Shading, Films and Window Attachments (SFWA)

Market Report

March 13, 2016
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CBEI Overview

**Vision:**
By 2050, deep energy retrofits that reduce energy use by 50% in existing SMSCB, which are less than 350,000 sq ft

**Mission:**
Develop, demonstrate and deploy technology systems and market pathways that permit early progress (20-30% energy use reductions) in Small and Medium Sized Commercial Buildings

**Our Goals:**
- Enable deep energy retrofits in small to medium sized commercial buildings
- Demonstrate energy efficient systems tailored for SMSCBs in occupied buildings – living labs
- Develop effective market pathways for energy efficiency with utilities and other commercial stakeholders: brokers, finance, service providers.
- Provide analytical tools to link state and local policies with utility efficiency programs

CBEI Partners

- Bayer MaterialScience
- United Technologies Research Center
- Ben Franklin Technology Partners
- PIDC
- Penn University of Pennsylvania
- Virginia Tech
- Drexel University
- Carnegie Mellon University
- Purdue University
- Morgan State University
- Rutgers University
Project Overview

• **Objective**
  – Provide a market analysis report and make recommendations for improving uptake on these technologies in the small- and medium-sized commercial building market

• **Metrics**
  – Description of market perspectives (barriers and opportunities) from a minimum of building owners, designers, shading and window attachment manufacturers/distributors, and incentive programs
  – Three potential strategies identified as a role of DOE in supporting deployment in the market

• **Final Deliverable**
  – Market assessment data and analysis for shading and window attachments including recommendations for overcoming market barriers
Removed punctuation to maintain consistency throughout
Kanojia, Monica (CONTR), 6/6/2016
## Project Overview

### Approach

<table>
<thead>
<tr>
<th>Step</th>
<th>Refine Project Scope</th>
<th>Interview Stakeholders</th>
<th>Summarize Results &amp; Recommendations</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Identify shading, film and window attachments (SFWA) relevant to small- and medium-sized commercial buildings</td>
<td>Conduct stakeholder interviews</td>
<td>Synthesize interviews to provide conclusions for the market and by stakeholder type</td>
</tr>
<tr>
<td></td>
<td>Conduct preliminary cost/benefit analysis for market sector</td>
<td>Assess overall market trends</td>
<td>Develop recommendations for potential DOE activities to increase market uptake</td>
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<tr>
<td></td>
<td>Identify list of stakeholders to interview</td>
<td>Develop summary of value chain and major market players</td>
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Market Overview
SFWA Industry Trends*

• **Overall SFWA market anticipated to grow with improved economy and greater interest in sustainable and energy efficient building products, or “green” products**
  
  – Consumption of blinds and shades fell during the economic downturn by an average of 9.5% per year from 2007 – 2010. In 2013, the consumption of blinds and shades increased by 6.8% and 12.5%, respectively, which can be primarily attributed to residential development and remodeling.
  
  – Automated window coverings are becoming more prevalent:
    
    • In 2014, just over 7% of all movable window coverings were automated
    
    • By 2019, approximately 10% of all movable window coverings are expected to be automated, the most popular include vertical blinds, and interior and exterior roller shades and shutters.
  
  – Green products and associated increasing interest by consumers is becoming an important trend in the industry and will continue to drive future energy efficiency efforts.

• **Films**
  
  – Despite adoption challenges, energy security and regulatory drivers will propel the market from today’s $450 million to $863 million by 2018.
  
  – Compared to competing technologies like switchable glazings, aerogel glazings, and daylighting skylights, after-market solar control films offer a low-cost, short-payback-period technology that can address the much larger retrofit market.
  
  – Emerging technologies like waterborne coatings of ceramic oxides will open up the possibility of using polyolefin in this application, having previously been limited to polyesters, polycarbonates, and fluoropolymers.

*Sources:*

- Note: The report has little differentiation of commercial and residential markets.
Market Overview
Green Construction Industry Trends*

**NATIONAL GREEN CONSTRUCTION SPENDING ($)**

Green construction spending forecasted to grow 15.1% year over year to $224 billion in 2018

**NATIONAL LEED CONSTRUCTION SPENDING ($)**

LEED construction spending forecasted to grow 12.3% year over year to $78.6 billion in 2018

## Market Overview

### Select SFWA Product Types and Installed Cost

<table>
<thead>
<tr>
<th>Application</th>
<th>Technology Type</th>
<th>Cost per sq. ft. window area¹</th>
<th>Cost per window²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior</td>
<td>Roller Shade</td>
<td>$3</td>
<td>$33</td>
</tr>
<tr>
<td></td>
<td>Solar Screens (fixed panel)</td>
<td>$4</td>
<td>$45</td>
</tr>
<tr>
<td></td>
<td>Motorized Louvered Shade</td>
<td>$30</td>
<td>$375</td>
</tr>
<tr>
<td></td>
<td>Motorized Louvered/ Hinged Shutters</td>
<td>$30</td>
<td>$375</td>
</tr>
<tr>
<td></td>
<td>Motorized Solar Screen/ Roller Shade</td>
<td>$40</td>
<td>$500</td>
</tr>
<tr>
<td>Interior</td>
<td>Louvered Shutter (“Venetian” Blind)</td>
<td>$3</td>
<td>$31</td>
</tr>
<tr>
<td></td>
<td>Roller Shade</td>
<td>$4</td>
<td>$55</td>
</tr>
<tr>
<td></td>
<td>Applied Film (standard solar control)</td>
<td>$6</td>
<td>$80</td>
</tr>
<tr>
<td></td>
<td>Applied Film (advanced or spectrally-selective)</td>
<td>$10</td>
<td>$125</td>
</tr>
<tr>
<td></td>
<td>Interior Panels (“storm windows”)</td>
<td>$12</td>
<td>$150</td>
</tr>
<tr>
<td></td>
<td>Cellular Shade (quilted)</td>
<td>$18</td>
<td>$225</td>
</tr>
<tr>
<td></td>
<td>Cellular Shade (insulated with side tracks)</td>
<td>$42</td>
<td>$525</td>
</tr>
</tbody>
</table>

¹ Average cost per square foot based on stock size for a non-custom, 60”x30” window size

² Average cost based on cost for a non-custom, 60”x30” window size

*Source: DOE/LBNL site www.efficientwindowcoverings.org*
## High-Level Techno-Economic Analysis

**Gauging Energy Performance Requirements for Cost Feasibility**

<table>
<thead>
<tr>
<th>Commercial Building Use Type</th>
<th>Building Size (SQFT) *avg.</th>
<th>Window Space (SQFT)</th>
<th>Electric Demand (MMBTU)</th>
<th>Gas Demand (MMBTU)</th>
<th>Energy Use Intensity (EUI)</th>
<th>SFWA Product Cost $2 per Sq. Ft.</th>
<th>SFWA Product Cost $10 per Sq. Ft.</th>
<th>SFWA Product Cost $40 per Sq. Ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly</td>
<td>15,700</td>
<td>2,512</td>
<td>1,062</td>
<td>565</td>
<td>0.104</td>
<td>5%</td>
<td>23%</td>
<td>93%</td>
</tr>
<tr>
<td>Education</td>
<td>31,600</td>
<td>5,056</td>
<td>2,638</td>
<td>1,138</td>
<td>0.119</td>
<td>4%</td>
<td>19%</td>
<td>77%</td>
</tr>
<tr>
<td>Food Sales</td>
<td>7,400</td>
<td>1,184</td>
<td>1,431</td>
<td>266</td>
<td>0.229</td>
<td>2%</td>
<td>9%</td>
<td>36%</td>
</tr>
<tr>
<td>Food Service</td>
<td>4,800</td>
<td>768</td>
<td>1,162</td>
<td>173</td>
<td>0.278</td>
<td>1%</td>
<td>7%</td>
<td>29%</td>
</tr>
<tr>
<td>Health Care</td>
<td>12,100</td>
<td>1,936</td>
<td>2,452</td>
<td>436</td>
<td>0.239</td>
<td>2%</td>
<td>8%</td>
<td>34%</td>
</tr>
<tr>
<td>Lodging</td>
<td>37,400</td>
<td>5,984</td>
<td>3,792</td>
<td>1,346</td>
<td>0.137</td>
<td>3%</td>
<td>16%</td>
<td>65%</td>
</tr>
<tr>
<td>Office - Large</td>
<td>15,800</td>
<td>2,528</td>
<td>1,508</td>
<td>569</td>
<td>0.131</td>
<td>3%</td>
<td>17%</td>
<td>69%</td>
</tr>
<tr>
<td>Office - Small</td>
<td>15,800</td>
<td>2,528</td>
<td>1,197</td>
<td>569</td>
<td>0.112</td>
<td>4%</td>
<td>21%</td>
<td>84%</td>
</tr>
<tr>
<td>Mercantile/Service</td>
<td>12,600</td>
<td>2,016</td>
<td>1,047</td>
<td>454</td>
<td>0.119</td>
<td>4%</td>
<td>19%</td>
<td>78%</td>
</tr>
<tr>
<td>Warehouse</td>
<td>16,400</td>
<td>2,624</td>
<td>604</td>
<td>590</td>
<td>0.073</td>
<td>8%</td>
<td>39%</td>
<td>155%</td>
</tr>
<tr>
<td>Other</td>
<td>16,000</td>
<td>2,560</td>
<td>1,379</td>
<td>576</td>
<td>0.122</td>
<td>4%</td>
<td>19%</td>
<td>75%</td>
</tr>
</tbody>
</table>

### Conversion Approach & Assumptions

- 10 ft. ceiling – base general assumption
- 10,000 sq. ft. floor space – base assumptions
- Results in 1:2.5 ratio of window to floor space
- ASHRAE 90.1-2010 specifies 40% window to wall ratio (WWR)
- Results in conversion of 16% of floor space is equivalent window space
- Assumed 3 year payback. Interview results noted 3 year payback commonly used for retrofits but can range to 5 years. New construction is typically 5 – 7 payback.

*This analysis is for illustrative purposes only and is limited in its application, because it does not take into account the multiple other benefits of SFWA. This analysis was developed at DOE’s request to assess a relative price point necessary for energy savings to be a driving factor for the application of SFWA in retrofits of SMSCB.
Stakeholder Outreach
Product Supply Chain & Communication Pathways

**Solution Developer**
- **Research & Development**
  - Product Conceptualization
- **Manufacturing**
  - Intermediate Product Manufacturing (Components)
  - Final Product Manufacturing
- **Distribution/ Wholesale**
  - Wholesale to SPs, Retail Franchises, Product Representatives

**Service Provider**
- **Architecture & Engineering Firms**
  - Project development, design and configuration
  - Preliminary product specifications
- **Consultants**
  - Envelope experts, energy modeling
- **Construction & General Contractors**
  - Product purchasing
  - Product installation

**Enablers**
- Associations
- Educational Institutions
- National Laboratories
- States/ Municipalities
- Utilities

**End User**
- Building Owners
- Building Operators
- Tenants
- Developers
- Project Managers

**Legend**
- Paths of Communication & Coordination between Stakeholders
- Material and Design Flow
**Stakeholder Outreach**

**Company Representative Interviews**

**Solution Developers**
- Alcoa, Building and Construction
- Dow Chemical
- Draper
- Glen Raven
- Huper Optik (Certified Energy Consultants)
- Larson Manufacturing Company
- Lutron Electronics Company
- MechoShade Systems
- Monmouth Beach Plantation Shutters & Blinds
- Renson
- Rollease Acmeda
- Springs Window Fashions

**Service Providers**
- Atelier-Ten
- Ballinger
- Bartenbach GmbH
- Integral Group
- Jibe Design
- Keen Design, LLC
- Transsolar
- Wiss, Janney, Elstner Associates, Inc.

**End Users**
- Booz Allen Hamilton
- Broad Street Realty
- CBRE
- General Services Administration (GSA)’s Green Proving Ground
- Jones Lang LaSalle (JLL)
- Lerner Company
- StonebridgeCarras
- Zuckerman Gravely

**Enablers**
- Absolute Perfection
- Attachments Energy Ratings Council (AERC)
- Austin Energy (TX)
- Carnegie Mellon University (CMU)
- City of Aspen – Department of Environmental Health and Sustainability
- Honeywell
- Lawrence Berkley National Lab (LBNL)
- Lockheed Martin
- National Fenestration Rating Council (NFRC)
- PECO - Smart Ideas Program
- PennDesign, University of Pennsylvania
- Window Coverings Manufacturers Association (WCMA)
<table>
<thead>
<tr>
<th>Stakeholder Outreach</th>
<th>Interview Questions</th>
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</thead>
<tbody>
<tr>
<td><strong>Solution Developers</strong></td>
<td><strong>Service Providers</strong></td>
</tr>
<tr>
<td>• Company size and geographic coverage</td>
<td>• Company size and geographic coverage</td>
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<tr>
<td>• Products/services supplied</td>
<td>• Products/services supplied</td>
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<tr>
<td>• Market segments (building types/sizes) covered</td>
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<tr>
<td>• Percent of business devoted to this market segment</td>
<td>• Percent of business devoted to this market segment</td>
</tr>
<tr>
<td>• Strategies for reaching market (successful and unsuccessful)</td>
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<tr>
<td>• Client buying trends/perspectives on products</td>
<td>• Client buying trends</td>
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<tr>
<td>• Energy performance of products offered</td>
<td>• Client perspectives on including or not including SFWAs</td>
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<tr>
<td>• Engagement with program administrators</td>
<td>• Relationship to incentive programs</td>
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<tr>
<td>• Challenges for business growth</td>
<td>• Challenges for business growth</td>
</tr>
<tr>
<td>• Perspective on how codes affect business</td>
<td>• Perspective on how codes affect business</td>
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<tr>
<td>• Recommendations for improving market conditions</td>
<td>• Recommendations for improving market conditions</td>
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Stakeholder Outreach Synthesis

Overarching Market Messages

• General
  – End users are risk averse – tend to stick to what they know
    • Need confidence in product applied, and the business case needs to be clear; SFWA products have a more complex value proposition which is hard to quantify
    • End user decisions are driven by cost, code, and branding (e.g., Energy Star and LEED Certified space)
    • Innovative technologies are generally the first to be replaced with low cost options as construction budgets balloon
  – Market is slowly shifting
    • Manufacturers and service providers are seeing growth in interest for innovative technologies for occupant comfort, health, and productivity and energy efficiency
    • Tenant requests for green space are increasing
  – Overwhelming interest for more information to inform end users
    • Case studies are an effective way to inform end users
    • Technology-specific performance data are particularly valuable for service providers
    • Overwhelming support for a rating system to take some of the complexity out of decision making
    • Solution developers and service providers are willing to provide recommendations for case studies
Stakeholder Outreach Synthesis
Overarching Market Messages

• Interior Products
  – Shading devices
    • Often excluded as an option, because exterior shading can alter the aesthetic design of the building and concerns about operational and maintenance cost
    • Shape, size and configuration of windows can significantly impact project cost when considering motorized solutions
    • Beginning to develop technologies to affect human behavior (e.g., colored lights to inform occupants on best shading adjustments)
  – Films
    • More likely to be applied in retrofits than new construction
    • Low maintenance – typically no additional operational expense required
    • Increasing growth in number of film types (e.g., ceramic vs. metallic components)
    • Higher levels of interest for these products in higher education, museums, research institutions to protect building contents and avoid the need to replace windows
    • Security/resilience and historic preservation remain key drivers for use of films over energy efficiency
    • Unique barriers
      – Metalized films reduce cell signal, often requiring installation of costly boosters
      – Can void window warranty
Stakeholder Outreach Synthesis
Overarching Market Messages

- **Exterior Products**
  - New construction provides greater opportunity to incorporate these solutions; retrofitting is hindered by existing building design, cost and requires integrated design
  - Growing interest in these products but end users lack an understanding of potential energy saving benefits and maintenance challenges
  - Trend for service providers/end users to apply external devices for aesthetic reasons rather than energy efficiency (e.g., product not sized to scale to provide energy efficiency benefits to building)
  - High solar reflective technologies can reduce HVAC energy consumption by 10-20% for cooling but are dependent on climate, window glass specifications, and solar reflectiveness of fabrics used
  - Typically costly due to high likelihood for customization for individual building resulting in application of tried and tested interior solutions despite positive trend in preference
Stakeholder Outreach Synthesis
Solution Developers

• **Industry Snapshot**
  – Bifurcated market of (1) shading and window attachment providers and (2) film providers that create an either/or decision for end users
  – Shading and window attachment manufacturers providing a wide variety of products
  – Film providers typically provide a more narrow set of differentiated products

• **Approaches to Reaching Customers on Energy Efficiency**
  – Customers can include service providers and end users; however, there is a strong focus on educating and selling to service providers, who are the primary interface with end users
  – Distributors and wholesalers reach customers by sales calls, advertising, conference and expo participation, service provider networks, and big box retail channels
  – Energy savings listed as an advantage along with increased comfort and productivity, but little quantitative information is available on potential savings
  – Several have developed simple online calculators but no indication of how frequently they are used, or whether they result in sales
  – More open audiences include owner-occupied buildings (e.g., owner strongly interested in occupant comfort, health, and energy)
Stakeholder Outreach Synthesis
Solution Developers

- **Challenges**
  - Often need to rely on inexperienced service providers that are unable to effectively sell more efficient, but costly, products
  - Insufficient information on potential energy savings, particularly in real-world situations, to support claims of product benefits
  - Motorized shading products have cost and integration issues
    - Costs for sensors and actuators drive higher costs of motorized shading devices
    - Additional consideration required during space planning for installation of motors and supporting product systems
    - Integration between automated systems and the BAS is challenged by mismatch in system interfaces
  - Films
    - Require specialized skills to install properly
    - Window manufactures do not have the technical capability to install films inside a multi-pane window where they would be most effectively placed
    - Window manufacturers are more receptive to coating versus films because they are familiar and comfortable with the application process
Stakeholder Outreach Synthesis
Service Providers

- **General Stakeholder Perspectives**
  - Market is showing a growing interest in integrated design for new construction and retrofits, which provides opportunity to educate end user on inter-related benefits
  - Service providers generally learn about solutions from in-office meetings with technology representatives
  - Design firms without in-house engineering may reach out to boutique consultants, which can assist in growing market demand through their reputations, for modeling to support envelope and daylighting design

- **Approaches to Reaching Customers on Energy Efficiency**
  - Typically make general statements on energy efficiency, since there is limited 3rd party evidence that can be referenced
  - Modeling supports case but is not used for many small- and medium-sized commercial buildings, unless they are showcase projects
  - Case studies effective for making case to end users

- **Challenges**
  - End users continue to focus on SFWAs as last decision to be made and first opportunity to cut costs and are not aware of overall benefits
  - Service providers need more information on technology advancements
Stakeholder Outreach Synthesis

End Users

• General Stakeholder Perspectives
  – Owner-occupied building end users pay more attention to SFWA options to improve occupant health and productivity, as well as building efficiency
  – Owners/operators predominantly influenced by service providers as they are more trusted advisors than solution developers, unless there is a pre-existing relationship with the solution developer
  – Owner typically specifies what tenants can use and often only provides tenants with interior options due to exterior options potentially affecting the exterior design
  – Codes and certification programs are bigger drivers to consider more effective solutions
  – Growing interest in exterior shading, but concerned by:
    • Maintenance issues, particularly associated with window cleaning
    • Impacts of snow/ice
    • Potential for bird nesting
  – Owners want payback within 5 years due to 5-7 year tenant turnover Opinions vary on window films and product performance over time, bubbling and degradation of certain films have been an issue and have created distrust in the product category
  – Product demonstrations are preferred by owners as they build confidence and may increase uptake

• Considerations on Energy Efficiency
  – The energy savings potential is still low on the priority list; however, in warmer climates developers have shifted it up in priority
  – Lack demonstrable proof and M&V standard approaches to evaluate whether more expensive options will result in sufficient payback
Stakeholder Outreach Synthesis

End Users

• Challenges
  – Owners are distrusting of advertised product performance, third party verification would be useful to combat this barrier
  – More sophisticated owner/operators feel that they are educating service providers about new technologies
  – In leased spaces, tenants rarely voice interest in specific technologies unless their employees complain about comfort or glare
  – City codes related to overhang can present barriers to the application of exterior shading
  – Owners/operators continue to express concerns about control technologies and automation for SFWA having design flaws that lead to additional operating expense (e.g., controls break easily)
  – Additional utility incentives would raise the visibility and interest in more sophisticated technologies
Stakeholder Outreach Synthesis
Market Enablers

• **General Stakeholder Perspectives**
  – The majority of applications for “building envelope” are under a custom program and require modeling simulations and calculations
  – A few utilities offer prescriptive programs with set rebate amounts in $/sq. ft. of film installed
  – Proof of concept and accurate approaches to estimating potential savings is critical as many utility managers are skeptical of existing methods

• **Challenges**
  – Need more demonstrations and case studies to show benefits
  – Industry lacks uniform methodologies for quantitative analysis in this product category
  – Lack of “design for climate” in architecture schools, with climate-specific approaches to how energy efficiency techniques can be optimized in the building design
Stakeholder Outreach Synthesis

Market Enablers

• Utility Programs
  – 27 utility programs offering window film incentives were reviewed in 17 different states (AZ, CA, CO, FL, GA, HI, IN, MD, MN, NC, NM, NV, PA, SC, TX, VA, WA)
    • Of these 27 programs, 19 offer Prescriptive Incentives for SFWAs and 8 offer Custom Incentives
  – Prescriptive Incentive Programs
    • Rebate amounts are typically offered as an amount ($) per sq. ft. of window space
    • Eligibility requirements include: solar heat gain coefficient (SHGC), based on individual product performance test, or performance measurements conducted post installation
    • Some programs offer tiered rebate amounts per SHGC (e.g., SHGC improved (post install) by ≥ 0.40, 0.30-0.39, <0.30; will equate to rebate allotments in the amount of $0.85, $0.65 and $0.45 respectively)
    • Some programs have prerequisites for window orientation (south, north, east, west)
  – Custom Incentive Programs
    • Rebate amounts are based on projected annual savings ($/kWh), estimated by modeling building performance, pre-install and post-installation
    • Some programs have standard cost and savings calculations, and some require submission of all savings and cost estimates for pre-approval; variables typically included in these calculations are: baseline energy consumption, peak demands, HVAC schedule, climate, cooling savings, and heating penalty

*Source: DOE/LBNL site www.efficientwindowcoverings.org
Stakeholder Outreach Synthesis
European Market

• **Feedback on reasons for higher uptake in Europe than US**
  – Longer tradition of designing buildings without air conditioning (as a result of milder weather than in US) has resulted in greater acceptance and use of SWFA, results in:
    • Greater acceptance of higher cost SFWA products
    • Simpler mechanical systems
  – Higher energy costs have created a culture of conservation
  – Building codes designed to ensure greater application of SFWA
    • For example, France requires review of SFWAs before approval of HVAC permit
  – Larger maintenance market for SWA technologies due to SWA prevalence in market
  – Prevalence of applied technologies varies by country
    • Germany focused on exterior shading
    • France more fabric focused
    • UK more louvers and operational systems
Recommendations for DOE
Research & Development

• **Sensors and controls**
  – Need innovations, particularly in actuators, to drive down cost for automated systems
  – Need integrated solutions for SFWA and lighting products as a system

• **Battery power improvements for automated shades**
  – Greater storage capacity allows for longer life and improved wireless capabilities

• **Integration with BAS**
  – Individual motorized SWA systems need standardization and integration to BAS systems to allow for easier use

• **Improved tools**
  – Simplistic calculating tools to include more variables for robust quantitative analysis
  – Improve modeling capabilities by incorporating additional building characteristics; climate region, solar exposure, building design and configuration of envelope components
Recommendations for DOE Deployment

- **Demonstration projects and case examples**
  - Overwhelming request from solution developers and service providers
  - Not necessary to cover every climate zone or building design, but should have sufficient information on long term savings (e.g., maintenance implications)
  - Data should be made available for simulations and modeling of similar buildings
  - Show energy savings benefits as well as comfort, productivity, and air quality

- **Education**
  - Technology Performance – focus on service providers and end users
    - Work with NIBS to include additional educational materials as part of their enclosure training (suggested broadening training to include passive solar, low-e films and daylighting)
    - Leverage social media, blogs, tradeshows, case studies, and offering opportunities to earn continuing education credit
    - Modeling tools – focus on architects to understand how modeling can help make the case

- **Improvements in code and program incentives valuable to support market**