WHY FIBERGLASS?
TACKLING THE DILEMMA OF ENERGY PERFORMANCE & WINDOWS

Understanding how fiberglass windows deliver highly livable spaces, while dramatically increasing a building's energy efficiency and reducing energy consumption.

The importance of energy efficiency has become a near universal truth over the last half-century. Whether you place value on reducing costs associated with operations or reducing environment impact through less consumption, efficiency is the nexus where these conversations meet.

Over the last 20-years, the energy efficiency of buildings has become a key focus, as we've come to better understand the efficiency of the buildings we live and work in. Or rather, the inefficiency of our buildings.

One large contributor to a building's poor energy performance are windows. Often cited as the weakest link in a building's envelope, windows waste—or lose—the most energy of any element of a building. But this waste is not the fault of "windows" per se, but rather the materials they're built with and the compromises therein.

Metal frames lose large amounts of heat—easily conducting it back and forth from interior to exterior of a building. Plastic frames require frequent and wasteful replacement. Fiberglass frames solve these two issues simultaneously, and offer a product that tackles many other shortcomings of a building envelope's weakest link.

THE PROBLEM WITH BUILDINGS -
Before we discuss a different approach to windows though, it's important to understand their impact on a building.

In the US alone, buildings account for nearly 47% of all greenhouse gas emissions and nearly 49% of overall energy consumption (Architecture 2030, 2020). Of that energy consumption, an estimated 37% (Broeckx-Smith, S., Suh, S., 2019) goes to heating and cooling. And that's where traditional windows make their mark.

Windows currently account for anywhere between 30-50% of the heating and cooling energy loss in a building (Broeckx-Smith, S., Suh, S., 2019). That means for every dollar spent on heating and cooling, up to 50-cents is lost through the window. But it's important to understand what part of the window is letting that money escape, so let's zoom in on the window components.

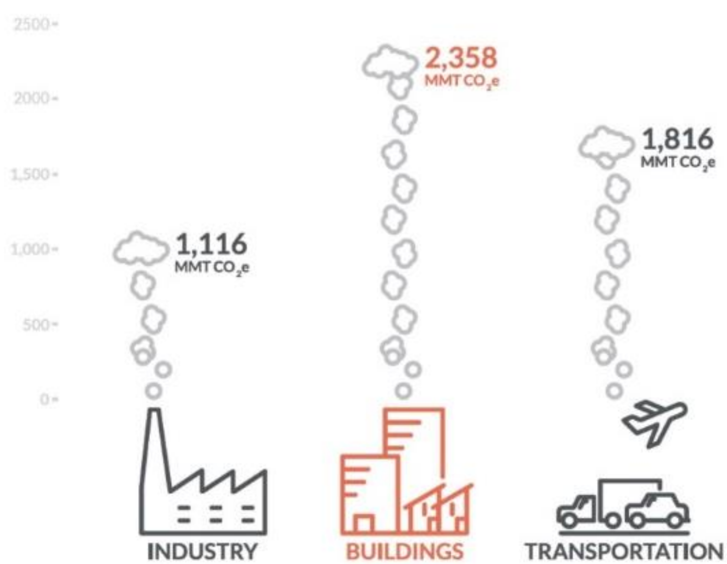

Figure 2 - Architecture 2030 / Illustration: hammerandhand.com

As production advancements improved the efficiency of a window's glass—with the advent of double and triple glazed IGUs (insulated glass unit) filled with various inert gases—innovation of the window frames was largely stagnant. In aluminum windows, a typical innovation was a more complex thermal break between various conductive metal materials. This type of change would yield minimal improvements despite significant cost increases and a more complex product. In vinyl/uPVC windows, an innovation was adding steel reinforcements within the frame to provide rigidity and strength. But introducing this steel diminished the thermal performance of the frame itself.

Both examples were false innovations though, often making trade-offs among weaknesses, but not addressing the underlying issue—the frame is the key. In fact, the frames typically account for between 20-30% of the total window area (Broeckx-Smith, S., Suh, S., 2019), making them a significant weakness in the thermal efficiency of the overall window. And while the frame only represents around a quarter of the total window area, it's responsible for a disproportionately high amount of the heat loss.

Now zoom back out and consider how important a high number of windows is to create a highly livable building. In some ultra-competitive real estate markets—such as Vancouver—developers are targeting almost 75% total glazing area for a high-rise building in order to make the project viable. Combine that with a median building lifespan of 70-75 years (D&R International, Ltd, 2012), the problem with buildings can become staggering.

Coding a Solution –

To help address the scope of this efficiency problem and spur innovation, municipal and state jurisdictions have begun introducing increasingly stringent performance requirements, requiring higher thermal performance from windows specifically, as well as the overall building envelope in general. Indeed, some are beginning to look at increasing renovation and rehabilitation requirements as well.

The introduction of these code changes has led to much hand-wringing in architecture and developer circles, as some struggle to create buildings that meet consumer demands for natural light and livability as well as a viable construction budget. In some extreme cases, projects have seen proposed glazing area reductions of 50% to meet new energy performance requirements.

The Washington State Energy Code, the BC Step Code, and the Energy Conservation Construction Code of New York State (ECCCNYS) are just a few of regulatory changes seeking to improve a building's energy performance. And some local jurisdictions are going even further.

Recently, the City of Vancouver updated bylaws to offer incentives for building to Passive House standard in both Part-3 and Part-9 construction. For the uninitiated, Passive House is the only internationally recognised, performance-based energy standard in construction, employing a comprehensive and integrated approach to design, material sourcing and performance measures of the completed building. Through Vancouver's new bylaw, a MURB (multi-family urban residential building) project can add 5% floor area (ratio of lot square footage), 18% more for an SFD (single family dwelling) and 16% more for a duplex.

This kind of incentive—used to maximize the value of an already expensive piece of earth—will more than pay for any added construction cost to make the building reach Passive House levels, without penalizing existing "to-code" projects.

The Facts About Fiberglass –

Fiberglass windows offer an avenue to deliver highly livable, durable homes and commercial buildings, while at the same time improving the energy efficiency and overall environmental impact of those buildings. Since the fabrication technology emerged nearly 40 years, this innovation has been adopted in some markets, but has lagged behind in North America.

Fiberglass is an ideal structural material for window and door frames—specifically fiberglass with a high glass-fiber-to-resin formula. Nearly 10 times stronger than traditional vinyl/uPVC, the thermoset fiberglass, is dimensionally stable, meaning it won't creep and deflect over time. This stability and strength allow fiberglass frame windows to withstand higher wind load, resulting in larger possible windows – even on tall buildings with high wind loads.

Compared to traditional aluminum windows, fiberglass represents less embodied carbon in both sourcing its raw materials and fabrication, carbon draw during its service life, as well as its end of life recycling (Broeckx-Smith, S., Suh, S., 2019).

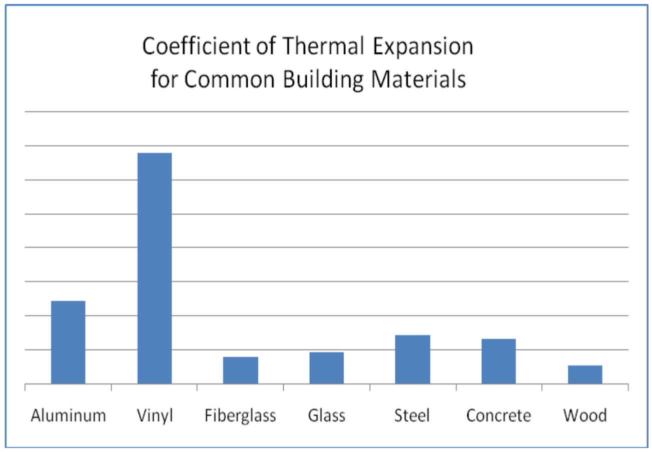

Figure 2 - Comparative thermal expansion of different materials

Impervious to decay, insect attack, and corrosion, fiberglass windows are also capable of weathering extreme temperatures (-40°F through 350°F, and higher) without becoming brittle or soft, giving them a modelled lifespan of 50-80 years. That's over 4-times the lifespan of vinyl/PVC and twice the serviceable lifespan of aluminum windows (Broeckx-Smith, S., Suh, S., 2019).

The simplified frame design of fiberglass windows—free of complicated internal thermal breaks and a medley of different manufacturing materials—makes for a more robust and easier to service final product. The service point is somewhat moot, however. Since fiberglass possesses a low thermal expansion coefficient—similar to glass itself—combined with its inherent durable nature, fiberglass window frames put less stress on their adjacent glass units, meaning less failed seals and air gaps.

But durability and longevity are only secondary to fiberglass' key benefit—its conductivity. Or rather, lack there of.

Not All Windows Are Created Equal

Fiberglass possesses an inherently low thermal conductivity, meaning without any additional thermal breaks or additional materials, fiberglass is 500-time less conductive than aluminum. That means a large-span double-glazed fiberglass window is over 100% more thermally efficient that a comparable aluminum window. In terms of R-values, that's a rating of R-4.1 versus R-2.0.

Such a dramatic increase in the weakest link of a building envelope's overall thermal performance can mean significant improvements overall. And the impact of this improvement doesn't stop at the edge of the window frame. Because the heating and cooling load on the building is less, mechanical systems can be reconfigured and reduced in size, complexity and cost as a result. That means less construction costs, as well as more flexibility in building layout since there are less HVAC duct runs and space used for heating/cooling apparatus. And remember, these benefits are achieved while defending the amount of overall glass area, and in some instances increasing the glazing area.

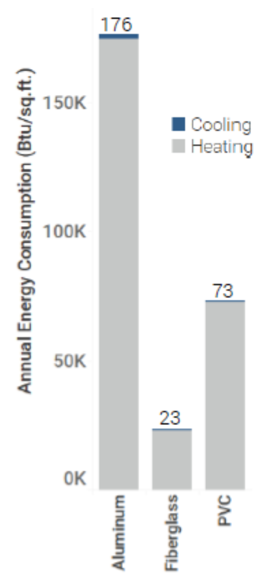

Figure 3 - Annual primary energy loss per square foot of window frame surface (VitaMetrics)

What Lies Ahead –
Conversations around the energy performance of buildings are not going anywhere. The cat's out of the bag in terms of the demands building place on our energy infrastructures, with multiple layers of regulatory jurisdictions seeking to address the issue, not to mention consumers demanding livable, long-life homes and offices.

But these new market pressures don't have to be scary. We don't need to embark upon extraordinary efforts to affect change and see real improvement. With existing building science knowledge, skilled tradespeople and innovative building products, we can create impact now. Tested, proven-in-the-field and readily available, fiberglass windows are one of those innovations. By targeting this weakest link of a building's envelope—but one that directly benefits the building's occupants—we can make leaps and strides towards more efficient, better buildings. All it will take is people viewing windows in a different way.

REFERENCES

Works Cited

Architecture 2030. (2020, 03 30). *About - FAQ - Why Building Products*. Retrieved from Architecture 2030: https://architecture2030.org/about/faq/#toggle-id-23

Broeckx-Smith, S., Suh, S. (2019). *Comparative Life Cycle Energy and Greenhouse Gas Emission Performance of Window Frame Materials.* Goleta, CA, USA: VitalMetrics (IERS LLC.).

D&R International, Ltd. (2012). *2011 Buildings Energy Data Book.* Silver Spring, Maryland: Pacific Northwest National Laboratory (PNNL) with support from the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE).

Appendix 1 –

Executive Summary of *Comparative Life Cycle Energy and Greenhouse Gas Emission Performance of Window Frame Materials*, VitalMetrics

APPENDIX 1 -

Comparing the Environmental Performance of Fiberglass, Aluminum, and Vinyl Window Frames

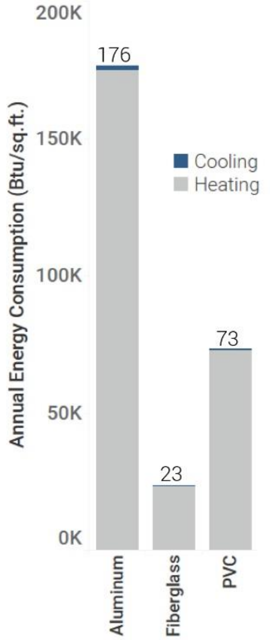

Figure 1: Annual primary energy loss per square foot of window frame surface area.

Window systems play an important role in determining the environmental and energy performances of a building. Energy losses through windows demand additional heating or cooling to maintain desired internal building temperatures, which in turn increases energy costs and greenhouse gas (GHG) emissions associated with the additional heating or cooling needs. One major contributing factor in the overall thermal insulation performance of a building is the window frame material selected..

A third party study* conducted for Cascadia Windows & Doors found that Cascadia's fiberglass window frames conserve 68% more heating and cooling energy than typical vinyl (PVC) window frames, and conserve 87% more energy than thermally-broken aluminum frames (Figure 1). This can translate to increased costs for users, but what environmental impacts do these additional energy needs create?

While the difference in annual emissions between fiberglass and PVC frames is less than 3 kg of carbon dioxide equivalent (CO_2eq) per square foot of frame, these emissions are more substantial when scaled up to an entire structure. Considering a typical high school building with 400 PVC windows, the annual GHG emissions mitigated by retrofitting all windows with fiberglass frames is about 1.6 metric tons CO_2eq, which is about the same as combusting an additional 180 gallons of gasoline per year (Figure 2).

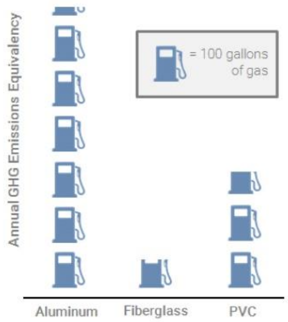

Figure 2: Annual GHG emissions equivalencies due to window frame energy loss for a typical high school building.

VITALMETRICS

*All results are based on a Seattle, WA climate scenario.

APPENDIX 1 (continued) -

When purchasing window frames, other important factors to consider are the frame service life and energy performance over time. On average, aluminum window frames have a service life of about 40 years while PVC frames last about 22 years. Fiberglass window frames boast a service life of more than 80 years, meaning two aluminum frames and four PVC frames are needed to do the same job as one fiberglass window frame. Not only does this increase replacement frequency, but the primary energy needed for the manufacturing of new frames and disposal of old ones also increases. Over the course of its life cycle, the primary energy consumed is far less for fiberglass frames than either PVC or aluminum, with PVC consuming the most energy over the 80 year period due to its short service life and relatively high embodied energy (Figure 3).

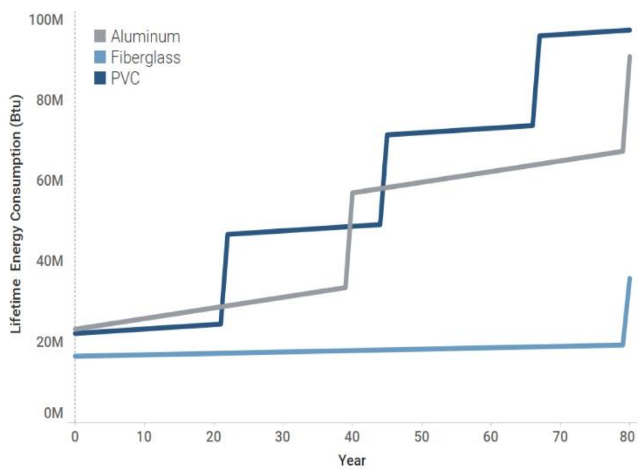

Figure 3: Life cycle primary energy consumption of one window frame, including embodied energy, use phase energy loss, and disposal energy requirements. Sudden increases in energy consumption indicate window frame replacement and represent the energy required to dispose of the old frame as well as manufacture a new one.

If all 37,100 high schools in the United States each had 400 windows and were to switch from PVC or aluminum window frames to fiberglass frames, the total amount of direct energy saved per year would be about the same as the natural gas energy consumed by about 38,000-115,000 households in the state of Washington each year.

Cascadia Windows & Doors manufactures fiberglass frames with superior thermal and durability performance that contributes to a longer service life and decreased energy consumption compared to aluminum and PVC frames. The use of these frames presents opportunities for cost savings and reduced environmental impact.

VITALMETRICS

*All results are based on a Seattle, WA climate scenario.