• Envelope
  – **ORNL**: R-25 Polyisocyanurate Composite Insulation Material
  – **Fraunhofer**: Bio-based, Inexpensive, Non-corrosive, Non-flammable Phenolic Foam for Building Insulation
  – **LBNL**: CBERD Building Envelopes R&D
Two exciting panel discussions

• 12:05 PM – Additive Manufacturing for the Building Envelope
  – Roderick Jackson, Building Envelope Systems Research Group, Oak Ridge National Laboratory
  – Sneh Kumar, Business Technology Lead for Building and Construction Systems, Alcoa
  – Uday Vaidya, Chief Technology Officer, Institute for Advanced Composites and Manufacturing Innovation
  – Lucas Tryggestad, Associate Director, Skidmore, Owings, and Merrill

• 3:05 PM – Customer Perspectives on Envelope R&D Opportunities
  – Doug Anderson, ENERGY STAR Project Manager, US Environmental Protection Agency
  – Yves Gauthier, Senior Associate, Perkins+Will
  – Geoffrey Eddy, Senior Engineer, Arup
  – Dean Potter, VP Quality and Home Production, K. Hovnanian Companies
• Findings from the Residential Energy Code Field Study