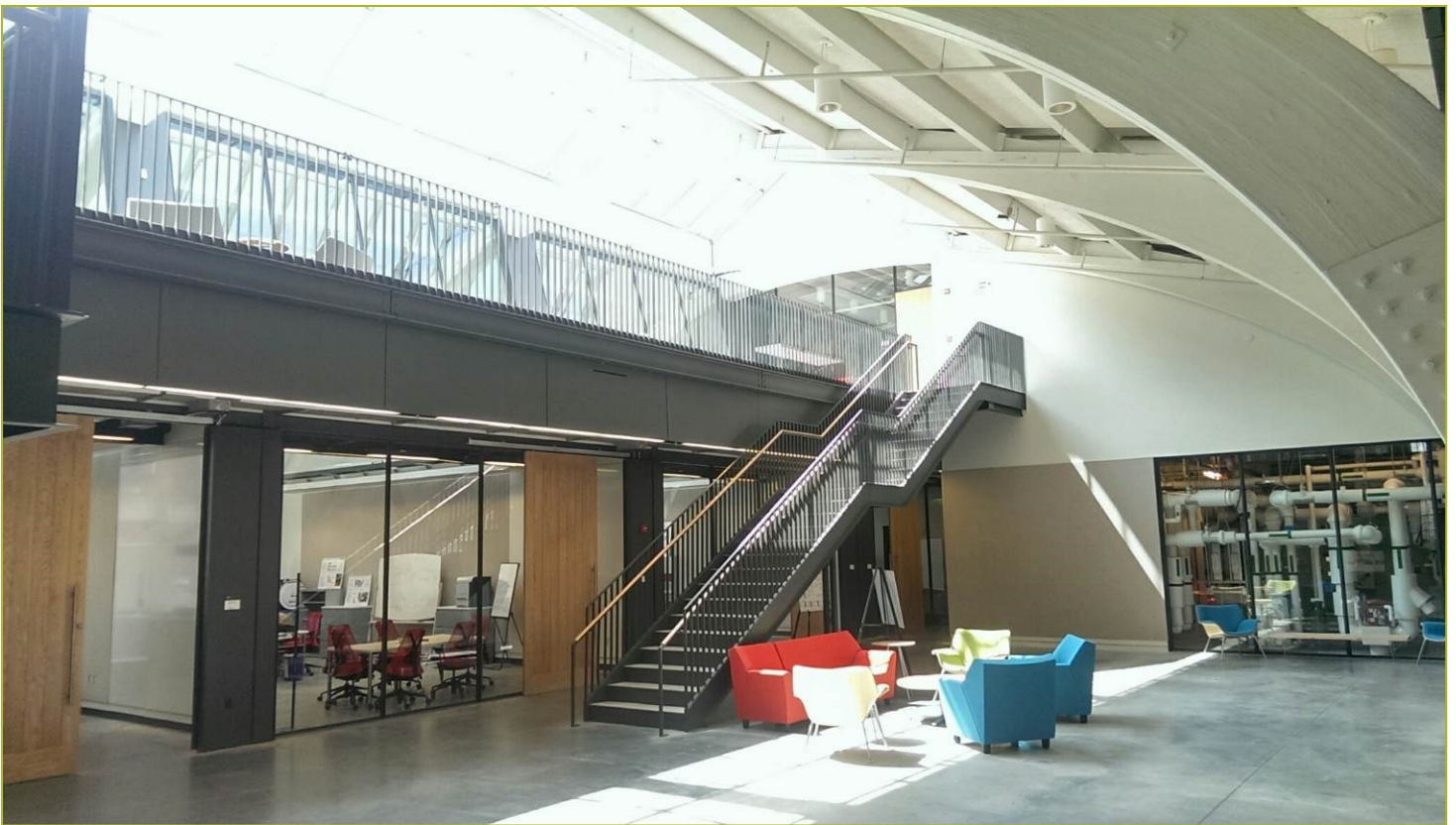


Title: Shading and Window Attachment Market Report

Report Date: April 29, 2016

Report Author: Dr. Timothy Wagner



Report Abstract

Provides a market analysis report and recommendations for improving uptake on shading, film, and window attachments (SFWA) products in the small to medium-sized commercial buildings.

Report includes different market perspectives (barriers and opportunities) from; building owners, designers, shading and window attachment manufacturers/distributors, and utility incentive program managers.

Recommendations offer three potential strategies and roles for DOE, as supporting deployment in the market.

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CONSORTIUM for BUILDING ENERGY INNOVATION

Shading, Films and Window Attachments (SFWA) *Market Report*

April 29, 2016



Contents

- CBEI Overview
- Project Overview
- Market Overview
- High-level Techno-Economic Analysis
- Stakeholder Outreach Synthesis
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CBEI Overview



Vision:

By 2030, deep energy retrofits that reduce energy use by 50% in existing SMSCB, which are less than 250,000 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

Industry



Ben Franklin Technology PARTners

Economic Development Organizations

PENNSTATE



RUTGERS

Universities



CONSORTIUM for BUILDING ENERGY INNOVATION

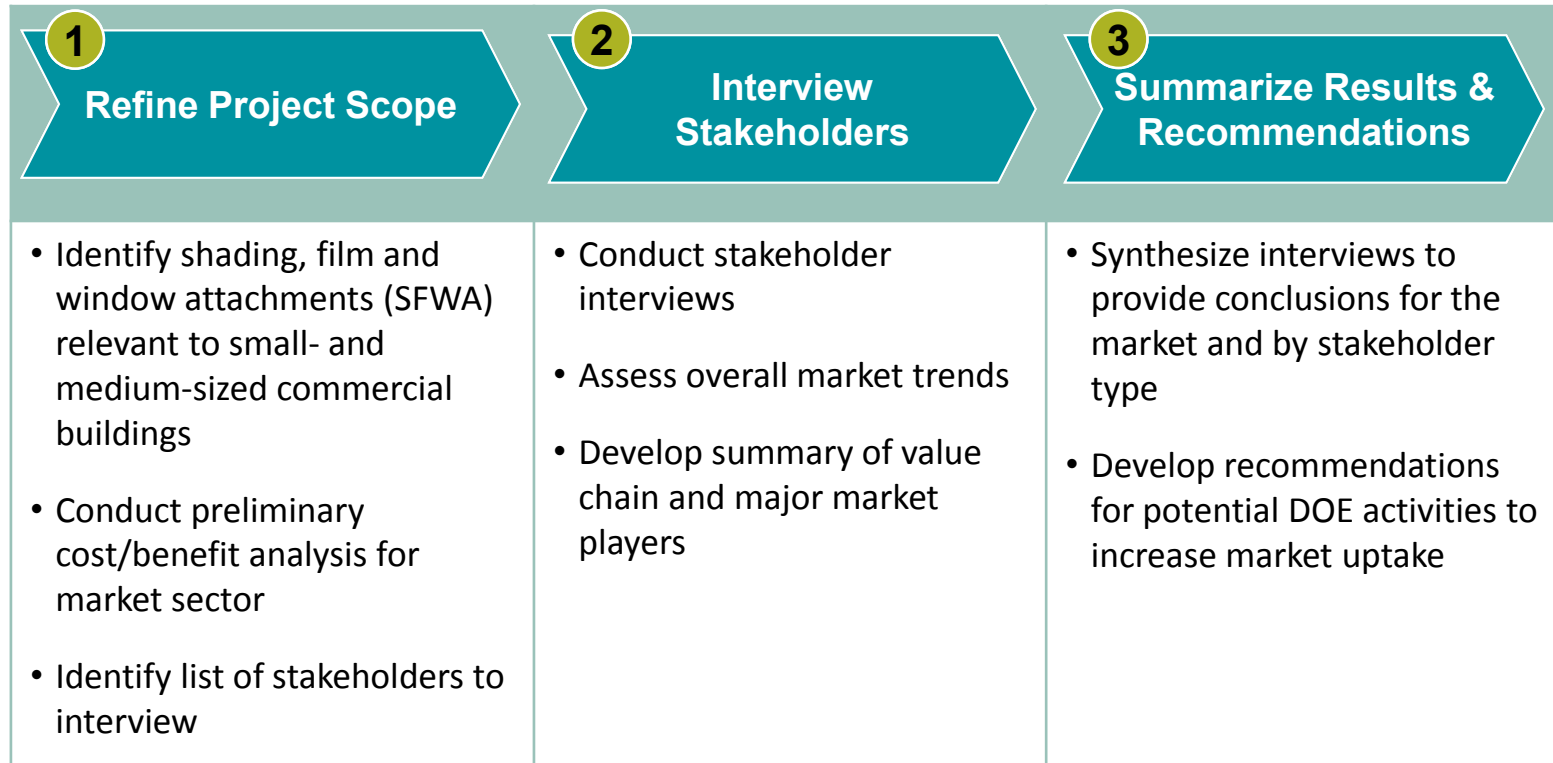
Project Overview

- **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



Project Overview

Approach



Market Overview

SFWA Industry Trends*

- **Overall SFWA market anticipated to grow with improved economy and greater interest in green**
 - Consumption of blinds and shades fell by an average of 9.5% per year from 2007 – 2010 during the economic downturn
 - In 2013, the consumption of blinds and shades increased by 6.8% and 12.5%, respectively, and primarily attributable 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 are becoming an important trend in the U.S. window coverings industry and the interest in green will drive future importance of energy efficiency
- **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

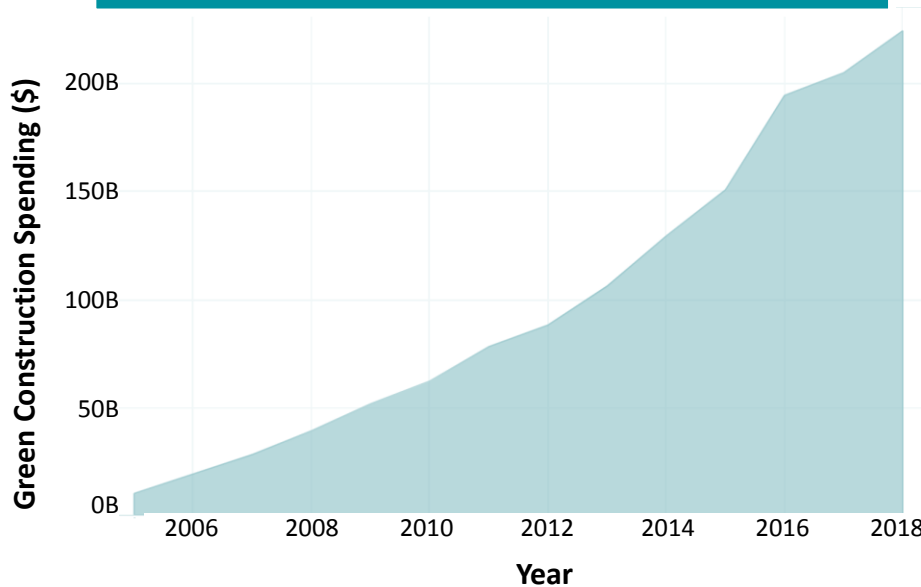
Sources:

- “State of the Industry Blinds and Shades in the US,” Sundale Research, February 2015.
Note: The report has little differentiation of commercial and residential markets
- https://portal.luxresearchinc.com/research/report_excerpt/17183

Market Overview

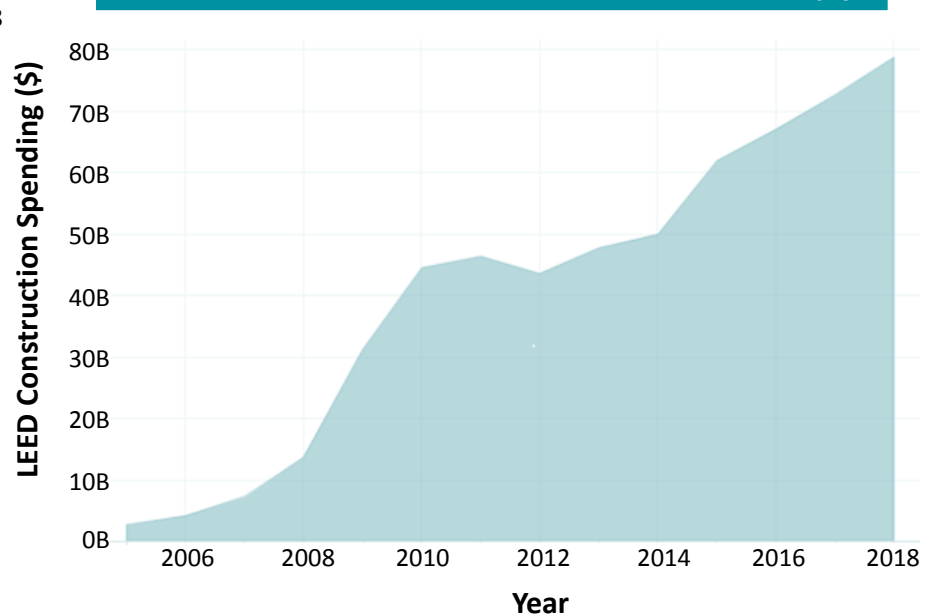
Green Construction Industry Trends*

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

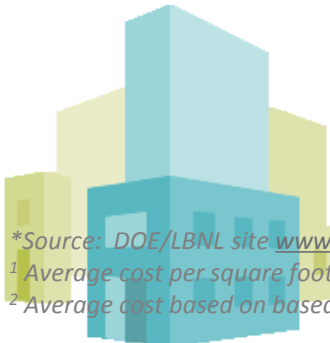
Source: "Green Building Economic Impact Study," U.S. Green Building Council and Booz Allen Hamilton, September 2015

Market Overview

Select SFWA Product Types and Installed Cost

| Application | Technology Type | Cost per sqft window area ¹ | Cost per window ² |
|-------------|-------------------------------------------------|----------------------------------------|------------------------------|
| Exterior | Roller Shade | \$3 | \$33 |
| | Solar Screens (fixed panel) | \$4 | \$45 |
| | Motorized Louvered Shade | \$30 | \$375 |
| | Motorized Louvered/ Hinged Shutters | \$30 | \$375 |
| | Motorized Solar Screen/ Roller Shade | \$40 | \$500 |
| Interior | Louvered Shutter (“Venetian” Blind) | \$3 | \$31 |
| | Roller Shade | \$4 | \$55 |
| | Applied Film (standard solar control) | \$6 | \$80 |
| | Applied Film (advanced or spectrally-selective) | \$10 | \$125 |
| | Interior Panels (“storm windows”) | \$12 | \$150 |
| | Cellular Shade (quilted) | \$18 | \$225 |
| | Cellular Shade (insulated with side tracks) | \$42 | \$525 |

Typical product types used in retrofits



*Source: DOE/LBNL site www.efficientwindowcoverings.org

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

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

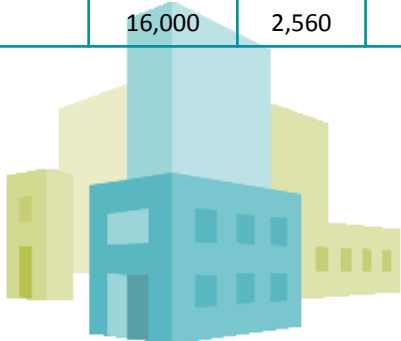


High-Level Techno-Economic Analysis

Gauging Energy Performance Requirements for Cost Feasibility

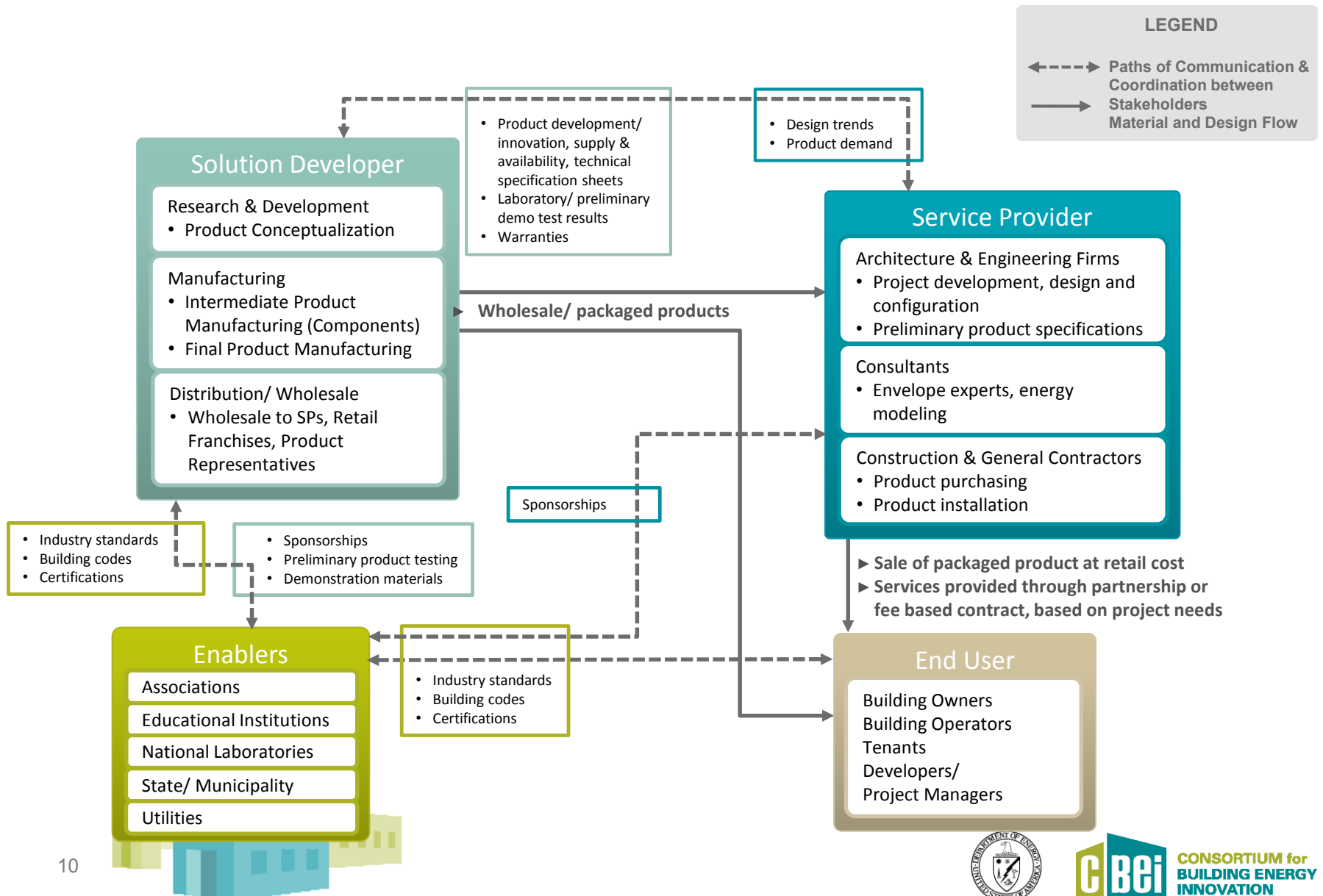
Savings Required to Achieve a 3 Year Payback – For 3 Product Cost Levels

| Commercial Building Use Type | Building Size (SQFT) *avg | Window Space (SQFT) | Electric Demand (MMBTU) | Gas Demand (MMBTU) | Energy Use Intensity (EUI) | SFWA Product Cost | | | Conversion Approach & Assumptions |
|------------------------------|---------------------------|---------------------|-------------------------|--------------------|----------------------------|-------------------|---------------|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | | | | | \$2 per SqFt | \$10 per SqFt | \$40 per SqFt | |
| Assembly | 15,700 | 2,512 | 1,062 | 565 | 0.104 | 5% | 23% | 93% | <ul style="list-style-type: none"> • 10 ft ceiling – base general assumption • 10,000 SQFT 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. <p><i>*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.</i></p> |
| Education | 31,600 | 5,056 | 2,638 | 1,138 | 0.119 | 4% | 19% | 77% | |
| Food Sales | 7,400 | 1,184 | 1,431 | 266 | 0.229 | 2% | 9% | 36% | |
| Food Service | 4,800 | 768 | 1,162 | 173 | 0.278 | 1% | 7% | 29% | |
| Health Care | 12,100 | 1,936 | 2,452 | 436 | 0.239 | 2% | 8% | 34% | |
| Lodging | 37,400 | 5,984 | 3,792 | 1,346 | 0.137 | 3% | 16% | 65% | |
| Office - Large | 15,800 | 2,528 | 1,508 | 569 | 0.131 | 3% | 17% | 69% | |
| Office - Small | 15,800 | 2,528 | 1,197 | 569 | 0.112 | 4% | 21% | 84% | |
| Mercantile/Service | 12,600 | 2,016 | 1,047 | 454 | 0.119 | 4% | 19% | 78% | |
| Warehouse | 16,400 | 2,624 | 604 | 590 | 0.073 | 8% | 39% | 155% | |
| Other | 16,000 | 2,560 | 1,379 | 576 | 0.122 | 4% | 19% | 75% | |



Stakeholder Outreach

Product Supply Chain & Communication Pathways



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



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 Gravelly



Service Providers

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



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)



Stakeholder Outreach

Interview Questions

| Solution Developers | Service Providers | End Users | Enablers |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> • Company size and geographic coverage • Products/services supplied • Market segments (building types/sizes) covered • Percent of business devoted to this market segment • Strategies for reaching market (successful and unsuccessful) • Client buying trends/perspectives on products • Energy performance of products offered • Engagement with program administrators • Challenges for business growth • Perspective on how codes affect business • Recommendations for improving market conditions | <ul style="list-style-type: none"> • Company size and geographic coverage • Products/services supplied • Market segments (building types/sizes) covered • Percent of business devoted to this market segment • Strategies for reaching market (successful and unsuccessful) • Client buying trends • Client perspectives on including or not including SFWAs • Relationship to incentive programs • Challenges for business growth • Perspective on how codes affect business • Recommendations for improving market conditions | <ul style="list-style-type: none"> • Portfolio size • Decision Criteria for choosing SFWA products (e.g., performance, aesthetics, cost) • Experience with using SFWAs (actual use) • Occupant experience • Experience working with service providers and how they sell and install SWAs • Importance of incentives to making decisions • For owners, approach to working with tenants • Changes necessary to increase interest in SFWAs • Prioritization of energy efficiency retrofit projects | <ul style="list-style-type: none"> • Market segments (building types/sizes) covered • Strategies for understanding market <p>For Associations:</p> <ul style="list-style-type: none"> • Client buying trends • Client perspectives on including or not including SFWAs • Relationship to incentive programs • Barriers for market growth • Recommendations for improving market conditions • Challenges demonstrating product performance <p>Utilities:</p> <ul style="list-style-type: none"> • Strategy for reaching customers • Incentives provided for SFWAs • SFWA trending uptake • Engagement with Service Providers • Evidence necessary to incorporate (or incorporate more) SFWAs in program • Challenges or issues encountered for assessments and calculations of energy efficiency • Prospective on how codes affect business • Recommendations for improving market conditions • Incentive programs successful and unsuccessful |



Stakeholder Outreach Synthesis

Overarching Market Messages

- **General**

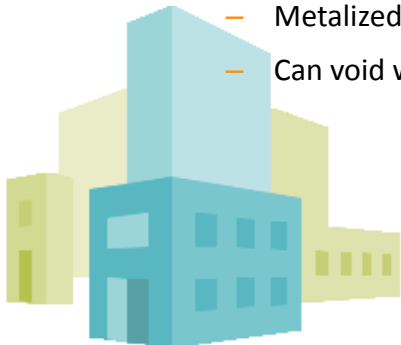
- End users are risk averse – tend to stick to what they know
 - Need confidence in product applied, and the business case needs to be clear; SFWA products have a more complex value proposition which is hard to quantify
 - End user decisions are driven by cost, code, and branding (e.g., Energy Star and LEED Certified space)
 - Innovative technologies are generally first to be replaced with low cost options as construction budgets balloon
- Market is slowly shifting
 - Manufacturers and service providers seeing growth in interest for innovative technologies for occupant comfort, health, and productivity and energy efficiency
 - Tenant requests for green space is increasing
- Overwhelming interest for more information to inform end users
 - Case studies are effective to informing 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 making a decision
 - Solution developers and service providers 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 their benefits (energy savings) and challenges (maintenance)
- 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 dependent on climate, window glass specifications, and solar reflectiveness of fabrics used
- Typically costly due to high likelihood for customization for individual building (trend in desire but cost quickly results in tried and tested interior solutions)



Stakeholder Outreach Synthesis

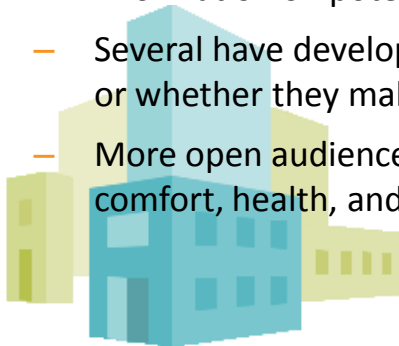
Solution Developers

- **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 provide a diverse variety of products used in both new construction and retrofits
 - Film providers typically provide a narrower set of differentiated products, which have greater uptake for retrofits
- 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, strong focus on educating and selling to service providers, which 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 with comfort and productivity, but little quantitative information on potential savings
- Several have developed simple on-line calculators but no indication of how frequently they are used or whether they make sales
- More open audiences include owner-occupied buildings (e.g., owner strongly interested in occupant comfort, health, and energy)

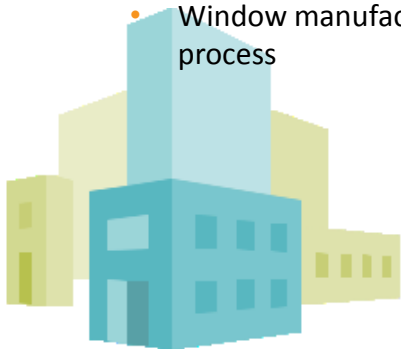


Stakeholder Outreach Synthesis

Solution Developers

- **Challenges**

- Often need to rely on service providers to make the sale to end users. Service providers may not have the expertise to make a sale of more efficient (and more 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 it would be most effectively placed
 - Window manufacturers more receptive to coating vs films because they are familiar and comfortable with the 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 to boutique consultants for modeling to support envelope and daylighting design. These niche firms can be useful to growing the market because of their respected reputation

- **Approaches to Reaching Customers on Energy Efficiency**

- Typically make general statements on energy efficiency, since there is limited 3rd party evidence that they can reference
- 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 not aware of overall benefits
- Service providers need more information on technology advancements



Stakeholder Outreach Synthesis

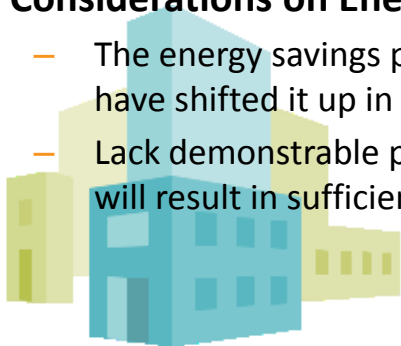
End Users

- **General Stakeholder Perspectives**

- Owner-occupied building end users pay more attention to SFWA options for occupant comfort and health and building efficiency
- Owners/operators predominantly influenced by service providers as more trusted advisors than solution developers directly, 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 tenant turnover in 5 to 7 year
- 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, 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 or 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, and third party verification would be useful
- 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 \$/sqft of film installed
- Proof of concept and accurate approaches to estimating potential savings is critical, and 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



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, tradeshow, 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**

