

# THE UNIQUE BENEFITS OF PVC WINDOWS IN MULTIFAMILY HOUSING

Presented by:



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## MARKET FORCES DRIVING MULTIFAMILY HOUSING CONSTRUCTION

From rising construction costs to declining homeownership rates, myriad factors have been driving the proliferation of multifamily housing developments over the past decade. Among these are an aging U.S. population, declining homeownership rates, a need for renewable resources and climate friendly solutions, and growing demand for affordable high-performance construction that meets the needs of owners and building occupants.

### Need for multifamily housing

In communities across the United States, there's a multifamily housing boom in progress. What has spurred this shift toward multifamily construction? Consider that in the first quarter of 2016, the U.S. homeownership rate fell to 63.5 percent which, according to the U.S. Census Bureau<sup>1</sup>, is lower than the fourth quarter 2015 rate of 63.8 percent. This marks the lowest homeownership rate since 1995.

In May of 1995, President Clinton unveiled the National Homeownership Strategy. This initiative drove a boom that continued until 2006–7 when the housing market crisis emerged. In 2008, the Case-Shiller home price index reported its largest price drop in history.

Following a plummeting of the national homeownership rate since 2006 was the decline in the number of owner-occupied housing units and an increase in the number of renter-occupied units (approximately 18 percent) during the same period. Single-family construction has therefore weakened while multifamily construction has risen sharply.

Considering the under-building of multifamily housing during the 2000s and the aging of a population that no longer wants the burdens of home maintenance labor and costs, the current momentum of multifamily construction is needed and will likely to continue.

## LEARNING OBJECTIVES

Upon completion of this course the student will be able to:

1. Discuss the market forces driving multifamily housing construction
2. Describe the evolution and implementation of PVC in residential construction
3. Contrast the benefits of PVC to aluminum windows
4. Explain PVC window selection criteria for multifamily residential projects

## CONTINUING EDUCATION

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## Solutions through high-performance construction

The demand for multifamily housing has also led to greater need for high-performance construction to help meet key project goals:

- Energy efficiency
- Lower operating costs
- Efficient construction and maintenance
- Occupant comfort and safety

Windows are a critical element of a building's performance as a source of daylighting, ventilation, and visual connection to the outside. However, underperforming windows are also a source of heat loss, excess heat gain, leaks, mold problems, noise penetration, and condensation problems.

The building industry has responded to these problems with new technologies and improvements, including the evolution of unplasticized polyvinyl chloride (uPVC) over other window materials.

Why uPVC for windows? PVC, often referred to as "vinyl," is a thermoplastic material that can be re-melted and recycled. Its composition gives it some unique technical properties that make it suitable for eco-friendly, high-performance construction.

According to PVC.org, a European based non-profit that tracks the PVC industry, PVC's cost effectiveness makes PVC a highly versatile polymer for the building industries. "PVC plays a major role in delivering and sustaining the quality, comfort, and safety of modern life-styles."<sup>ii</sup>

### Call for climate-friendly solutions

Increased pressure and incentives from certain municipalities for lowering their carbon footprint are also driving developers, contractors, and owners toward sustainable building solutions.

Because it's made of 57 percent common salt and only 43 percent oil, PVC requires less non-renewable fossil fuel than any other plastic. In fact, PVC is fully recyclable. During the manufacturing process, PVC is easily chipped into reusable waste material and extruded into new products. Ninety-nine percent of vinyl's manufacturing waste can be reprocessed and recycled.

According to the British Plastics Federation<sup>iii</sup>, PVC consumes less primary energy in its production than any of the other commodity plastics and has a relatively low carbon footprint. Compare, for example, the CO<sub>2</sub> impact equivalents for producing one ton of aluminum versus PVC: the production of aluminum creates 22,000 lbs. of CO<sub>2</sub>, which is more than 5 times the amount created during the production of PVC (4,180 lbs.).

### EVOLUTION AND IMPLEMENTATION OF PVC IN RESIDENTIAL CONSTRUCTION

Used in an array of applications ranging from medical to communication to construction, PVC has demonstrated exceptional durability

and dependability. However, it was slow to take hold as a building material until a convergence of market forces put pressure on builders to deliver higher performing buildings without sacrificing affordability. Integration of PVC windows made it possible for them to meet market demands successfully.

### History of PVC

Now one of the most common building materials in the world, PVC has come a long way since the 1940s. The unplasticized version, used in windows, was developed in Germany during the 1960s.

Because PVC has proven to be both durable and protective, it has gained widespread adoption in both the medical and food and beverage industries. Pre-sterilized PVC is used for tubing, disposable medical devices, catheters, pill packs, gloves, masks, and more. PVC is also used in food packaging because it is lightweight, reduces waste, and protects consumables by providing a water and oxygen barrier.<sup>iv</sup>

PVC products became essential to the construction industry due to their resistance to light, chemicals and corrosion; their durability and lightness; and their resilience. The first PVC window in the U.S. was introduced in 1964 by

Thermal Industries. According to the American Architectural Manufacturer's Association (AAMA), PVC windows accounted for 36 percent of the entire residential market by 1996 and had soared to 68 percent of the total residential window market by 2012<sup>v</sup>. Although PVC windows were initially introduced as replacement options for the remodeling market, within a decade they had also gained greater traction in new construction.

This rise in adoption in both existing and new construction is due in large part to PVC's thermal efficiency. As consumers sought to save energy by replacing old windows, they found the best value in PVC. Vinyl window systems have further proven more durable, easy to maintain, and affordable compared to other window options. Now PVC windows have found a place across all housing markets, ranging from custom and high-end to tract housing and multifamily complexes.

The following three case studies demonstrate how PVC window systems have been used successfully to solve a range of multifamily design and construction challenges. Each of the represented projects had different goals that were met with innovative and sustainable approaches, encompassing the entire "ecosystem" of function and aesthetics.



Photo courtesy of DAS Architects & Halkin Mason Photography

## CASE STUDIES

**Orchards at Orenco: 3-story, 57-unit, multifamily residential affordable housing complex with 265 windows**

*Goal: Play key role in the largest U.S. multifamily passive house building*

Orchards at Orenco, a residential affordable housing complex in suburban Portland that meets Passive House certification standards, is one of the most ambitious REACH Community Development housing projects to date.

Originating in central Europe, Passive House is an advanced energy-efficiency standard that produces



Photo courtesy of REACH/Ankrom Moisan Architects

buildings with superior indoor air quality and thermal comfort while eliminating heating energy use. With more than 57,750 square feet of space, Orchards at Orenco is the largest multifamily Passive House building in the United States.

A project that sets such a high bar for energy efficiency requires unique materials and a careful approach to design. "Our superintendent has a sign up on site that says, 'The word 'normally' will not be used on this project.' From the way that we constructed the foundation, all the way through our framing and our



Photo courtesy of REACH/Ankrom Moisan Architects

waterproofing and insulation strategy, everything is different than the typical project," says project general contractor Marty Houston, quality director for Walsh Construction Co.

It is especially important in Passive House projects to find windows and doors that contribute to the building's exceptional thermal performance, air infiltration ratings and durability. The developers selected PVC tilt-turn windows and exterior hinged doors.

The windows and doors proved to be up to the task according to the results of a preliminary air tightness test. A Passive House's air tightness must be demonstrated with a pressure test (the so called Blower Door test), wherein the allowable air change at a pressure differential of 50 Pascals cannot exceed 0.6 times a room's volume per hour.

A preliminary air tightness test of Orchards at Orenco after the windows and doors were installed recorded 0.056—more than 10 times the efficiency required.

The Orchards at Orenco project passes the original and more stringent European standards for Passive Houses rather than the U.S. standards, which have been relaxed to allow for North America's more extreme temperatures.

**Oceanside Atlantic City Boardwalk Apartments: 347-unit apartment complex with 2,311 windows**

*Goal: Rescue of chronic leaking problems*

The Ocean at 101 Boardwalk, an immense apartment complex on the Atlantic City Boardwalk, was built in the late 1950s with steel salvaged from old naval ships. Unfortunately, the complex's 347 apartments proved to be less than seaworthy against the harsh coastal storms that frequently hit the area. The windows at 101 Boardwalk leaked drastically. David Coluzzi, CEO of The Esquire Group, the developer who purchased the Boardwalk in a bankruptcy auction in 2012, says the windows were a bigger problem than the developer had realized. The Esquire Group promised tenants that keeping them dry was the priority and selected Craig F.

Dothe Architect LLC, an Atlantic City firm, to develop a cost-efficient solution that would not only keep the building dry, but would make the apartments more energy efficient.

The building tenants were skeptical when the latest renovation project was announced in early 2013. Previous owners' attempts to repair the leaky windows only seemed to exacerbate the problem.

This time, the architect called for complete removal of the façade to properly replace all 2,311 windows with 580 PVC tilt-turn windows and 1,731 fixed windows. The tilt-turn windows incorporate multiple locking points and dual compression seals that provide optimal air and water tightness. The multi-chambered walls of the fixed window system increases strength, improves energy

efficiency and allows for efficient water drainage. Both systems exceeded New Jersey performance requirements for hurricane and impact-resistance.

The Esquire Group considered numerous window systems before selecting high-quality uPVC windows for their value and their expected payoff from energy efficiency. "Price, quality and workmanship sold the job," Coluzzi said. "We were impressed by the ability to build them quickly and the ease of installation. The windows had to be customized to fit the building and not the other way around."

Prior to the renovation, bathrooms would pond during a hard rain. Now tenants are excited about their dry apartments.

**Circa Green Lake: Upscale residential complex with 1,084 windows**

*Goal: Modern design that maximizes daylighting while providing high levels of energy efficiency*

The upscale residential complex of Circa Green Lake, adjacent to Seattle's Green Lake Park, features modern amenities and design elements that appeal to the area's metropolitan lifestyle. To maximize daylighting in the residential units, while maintaining a high level of structural performance and energy efficiency, developers selected a PVC compression-seal casement window design.

Provided as combination units, these windows also feature an architectural bronze exterior finish, achieved



by applying an environmentally friendly polymer foil engineered for long-term weather resistance. The result is a visually appealing, reliable window solution that contributes to the overall comfort and satisfaction of Circa Green Lake residents.

The compression-seal projected windows provide high energy-efficiency, structural and acoustical performance, and security. Compression-seal windows generally provide better long-term air infiltration and water penetration resistance than sliding windows because they reduce friction and wear on weather stripping. The system has achieved hurricane impact ratings, providing design flexibility along the coastal regions which require adherence to strict building codes.

## BENEFITS OF PVC VERSUS ALUMINUM WINDOWS

The green building community has embraced vinyl window and door systems for their high performance and energy efficiency despite controversy surrounding the manufacture, use, recycling and sustainability of PVC—primarily because of its association with the chlorine industry. Yet much of this argument has been driven by emotion rather than scientific scrutiny.

In reality, vinyl has surpassed aluminum on several fronts:

- Aluminum production creates five times more CO<sub>2</sub> than does PVC.
- Aluminum windows cause up to 60 percent more drafts and twice the potential for leaks.
- Aluminum's thermal conductivity is more than 500 times higher than that of PVC.
- Aluminum window life expectancy is 50 percent less that of PVC windows.

On the other hand, PVC is eco-friendly, energy efficient, fully recyclable and cost effective, and thus ideal for residential projects ranging from single to multifamily construction.

### Eco-friendly and sustainable

During manufacturing, PVC is easily chipped into reusable waste material and extruded into new products. Ninety-nine percent of vinyl's manufacturing waste can be reprocessed while millions of pounds of post-consumer vinyl can be recycled.

Aluminum frames cause the highest burden to the environment because of their high energy consumption during production and the dangerous pollutants they release.

PVC is lightweight, so requires less fuel for transportation than do other materials. And its long life and resistance to weathering translate to far less frequent replacements, which conserves raw materials and prevents pollution typically associated with the manufacturing and disposal of alternative materials with shorter life spans.

## QUIZ

- Which of the following is not a contributing factor in the recent surge in multifamily housing?
  - Declining homeownership rates
  - A need for climate friendly solutions
  - Need for more transient lifestyles
  - Demand for affordable construction
- High performance uPVC window systems offer which of the following benefits?
  - Lowering operating costs
  - Occupant comfort
  - Energy efficiency
  - All of the above
- True or False? PVC has a high salt content.
  - True
  - False
- Why are aluminum windows more commonly used than PVC windows?
  - Aluminum allows more heat transfer
  - PVC is more commonly used for plumbing pipes
  - Aluminum has become the default industry standard
  - PVC is difficult to recycle
- How do owners benefit from using uPVC windows in multifamily construction?
  - Easy installation
  - Value/benefit ratio
  - Occupant comfort
  - All of the Above
- True or False? uPVC is resistant to moisture.
  - True
  - False
- How can high-performance uPVC windows increase a building owner's return on investment?
  - They meet PHIUS standards
  - They have better energy performance and thus lower HVAC operating costs
  - They are available in an array of colors and shapes
  - They can be recycled into other products
- What is the role of compression-seal technology in uPVC windows?
  - Provides a seamless surface for painting
  - Enables easier cleaning
  - Maximizes window surface
  - Keeps treated air sealed in and reduces noise
- Which of the following is not a benefit of green certification?
  - Shows curb appeal
  - Demonstrates positive environmental impact
  - Helps get rebates
  - Boosts property values
- Which is true of performance ratings?
  - They are mandatory
  - Help architects make aesthetic choices
  - Show a products ability to perform to a desired standard
  - Demonstrate high performance in all weather

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Course valid through November, 2019

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PVC reprocesses well and offers an even smaller carbon footprint when it is recycled into second-life applications. The recycling process uses approximately half the primary energy to process the original PVC and emits only 39 percent of the greenhouse gases, so it has significantly lower global warming impact.

Further, replacing aluminum with vinyl windows in a project of 5,000 square feet of window surface can save as much as 4,500 tons in CO<sub>2</sub> emissions over a period of 25 years. To put this in perspective, the average personal vehicle will emit 110 tons of CO<sub>2</sub> within the same period.

### Energy efficiency

PVC profiles come with a lower coefficient of thermal conductivity than aluminum products and therefore provide superior thermal insulation. PVC is also an ideal window material because it doesn't conduct heat well, so there's no heat transfer between inside and out. Aluminum does conduct heat, so it tends to feel cold in winter and hot in summer.



### Durability and weatherability

Aluminum windows, on average, have a life expectancy of 15 years. PVC windows can last as long as 40 years. PVC also has good weatherability to withstand extremes in different environments. Unlike alternative materials, uPVC frames are water and salt resistant and thermally non-conductive so they don't rot, peel, or chip.

### Comfort and wellness

Replacing aluminum with uPVC windows in a project will result in up to 25 percent noise reduction and up to 60 percent less air infiltration. The fusion-welded corners of high-performance uPVC windows also prevent leakage, mold, and associated health risks.

### Fire resistance

Contrary to what many would expect, PVC is an inherently fire resistant plastic: without an external heat source, uPVC is self-extinguishing.

In addition, PVC releases less combustion heat than other plastics, which helps stop the spread of fire. As explained in the Vinyl Institute's brochure, "Fire and Polyvinyl Chloride," a burning object spreads to nearby objects only if it gives off enough heat to ignite them. So the rate of heat release is far more important than ease of ignition, smoke toxicity, or flame spread in controlling the time available for escape.

The burning of PVC "yields an expanded carbonaceous structure usually called 'intumescence'." This structure forms a thermal barrier protecting underlying parts.<sup>vi</sup> This fire resistance makes PVC window profiles particularly suitable for multifamily residential projects that have stringent fire rating requirements.

### PVC WINDOW SELECTION CRITERIA FOR MULTIFAMILY PROJECTS

In selecting PVC windows for multifamily construction projects, architects and specifiers must balance performance and aesthetics, while ensuring occupant comfort and well-being through access to fresh air, views, natural light, protection from the elements, and sound control. Sound transmission and sight lines are of major concern in multifamily living, especially in urban areas where you have a cacophony of sounds throughout the day.

Although architects may be aware of the properties and benefits of PVC windows, this is not always the case with owners and other stakeholders. Architects can help educate owners of multifamily residential projects, making the case for PVC's role in meeting project goals including the following:

- Access to an array of design options
- Energy efficiency
- Thermal and acoustic comfort
- Adherence to schedule and budget
- Low maintenance and operating costs
- Safety and security

### Design flexibility

Because vinyl is a thermoplastic material, it can be molded, bent, and shaped into a wide range of customized shapes (round, half-round, triangular, rake-top, ellipsoidal windows). It is also available in a range of colors, textures, and patterns. This flexibility gives architects and designers greater creative latitude to specify windows for applications ranging from ultramodern to traditional to historic conservation.

PVC window options further accommodate different building styles and construction requirements:

- **Casement windows** are hinged at the side and are opened with a crank, lever, or handle that serves as a window lock. They deliver optimal tightness and energy efficiency based on compression-seal technology.



- **Tilt-turn windows** are three windows in one: an inward opening casement in the turn position, a secure top-venting hopper in the tilt position, and a picture window when closed. Tilt-turn windows feature compression-seal technology for optimal tightness and energy efficiency and can simulate the look of a traditional hung window.



### Ease of installation

The installation process is a critical element of any project's budget because even a minor setback has the potential to negatively impact a project's completion schedule and budget.

Aluminum windows are time and labor intensive, requiring sill pans/flashing systems. The cutting of receptors, sill flashes/sub sills and the caulking of mechanical corners are among the time-consuming steps. This process makes schedule and cost overruns more likely.

On the other hand, PVC windows have welded corners and so don't require pan flashing. This translates to a potential time savings of up to 55 percent. In a 500-window project, for example, this means time savings of up to 209 hours compared to aluminum window units.

### Performance ratings and requirements

Not all PVC window systems are created equal. Like any building material, they run the range from low to high quality. Therefore, architects need to rely on performance-based standards of ratings that evaluate window systems based on structural strength and deflection resistance, resistance to air and water leaks, impact resistance, thermal and acoustic insulation, and fire resistance and security.

Municipal codes and performance requirements also impact project scope and expected outcomes. Owners depend on architects to specify windows that have undergone rigorous testing to meet or exceed the North American Fenestration Standard (NAFS) structural, air and water standards.

NAFS standards and product quality ratings look at windows as an integrated system encompassing all components: frame extrusions, finishes, flashing, sealants, and so forth.

In addition, the American Society for Testing and Materials (ASTM) provides PVC testing protocols and specifications:

**ASTM D4216 Specification for Rigid PVC and Related Plastic Building Product Compounds:** property specifications for compounds used for windows and doors including minimum values and ranges for strength, expansion coefficient, and heat deflection temperature.<sup>vii</sup>

**ASTM D4726 Specification for Rigid PVC Exterior-Profile Extrusions Used for Assembled Windows and Doors:** specifications establish detailed physical and performance requirements for PVC including dimensional stability, weatherability and extrusion quality of rigid PVC exterior profile extrusions used to assemble windows and doors.<sup>viii</sup>



Sound transmission class (STC) ratings are important in uPVC window selection because they indicate the level of soundproofing (acoustical comfort) that a window system provides. The higher the STC value, the more soundproof the window system. For example, an **ASTM E90 Acoustical (STC)** rating of up to 40 decibels for a window system indicates a high level of noise reduction.

Knowledgeable buyers and specifiers look for ENERGY STAR labels when selecting window systems. Windows with this label demonstrate optimal energy efficiency as expressed by their U-factor. U-factor measures the rate of heat transfer in a window, with a lower U-factor indicating a better insulated window.<sup>ix</sup> To qualify for an ENERGY STAR label, window systems must be tested and certified by the National Fenestration Rating Council (NFRC).

### Lifecycle costs and efficiency

The costs to a building owner depend a great deal on the durability of the building materials and the amount spent on energy each year. Windows account for a large chunk of thermal gains and losses. According to the U.S. Department of Energy, heating and cooling comprise the largest energy expense for most buildings, accounting for 56 percent of overall energy use.

The compression-seal technology of uPVC windows keeps heated and cooled air sealed in tightly within a building so that heating and air conditioning systems don't have to work as hard to maintain the desired temperature. This conservation of energy translates to significant financial savings from season to season.

For a replacement project, replacing aluminum with PVC windows can result in as much as a 45 percent improvement in energy performance. This could mean a five-digit savings in the first year for a multifamily project.



Photo courtesy of DAS Architects & Halkin Mason Photography

Vinyl windows can further lower an owner's investment by allowing for smaller, more cost-effective and efficient heating and cooling systems. Energy conservation, maintenance requirements, and durability all are critical factors when calculating a building's lifecycle costs and return on investment. Based on these factors, an investment in vinyl windows can often be recouped in as few as two years.

### Savings based on durability and resistance

PVC windows are also a good investment because they outlast and outperform alternative materials, like aluminum, which often corrode from exposure to weather and pollution.

PVC has shown it resists fading even in extreme climate zones. In addition, uPVC is naturally resistant to moisture and atmospheric pollutants such as acids, alkalis, and salt air. It is impervious to rot, rust, blistering and flaking, insect (including termite) infestations, and resists mold, mildew, and scratching. With this level of resistance, PVC windows do not require any touch-up as do wood or metal windows.

By maintaining their appearance over the long term, PVC windows reduce replacement and maintenance costs and help retain a property's value. This perceived value and curb appeal is particularly important in rental and condominium developments where there is more wear and tear and more frequent resident turnover.

### LEED® Certification and Passive House Certification

Depending on the municipality, projects may need to meet certain green standards. In addition, high performance green buildings can help

owners get rebates and boost property values. High-performance PVC window formulations deliver enhanced performance, energy efficiency and environmental sustainability and can help projects achieve a prestigious Leadership in Energy and Environmental Design (LEED) rating through the US Green Building Council.

In addition to LEED, there is the Passive House Institute U.S. (PHIUS) Certified Data for Window Performance Program. This program provides a comprehensive guide to high-performance windows and offers participating window manufacturers a way to certify their products as promoting high performance construction and passive building standards in North America. Architects and specifiers can use the program to specify window systems that are tailored to their climate zone.<sup>x</sup>

To ensure they can meet LEED and Passive House standards, architects and specifiers need to look for PVC window products that have earned stringent performance and thermal ratings and use less energy to manufacture than do alternatives.

### CONCLUSION AND ASSESSMENT

PVC has proven to be an ideal material for multifamily residential window profiles, outperforming aluminum on many fronts. PVC windows deliver a high level of energy efficiency, lower operating costs, efficient construction and maintenance, and occupant comfort and safety. uPVC windows significantly reduce noise (a common problem in multifamily construction), heat (and cold) transfer, and water and air leaks without sacrificing design flexibility.

In understanding and successfully communicating the benefits of uPVC over aluminum windows, architects can help clients meet high performance building standards in multifamily construction to better serve the health, comfort, and safety needs of building occupants while also delivering return on investment for owners. ■

### SOURCES

<sup>i</sup> <http://www.census.gov/housing/hvs/files/currenthvspress.pdf>

<sup>ii</sup> <http://www.pvc.org/en/p/sustainability>

<sup>iii</sup> [http://www.bpf.co.uk/topics/12\\_Good\\_Reasons\\_to\\_Specify\\_PVC.aspx](http://www.bpf.co.uk/topics/12_Good_Reasons_to_Specify_PVC.aspx)

<sup>iv</sup> <http://www.pvc.org/en/p/packaging>

<sup>v</sup> <http://www.aamanet.org/news/1/10/0/all/918/vinyl-windows-an-impressive-growth-history>

<sup>vi</sup> <http://www.pvc.org/en/p/fire-retardant-properties>

<sup>vii</sup> <https://www.astm.org/Standards/D4216.htm>

<sup>viii</sup> <https://www.astm.org/Standards/D4726.htm>

<sup>ix</sup> [https://www.energystar.gov/products/building\\_products/residential\\_windows\\_doors\\_and\\_skylights/independently\\_tested\\_certified\\_energy\\_performance](https://www.energystar.gov/products/building_products/residential_windows_doors_and_skylights/independently_tested_certified_energy_performance)

<sup>x</sup> <http://www.phius.org/phi-us-certification-for-buildings-and-products/phi-us-product-data-certification/certified-data-for-window-performance-program>