INOVUES
ADAPTIVE GLAZING SHIELDS

INOVUES, INC.
2700 Post Oak Blvd, Ste 2100, HOUSTON, TX 77056
(833) 466-8837 (INO-VUES) | www.inovues.com | info@inovues.com

Exterior vs. Interior Insulating Glass Retrofits *

#	Criteria	Exterior	Interior
1	Energy Efficiency/Savings	Higher cooling savings (lower solar heat gain) Higher heating savings (lower frame U-factor)	-
2	Up to 100% of the Façade Can Be Upgraded	Yes (Vision and Opaque Windows)	No (Only Vision Windows)
3	Level of Disruption to the Building/Occupants	No disruption (like window washing)	Minimal Disruption
4	Minimizing/Eliminating Air & Water Leakage	Weather Barrier, Protect Original Seals/Joints	Secondary Barrier
5	Providing Additional Safety/Protection	Primary/Front barrier Protection	Secondary Barrier Protection
6	Extending Lifespan of Original Windows	Direct	Indirect
7	Existing Window Films	Can Be Kept	Must Be Removed
8	Aesthetic Options	Preserve or Enhance Building Appearance	Preserve Only, Ideal for Landmarks
9	Compatibility with Clear PV Glass	Compatible (Original Efficiency Maintained)	Less Compatible (Lower Efficiency)
10	Compatibility with Dynamic Smart Glass	Compatible	Not Compatible
11	Ease of Installation	-	Often Easier
12	Time of Installation	Slower in Buildings w/out Easy Façade Access	Slower if Access to Rooms is Limited
13	Installation Schedule (Start Date & Duration)	Subject to Weather Conditions & Temp Levels	Subject to Temperature Levels Only
14	Product Base Cost	No Difference	-
15	Associated Extra Costs	Façade Access Equipment (if not available)	Window Film Removal (if existing)

** INOVUES offers both exterior and interior insulating glass retrofits.*

1. Energy Efficiency/Savings

Exterior insulating glass retrofits allow to fine-tune solar heat gain performance in exterior installations by preventing solar gain from going into the building, resulting in significant cooling energy savings. Solar control layers are more effective on the outside. For existing tinted glass (depending on type), interior installations are limited in its ability to affect the solar heat gain performance of the final glass assembly. The ability to fine-tune solar heat gain performance may result in less frequent use of internal window shading devices (shades, blinds, etc.), while improving occupant comfort and experience by increasing the use of natural light. Also, an exterior installation leads to increased thermal performance of the framing portion of the retrofitted window, resulting in improved overall thermal performance (better U-factor) of the entire window system.

2. Up to 100% of the Building Facade Can Be Upgraded

Many commercial buildings have glass façades and curtain-walls with vision and non-vision windows—i.e., opaque, spandrel, or shadow box glass panels. With interior window retrofits, building owners can address the performance of vision windows only. However, the non-vision glass areas often make up a significant part of the envelope of such buildings, representing 50% or more of the façade area. Thus, upgrading them offers a huge opportunity to (1) increase the overall insulating value and energy efficiency of the building envelope, leading to significantly more reduction in energy consumption and peak heating and cooling loads (i.e., higher environmental impact), (2) provide up to 2x the energy savings, resulting in a much higher net operating income for owners (i.e., higher economic impact). That said, exterior insulating glass retrofits enable building owners to upgrade all glass panels and address up to 100% of the façade area.

3. The Level of Disruption to Building Operations or Occupants

Interior insulating glass retrofits are less disruptive than a complete rip-out and replacement option, but they are not completely non-disruptive. The perimeter areas would need to be cleared and the occupants would not be able to access the perimeter areas during installation. This is a concern for some businesses, primarily hotels where one of the primary challenges contractors often face is getting access to the hotel rooms—the majority are almost always operating 24/7. With exterior insulating glass retrofits, the windows can be retrofitted from outside without disrupting building operations or occupants. The interior retrofit option might not be feasible in such cases. Although it is less-disruptive compared with replacing the windows, they still require interrupting the occupancy of each room for a few hours, which not only can result in taking each room one night off the market (profit loss) but also results in longer project duration and higher costs—i.e., a longer payback period.

4. Minimizing or Eliminating Air/Water Leakage

The first part that fails in a window system is often the rubber gaskets and/or sealant joints, causing air infiltration and water penetration, which is found in many 20+ years old buildings. Interior window retrofits can address air/water leakage, but they cannot do so as effectively as exterior retrofits. In an exterior retrofit, those critical window components will no longer be exposed to the elements because a new weather barrier is created—the perimeter sealant in INOVUES Glazing Shield system covers the original gaskets/joints and protects against air/water leakage. This was validated in a before-and-after curtain-wall mockup testing that was performed by Intertek, a leading independent testing company. The curtain-wall panel that did not have the INOVUES product failed the dynamic water leakage test after just 3 minutes into the test, while the other identical curtain-wall panel that was retrofitted with the INOVUES system passed the test and even exceeded the AAMA standard. It is worth noting here that INOVUES Glazing Shield system, even when installed as an interior retrofit, does not require testing the existing windows for water leakage because it is attached directly to the exisitng glass—unlike other systems that are attached to the exisitng frame. In other words, INOVUES' secondary window system creates a glass-to-glass seal, which is more effective at preventing water from leaking into the air gap compared with a glass-to-frame seal.

5. Providing Additional Safety/Protection

Exterior window retrofits can effectively protect the original glass from breaking due to external elements/causes such as windborne debris or forced entry. With interior retrofits, the new retrofit panel adds a layer of protection behind the window, but the first barrier would still be the original glass. Thus, if it gets damaged or broken, the owner will have to remove the interior retrofit panel (after vacating the perimeter area), replace the original glass, and then re-install the retrofit panel—which might not be needed at that point after replacing the original glass. In the case of exterior retrofits, the newly-added glass becomes the first barrier, which can be specified as laminated safety glass, enabling the windows to meet today's building code requirements without replacing anything at all. And if the new glass gets damaged or broken, the building owner would only need to replace part of the INOVUES product because it is designed to be upgradeable. Using safety glass (laminated or tempered) in an exterior retrofit adds even more protection because if it breaks, it would result in less damage compared with the damage that could result from the breakage of the original non-safety glass panels (laminated safety glass will stay in place and not fall, and tempered glass will shatter into thousands of non-damaging small pieces). This added safety benefit is an important point for building owners, particularly in the government and education sectors.

6. Increasing the Lifespan of the Original Windows and the Sustainability of the Building

Creating a new weather barrier with an exterior retrofit, as mentioned in point 3 and 4, would significantly extend the lifespan of the facades and windows. This helps building owners save on their long-term capital upgrade budget. For example, if an owner installs new interior window retrofits behind 20-year-old windows with sealants/gaskets that have a typical ~25-year lifespan, the building

owner might still need to address some failure issues in those components after ~5 years anyway. The new interior panels might remediate the failure and prolong the life of the windows, but they cannot stop those critical window components from aging or deteriorating. In the case of exterior window retrofits, the newly-created weather barrier will protect/cover those window components. Thus, the lifespan of the new retrofit becomes the lifespan of the window, and at the end of that period, building owners will not need to replace any original components, they can just upgrade part of the INOVUES system, which is designed to be easily upgraded, replaced, or completely removed if needed without causing any change or damage to the original windows. Such ability to easily upgrade just the critical part of the façades and windows without having to replace the barebones/frames, makes buildings more sustainable and resilient.

7. Compatibility with Window Films

Following up on the previous point, if there are window films already installed, they would need to be removed before installing an interior secondary window for compatibility issues. This increases the overall costs and project duration and can result in longer disruption to the interior spaces. In the case of exterior window retrofits, the outer face of the original glass is typically clear with no window films, so there are no compatibility issues or additional cost/work needed.

8. Providing Options to Preserve or Enhance the Appearance of the Building

Interior window retrofits cannot offer building owners the option to change or enhance the image of the building if desired, which was found to be one of the top 3 drivers for façade/window upgrades. In the case of exterior retrofits, building owners can choose modern glass colors or unique designs with prints or frit patterns, for example, to enhance the appearance of the building without altering its architectural identity. This can be nicely achieved with the INOVUES retrofit system because it has a compact, low-profile design and a frameless-look with edge-to-edge glass, so it is visually inconspicuous as a system. Thus, if a building owner wants to preserve/maintain the appearance of the building, incorporating highly transparent glass would make the retrofit look nearly invisible. On the other hand, many buildings, for example, have lost the original uniform look of the facades over the years due to partial glass/window replacements—it is very challenging to match the color and transparency of discontinued glass. So, with an exterior facade retrofit, owners have an opportunity to restore the uniform look of their buildings. They can also have the exterior window retrofit be part of a full-building over-cladding for a low-cost image update. With exterior retrofits, owners of older buildings have a cost-effective option to make their properties look fresh and new again, which significantly helps re-position a building in the real estate market following a deep energy retrofit for example, resulting in a faster payback and higher ROI. Providing building owners with such a valuable non-energy benefit gives them an additional incentive to upgrade the facades and windows and improve the efficiency of the building envelope. This, in addition to the other non-energy benefits above, would help eliminate the split-incentive barrier and accelerate the adoption of a currently less-pursued, yet highly effective, energy retrofit measure in existing buildings.

9. Provides Higher Efficiency with Clear PV Glass

Installing energy-harvesting or clear photovoltaic (PV) glass behind an existing window would significantly lower the efficiency/output of the PV module, often by more than 50%. This is because the existing glass would minimize the amount of energy the PV glass is able to capture/absorb, especially if it is coated or tinted, which is the case in most buildings. For optimal results, the PV glass should be installed in front of the existing windows. Additionally, exterior retrofits can be used to turn spandrel windows into solar panels using traditional BiPV technologies, unlike interior retrofits.

10. Enables the Adoption of Smart Glass Technologies

In addition to the previous point, in order for smart, dynamic-tinting glass technologies to effectively work and control solar heat gain, they need to be installed in front of the existing windows, otherwise they can cause thermal stress breakage in the original glass when they are at the tinted state. That is why in new smart windows, the active pane in the insulating glass unit is always the first exterior pane

and the low-e coated glass is the second back pane. Thus, exterior window retrofits would enable the adoption of advanced glass and smart windows in existing buildings, unlike interior retrofits.