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Commercial Window Attachments: Secondary Window Market Characterization

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1 Executive Summary

The Northwest Energy Efficiency Alliance (NEEA) engaged Evergreen Economics to conduct a characterization study of the market for secondary windows. This research informs NEEA's development of a program intended to transform the market so that secondary windows become established as the standard product and practice for addressing low-performing windows in existing commercial buildings.

Commercial secondary windows are retrofit products that enhance the performance of an existing window without a full replacement or reglazing. They can be added to existing windows with poor energy performance to mitigate air infiltration, energy loss, or unwanted solar gain, while also offering non-energy benefits to building occupants, thereby offering a lower cost alternative to window replacement. Secondary windows are appropriate for windows with single panes and, in some cases, those without low-emissivity coatings that were introduced in 1979 and became commonplace after 1990.

In contrast to other window attachments like window film, coverings, and shading devices, secondary windows add additional layers of glazing (and framing) to the interior or exterior of the existing window. They are historically related to storm windows used in residential buildings, but are designed and custom-produced for commercial applications. They can be constructed to offer add-ons such as multiple panes, low-emissivity coating, or gas-filled cavities to further enhance their performance and energy savings.

Study Objectives

The study builds on prior information gathered by NEEA and was guided by the following research objectives:

- Determine whether the market differentiates between low-emissivity storm windows and secondary glazing systems;
- Understand how secondary windows are offered by market actors;
- Understand market actors' perceptions of secondary windows;
- Learn market actors' understanding of the possible installation scenarios for secondary windows;
- Understand market actors' perceptions of the best applications for secondary windows;
- Document existing supply chain(s) for secondary windows;
- Confirm barriers and opportunities for secondary windows in the Northwest commercial market;
- Describe current commercial secondary window installations in the Northwest; and

- Identify priorities for a market test.

Study methods included reviews of public-facing market information about secondary window products, interviews with participants in the market's supply chain, interviews with market actors who could potentially use secondary windows in their commercial building upgrade projects, and the development of three case studies.

Key Findings and Recommendations

The market presents secondary windows as one product.

Secondary window providers do not distinguish meaningfully between low-emissivity storm windows (LES) and secondary glazing systems (SGS). Instead, they use varied terms for the products—such as storm windows, secondary windows, window insulation, and window systems—regardless of whether they are technically LES or SGS products.

We recommend that NEEA identify a consistent term to describe secondary windows for its outreach to the market that communicates the product's benefits while maintaining some linkage to the terminology manufacturers are already using.

Manufacturers advertise the availability of secondary windows directly to end-users and targeted market actors.

Manufacturers of secondary windows lead the outreach efforts to raise awareness of their products. Mechanisms include word of mouth, print and internet advertising, and industry events such as trade shows. Some manufacturers prospect by contacting building managers of pre-1980 buildings that still have their original windows.

Market actors have only a limited understanding of secondary windows.

Architects, general contractors, and specialized consultants base their understanding of secondary windows on residential storm windows, which some perceive as a make-shift solution. While they do understand that these products provide energy savings and allow retention of existing windows, they did not have a clear understanding of

- Installed costs of secondary windows compared to replacements;
- Technical specifications and performance characteristics, such as U-values, solar heat gain coefficients, light transmittance, and noise dampening effects; and
- How secondary windows fare with code requirements if a larger retrofit triggers code-based upgrade requirements.

We recommend that NEEA develop a comprehensive educational outreach campaign to address these information-based barriers. The program's outreach should include a one-stop shop for information about secondary windows and their applications. This resource should also address market actors' concerns and questions about secondary windows' costs and building code compliance. Integrating market outreach for secondary windows with other building upgrade opportunities would yield efficiencies and promote holistic building solutions.

Market actors are unsure what the installation process involves.

Market actors without prior awareness of secondary windows held the perception that installation would require specialized skills that are in short supply in the Northwest. However, those familiar with secondary windows believed their usual general contractors would be able to install them.

We recommend that NEEA provide technical assistance services to building decision makers who incorporate secondary windows into their projects for the first time. Technical assistance can overcome not only concerns about installation, but also the perceived risks and additional time required for specifying a building design solution for the first time.

Market actors think secondary windows are a niche product best for historic preservation projects.

Window upgrades are regularly deferred from building renovations due to their comparatively high cost, especially when they compete with other potential building improvements. When upgrades do occur, window replacement is the market norm to address performance issues or aesthetic upgrades to a building's envelope. Market actors think of secondary windows for commercial buildings in more limited terms—such as for historic preservation when existing windows need to be retained—and are unlikely to consider them for routine window upgrades.

We recommend that NEEA

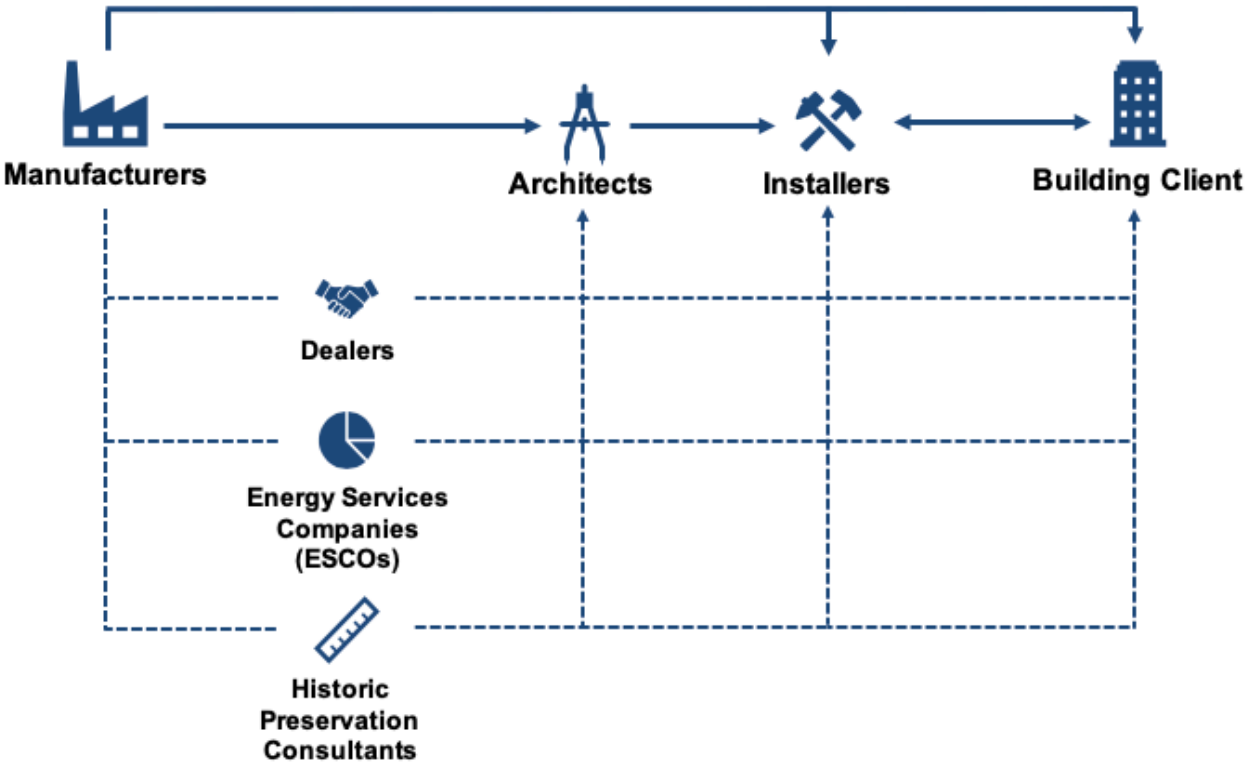
- ***Facilitate preservation efforts with window upgrades using funds available for historic preservation;***
- ***Design its educational campaign to broaden market perceptions of secondary windows' applicability; and***
- ***Consider limited financial incentives to nudge market actors who would otherwise defer action on low-performing windows.***

Manufacturers work directly with building decision-makers.

Manufacturers identified a relatively simple supply chain (Figure 1) in which they tend to work directly with market actors and building decision-makers, although there are variations by project and across manufacturers. Because secondary windows are custom products, they typically go

straight from a manufacturer to an installation site. The supply chain operates similarly throughout the nation.

Figure 1: Current Secondary Windows Supply Chain



Market actors suggest several challenges to market expansion for secondary windows, but also some opportunities.

Interviews with market actors in the Northwest who have used or might potentially use secondary windows for building upgrades suggest the following opportunities and barriers to use of secondary windows:

- **Moderate Awareness and Low Consideration**—Though market actors have some awareness of secondary windows, lack of knowledge about the technology prevents active consideration for most projects.
- **Uncertainty about Commercial Availability**—Some market actors expressed uncertainty about whether manufacturers would be able to scale up custom production sufficiently to meet the needs of large projects within a project's timeline.
- **Information about Technical Specifications**—Market actors involved in product specification and selection did not know where they could easily find needed product specifications for u-values, solar heat gain coefficients, and air infiltration.

- **Building Code Implications**—Some architects wondered whether secondary windows would meet building code requirements when code-related upgrades are triggered by larger renovations.
- **Installation**—Market actors with the least awareness of secondary windows suspected that installation would require specialized skills.
- **Maintenance**—Market actors who had never used secondary windows expressed uncertainty about whether condensation would be an issue and require on-going maintenance.
- **Aesthetic Flexibility**—Architects and historic preservation consultants noted the importance of products that match a building's aesthetics, which serves as a potential opportunity when retention of existing windows is desired (such as in historic buildings) and a potential barrier when secondary windows compete with window replacement (due to the perception that secondary windows are a make-shift solution).
- **Cost**—Manufacturers present secondary windows as a low-cost alternative to window replacement, but some architects and energy services companies perceived new windows and secondary windows as having similar costs. Actual cost comparisons are not readily found.
- **Lack of Comprehensive Strategy by Building Decision Makers**—Building decision makers typically do not use an integrated system strategy for mechanical systems and windows, instead prioritizing mechanical upgrades over building envelope needs.

Historic preservation is a main factor in known installations in the Northwest.

A search for secondary window installations in the Northwest yielded few commercial buildings. Case studies of three of these buildings all involved historic buildings, in which preservation of existing windows and continued operability were key considerations. Budget constraints helped lead to the selection of secondary windows, while noise reduction needs provided the impetus for window upgrades in one building and contributed in a second.

A NEEA market test should focus on expanding market consideration beyond historic buildings.

Historic buildings provide a logical entry point to the market, but NEEA will want to test ways to expand consideration of secondary windows to a broader market, including commercial buildings with single pane or early generations of double pane windows. Expanding the market will require effective information and education about secondary window applications, as well as their costs, benefits, and performance.

For NEEA's market test, ***we recommend the following three strategies:***

1. ***Begin with historic buildings as an entry point*** to showcase secondary windows and demonstration sites that feature not just the historic preservation value, but more general performance and aesthetic characteristics of the products;
2. ***Test the appeal of non-energy benefits***, especially thermal comfort and noise abatement for building occupants; and
3. ***Position program efforts within a broader context of retrofits for existing buildings*** rather than as a windows solution only, so that window improvements are considered by market actors looking to solve building issues that could involve mechanical systems, envelope improvements, or other solutions.

2 Introduction

2.1 Background

Commercial secondary windows are retrofit products that enhance the performance of an existing window without a full replacement or reglazing. In contrast to other window attachments like window film, coverings, and shading devices, they add additional layers of glazing to the interior or exterior of the existing window. They are based on the same principle as storm windows used in residential buildings, which add another layer of glazing and reduce heat transfer. Unlike residential storm windows, however, they are designed and custom-produced for commercial applications and offer additional framing and options that enhance their performance and energy savings. In this section, we describe the range of available products and offerings as well as their common features.

2.1.1 Available Products and Marketed Benefits

There is a wide range of products offered by manufacturers of secondary windows. Most manufacturers offer several different products that can be customized to meet specific needs. All secondary window products require custom measurement of the existing window openings. Different manufacturers and products require a varying number of measurements of the existing window opening for fabrication (e.g., height, width, diagonal). Secondary window products all add an additional layer of glazing to an existing window, creating a thermal break, but there are many product variations, nuances, and opportunities to customize them for clients, including

- **Placement on Either Side of the Existing Window** – Manufacturers offer secondary windows for placement on the inside of the existing window and frame, and some offer outside options that are affixed to the exterior side of the existing window. Interior products appear to be the most common in the commercial setting due to the ease of installation. Exterior installations above the ground floor become difficult due to the additional logistical considerations (such as scaffolding) and associated costs, although one manufacturer is able to install on mid-rise and high-rise commercial buildings.
- **Framing Material** – There is a wide range of framing materials used to house the additional glazing layers being added. The most common framing materials are aluminum, polymer, or wood. One product uses fiberglass. There is usually some level of aesthetic customization available as well; for example, most manufacturers are able to offer different colors to match the aesthetics of the building.
- **Glazing** – Most manufacturers offer a range of glazing options. Most manufacturers use glass glazing but there are some products available that use polymers instead. Some products add a single pane, while others add multiple panes (double or even triple). There

are options to use low-e or tempered glass and add suspended films. Some manufacturers offer double pane glazing, with an argon-filled gap between panes.

- **Installation and Sealing** – The installation methods differ across manufacturers, ranging from permanent to semi-permanent installations. Semi-permanent solutions are not necessarily intended to be removed, but can be if desired in order to clean. Permanent solutions are generally drilled into the existing frame (or some other affixture) and then often sealed with weather stripping. Semi-permanent installations use compression or magnets to affix the secondary window.
- **Manufacturer Support of Installation Process** – There are varying levels of manufacturer involvement in installation; some manufacturers complete the installation or send a representative to assist in the initial installation, while others provide detailed instruction and training to the installing parties.
- **Continued Operability of Existing Windows** – Some manufacturers offer secondary windows that retain the vertical or horizontal operability of the existing window intact; this sometimes requires rebalancing the weighting system, for operable wood windows in particular. Some installation methods render an existing window inoperable.

Figure 2 illustrates the general structure of an interior secondary window.

Figure 2: Example of an Interior Secondary Window

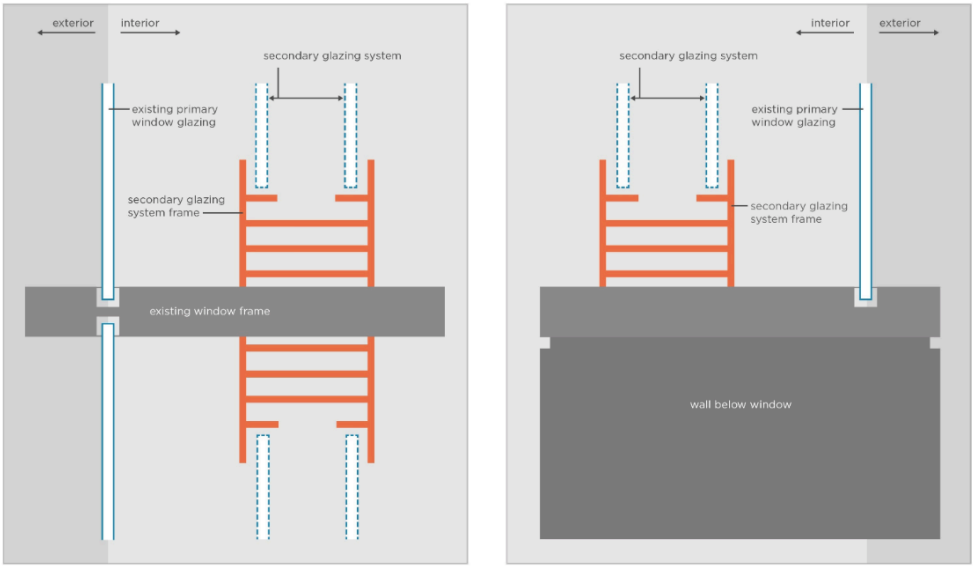


Illustration of a secondary glazing system, showing a center mullion plan view (left) and a sill section view (right).

Manufacturers stress some benefits that are common to secondary windows, while product variation results in unique attributes and benefits as well. Benefits marketed by all manufacturers include

- **Energy Savings** – All manufacturers we identified highlight the potential for energy savings due to decreased heating and cooling requirements. Secondary windows help to reduce energy usage by lowering heat transfer (i.e., lower u-value) and solar heat gain. Depending on the installation, they can also help to lower air infiltration due to leaky, existing frames. Some manufacturers prominently display technical specifications, such as u-values, solar heat gain, and air infiltration on their websites. However, these values can vary greatly depending on the existing window and frame, and total energy savings depend on building characteristics beyond just window specifications.
- **Cost Effectiveness Relative to Replacement** – Manufacturers highlight the low cost of secondary windows relative to a full replacement. They indicate that with installation of secondary windows, buildings get many of the same benefits of new windows for a fraction of the cost, but these costs vary widely and depend on the products and options selected, the size of the order, and installation. Some manufacturers noted that secondary windows could be 50 to 75 percent of the price of replacement windows.
- **Tenant Comfort (Noise and Thermal)** – Manufacturers indicate that secondary windows decrease noise and increase thermal comfort. Some manufacturers go so far as to provide data about these benefits. The added layer of glazing helps to drown out external noise; it also creates a thermal break that can help to stabilize temperature swings associated with inefficient windows, and depending on how they are installed, secondary windows can help reduce drafts from air leakage. These products can also help to stabilize temperature swings associated with solar heat gain that passes through the window.

Further, some manufacturers stress

- **Ease of Installation** – Products can be installed by any skilled general contractor and do not necessarily require a glazing expert. Some manufacturers of semi-permanent solutions even highlight that facilities managers would be capable of installing interior secondary windows.
- **Architectural Identity** – Secondary windows retain the existing window and accompanying architectural identity. This is especially important in historic preservation settings.
- **Increased Protection** – A limited number of manufacturers highlight the added security that secondary windows can provide. Secondary windows installed on lower level floors make break-ins through windows more difficult due to the additional layer of glazing. One manufacturer highlights the added blast (from explosion) protection that results from secondary windows.

Key information about these products that is not yet sufficiently quantified and documented includes their energy performance and tenant comfort benefits. While manufacturers advertise energy savings as a benefit, technical product specifications are not always featured, and actual energy performance in existing commercial buildings in the Northwest will depend on the state of the existing windows, the building's HVAC system, and local climate. Similarly, the performance of secondary windows for building occupants has not been quantified or characterized in a way that provides managers of commercial buildings or design professionals with enough detail to make informed choices. We present more thoughts on these topics in the discussion about field and market tests below.

For more background on secondary windows, the available products, and the manufacturers that offer them, see Section 3.1. The remainder of the report focuses on the research objectives and insights gained about each one.

2.2 Study Objectives and Methods

2.2.1 Objectives

The research objectives addressed by this study are to

- Determine whether the market differentiates between low-emissivity storm windows and secondary glazing systems;
- Understand how secondary windows are offered by market actors;
- Understand market actors' perceptions of secondary windows;
- Learn market actors' understanding of the possible installation scenarios for secondary windows;
- Understand market actors' perceptions of the best applications for secondary windows;
- Document existing supply chain(s) for secondary windows;
- Confirm barriers and opportunities for secondary windows in the Northwest commercial market;
- Describe current commercial secondary window installations in the Northwest; and
- Identify priorities for a market test.

2.2.2 Methods

The study relied on a staged investigation of products and supply chains; existing applications of secondary windows; and exploration of awareness, perceptions, and potential applications by market actors who have not previously used secondary windows. This work drew on a review of secondary information sources and NEEA documents followed by interviews with the following market actors:

- Secondary window manufacturers;
- Building owners and decision-makers for building renovation projects in the Northwest that employed secondary windows; and
- Downstream market actors—such as architects, energy services companies, historic preservation consultants, and installers (general contractors and glaziers)—who could use secondary windows or advocate for them on projects, but have not yet done so.

We analyzed interview responses, as well as documents provided to us by interviewees and public-facing product information (for manufacturers) and building information (for case study sites). The focus of our analysis was to understand products, stated and revealed preferences, and market potential through a comparison of providers' (manufacturers') value propositions and reactions to secondary windows from downstream market actors.

Table 1 summarizes the data collection activities and sources by research objective.

Table 1: Data Collection Summary

Research Objective	Data Collection Method				
	Program staff and industry association interviews (n=7)	Secondary research and document review	Manufacturer interviews (n=9)	Users of secondary windows interviews (n=4)	Potential users of secondary windows interviews (n=19)
Determine whether the market differentiates between low-emissivity storm windows and secondary glazing systems	✓	✓	✓		
Understand how secondary windows are offered by market actors		✓	✓		
Understand market actors' perceptions of secondary windows	✓			✓	✓
Learn market actors' understanding of the possible installation scenarios for secondary windows			✓	✓	✓
Understand market actors' perceptions of the best applications for secondary windows			✓	✓	✓

Research Objective	Data Collection Method				
	Program staff and industry association interviews (n=7)	Secondary research and document review	Manufacturer interviews (n=9)	Users of secondary windows interviews (n=4)	Potential users of secondary windows interviews (n=19)
Document existing supply chain(s) for secondary windows			✓	✓	
Confirm barriers and opportunities for secondary windows in the Northwest commercial market			✓	✓	✓
Describe current commercial secondary window installations in the Northwest			✓	✓	
Identify priorities for a market test			✓	✓	✓

3 Findings

3.1 Market presents secondary windows as one product.

Research objective addressed:

Determine whether the market differentiates between low-emissivity storm windows and secondary glazing systems.

One core question NEEA posed for this market characterization was whether the market presents low-e storm windows (LES) and secondary glazing systems (SGS) as one product or differentiates between them. An examination of available products and how they are positioned indicates that manufacturers and the market characterize both types of secondary windows as a single solution; both products enhance the existing window without replacement. The interior and exterior distinction is presented as a detail rather than a distinguishing factor.

We identified 19 manufacturers that provide secondary window products and completed in-depth interviews with nine of them. Information on the remaining manufacturers was collected from manufacturer websites and other publicly available information. These manufacturers vary in size and sophistication, products offered, and markets served. A majority of manufacturers are located in the Midwest and Northeast, where commercial secondary windows are a more common application. Eleven manufacturers offer secondary windows for commercial and residential use, while some only offer products intended primarily for application in one (two for residential and six for commercial).

As shown in Table 2, the 19 manufacturers we identified use varied terms to refer to their products. A variation of storm windows is most common; only a third include any reference to their products' placement on the inside of existing windows in their primary terminology.

Table 2: Known Manufacturers of Secondary Windows

Manufacturer	Location	Product Description (Manufacturer Language)	Interior or Exterior Product	Market Served	Primary or Auxiliary Product
Allied Window	Cincinnati, OH	Storm Windows	Both	Residential and Commercial	Primary

Manufacturer	Location	Product Description (Manufacturer Language)	Interior or Exterior Product	Market Served	Primary or Auxiliary Product
Alpen	Niwot, CO	Secondary Window	Interior	Residential and Commercial	Auxiliary
ARC	California, New York	Window Insulation Panels	Interior	Unknown	Primary
Chosen	Canby, OR and Seattle, WA	Insulating Pane	Both	Residential and Commercial	Auxiliary
Cityproof	Long Island City, NY	Interior Windows	Interior	Commercial	Primary
Climate Seal	Chaska, MN	Storm Windows	Interior	Residential and Commercial	Primary
Indow	Portland, OR	Storm Window Inserts	Interior	Residential and Commercial	Primary
Innerglass	Simsbury, CT	Interior Storm Windows	Interior	Residential and Commercial	Primary
Inovues	Houston, TX	Glazing Retrofit System	Exterior	Commercial	Primary
Larson	South Dakota, Iowa, North Carolina	Interior and Exterior Storm Windows	Both	Residential and Commercial	Primary
Magnetite	Houston, TX	Interior Secondary Glazing Panel	Interior	Residential and Commercial	Primary
Maine Glass	Chicago, IL	Interior Insulating Windows	Interior	Commercial	Primary
ProVia	Sugarcreek, OH	Storm Windows	Both	Residential	Auxiliary
QuantaPanel	Lancaster, PA	Storm Windows	Both	Residential and Commercial	Primary
Renovate by Berkowitz	Narberth, PA	Window Retrofit	Interior	Commercial	Primary
Thermolite	South Bend, IN	Secondary Interior Window Systems	Interior	Commercial	Primary
Wausau Window	Wausau, WI	Interior Accessory Windows	Interior	Commercial	Auxiliary

Manufacturer	Location	Product Description (Manufacturer Language)	Interior or Exterior Product	Market Served	Primary or Auxiliary Product
Wex Energy	Rochester, NY	Windowskins	Interior	Residential and Commercial	Primary
Window Saver Company	Edmond, OK	Interior Storm Windows	Interior	Residential	Primary

3.2 Manufacturers promote secondary windows directly.

Research objective addressed:

Understand how secondary windows are offered by market actors.

Manufacturers of secondary windows vary in their size, in the role secondary windows play in their overall portfolios of products, and consequently in their marketing. We reviewed market-facing information of 19 manufacturers and interviewed representatives from 9 of these companies. Many manufacturers focus on a broad market that can include both the commercial and residential sectors, while some address specific markets, such as historic preservation, hospitality, and government applications. Secondary windows are the primary product of most manufacturers identified (15 of 19 manufacturers), but there are some that offer them as an auxiliary product or in conjunction with some other service.

Most manufacturers market directly to potential end-users and project specifiers. They rely heavily on word of mouth by market actors that have used the products on previous, successful implementations. These initial implementations may have been generated by traditional marketing or active prospecting. Prospecting generally focuses on particular vintages and conditions of local commercial buildings and may involve reaching out to building managers of pre-1980 buildings that still have their original windows.

Some manufacturers also engage in traditional marketing such as print and Internet advertising, or have a presence at trade shows. Large companies, usually those that offer secondary windows as an auxiliary product, have more extensive marketing and supply chain efforts than smaller, sometimes family-run businesses.

3.3 Market actors have a limited understanding of secondary windows.

Research objective addressed:

Understand market actors' perceptions of secondary windows.

Market actors interviewed for this study did generally acknowledge awareness of secondary windows, but tended to think of the product in a limited capacity. Most architects and installers and all historic preservation consultants and energy service company representatives we interviewed indicated that they knew of secondary windows. Some specifically called out awareness of one Northwest-based manufacturer (Indow). For others, awareness was driven by knowledge of storm windows for the residential sector and an understanding that similar principles apply to commercial windows. However, residential storm windows sometimes carry the stigma of being an inelegant make-shift solution. There was little awareness of the full breadth of products and manufacturers available to the commercial market.

Active consideration for projects was low. Market actors indicated that they were open to and interested in using them "if the right project came along." An architect heavily involved in one of the case studies we developed echoed this idea. He said he would use secondary windows again now that he has had positive experiences with them, but even he thought of the product in a limited vein—in his case, for historic buildings.

Furthermore, while market actors interviewed for this study do understand that these products provide energy savings and allow retention of existing windows, they indicated a need for more information about

- Installed costs of secondary windows;
- Technical specifications and performance characteristics; and
- Building code implications if a larger retrofit triggers code-based upgrade requirements.

3.3.1 Market actors are unsure of installation costs.

Not surprisingly, costs were identified as a key driver of whether windows are upgraded and in what way. Although manufacturers of secondary windows feature them as a low-cost alternative to window replacement, some architects and energy services companies expressed the perception that new windows would be generally in the same cost range or not much more expensive than custom-produced secondary windows. Given the importance of lower cost as a driver for

secondary windows, the high variability and lack of clarity about the actual cost differential to window replacement is key.

As one architect who was not previously aware of secondary windows said,

> *"I would assume it would be less expensive than a new window, otherwise I wouldn't use it."*

At the same time, market actors noted that any type of window upgrade is expensive and sometimes gets crowded out of comprehensive retrofit projects for this reason.

3.3.2 Market actors cannot easily find technical specifications.

Market actors involved in product specification and selection—such as architects—identified the need for easily available product specifications for such parameters as U-values, solar heat gain coefficients, and air infiltration. Indeed, manufacturers' market-facing product information does not tend to feature these parameters in an easy-to-find or easy-to-compare way.

For example, one architect who was not aware of secondary windows said he would consider them, but "*there would have to be U-value testing, otherwise I would not bother.*"

3.3.3 Architects are unsure of building code implications.

Some architects indicated uncertainty whether secondary windows would meet building code requirements when code-related upgrades are triggered by larger renovations. Architects noted that they understand the code requirements where they work most frequently, but recognize regional variation in both the code requirements and what level of renovations would trigger the need to upgrade systems to current codes.

3.4 Market actors are unsure what the installation process involves.

Research objective addressed:

Learn market actors' understanding of the possible installation scenarios for secondary windows.

Installation was generally not a major concern among market actors, but maintenance considerations did reveal some concerns about condensation. Architects, in particular, mentioned that they would rely on their general contractors to figure out installation and did not express specific concerns about the process of getting secondary windows installed. Nevertheless, some interviewees did comment that they see a shortage of skilled labor for any kind of work on

windows (i.e., for reglazing and window restoration) and may be under the impression that secondary window installations could require that level of skill.

The small number of downstream market actors we interviewed who had not previously been aware of secondary windows did express concerns about potential condensation, and some of our interviewees were under the impression that secondary windows would need to be removed seasonally or require removal for cleaning.

3.5 Market actors think secondary windows are a niche product.

Research objective addressed:

Understand market actors' perceptions of the best applications for secondary windows.

Architects consistently described replacement of windows as the standard market solution for addressing window performance issues or improving aesthetics of existing buildings. This market norm—coupled with market actors' limited knowledge of the full range of potential applications for secondary windows—means secondary windows rarely get consideration for window upgrade projects or building renovations that require some form of window improvement. Instead, market actors who indicated some awareness of secondary windows suggested that they would think of them if their primary solution is not feasible, such as for historic buildings where existing windows need to be retained.

3.6 Manufacturers work directly with building decision-makers.

Research objective addressed:

Document existing supply chain(s) for secondary windows.

Manufacturers of commercial secondary windows identified a relatively simple supply chain in which they tend to work directly with building decision-makers or their direct representatives, generally bypassing midstream actors such as distributors, wholesalers, or retailers. Because secondary windows are custom products, they typically go straight from a manufacturer to an installation site. Our assessment of the supply chain revealed four primary market actors:

1. **Manufacturers** offer a wide range of products and solutions. The manufacturers offer base models with customization options and tend to work with customers directly to identify

and tailor the best solutions for their needs. The direct relationship also facilitates custom-manufacturing to customer sizing needs.

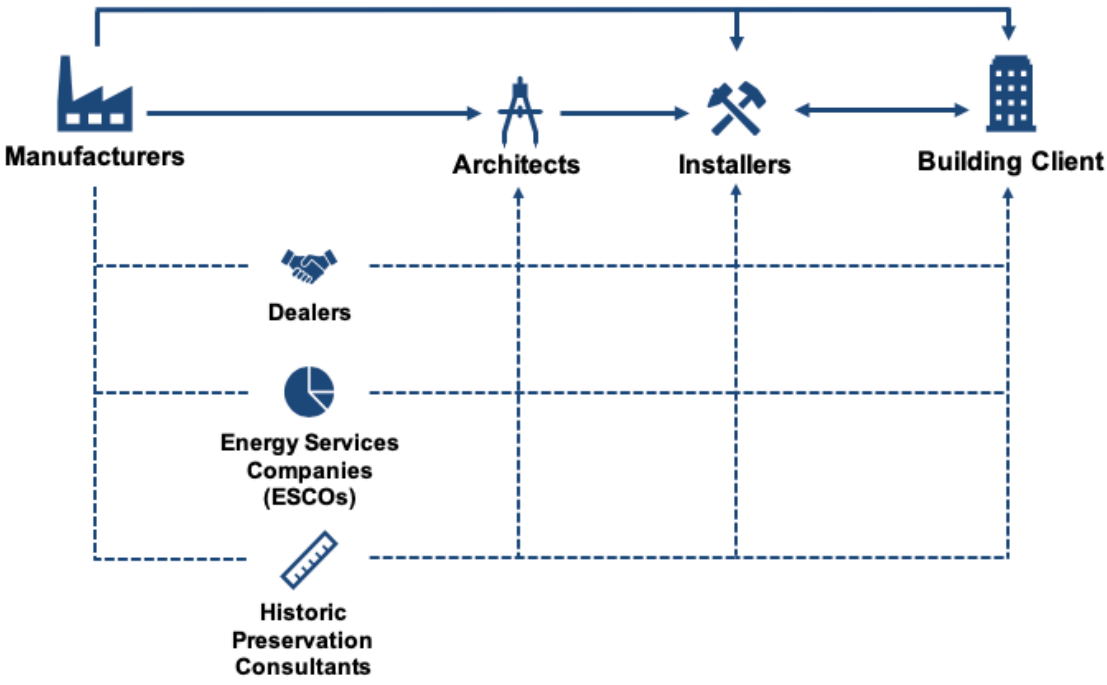
2. **Architects** present secondary windows for consideration as part of a larger renovation, or may be involved as consultants to assess structural or other implications in window-only replacement applications. They may rely on general contractors to research specific manufacturers and products.
3. **Installers** are usually general contractors or glazing experts. Most manufacturers do not require or expect their products to be installed by glazing experts, but it appears that other market actors tend to think of and turn to specialists for window installations of this sort. These individuals work with all other actors involved in the process.
4. **Building Clients** may consist of an owner's representative, property management firm, development firm, or facility managers. They ultimately sign off on the final decision to use secondary windows as a solution, tend to be involved in weighing trade-offs among competing strategies (e.g., secondary windows or replacement), and be presented with the secondary window to be installed. To the extent that a building upgrade is being conducted for specific tenants or as part of churn in tenancy, building tenants may be part of the "building clients" group.

For some manufacturers or projects, secondary market actors provide recommendations and support to primary actors as needed:

1. **Dealers** may represent multiple product types (beyond secondary windows) and manufacturers. Only large manufacturers with existing infrastructure utilize regional dealers.
2. **Energy Services Companies (ESCOs)** assist with projects that help buildings save energy and decrease operational costs. They may work on standalone projects or be involved in a larger renovation. These market actors are the most technically advanced group.
3. **Historic Preservation Consultants** help clients in the restoration or rehabilitation of a building with historic significance. This usually involves accessing publicly available funds to pay for the restoration.

A detailed supply chain of interactions is presented below in Figure 3. A commentary of the most common interactions and scenarios follows.

Figure 3: Current Secondary Windows Supply Chain



The dashed lines represent interactions that occur less frequently. They represent intermediate connections that enable and promote the decision-making process to include secondary windows. A limited number of manufacturers sell products through third party dealers. In projects that involve these products, market actors purchase from and interact with the dealer. Limited scope retrofits and larger renovations may involve an ESCO or historic preservation consultant. These market actors may suggest or specify secondary windows as a solution.

From the manufacturer's perspective, projects involving secondary windows fall into two groups, each with a different project initiation process:

Stand-alone window upgrade projects may be initiated by building decision-makers who have identified a window-related need or involve prospecting by manufacturers who successfully sold the value of a window upgrade. In both cases, manufacturers are often the ones that inform building decision-makers of the availability of secondary windows as a more affordable option to window replacement.

Large-scale building renovations that include window upgrades are initiated by building decision-makers and involve the use of an architect, design-build firm, or general contractor. In these cases, manufacturers seek to engage the design team or general contractor and inform them of secondary windows as an option for window upgrades.

These two scenarios appear to be the predominant paths from manufacturers to buildings; they are presented as solid links in the supply chain above. As noted, some manufacturers are able to identify potential projects based on the vintage and condition of commercial buildings. In general, manufacturers that seek to identify specific buildings for marketing are looking for structures built before the 1980s that are likely to have single pane (or early double pane) windows.

Simultaneously, manufacturers are seeking to increase awareness of their products through general outreach to design professionals for consideration in their portfolios of work. Most rely heavily on word of mouth among market actors (such as general contractors or architects) that have used the products on previous, successful implementations. Some manufacturers engage in traditional marketing, such as print and internet advertising, and have a presence at trade shows to complement their active prospecting for specific candidate buildings.

Manufacturers appear to be more established and see more market activity in the Northeast and Midwest than in the Northwest, where fewer relationships have been cultivated. However, their supply chain works the same across the entire country. Generally, they initiate outreach and conduct their work from wherever they are based, and manufacturers expressed enthusiasm about serving the Northwest more than they currently do.[1]

In addition to mapping the supply chain as it appears to manufacturers, we explored decision-making about upgrades from the perspective of building decision-makers and discuss our findings in Appendix B.

3.7 Market actors suggest multiple challenges and some opportunities.

Research objective addressed:

Confirm barriers and opportunities for secondary windows in the Northwest commercial market.

[1] Questions NEEA posed about the practicality of shipping window products long distances from manufacturing sites to buildings in the Northwest did not come up during manufacturer interviews. In one case study, we note that a Portland-based manufacturer was able to treat existing windows from a building in Eugene then install secondary windows upon re-installation. Otherwise, interviewees did not discuss distance.

Discussions with downstream market actors revealed multiple potential opportunities, barriers, and other considerations that would affect whether they might use secondary windows in commercial applications in the future.[2]

3.7.1 Moderate Awareness and Low Consideration (opportunity and barrier)

As noted previously, market actors interviewed for this study did generally acknowledge awareness of secondary windows, but tended to think of the product mostly for historic preservation projects and were not attuned to their application in other existing buildings. As a result, active consideration of secondary windows for window upgrades is low. See Section 3.3 for further discussion of market actor awareness.

3.7.2 Uncertainty about Commercial Scale Availability (barrier)

When asked further about potential use of the products, some market actors expressed concern about the scale at which secondary windows would be available for commercial applications. Interviewees tended to be familiar with smaller manufacturers that, they believed, could not scale up quickly to meet the demands and timeline of a larger-scale commercial project. Availability of products when window work fits into a project—especially for larger remodels in which project stages need to be coordinated—is important.

To illustrate, one architect stated that

> *"We are familiar with a limited number of products that are mostly aimed at the residential market. Most of these manufacturers are not geared to provide quantity or schedule for commercial application."*

3.7.3 Technical Specifications Important for Product Selection (barrier)

Market actors involved in product specification and selection—such as architects—identified the need for easily available product specifications for such parameters as U-values, solar heat gain coefficients, and air infiltration. Indeed, manufacturers' market-facing product information does not tend to feature these parameters in an easy-to-find or easy-to-compare way. See Section 3.3.2 for further discussion about the need for technical specifications.

[2] Prior sections of the report also discuss some of these opportunities and barriers in the context of other research objectives. We repeat previously identified barriers and opportunities in this section in the interest of providing a comprehensive list here.

3.7.4 Clarity of Building Code Implications (barrier)

Some architects indicated uncertainty whether secondary windows would meet building code requirements when code-related upgrades are triggered by larger renovations. See Section 3.3.3 for further discussion about building code considerations.

3.7.5 Uncertainties about Installation (barrier)

Installation was generally not a major concern among market actors except for a small number who had not previously heard of secondary windows at all. When we described the product to them, they wondered whether it would require specialized installation skills. See Section 3.4 for further discussion of this potential barrier.

3.7.6 Uncertainties about Maintenance (barrier)

Similarly, market actors without experience with secondary windows expressed concerns about potential condensation and wondered how moisture build-up would need to be handled. See Section 3.4 for further discussion of this potential barrier.

3.7.7 Aesthetic Flexibility (opportunity and barrier)

Architects and historic preservation consultants raised the importance of aesthetics. Some volunteered the perception that secondary windows would be aesthetically unpleasing even if they are functionally effective. They noted that it is important that any window solution they specify be a good fit with a building's overall aesthetic and that the windows should remain functional. Not having seen secondary windows in actual buildings, interviewees seemed uncertain whether secondary windows would meet their aesthetic needs.

Historic preservation consultants highlighted the importance of matching the aesthetics and materials (i.e., using wood secondary windows if the existing windows are wood) of the historic time period of a building, which again requires aesthetic flexibility. Here, too, historic preservation consultants appeared to be speaking broadly and were generally (but not exclusively) concerned about external aesthetics and the historic integrity of building facades. Historic preservation consultants noted that within the historic preservation community, there tend to be negative views of energy efficiency efforts. This is due to the fact that energy efficiency efforts usually promote the replacement of components of historically significant buildings, while secondary windows may work better for historic preservation than most other energy efficiency opportunities.

3.7.8 Unclear Product Costs (opportunity and barrier)

While manufacturers feature secondary windows as a low-cost alternative to window replacement, some architects and energy services companies expressed the perception that new windows would be generally in the same cost range or not much more expensive than custom-

produced secondary windows. See Section 3.3.1 for further discussion of this potential opportunity and barrier.

3.7.9 Lack of Comprehensive Strategy by Building Decision-Makers (barrier)

Downstream market actors and manufacturers interviewed for this study consistently commented that building decision-makers do not follow integrated building system strategies and that mechanical systems often get consideration before building envelope needs. This hierarchy and lack of holistic thinking about energy needs result in inaction on windows (or other shell improvements) as an option for improving energy efficiency.

3.7.10 Most Promising Fit for Secondary Windows

Results from this market characterization suggest a hierarchy of potential real-world applications for secondary windows. We present promising applications in Table 3.

Table 3: Preconditions and Promising Applications

Consideration	Conditions that Present the Best Fit	Notes
Building constructed before 1980	Buildings with official historic building designations. Older buildings in which the owner values the older exterior and appearance.	Newer buildings have double pane windows and more sophisticated window systems for which secondary windows offer less benefit. There may be some benefit for buildings constructed in the 1980s if the secondary windows add low-e coating. Otherwise, older buildings are the best fit.
Building or occupant issues	Issues with thermal heat loss / solar gain (especially when paired with less efficient HVAC). External noise. Cold or drafty occupant spaces near windows.	These are key non-energy benefits that have prompted existing installations, both for occupant benefits and for market competitiveness of leased space.
Market conditions	Markets in which older buildings compete for tenants (with each other or with new construction).	May point to markets with excess supply or with high rates of growth and new construction, such as Portland, Seattle, and Boise.

Consideration	Conditions that Present the Best Fit	Notes
Building design activity	Buildings in which facility staff are actively problem solving to address performance concerns associated with windows. Buildings with planned retrofits that are early in the design process.	Introducing secondary windows into existing problem-solving considerations may be easier than targeting those experiencing latent issues, but there are narrow windows of opportunity during design processes before choices are locked in place.
Priority for energy and sustainability	Green or sustainability goals Decision-maker incentives / agency	Decision-makers who value energy efficiency for its own sake and who prioritize it for cost savings (if split incentives are not present) will experience greater benefits. Those with sustainability goals may also be swayed by the benefit of maintaining existing windows and reducing construction waste.
Building heating and cooling load **Existing mechanical systems** **Climate**	Presence of high heating and cooling loads. Inefficient heating and cooling system. Colder climates for heating benefits, warmer climates for cooling benefits.	Building-specific heating and cooling needs, existing mechanical systems, and local climate factors interact to create building-specific benefits (or lack thereof) of addressing window performance issues.

3.8 Historic preservation is a main factor in known Northwest installations.

Research objective addressed:

Describe current commercial secondary window installations in the Northwest.

A search for secondary window installations in the Northwest yielded few commercial buildings. Case studies of three such buildings revealed preservation of existing windows in older buildings and continued operability as factors leading to the selection of secondary windows while also

revealing additional considerations, processes, and satisfaction with the secondary windows' performance.

Potential case studies were gathered from NEEA and manufacturers interviewed for this study. Some potential case studies proved not to be feasible due to false leads, decision-maker disinterest, and job changes. The case study data collection included questions about the project background, decision-making, installation process, and project outcomes. Individuals that participated were offered an incentive for their time. Table 4 presents an overview of the three completed case studies. The full case studies are attached as Appendix A.

Table 4: Completed Case Studies

Building Name	Location	Building Type	Number of Interviews	Interviewee Roles
University of Oregon Straub Hall	Eugene, OR	University lecture and office building	2	• Architect • Windows manufacturer and installer
Olympic Mills Commerce Center	Portland, OR	Office commercial building	1	• Property manager (who also provided tenant testimony)
Society Hotel	Portland, OR	Hotel	1	• Energy consultant, general contractor, and property manager

Each case study provided a different perspective and application of secondary window attachments. However, there were commonalities and key take-aways shared among case studies, which we summarize here:

- **Windows with historic value:** Interviewees from all three sites identified historic building preservation as one of the main goals of the window retrofit. Both the Olympic Mills Commerce Center and the Society Hotel were registered historic preservation sites and had to follow specific requirements, while the University of Oregon itself wanted to preserve the appearance of Straub Hall.

- **Windows that need to remain operable:** Both the Straub Hall site and the Olympic Mills Commerce Center identified window operability as a benefit of using secondary attachments. In comparison to external storm windows, which would make a window inoperable, the secondary attachments were installed on the building interior and allowed for the continued operation of the windows.

- **Windows with soundproofing needs:** Both the Olympic Mills Commerce Center and the Society Hotel chose secondary attachments for their soundproofing ability. Many tenants at the Olympic Mills Commerce Center reported noise disruptions due to nearby trains, and they were pleased with the noise reductions after the attachments were installed. Similarly, the Society Hotel's proximity to nearby clubs and bars made soundproofing the windows one of the owners' main goals. The secondary attachments eliminated most of the noise from the nearby venues, and the owners were satisfied with the performance of the attachments.

- **Cost-effective solution within project budget:** Interviewees from all three sites mentioned cost as an important factor in the decision-making process. At all three sites, window attachments provided a lower-cost alternative that had comparable benefits (e.g., energy savings, noise and thermal insulation) to complete window replacements. An interviewee representing the Society Hotel site in particular mentioned that the window attachments were the most cost-effective renovation option, given their limited renovation budget.

3.9 Market test should focus on expanding market considerations.

Research objective addressed:

Identify priorities for a market test.

Given the current early stage of the secondary windows market and uncertainties concerning its full potential, we anticipate that NEEA's market testing will entail a staged approach. This staged approach will first explore whether secondary windows have traction in markets, buildings, and scenarios that offer the best potential fit for the products and then broaden the exploration to understand where else in the market the products might obtain a foothold.

The staged approach would suggest that market testing among early adopters would be most viable in

- **Historic buildings** – As noted, historic buildings appear to offer the best fit and most logical entry point to the market for secondary windows. While a niche market, historic buildings

offer an opportunity to showcase secondary windows and provide a launch point that can generate demonstration sites, which can be useful for allowing decision-makers who work with other building types to see the products once installed. Historic buildings are relatively easy to identify, and the availability of funding for historic building renovations can leverage NEEA investments in market tests.

- **Buildings with applicable occupant concerns, such as noise and comfort issues near windows** – While more challenging to identify, buildings with current occupant concerns such as external noise and comfort issues near single pane windows offer a second logical test market. Testing the potential traction and interest in secondary windows among building owners whose occupants experience these concerns offers the opportunity to test interest in secondary windows as well as potential marketing channels and messages. Testing potential traction and interest also offers the opportunity to further understand the strength of identified drivers and barriers.
- **Buildings undergoing broader retrofits to improve their performance** – Given that existing commercial buildings often offer a wide range of performance upgrade opportunities—spanning from improved operation and maintenance practices to lighting and HVAC system upgrades to controls—secondary windows could be presented to building owners and operators as one of a menu of upgrade options. Presenting the full range of performance enhancing opportunities is more efficient for the target audience and for program staff, although it does require coordination across teams. NEEA could test secondary windows as part of any existing holistic outreach by NEEA and its utility partners to decision-makers for existing buildings, or NEEA could test such outreach and examine how secondary window opportunities are received when presented alongside other retrofit options.

Market interventions that NEEA may wish to test early in the process include

- **Information and education.** Market-facing information will need to address the limited understanding and information gaps currently prevalent among market actors, including perceptions that secondary windows are primarily for historic buildings and the detailed information on costs and performance characteristics.
- **Technical assistance to interested market actors wishing to explore secondary windows.** NEEA-provided technical assistance can reduce the risk and learning curve and associated costs for market actors exploring secondary windows for the first time.
- **Inclusion of secondary windows as an option provided as part of other existing building retrofit programs.** Secondary windows could be added as an option offered and discussed by existing utility or similar programs in the Northwest that serve the commercial building retrofit market.

We provide some additional observations about NEEA's field test in Appendix C.

4 Recommendations

The results of our characterization study have implications for an overall program design and potential interventions, as well as more near-term testing that NEEA incorporates into its initiative lifecycle process. Based on the characterization of the market, opportunities, and barriers described above, we recommend that NEEA:

Identify a consistent term to describe secondary windows for its outreach to the market that communicates the product's benefits while maintaining some linkage to the terminology manufacturers are already using.

Develop a comprehensive educational outreach campaign to address information-based barriers. The program's outreach should include a one-stop shop for information about secondary windows and their applications. This resource should also address market actor concerns and questions about secondary window costs and building code compliance. Integrating market outreach for secondary windows with other building upgrade opportunities would yield efficiencies and promote holistic building solutions.

Provide technical assistance services to building decision makers who incorporate secondary windows into their projects for the first time. Technical assistance can overcome not only concerns about installation, but also the perceived risks and additional time required for specifying a building design solution for the first time.

Structure its efforts to grow the market for secondary windows by

- ***Facilitating preservation efforts with window upgrades using funds available for historic preservation;***
- ***Designing its educational campaign to broaden market perceptions of secondary windows' applicability; and***
- ***Considering limited financial incentives to nudge market actors who would otherwise defer action on low-performing windows.***

For NEEA's market test, ***we recommend the following three strategies:***

1. ***Begin with historic buildings as an entry point*** to showcase secondary windows and demonstration sites that feature not just the historic preservation value, but more general performance and aesthetic characteristics of the products;
2. ***Test the appeal of non-energy benefits***, especially thermal comfort and noise abatement for building occupants; and

3. ***Position program efforts within a broader context of retrofits for existing buildings*** rather than as a windows solution only, so that window improvements are considered by market actors looking to solve building issues that could involve mechanical systems, envelope improvements, or other solutions.

Appendix A: Case Studies

We developed three case studies of current, known installations of secondary windows in the Northwest. We described core findings from those studies in Section 3.8 and attach the full case studies here.

University of Oregon Straub Hall

Secondary Window Attachment Case Study

Executive Summary

The University of Oregon completed a major renovation of Straub Hall in 2014 that included modernization of the building's original single-pane windows. The university selected Chosen Windows' SLIP attachments to preserve the historical appearance and window operability while improving thermal comfort and efficiency. Chosen Windows' presence on the project team and laboratory testing by the university facilitated selection of window attachments over replacement.

Project Timeline

Quick Facts

Building Facts:

- **Location**: Eugene, OR
- **Size of Building**: 58,000 square feet
- **Age**: Built in 1928 – 91 years old
- **Occupancy**: Classrooms, lecture halls, faculty offices
- **Ownership**: University of Oregon
- **HVAC system**: Hydronic Radiant Heating and Chilled Water Cooling (updated during renovation to match the university-wide hydronic radiant heating system)

Window Facts:

- **Number of Windows Upgraded**: 250 (100% of windows)
- **Size of Windows**: 3 ft wide x 5 ft tall
- **Window Frames**: Wood
- **Previous Window Type**: Single-pane and double-hung
- **Condition of Original Windows**: Excellent
- **Cost of Window Attachment Project**: $500,000
- **Cost of Entire Renovation Project**: $44 million

University of Oregon Straub Hall

Secondary Window Attachment Case Study

Project Background

Originally constructed in 1928, the University of Oregon's Straub Hall building first operated as a dormitory and later as the central location for the school's Psychology and Linguistics departments. With four stories of classrooms and lecture halls, Straub Hall is a prominent historical landmark on the university's Northeast Central campus.

Project Impetus

The University of Oregon began to discuss the major renovation of Straub Hall in 2011. This renovation was necessary to meet the educational needs of students and faculty: creating modern learning spaces (including the first two-story lecture hall) and expanding the building space. The university aimed to preserve the historic appearance of Straub Hall, particularly in the case of the building exterior, which included approximately 250 windows.

Original windows

The original windows in Straub Hall were single-pane, double-hung windows. The window panes themselves were in an excellent condition and had wooden frames, which were also in a good condition. However, many of the windows in Straub Hall had become inoperable over time. As a result, many building occupants were unable to open their windows.

Additionally, the original windows were not weather-stripped, so many spaces in Straub Hall were drafty, particularly in the winter. Before the 2014 renovation, occupants stated that although sections of the building had felt warm (due to fireplaces within the building), sections of the building near the windows felt chilly.

University of Oregon Straub Hall

Secondary Window Attachment Case Study

Decision Making

While the windows themselves were only a small part of the larger project, many individuals were involved in the decision-making process, including:

- **University of Oregon** officials, who were the main financial decision makers and hired Chosen Windows for the renovation project. The university wanted to preserve the historical appearance of the building.
- **Rowell Brokaw**, the project architects.
- **Chosen Windows**, a windows restoration and repairs company, which suggested different window options based on the goals of the project.
- The University of Oregon **Energy Studies in Buildings laboratory**, which was able to empirically test multiple window scenarios to determine the most energy efficient option.

Manufacturer's Role: Chosen Windows

The University of Oregon selected Chosen Windows to lead the window installation. Because Chosen Windows had the capability of installing the windows in addition to manufacturing the windows, the University of Oregon was able to contractually hand over all of the responsibility for the windows to Chosen, rather than splitting the responsibility between a manufacturer and a glazing subcontractor.

As a result, Chosen Windows was on-site for all steps of the decision-making process: fixing the existing wooden frames, installing the new windows with SLIP attachments added to them in the building, and updating anything related to the sash weights.

Chosen Windows restoring Straub Hall window sashes in shop

University of Oregon Straub Hall

Secondary Window Attachment Case Study

The project team debated over multiple approaches to the building's windows during the first year (2011-2012) of renovation planning:

Option 1: Complete Window Replacements	Option 2: Adding Film to Existing Windows	Option 3: SLIP Window Attachments
The proposed window replacements would be double-pane, divided light windows that would have created a similar appearance to the original windows when installed. However, university officials disregarded this option. While the new windows were similar to the original windows, they felt that the replacements were not similar *enough* to the original design.	As both the frames and panes were in an excellent condition, the second option was to replace the glazing on the current windows with an insulated film. However, while this would maintain the original appearance of the windows, this method was projected to be both more expensive than other options and more time-consuming.	The SLIP attachments were cheaper than replacements, maintained the look of the original windows, and allowed the windows to remain operable. However, the attachments would add weight to the windows, which could potentially interfere with the weight system that operated the windows.

The University of Oregon hired the on-campus Energy Studies in Buildings laboratory to test the effectiveness of the following scenarios: the original windows, windows with one layer of insulated film, insulated glass conversions, and Chosen Windows's SLIP attachments. Analyses from the UO energy lab confirmed the following:

1. Even one layer of insulated film provided significantly better insulation than the original windows.
2. The insulated glass conversion option and the SLIP attachments provided nearly identical levels of insulation.

UO Energy Lab testing windows in Straub Hall

The full energy report can be found at https://windowslip.com/commercial/ by clicking on the energy testing tab. This report allowed the team to move forward with the cheaper SLIP attachment option.

University of Oregon Straub Hall

Secondary Window Attachment Case Study

Installation and Quality Assurance

Installation was a three-step process:

1. **Before Installation**: Chosen Windows removed the existing window sashes and took them back to their Portland shop. Because the windows renovation was part of a larger renovation, it was easier for Chosen to take the window sashes back to their shop rather than work around the other subcontractors on the renovation. At the shop, the original window sashes were stripped down, and the SLIP attachments were installed.

2. **On-Site**: Chosen Windows then transported the window sashes back to Eugene. In addition, the window frames were restored on site. However, one of the flaws of window attachments in older buildings is that they add weight to the existing windows. The original windows had operated on a weight system, which used the windows' original weights to allow occupants to open the windows. The original weight system had to be rebalanced to accommodate the additional weight of the window attachments before the new windows could be installed.

3. **Installation**: After re-balancing the weight system and coordinating with other subcontractors on the project (e.g., the insulation subcontractor), Chosen Windows installed the new windows. Each window took approximately 2 to 4 hours to install (also accounting for the time it took to rebalance the weights), and the installation generally went very smoothly. However, Chosen Windows stated that a few window attachments had to be removed and reinstalled, as other subcontractors would occasionally accidentally scratch the windows.

The architects on the project performed quality assurance checks, which included a visual inspection of the windows and a spray test, which involves spraying the glass with a controlled stream of water to make sure that there were no leaks on the inside. The re-installed windows passed both tests.

An example of a window re-installation

University of Oregon Straub Hall

Secondary Window Attachment Case Study

Outcomes

Since the completion of the building renovation in 2014, the feedback on the windows retrofit (and the larger renovation) has been universally positive. According to Chosen Windows, University of Oregon administrators have since asked Chosen Windows to come back and install SLIP window attachments in other department buildings (Gerlinger Hall and the Volcanology Building).

While the architect hadn't heard of window attachments before the University of Oregon project and hasn't worked with secondary window attachments since the project, he said that he would work with window attachments again if they were applicable to any of his new projects. He believed that secondary window attachments would work best in historical buildings (where the original windows needed to be preserved) with windows that had wooden or steel frames.

Window with SLIP attachment added

Conclusions & Implications

Interviews conducted for this case study suggest that there may be potential for secondary window attachments in the following scenarios:

- Windows with historic or sentimental value
- Windows that need to be operated
- Windows with wooden or steel frames

Thus, while window attachments may not be the appropriate solution for every building, the emphasis on the historical preservation of Straub Hall in combination with the excellent quality of the pre-existing windows and wooden frames, made Chosen Windows' SLIP attachments an effective solution for this specific project.

Olympic Mills Commerce Center

Secondary Window Attachment Case Study

Executive Summary

The Olympic Mills Commerce Center completed a series of window retrofits from 2012 to 2017 in response to soundproofing requests from building tenants, as noises from the nearby train tracks disturbed many tenants. The tenants wanted windows that would reduce the noise from the train while maintaining window operability. However, because Olympic Mills was a national historic building with specific renovation guidelines, the property manager knew that it would be difficult to receive approval for modern window replacements.

The property manager's previous knowledge of Indow led him to choose the Indow commercial-grade window inserts, which reduced external noises without having to replace the windows.

Olympic Mills Commerce Center & nearby railroad

Building Quick Facts

- **Location**: Portland, OR
- **Size of Building**: 108,117 square feet (eight stories)
- **Age**: Built in 1920 – 100 years old
- **Occupancy**: Commercial (approximately 80 tenants representing multiple industries, including creative, design, architecture, and legal)
- **Ownership**: Tenants can lease spaces through a third-party management company
- **HVAC System**: Water source heat pump in each tenant space, with a central boiler and cooling towers

Windows Quick Facts

- **Number of Windows Upgraded**: 115-130 (all windows on the west side of the first and second floors, with additional windows on request)
- **Window Frames**: Pine wood
- **Previous Window Type:** 60% double pane windows & 40% single pane windows – all operable
- **Condition of Original Windows**: Good – some of the wooden frames needed to be updated before installation
- **Average Cost per Window**: $1,200
- **Range of Total Project Costs:** $1,200-$20,000

Olympic Mills Commerce Center

Secondary Window Attachment Case Study

Project Background

Located in Portland, Oregon, the Olympic Mills Commerce Center originally functioned as both a cereal mill and a West Coast hub for the shipment of flour products. In the 1980s, the building was registered as a historic site in the National Register of Historic Places and has received funding through historical trust fund organizations. Between 2007 and 2008, the Olympic Mills Commerce Center underwent a major renovation that modernized the building interior while maintaining the historical exterior of the building, although the windows were not included in this renovation.

Olympic Mills Commerce Center in 1923
(Oregon Historical Society Image 017494)

Olympic Mills Commerce Center in 2019

Project Impetus

NAI Elliott, the company in charge of the Olympic Mills Commerce Center, initiated the window retrofits due to tenant feedback about noise. The west side of the Olympic Mills building is adjacent to a set of active train tracks (with some spaces being as close as six feet away from the tracks. As a result, NAI Elliott had difficulties finding new tenants to occupy the empty spaces on the west side of the building, and existing tenants located near the train tracks complained about noise and asked for better sound control in their spaces.

NAI Elliott could not simply replace the (otherwise functionally adequate) windows, as the building was associated with the Historic Trust in Oregon. The property manager believed that window replacements would be difficult to get approved by the Historic Trust.

Olympic Mills Commerce Center

Secondary Window Attachment Case Study

Decision Making

Building-Level Decision-Making:

The property manager first heard about Indow in 2010, when he read a news article about the company opening in Portland. He liked that Indow was a local company, and he emphasized that one of the reasons he chose to work with Indow was because they were a local company.

Before deciding to work with Indow, however, the property manager considered a few options for the existing windows. As tenants would be responsible for the costs, the property manager did not consider cost a significant factor in the building's decision to use the Indow secondary attachments.

1. The first option that they considered was **complete window replacements**. However, as the Historic Trust in Oregon focused mainly on preserving the building's historical appearance, NAI Elliott would need to have a strong argument for window replacements. According to the property manager, the historical preservation aspect of the building eliminated any potential replacement options, as they were limited by things such as the pine wood frames on the existing windows (which are less commonly seen with modern windows).

2. The property manager also considered **exterior storm windows**. However, while this option would improve sound control, the exterior storm windows would render the windows inoperable. Window operability was very important to the tenants, so the property manager searched for other options.

3. The **Indow commercial-grade window inserts**, similar to the exterior storm windows, would improve sound control in tenant spaces. However, unlike the storm windows, the Indow inserts also allowed the windows to remain operable, were easy to remove and re-install, and were easy to store and clean. In addition, the property manager stated that he did not have to fill out any paperwork, consult with any third-party designers or reviewers, or get approval from the Historic Trust to use the Indow inserts.

Olympic Mills Commerce Center

Secondary Window Attachment Case Study

Tenant-Level Decision-Making:

The property manager stated that Olympic Mills uses the same type of commercial attachment every time they use the Indow inserts, since the commercial glass is slightly thicker than other options. Their only requirement is that the secondary attachments match the rubber gaskets on the existing windows, and that the tan color of the attachments matches the existing wooden frames.

There are two typical scenarios when tenants decide whether to install Indow inserts:

Original windows

1. For new tenants who are renting a previously unoccupied space, NAI Elliott will typically include the cost of the windows in their lease package. Tenants and landlords will then negotiate the terms of payment.

2. In the case of a tenant who wants to add secondary attachments to their space, NAI Elliott will work with the tenants to develop a cost package that will typically be referred to as a tenant improvement package. Once the tenant sees the estimated costs, they can decide whether to go through with the secondary attachments.

Manufacturer's Role: Indow

Indow Windows was responsible for manufacturing the secondary attachments. Indow Windows offers multiple types of secondary attachments and suggests different options to customers based on what their customers need. The commercial grade inserts were sturdier and thicker than the Indow standard grade windows and blocked an equal amount of noise to the Indow acoustic grade soundproofing inserts (a 50 to 70 percent noise reduction).

Once a tenant submitted their request for secondary attachments, Indow Windows would go on-site to take measurements of the existing windows. Once they had window measurements, Indow Windows was able to create attachments that would fit exactly with the existing windows.

Olympic Mills Commerce Center

Secondary Window Attachment Case Study

Installation and Quality Assurance

The property manager had a general contractor install the window inserts. According to the property manager, the contracting companies they used for the windows projects also worked on other building-related projects.

In general, the installations went very smoothly and provided minimal disruptions to tenants. Because the Indow secondary attachments were designed to be installed by anyone, the installation was as simple as installing a new screen into a window. In the case that a tenant was already in the space, installations were typically done after work hours. However, depending on tenant requests, installations could also be completed during business hours. The property manager stated that over the course of 130 installations, they never had to send any secondary attachments back to Indow Windows due to errors.

A window close-up after attachment installation. The attachment frame is in white and fits directly into the existing brown wooden frame.

After the attachments were installed, Indow Windows first did an installation check with the general contractor. The company also followed up with the property manager to ensure that the secondary attachments were functioning properly.

Outcomes

The property manager saw the secondary attachments as a viable noise reduction strategy. Tenants facing the train tracks have reported reduced noise. One tenant, in particular, stated that after the attachments were installed, they did not even notice the sound of the train anymore. Other tenants on the west side of the building also said that the sound of the trains no longer bothers them, although they could still feel the train passing by through the vibrations from the building.

Office windows post-installation

Olympic Mills Commerce Center

Secondary Window Attachment Case Study

In addition, the property manager stated that he had not noticed or heard of any changes in energy consumption due to the windows alone. However, he did not consider energy efficiency as a main goal in these installations and had not specifically compared changes in energy savings. He said that the building was already energy efficient (e.g., smart lights installed throughout the building), and he assumed that tenants with secondary attachments likely did not experience significant decreases in their energy costs.

The property manager did note that condensation occasionally does get trapped in between the attachment and the window, which requires the firm to remove the attachments to wipe away the condensation. However, he can easily re-attach the window inserts after cleaning them, so he said that it was not a major inconvenience.

While the property manager had not worked with secondary window attachments before (he had only done generic window replacements), he said that he would be willing to use them again if they were an appropriate solution. Currently, the Olympic Mills Commerce Center does not have any plans to do future window renovations, but all of the tenants are aware that they can still request the attachments if they are interested. According to the property manager, none of NAI Elliot's other properties had secondary window attachments installed, primarily because there was less of an emphasis on preserving the historical appearance of the other buildings.

Windows with attachments

Conclusions & Implications

Interviews conducted for this case study suggest that there may be potential for secondary window attachments in the following scenarios:

- Windows with historic value
- Windows that need to be operated
- Buildings that need to be soundproofed
- Tenant preference (i.e., if a tenant requests secondary attachments)

Overall, the focus on the historical preservation of the Olympic Mills Commerce Center and the tenant emphasis on window operability made Indow window inserts an effective solution for this historic building with noise concerns.

The Society Hotel - Portland

Secondary Window Attachment Case Study

Executive Summary

The Society Hotel underwent a major renovation in 2014 and 2015, which transformed a space previously used for community organization meetings into a hotel in Portland, Oregon. As part of the renovation, the co-owners of the hotel decided to install secondary window attachments instead of replacing their windows, which allowed them to maintain the historical appearance of the building, remain within their budget, and perform the installation themselves.

Society Hotel exterior

Building Quick Facts

- **Location**: Portland, OR
- **Size of Building**: 12,000 square feet
- **Age**: Built in 1881 – 139 years old
- **Occupancy**: Hotel
- **Ownership**: Owner occupied (four co-owners)
- **HVAC System**: Variable refrigerant flow (VRF) system with an energy recovery ventilator (ERV) heat recovery.

Windows Quick Facts

- **Number of Windows Upgraded**: 50-60 windows (almost 100%)
- **Window Frames**: Wood
- **Previous Window Type**: Single pane, double hung – most were operable, and some were fixed
- **Condition of Original Windows**: Good
- **Cost of Entire Renovation**: $3-4 million

Project Background

Originally built in 1881, the Society Hotel originally functioned as lodging space for sailors who needed to stay overnight in Portland, Oregon. Since being constructed, the building was registered in the National Register of Historic Places, and has operated as a hospital, a hotel, and a meeting space for non-profit organizations. From 2013, when the current owners purchased the property, to the hotel's grand opening in November 2015, the four co-owners completed a major renovation of the property, which included the windows.

The Society Hotel - Portland

Secondary Window Attachment Case Study

Project Impetus

Once the co-owners registered the building as a historic place, they began the renovation of the property. Through the State Historic Preservation Office in Oregon, the owners received a federal tax credit of 20% on their building renovation. The office had to approve each step of the renovation, but according to one of the owners, the office cared more about maintaining the overall appearance of the first floor than the private rooms. As a result, the owners had an easier time getting approval to use secondary attachments in the private rooms than on the first floor, and they opted for a special glass coating on the first-floor glass instead.

Pictures of windows before renovation

Pictures of windows before renovation

Decision Making

The four co-owners of the hotel had experience with energy consulting, construction, general contracting, and hotel operations. One of the co-owners was familiar with secondary window attachments and ultimately selected Indow's attachments based on his prior knowledge. Because one of the other co-owners owned a contracting firm, they were able to perform the installation themselves. This combination of skills allowed them to make all of their decisions on the windows without consulting any third parties.

The co-owners of the Society Hotel had a few main goals when it came to the windows renovation:

Pictures of windows before renovation

The Society Hotel - Portland

Secondary Window Attachment Case Study

1. First, they wanted to stick to their budget (approximately $3 million). Given that the co-owners had experience in the energy efficiency industry, their ideal window option was a triple-pane, double-hung window, as that was the most energy efficient window option for their building. However, these windows were expensive, and the co-owners needed to find a more cost-efficient option.

2. In addition, they wanted to maintain the historical character of the building. Because the building was registered in the National Register of Historic Places, the co-owners would have to get approval from the State Historic Preservation Office to make any changes to the windows. Thus, according to one of the co-owners, window replacements were not an option even if they could afford replacements, as they needed to modify the existing windows to preserve the original look of the building.

3. Finally, they wanted to improve both thermal comfort and sound control. Because the windows were old, a lot of air passed through the existing windows, which made the building drafty and caused the surface temperatures in the building to run cold. Further, because the co-owners kept the original brick building, the exterior walls had no insulation. As the building was in an area with many clubs and bars, the co-owners knew they needed to find a solution that would reduce noise and increase the surface temperature in the building.

Given that the co-owners were familiar with both secondary attachments and Indow Windows before this project, one of the co-owners mentioned that they did not consider any other options. The owners also liked that the windows could be self-installed, were easy to remove, and were easy to clean. However, the ease of removal also ended up being a negative quality of the attachments, as a few of the attachments fell out and broke after installation. Overall, the window inserts were less expensive than energy efficient window replacements and still allowed the owners to meet their other goals.

The Society Hotel - Portland

Secondary Window Attachment Case Study

Manufacturer's Role: Indow

Indow Windows was responsible for manufacturing the secondary attachments. However, because the Indow window inserts could be self-installed, the owners of the hotel completed the rest of the work on their own.

Installation and Quality Assurance

According to one of the co-owners, the installation process generally went well, albeit with some fixes required to both the secondary windows and the installation process. The owners needed to send a few of the secondary windows back to Indow Windows to be recut to better fit the measurements of the existing windows.

In addition, as mentioned above, the seals on some of the larger windows would break due to pressure changes in the building from doors opening and closing. As a result, the co-owners designed their own clip system that integrated with the wooden window frames to keep the secondary attachments in place.

Windows with attachments

Outcomes

Overall, the owners have been satisfied with the performance of the secondary window attachments. They called out their satisfaction with the improvement of thermal comfort in the rooms. When the hotel opened in 2015, a few of the rooms still did not have secondary attachments installed. One of the owners mentioned that there was a clear difference between rooms with secondary attachments and rooms without secondary attachments. The rooms without attachments were draftier and noisier than rooms with attachments, and the owners quickly installed attachments in the remaining rooms.

The Society Hotel - Portland

Secondary Window Attachment Case Study

The owners suggested that the secondary attachments have done an adequate but incomplete job of reducing noise. One of the owners stated that most of the noise at the hotel is low frequency sounds from nearby clubs. While the low frequency noises are difficult to block with any type of material, the secondary attachments were better than having no attachments at all.

The owners mentioned that it was difficult to assess changes in energy efficiency, as they did not own the building before the renovation. However, they believed that the secondary attachments did reduce energy costs.

Finally, one of the co-owners mentioned that he had worked with secondary attachments before, although he had only used them in a residential context. He had even developed his own type of secondary window attachment: one that was more difficult to remove from the window frame but was still removeable. He mentioned that he had used secondary attachments in projects after the Society Hotel, although he alternates between attachments based on what would work best for each specific project.

Windows with attachments from hotel website

Conclusions & Implications

Interviews conducted for this case study suggest that there may be potential for secondary window attachments in the following scenarios:

- Windows with historic value
- Windows with wooden frames
- Windows that need to be soundproofed
- DIY-oriented decision-makers and facility operators

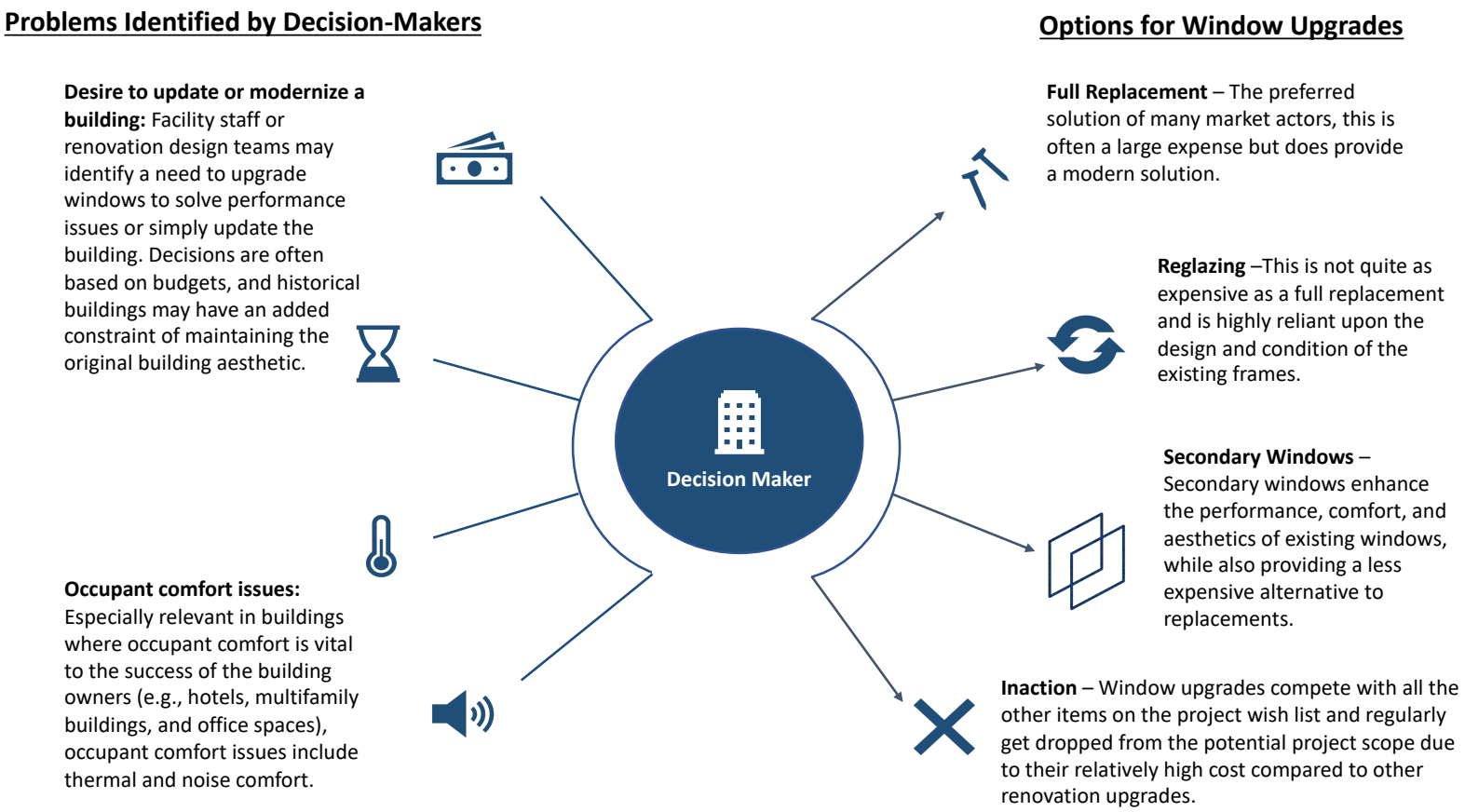
Overall, the focus on the historical preservation of the Society Hotel building and the limited renovation budget made Indow window inserts an effective solution for both preserving the building's historical integrity and allowing the co-owners to save on installation and restoration costs.

Appendix B: Building Project Decision-Making

We have examined the supply chain from the manufacturer's perspective—that is, how products get from manufacturers to buildings. We will now analyze how building representatives make decisions that may involve secondary windows. As noted in the introduction to this report, single pane windows and early double pane windows can create problems with building performance and for occupants that may trigger a desire for window upgrades. Aesthetics can also play a role in the decision to upgrade windows.

Figure 4 visually presents triggers for potential window upgrades and options that building decision-makers may consider.

Figure 4: Triggers and Options for Window Upgrades



Secondary windows can be incorporated into existing buildings either as a stand-alone retrofit to upgrade original windows or as part of a larger building renovation. Consideration of secondary windows can differ between these two scenarios; Table 5 summarizes some of these differences.

Table 5: Key Differences between Stand-Alone Window Upgrades and Building Renovations

Factor	Stand-Alone Window Upgrades	Building Renovations
Trigger	Occupant comfort or aesthetics	Building performance or aesthetics
Competing against	Window replacement; inaction	Many potential building improvements
Decision-maker	Likely to be architect or windows specialist	Could be architect, windows specialist, or engineer focused on mechanical systems or lighting

Appendix C: Field Test Considerations

Field tests by NEEA will vet the real-world technical performance of secondary windows to provide data needed by program designers, program implementers, and market actors considering performance trade-offs between secondary windows and other options empirically.

The results of this study suggest that:

Energy performance testing would strengthen the product position in the marketplace. Understanding the energy savings associated with secondary windows is an important consideration for market actors who have not used secondary windows. In interviews, market actors consistently requested information about energy performance and expressed doubt that these products would save much in the parts of the Northwest with mild climates. They also asked for easy access to product specifications. Product specifications and the resulting energy savings from modeling or field tests should be a useful combination for the market. The range of products available (each with unique performance characteristics), the varied climate throughout the four Northwest states, and variability in existing building conditions will make it challenging for NEEA to develop energy performance data that will satisfy the market's needs. Strategies NEEA may consider in setting up field tests include

- Narrowing the testing to specific manufacturers and products;
- Testing ideal scenarios first and moving to less ideal conditions thereafter; and/or
- Working toward a performance calculator that is based on field tests and modeling, so that a user can provide a climate zone, key building characteristics, and a secondary window product to receive an energy savings or energy performance metric as output, possibly using technical information about specific products that is already available from the Attachments Energy Rating Council (AERC).

Project costs and benefits that accrue to building occupants, such as reduced noise and increased comfort, should be tracked and documented in any early NEEA-initiated installations. Building occupant considerations appear to have been a more important driver than energy savings for the early installations we studied. Noise and comfort of occupants near windows were particularly important, and controlling glare and light conditions could play a role in other buildings. These factors could be measured alongside energy performance in field testing and documented for later use in market-facing program information. The noise dampening performance of secondary windows can be measured empirically with pre/post comparisons; occupant comfort and light conditions could be compared before and after installation with technical measurements or tracking of occupant satisfaction. In parallel, NEEA could track product

and installation costs, differentiating between those unique to early installations with NEEA involvement and costs that would have been incurred in a more mainstream project.

The market may need two different baselines against which performance characteristics for secondary windows can be compared. Decision-makers need to be able to weigh the costs of secondary windows versus the alternatives: the "do nothing" scenario, replacing some windows, and replacing all windows. Ideally, NEEA would be able to offer data for both secondary windows compared to replacements and secondary windows compared to inaction.

Appendix D: Supply Chain Mapping Interview Guide

The following interview questions were used to understand the existing window attachment supply chain and the relationships among relevant market actors. These interviews aimed to address the following objectives:

- Understanding who the currently active market actors are and how they interact;
- Understanding how active market actors use SGS and LES products, including overlap, differences, and whether they are treated as one product or two; and
- Mapping supply chain relationships in the Northwest and Northeast.

Screener (if needed)

- What is your role within company/organization?

Background

- What share of the company's work is in commercial sector windows?
    - What kinds of services and products do you offer for commercial building window upgrades or replacements (retrofits or renovations)? [Listen for secondary attachments and replacements.]
- How much business are you seeing with secondary window attachments (use language of the manufacturer)? What are the trends?

Objective 2

- Describe to me the product that your company sells (i.e. materials, location, # of panes)? [Capture all product variations]
- What other product variations are you aware of within the market? [Ask to name different products/companies]
- How does your product differ from others on the market?
- What situations/buildings do your products work best in? When do they not work well?
- What are the greatest benefits of the product your company offers?
    - Do these benefits differ by building type? Geographic location?
    - How do customers generally value energy and non-energy benefits?
- Are there instances where some other product on the market (from those mentioned in above question) work better than your product? Or are they interchangeable?

Objective 1

- How do you prospect (i.e. generate leads and sales) for secondary window attachment projects? [If needed, probe: Does someone come to you with a project or do you go to market for business?]
    - Why do customers generally seek out window attachments?
    - Who (role, i.e. engineer, architect) brings up the option to secondary window attachments with the customer?
    - To whom do you typically try to sell projects (role or building type)? Are there any intermediate distribution channels that you sell to?
- Who else do you need to engage in projects to make them happen? [If needed, probe: Does an installation require any other firms or is what you do entirely turnkey? What kind of firms?]
- What geographic area do you cover? How much business is there for this type of work in that region? [If needed: What about the Northwest, the Northeast?]
- How many other companies offer similar services for secondary window attachments in the area as you do? [Ask them to list companies]
- What would the supply chain need to look like if the market and demand grew substantially?
    - Who else would need to be involved who currently isn't?
    - What would need to change in awareness, perceptions, and so forth?
    - Are there any parts of the supply chain or specific functions that would be a bottleneck?

Objective 3

- [Interviewer note: If already covered earlier, summarize your understanding of what the supply chain looks like and ask if there are any other people involved.] What does the supply chain look like? Who all is involved in making these projects happen? [If needed, prompt: describe what we mean by supply chain. Do they sell directly to buildings or are there other steps?]
    - Are there distributors, architects and engineers, general contractors, or anyone else?
    - So, who specifically would be involved if you had a project in, say, Portland? Seattle? Boise, Billings? Other cities?
- We are also looking at doing some case studies to understand existing secondary window attachment installations. Do you have any suggestions how we could best find such buildings? [Prompt for work done by company]
- List market actors given throughout the interview and ask for contact information. Confirm that interviewee is comfortable with us reaching out and ask whether we can use their name

Appendix E: Case Study Interview Guide

The following interview questions were used to identify the drivers, market barriers, decision-making processes, and logistics that market actors face in the use of commercial window attachments. These case studies highlight common elements, differences, and important takeaways with implications for future program designs and market interventions.

Interviewee Role [2-5 mins; all]

- To start, what is your role at [company]?
- What was your role in the [case study project]?
    - [maybe] What did that involve?
- From approximately when to when were you involved? [Probe as needed to understand the stages of the project during the project, defined either in terms of calendar time or project stages so we can relate observations to those of other interviewees.]

Project Background and Overview [3-5 mins; initial building contact for bulk of information; 2-3 mins for others]

[Ask the questions below if we don't have clarity yet; confirm the project basics with other interviewees as a way of easing into the discussion, jog their memories, and provide an opportunity to correct information.]

- Confirm project basics [as needed]:
    - What do you call the project?
    - What is the actual address of the building?
    - When was the commercial secondary window installation?
- Can you give a brief overview of the building?
    - Size
    - Age
    - Type of use (details, if mixed use)
    - Ownership & management structure (whether owner occupied, leased, or both; whether managed by owner or third-party management company)
- Was the window replacement part of a larger retrofit or purely a window retrofit?
    - [if bigger] What else was done?
- Can you give a brief overview of the scale of the window replacements?
    - # and size of windows or total square feet of windows retrofitted
    - share of the building windows that represents (in approximate percentage)
    - timeline from initial concept to actual installation [for just the windows part if this was a bigger renovation]

  - costs of the secondary window project [Distinguish from overall project costs if the whole project was bigger than just the windows]

Technical Details – Windows [5 mins, building contact or architect/specifier, installer]

- What types of windows were in place before the new window installations took place?
  - Single/double pane
  - Tinted/has film
  - External or internal shading systems
  - Operable or inoperable
  - Frame type
  - Condition of the existing windows and if anything was done to improve existing window before installing secondary windows
- What types of secondary windows were installed?
  - Manufacturer/models
  - Interior /exterior, operable/inoperable
  - Do you have before and after pictures of the windows that you could share with us?
- What type of HVAC system does the building have? [Record what they say for post-coding. Probe on heating, cooling, ventilation. Listen for such things as:
    - Packaged rooftop unit (RTU) - Electric, Gas Pack, Condensing
    - Makeup air unit (MAU)
    - Constant air volume
    - Variable air volume
    - Variable refrigerant flow (VRF)
    - Furnace (Gas or Electric)
    - Heat pump (Air source, Water source, Ground source)
    - Split systems, ductless heat pumps (invertor driven)
    - Packaged terminal AC or heat pump (PTAC or PTHP)
    - Unit heater (ceiling mounted)
    - Cabinet Heater (wall mounted)
    - Hydronic Radiant heating and cooling (ceiling and/or floor) – Chilled Beams, Radiant panels
    - Electric Baseboard Radiant Heat
    - Evaporative cooling (Swamp cooler)
    - Central Built up Systems – w/chillers, condensers, evaporators, boilers, etc.

Decision Making [10 mins; all]

- How did you get involved with this project?
- At what stage was the planning or decision-making? (If needed: Was the project in the early design stage, late design, or somewhere else? What aspects of window-related decisions had been decided and what was still open-ended?)
- Was a utility incentive provided? If so, by which utility?

[If not already understood from past interviews or useful to repeat for context / confirmation]:

- Who or what initiated this retrofit?
    - Why? What were they seeking to accomplish?
        - [If the project was larger than secondary windows] What prompted the overall project?
        - Was there a particular performance issue or satisfaction with the pre-existing windows?
    - [If multiple people are involved] What were their roles?
- Who or what first suggested commercial window attachments?
    - Why?
    - How was that idea received by members of the project team?
- *Were there any alternative options that were considered before deciding to move forward with the window attachments that were installed?
    - Were window replacements considered?
    - Were other types of window attachments considered?
    - Were other solutions not involving window replacements or attachments considered?
- What were the pros and cons associated with these window attachments compared to the alternatives? [If needed, probe on energy savings, comfort, etc.]
    - How did costs compare across the alternatives?
    - What were the ranges of costs per window for the alternatives? For the secondary windows that were installed?
- *Were there any prerequisites or issues that needed to be addressed before moving forward with this project? [If needed, probe on product selection, project approval, and installation]

Market Actors and Roles [5-10 mins; all]

- Who did you interact and/or coordinate with directly for this project?
- Who brought you onto the project?

If not already understood from past interviews:

- Who was involved in selecting the products that were used in this project?
- Who was involved in the manufacturing and delivery of the products?
- Who was involved in the installation of the windows?
- Who was involved in quality assurance of the window attachments?

Installation [5 mins; building contact; installer]

- How did the installation go?

- What was involved?
- How long did it take?
- Where there any complications or challenges?
- Did the existing windows need to be resealed?

Outcomes [10 mins; building contact]

- How have the secondary windows performed?
    - Have you observed any increases or decreases in energy consumption?
    - Have you gotten any feedback or observed any changes yourself in comfort or light conditions for occupants near the secondary windows? If so, what have you heard or seen? [If needed, probe on temperature, visual, light quality, and noise comfort]
    - How long did it take for these outcomes to be noticeable?
    - Were there any other positive or negative outcomes that occurred after the project was completed?
- Thinking about your role in the project, was there anything that you would have done differently if you could do the project again?

[Time permitting only...]

Interviewee's Perceptions and Future Role [5-10 mins; all except market actors we know are active in CWA]

- Had you worked with commercial window attachments before this project? How often?
- Do you think you would ever use them again?
    - Why/why not?
    - In what circumstances?
    - Where do you see them as a good fit?
    - What would it take for you to consider them more?

Final Questions [2-3 mins; all]

- Based on our conversation, it seems like [other market actor name / company] might also be a good person to speak to about this project. Would you be willing to provide his/her contact information?
- Who else should we speak with to get a well-rounded perspective on this project?

Appendix F: Supply Chain Interview Guide

The following interview questions were used to address the following objectives:

- Understanding what market actor interaction would look like in a more active Northwest market;
- Understanding openness to—and likely use of—SGS and LES products for varied applications and understand what they need/most helpful to differentiate the best products for projects;
- Identifying barriers to technically promising applications, including availability of products and capacity of supply chain market actors to identify opportunities, specify appropriate products, and install them;
- Obtaining market actor suggestions for ways to overcome barriers and market needs;
- Assessing strength or weakness of the Northwest supply chain's ability to specify and install secondary window attachments; and
- Identifying priorities for a NEEA market assessment (based on synthesis of the information collected for objectives 1-5; no specific questions for interviewees.)

Background (if needed):

- What is your role within company/organization?
- How much work does your organization do in the commercial space? [For GCs] What about multifamily? Residential?
    - How does this work involve windows in commercial buildings?
- [If not obvious] How, if at all, do upgrades of windows fit into that?

Awareness and Perception of Secondary Windows (Covers Objective 2):

- How often do you encounter buildings with vintage, single pane windows?
- What problems and challenges do they provide to building owners and occupants? [Listen for energy vs non energy issues]
    - In what sorts of buildings do you encounter these problems the most?
    - How would you compare the importance of energy and non-energy problems that arise from single pane windows?
- What sort of products/solutions are you aware of that enhance the performance of existing windows (without replacing)? [Capture all product variations, including solutions short of secondary windows]
- How often are they asked to address window issues?
- Are windows addressed on their own or when other large projects are being done?

[If interviewee mentions secondary windows]

- What product variations are you aware of? What manufacturers?
- Do you have any experience working with these products? Have you known of any peers using these products?
- What drives the decision to upgrade vintage windows that may be causing [problems listed above]? How do you make the decision between doing nothing, upgrading with secondary windows or a full replacement?

[If interviewee does not mention secondary windows]

- What are the solutions to address [problems listed above]? How do you consider doing nothing versus a full replacement?
- [Describe the product to them for the purpose of the rest of the interview]
    - ⇒ Secondary windows are products that enhance existing windows without replacement. They add an additional pane (or multiple) to the interior or exterior of the existing windows. There are variations in materials and installation methods.

Perceptions about Applications (Covers Objective 3):

[If interviewee has experience or knowledge of commercial secondary windows]

- How did you learn about commercial secondary windows?
- How did you identify the product as a solution faced by the building challenges?
    - What would alternative solutions to these building challenges be? A full window replacement? Something less extensive?
- Were there [If interviewee has not used: Would you anticipate] any complications in procuring window attachments? Are you aware of any difficulties doing this in the Northwest?
- What is involved in doing the installation? (Probe: Is it difficult? Is it possible for you to work with general contractors to install?)

[If interviewee has no experience or knowledge of commercial window attachments]

- Are there any barriers (technical or other) that would prevent you from exploring the potential of these products for future work?

  Probe on:

    - Based on what you know, where would there be potential applicability for these products in your work?
    - What are the key things you would need to know to consider them?
    - Where would you look for that kind of information?

  - What concerns, risks, or unknowns would prevent you from even thinking about them?
  - What else stands in the way of exploring these products further?

Assessment of Northwest Supply Chain (Covers Objective 5 and some of Objective 1):

We are trying to get a sense of the supply chain market for these products to know whether all the pieces are in place for secondary windows to be a viable option for people like you. [For interviewees not previously aware: For the next few questions, if you don't know, just say so and we will move on.]

- How much commercial window attachment product awareness is there amongst your peers? Is this something that you see being used a lot? Is that a fairly new trend?
  - [If little awareness] Is that lack of awareness unique to the Northwest? What challenges/barriers do you think exist in the Northwest?
- If you wanted to use secondary windows on a future project, could you do that using the people you usually rely on as project partners?
  Probe on:
  - For what function or service would you need to use someone different?
  - Where would you start?
- If you tried to get secondary windows into a project because you thought they were a good fit, how likely is it that you'd be able to get all the pieces in place to make it happen?
  - Why do you say that?
  - How much more effort would it be than just sticking with more typical solutions?

Manufacturer Involvement (Covers Objective 1):

- How might manufacturers interact with you to increase consideration of secondary windows where they are a good fit?
  - Would there need to be distributors or do you like working directly with manufacturers?
- Is there enough specialized labor to complete these projects in the Northwest?

NEEA Role (Covers Objective 4):

- How familiar are you with NEEA? [Briefly explain organization's role if needed.]
- Do you think there is something NEEA could be doing to increase awareness of these products and their appropriate fit in projects?
  - What would be the best way to do that amongst your community (i.e. profession)?

Closing:

- Thank interviewee
- Determine where to send incentive