Windows R&D at the DOE Building Technologies Office

BETEC Symposium

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Emerging Technologies
Building Technologies Office
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The Building Technologies Office (BTO) uses integrated approach to impact energy savings

**Research & Development**
- Develop technology roadmaps
- Prioritize opportunities
- Solicit and select innovative technology solutions
- Collaborate with researchers and market performers
- 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 and 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 and profitability
- Expand portfolio of energy efficient appliances and equipment
- Raise the efficiency bar
DOE’s Portfolio of Research in Advanced Technologies – Whole Building Approach

Advanced windows

Advanced refrigerator technology

Building energy models/calculators

Low global warming potential refrigerants

Heating, ventilating, air conditioning, water heating, and working fluids

Solid state lighting

Sensors and controls

Advanced heat pump technology:
- Air source heat pumps
- Ground source heat pumps
- Heat exchangers

Building Envelope: Next generation attic and roof systems
Windows are responsible for \(~ 12\%\) of all primary energy consumed by buildings in the US (2010 data).

DOE Windows & Building Envelope Funding

* tentative

Buildings in the 21st Century – International Green Building Summit

Buildings.energy.gov
How Does DOE Decide on Research?

(1) Workshops/Roadmaps

Results from Last Windows Workshop (June 28, 2012)

How Does DOE Decide on Research?
(2) The Prioritization Tool

Each measure (e.g. technology) requires four data inputs:
- **Performance improvement**: technical energy savings
- **Cost**: incremental cost of the technology over common baseline
- **Market**: stock this measure (e.g. technology) can impact
- **Supporting information**: lifetime, adoption rate, code/standard date, etc.

We apply standard analysis methodology:
- **Energy savings (technical potential)**: maximum technical savings is percent savings multiplied by market energy use
- **Stock and flow dynamics (two family)**: end-of-life equipment stock turnover used to determine practical limit to technology adoption
- **Staging framework**: overlapping savings identified by segmenting energy use; measure with lowest cost of conserved energy stages first
- **Technology diffusion**: innovator/follower dynamics
- **Cost of conserved energy**: present value cost of technology divided by lifetime energy savings (i.e. $/MMBTU)

This produces useful outputs (e.g. strategic game board) that can be tested through sensitivity analyses and viewed through various lenses such as:
- Maximum technical potential
- Energy savings vs. cost of conserved energy (no interaction – unstaged)
- Energy savings vs. cost of conserved energy (interaction – staged)
- Adoption adjusted energy savings potential
Prioritization Tool Output: Technical Potential
(R = residential, C = commercial)

Technical potential 2030 for Windows

- R+C: R-10 windows
- R: insulating shutters
- R: R-5 repl. Windows
- R: R-5 repl. Windows
- R+C: Dynamic windows
- R+C: Window attachments
- R+C: Low-e storm windows
- C: R-5 repl. Windows
- R+C: window films

Primary energy savings, quads

Buildings.energy.gov
Emerging Technologies Programmatic Goals are Defined Using Prioritization Tool

Lighting - aggregated 70% energy savings
Water heating - aggregated 60% energy savings
HVAC - aggregated 20% energy savings
Building envelope - aggregated 20% energy savings
Appliances - aggregated 20% energy savings
Sensors and controls – aggregated 30% energy savings
Building energy modeling – Significantly increase (10%/year) the number of users of building energy modeling tools, to actually reduce energy use in buildings (architects, builders, retrofit companies).

Relative to a 2010 baseline
## Current Windows Projects (1/3)

<table>
<thead>
<tr>
<th>Project</th>
<th>Goals</th>
<th>Performer(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electrochromic (EC) Windows:</strong> non-indium-based transparent conducting oxide layers; nanoparticle synthesis for nanoparticle-laden films</td>
<td>Go/no-go decision on Al-doped ZnO₂ as a replacement for ITO</td>
<td>LBNL</td>
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<tr>
<td><strong>Highly Insulating Windows:</strong> non-structural thin glass center layers; new thermal break technology for aluminum framing; low-cost Kr distillation; update software tools</td>
<td>Prototypes; Go/no-go on Kr distillation process</td>
<td>LBNL</td>
</tr>
<tr>
<td><strong>Advanced Façades, Daylighting, and Complex Fenestration Systems:</strong> refractive daylight redirecting systems; angular selective shading systems; smart controls for dynamic façades</td>
<td>Prototypes; industry workshop on smart controls</td>
<td>LBNL/3M (CRADA)</td>
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<tr>
<td><strong>Window Attachments:</strong> Explore Energy Star rating; re-engineer existing attachments for improved energy efficiency</td>
<td>Energy Star feasibility; prototypes</td>
<td>LBNL</td>
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### Current Windows Projects (2/3)

<table>
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<td><strong>Electrochromic (EC) Windows</strong>: laminated EC prototype with polyvinyl butyral (PVB) ion conductor layer; incorporate nickel oxide-based counter electrodes into Sage EC window; flexible, reflective EC film with US e-Chromic</td>
<td>Improved counter electrode; gel-based ion conductor with PVB; prototype reflective EC film</td>
<td>NREL/Sage /US e-Chromic (CRADAs)</td>
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<tr>
<td><strong>Durability Testing of Advanced Fenestrations</strong>: complete installation of the differential thermal cycling testing unit (DTCU); test existing vacuum-insulated glass (VIG) or gas-filled insulating glass and improve ASTM2190 test</td>
<td>DTCU readiness; improved ASTM2190 protocol</td>
<td>NREL</td>
</tr>
<tr>
<td><strong>High Performance Retrofit Windows</strong>: measure performance of efficient retrofit windows in two-story Flexible Research Platform (FRP)</td>
<td>Increase contribution of retrofit windows to energy savings by ≥10%</td>
<td>ORNL</td>
</tr>
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## Current Windows Projects (3/3)

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<td><strong>Nanolens Window Coatings for Daylighting &amp; Low-e Storm Windows Adoption</strong>: optimize nanoscale resonators for light redirection; implement low-e storm windows in simulation packages (BeOPT, NEAT, Energy Gauge) to stimulate adoption</td>
<td>Prototype demonstrating 10% light redirection; add data on low-e storm windows to Building America database</td>
<td>PNNL</td>
</tr>
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Energy Efficient Buildings Hub in Philadelphia, PA

The EEB Hub is a test bed of building efficiency activity focused on the Philadelphia region

• MODELING: Develop and deploy a state-of-the-art modeling platform

• TECHNOLOGIES: Demonstrate the market viability of integrating energy saving technologies

• POLICIES: Identify policies that accelerate market adoption and support policy makers in their development

• TRAINING: Inform, train, and educate

• NEW BUSINESS: Help launch ventures to exploit market opportunities

http://www.eebhub.org/
Moving Forward

- NEW IDEAS: What should be the new research directions for windows?
- MORE PARTICIPANTS: How to increase the number of window researchers (labs, companies, universities)?
- MORE OPEN SOLICITATIONS: Funding Opportunity Announcements (FOAs) are planned for each year.
- ANNUAL WORKSHOPS: Look for next workshop announcement on our blog.
- NEW WINDOWS/ENVELOPE PROGRAM MANAGER: Dr. Karma Sawyer will be joining the Buildings Technologies Office next week.