



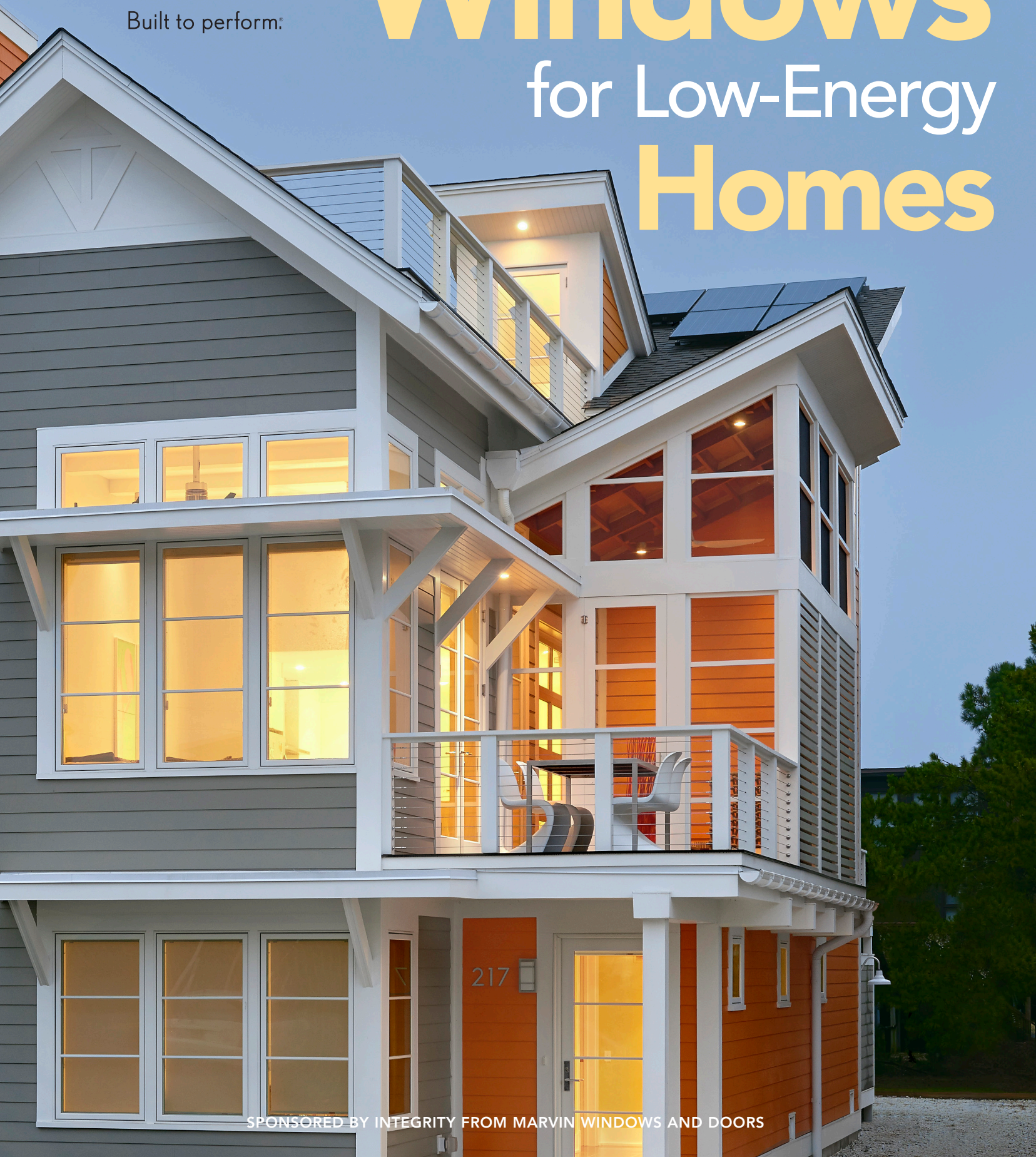
from **MARVIN**
Windows and Doors

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Windows

for Low-Energy

Homes



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Smart choices deliver long-term value

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As cheap energy became scarce, building science grew up, forcing designers and builders to find practical ways to improve the insulation and airtightness of their homes. With much higher R-values in foundations, walls, and roofs, there is new pressure on windows to perform. Their job isn't easy. Unlike the rest of a house, windows must let in a flood of daylight, and a breath of fresh air when called upon, while helping to maintain the thermal performance of the home.

The bar for energy-efficiency is higher than ever, but there is good news for today's earth- and value-conscious homeowners: Window technology has improved steadily and significantly, and there are great new options for low-energy homes, no matter the climate in which they are built.

Conveniently, the conversation about windows for new construction isn't all that different from the considerations for replacement windows. So if you are inspired by the energy savings and comfort that can come from replacement units, you'll still want to pay close attention to the window's critical performance attributes and the components that yield long-term durability.

This resource outlines the major factors that every designer, builder, or homeowner must assess when purchasing new windows. From understanding performance ratings to selecting the right glazing package, this guide will help ensure that you select the best window products for your next project.



Understanding efficiency ratings and performance

Unless you are building or renovating for a quick flip, you or your clients will be living with the new windows for a long time, so your decision is a critical one. Low-cost windows can be pricier than they first appear. Like any weak link in the building envelope, poor-performing windows require a larger HVAC system and ducting, which is pricier up front and also more costly in the long run.

“With insulating values as low as U-0.18, windows can have a huge impact on a home’s energy-efficiency rating and a cascade effect on the cost of the overall project,” said Brett Dillon, a longtime builder and developer in Texas, who chairs the technical standards committee for ResNet, a big nonprofit

that trains and rates residential energy auditors.

The logic is similar for existing homes. Insulation upgrades, better air-sealing, and replacement windows and doors can trim energy costs to a fraction of what they were, allowing smaller, more innovative HVAC systems with short payback periods.

Comfort is king

The math is easy, but not all builders and homeowners respond to it. “A lot of people don’t know how much they pay for energy and don’t really care,” Dillon says. “But everyone cares about comfort.”

By the time a new homeowner complains about drafty windows, or condensation, or rooms that overheat in summer, it’s too

late to rip out underperforming windows. Often the builder’s or homeowner’s solution is to upgrade the entire heating and cooling system.

Interestingly, complaints about draftiness can usually be traced to low-quality windows with cold glass, not air leakage, says Steve Baczek, an architect outside Boston. “People say, ‘This window feels drafty,’ but it’s really not a draft. The radiation rate of the window is too high and you feel the cold,” he says. “It’s the same reason that basements feel cool. Your body is losing heat at a much higher rate as it tries to warm the cold walls.”

Durability isn’t labeled

The National Fenestration Ratings Council provides a label on

every window that gives reliable numbers for its energy-efficiency (see “The NFRC label: Behind the numbers,” below). But performance, comfort, and overall value aren’t just about initial energy-efficiency. If windows aren’t strong and durable, that performance won’t last. Windows can even become a nuisance.

“There’s nothing worse than busting your butt all day at work and then coming home to find sticking windows, rotting siding, and more stuff to fix,” Dillon says. “It’s a big reason why more people are renting.”

Choosing windows that will save energy, stand up to the weather, and perform like new for decades might seem like a lofty goal, but today’s technologies put it well within reach.


THE NFRC LABEL: BEHIND THE NUMBERS

In 1993, the National Fenestration Ratings Council (NFRC) developed the first universally adopted method for evaluating the energy performance of windows, along with an information-packed ratings label that you’ll find on all windows sold in the

United States. Here’s what the numbers mean, especially the two big ones at the top. The most important rating is the U-Factor, which measures the heat transmission of the entire window unit, from the glass to the frame to the air that slips by the sashes.

U-Factor is similar to R-value, but while R-value measures a product’s resistance to heat transmission, U-Factor measures how much heat that product lets through. One is simply the inverse of the other, so an average window with a U-Factor of, say, 0.33 is equivalent to R-3. (The lower the U-Factor, the greater the efficiency.) With walls rated at much higher R-values, you can see how windows are the weak link in the building envelope, and worthy of serious consideration.

In addition to the U-Factor, the performance of a window also takes into account the air leakage through its components and the emissivity of the glass (see SHGC and AL, below). Both ratings have a substantial impact on a home’s overall comfort and efficiency.

 National Fenestration Ratings Council CERTIFIED	World's Best Window Co. Millennium 2000+ Vinyl-Clad Wood Frame Double Glazing • Argon Fill • Low E Product Type: Vertical Slider
ENERGY PERFORMANCE RATINGS	
U-Factor (U.S./I-P) 0.35	Solar Heat Gain Coefficient 0.32
ADDITIONAL PERFORMANCE RATINGS	
Visible Transmittance 0.51	Air Leakage (U.S./I-P) 0.2
Condensation Resistance 5'	
<small>Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. Consult manufacturer's literature for other product performance information. www.nfrc.org</small>	

Another important number on the label is the Solar Heat Gain Coefficient (SHGC), which measures the percentage of the sun’s heat that will radiate through a window. A lower SHGC helps keep solar heat out of homes in warm climates, while a higher SHGC lets it through—a potential benefit in homes built in very cold climates, as the heat coming through the window can supplement mechanical conditioning.

Below these big numbers are ratings for Visible Transmittance (VT), or how much light gets through, on a scale of 0 to 1.0. Windows with low VT ratings appear tinted, while those with higher ratings look more clear. Air leakage (AL) is another important rating. The lower the AL, the better. This value tends to be higher for sliding windows than for those that are pulled to close.

Balancing performance with building budgets

“Some builders think that if they meet code the house is efficient. No, that’s the worst house you can build legally.”

BRETT DILLON

When you go looking for guidelines for window efficiency, the first thing to realize is that local building codes, if they exist at all, are a minimum standard that is often out of date and out of line with current building science. “Some builders think that if they meet code, the house is efficient,” Dillon says. “No, that’s the worst house you can build legally.”

At the other end of the spectrum are superinsulated homes that are hard to justify with simple dollars and cents. Often their owners are willing to spend more or accept a payback period of several decades in order to erase their carbon footprint.

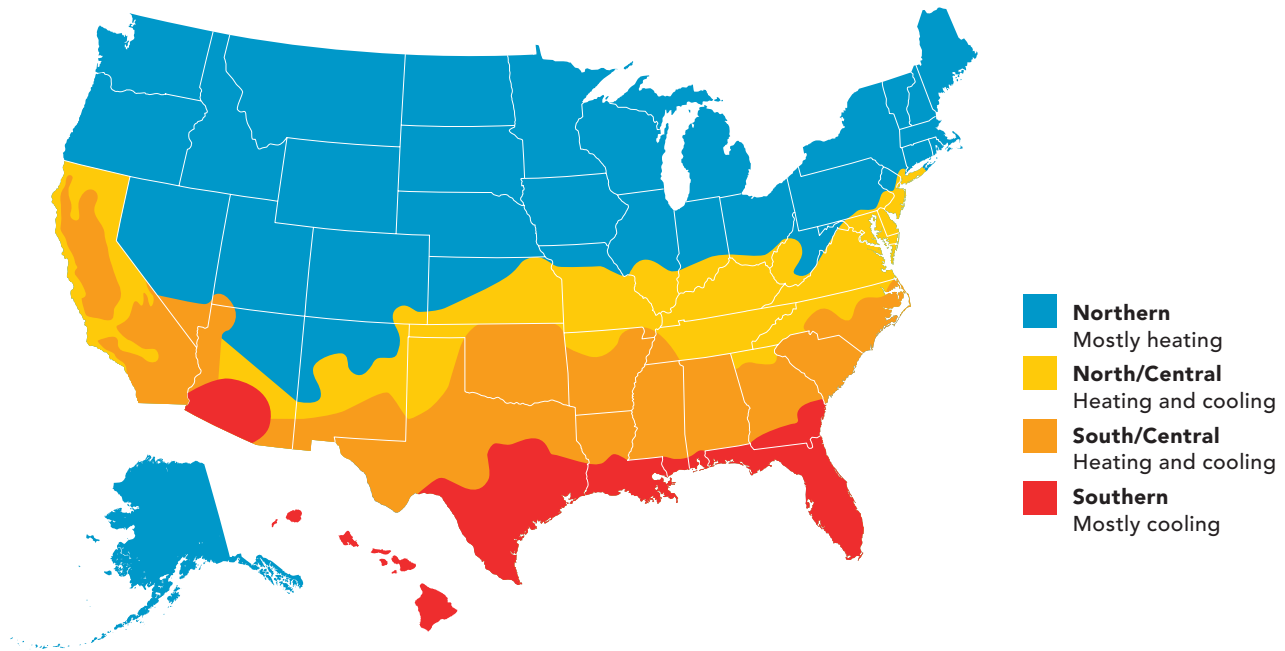
Better builders and savvy homebuyers fall somewhere in the middle, where the payoff from durable, low-energy windows is easy to calculate and justify. In fact, those calculations have been done by the U.S. government via the Energy Star program, which has been widely adopted by manufacturers. So your first step when shopping for energy-efficient windows is to look for the blue Energy Star label.



Energy Star label

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Balancing performance with building budgets *continued*



Energy Star recommendations are given for four climate zones in the United States: the mostly heating zone (Northern); two combination heating and cooling zones (North/Central and South/Central); and a mostly cooling zone (Southern). Every qualified window will list the zones it is certified for.

The Energy Star standard is a good benchmark for energy-conscious architects and builders, but every house is unique. To choose the best-performing windows, it's still recommended to work with a supplier to take into account factors such as site orientation and the size and number of windows.

The latest science on the value of passive solar

Until recently, experts on building science have pushed the benefits of passive-solar heating, in which a large array of south-facing windows with higher solar-gain numbers let in free heat in winter, while large roof overhangs block the sun at its higher summer angles. But recent tests and studies have shown little to no long-term payoff for the extra glass.

Gary Proskiw's influential 2010 report commissioned by the Canadian government, "Identifying Affordable Net Zero Energy Housing Solutions," calculated the break-even point for the cost of the additional windows at 160 years, compared to the 25-year lifecycle of the windows themselves. Builders have also found that passively heated rooms tend to overheat, creating a basic comfort issue.

So instead of balancing very low U-Factors with high SHGCs in cold climates, or even using a wide variety of SHGCs in the same house, the latest thinking is to just keep the U-Factors and SHGC numbers low everywhere.

With great options for every budget and situation, builders can offer customers much better windows than ever before. And with a little education and the help of clear, reliable ratings on every product, homeowners can be sure they are getting what they paid for. There is just no good reason to struggle with poorly performing windows over the life of a home.

Climate zone	U-Factor	SHGC	
Northern	≤ .27	Any	Prescriptive
	= .28	≥ .32	Equivalent energy performance
	= .29	≥ .37	
	= .30	≥ .42	
North/Central	≤ .30	≤ .40	
South/Central	≤ .30	≤ .25	
Southern	≤ .40	≤ .25	

WINDOWS BY CLIMATE ZONE

The Department of Energy organizes the United States into four climate regions (map). Under the Energy Star program, each region is assigned threshold U-Factor and SHGC ratings to determine qualifying windows (chart) for homes built in those specific locations.

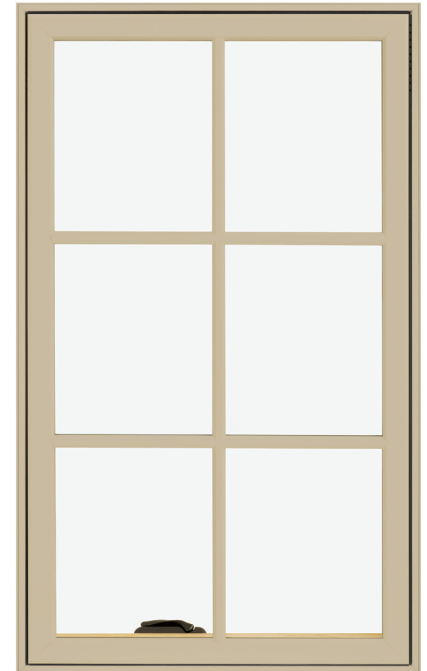
Choosing window types and frame materials



Double-hung



Awning



Casement

FORM + FUNCTION

While windows come in a variety of shapes and sizes to meet any design solution, it's important to be aware of each type's inherent performance attributes when selecting units for low-energy homes.

Windows are available in a wide array of types, styles, and packages. To get the most energy-efficiency and durability for your dollar, you have to break down the window into its parts.

The first consideration is the type of window itself—in other words, how it functions. Dig through any manufacturer's website and you'll find double-hung, casement, sliding, tilt-and-turn, and so on. Mostly these are aesthetic choices based on the style of the home and outside the scope of this article, but there are two types of air seals around the window that you should know about.

Casements, hoppers, awnings, and tilt-and-turns all swing outward or inward, and when locked, they are pushed or pulled tightly against their weatherstripping. From an energy-efficiency standpoint, their compression seals give those windows a distinct advantage over windows that slide, either sideways or vertically (such as single- and double-hungs).

So if you've been dead set on double-hungs, you might want to consider some windows that swing instead of slide. You'll get better insulation, with all other things being equal. Texas builder Matt Risinger agrees: "Get as many awning or casement windows as you can. They seal better, and their screens are on

the inside, so they stay cleaner and are easier to take off in winter."

There are a few functional caveats for swinging windows. They can be a hazard in areas where people walk by, such as decks, patios, or walkways.

Fixed windows, such as accents and pictures, are also worth considering. They are even more airtight than swinging windows, but be aware that nonoperational windows don't satisfy egress requirements in bedrooms.

Choose a frame material

After basic functionality, the choice of frame material has the greatest impact on price and performance.

Frame materials are generally the weak link in a window's thermal performance, and at 15% to 20% of the overall surface, the frame has a big impact on U-Factor. But there is also durability and weatherability to consider. The longevity of window frames, claddings, and finishes varies widely. Selecting the appropriate windows based on the environment is critical, especially in regions with extreme weather.

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Choosing window types and frame materials *continued*



MORE THAN BEAUTY

The materials used to construct and clad a window have a prominent impact on the window's aesthetics and the overall influence on the design of the home, but they also inform the window's long-term durability and performance.



The main frame materials for windows are vinyl, rolled or extruded aluminum, fiberglass, wood, and wood clad with a more weather-resistant material on the exterior—either rolled or extruded aluminum, fiberglass, or vinyl. Each material has its pluses and minuses.

Extruded aluminum, not rolled, is preferred for cladding because of its strength and weather-resistance. Clad windows shouldn't be confused with windows that have all-aluminum frames, which are typically less energy-efficient than the alternatives.

The white elephant in the room is vinyl, which accounts for roughly two-thirds of all of the windows installed in the United States. It's even less expensive than aluminum yet offers much better insulating values. That said, there are some good reasons to bypass vinyl, and to some extent even vinyl-wood composites, even if you are looking for long-term value.

Vinyl (and some composites) has poor strength, meaning it's prone to damage during installation and to warping over time. And its insulating capability is only moderate compared to wood and fiberglass, even when its extruded chambers are filled with foam. Third, vinyl is prone to UV damage, making it a poor choice in the sunniest states. The vulnerability to heat and UV light is why vinyl windows are manufactured mostly in white and almond tones. Vinyl doesn't take paint well, so you'll be stuck with those white windows.

Vinyl also expands and contracts at a rate seven times greater than glass, which means that seasonal temperature swings can break the insulating seals around the panes, letting in air and moisture. Vinyl also has poor resistance to wear and tear, as well as the worst impact resistance of any frame material.

Despite that, today's vinyl windows are a vast improvement over the leaky, single-pane wood windows of yesteryear.

Next up the price chain are all-wood windows. Wood is strong and a good insulator, and it adds beauty inside and outside the home. But wood windows require regular maintenance, which adds to their cost. If you neglect that cleaning and painting at any point, sun and rain can do permanent damage. This is why so many manufacturers offer a wood window clad with vinyl, aluminum, or fiberglass.

Fiberglass is unique

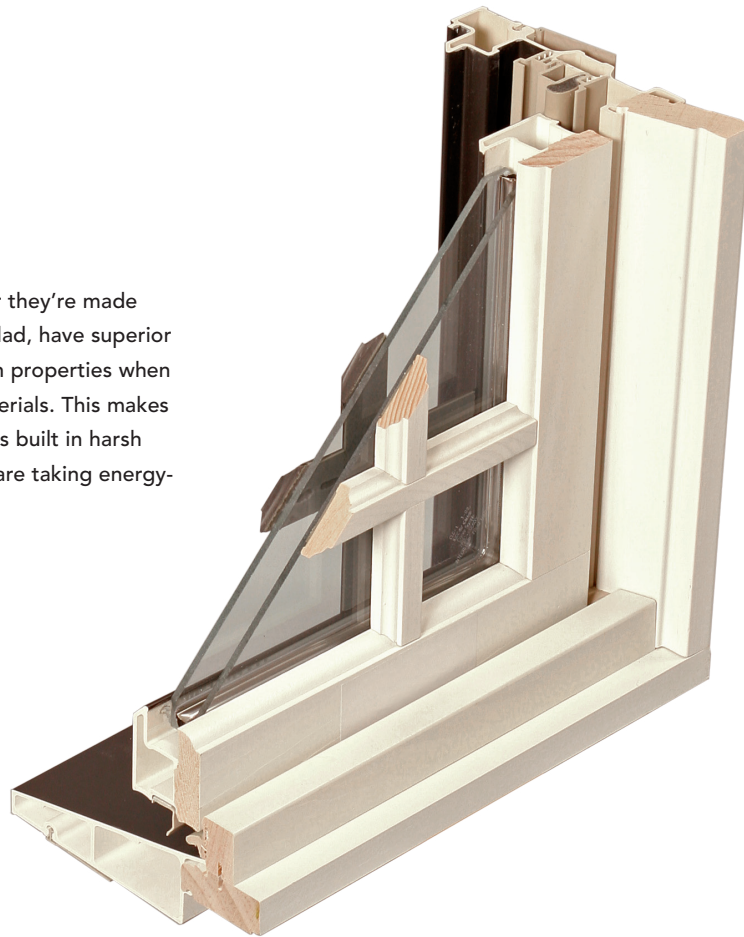
As a window-frame material, fiberglass offers an unmatched combination of energy-efficiency, durability, and long-term value. Integrity from

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Choosing window types and frame materials *continued*

FIBERGLASS OUTPERFORMS ALTERNATIVES

Fiberglass windows, whether they're made completely of fiberglass or clad, have superior weatherization and insulation properties when compared to alternative materials. This makes them ideally suited for homes built in harsh locations and in homes that are taking energy-efficiency seriously.



Marvin's Ultrex pultruded fiberglass, for example, is eight times stronger than vinyl and is coated with a thick acrylic finish so durable that it can be offered in dark colors without fear of UV degradation or fading.

With its very low conductivity, fiberglass is also the best insulator among window-frame materials. And it shrinks and expands at the same rate as glass, making its air-seals as durable as the rest of the unit. Its long-term stability also ensures that fiberglass windows will operate like new for decades to come.

Fiberglass windows can be priced higher than vinyl, and a bit more than all-wood, but the payback in energy-efficiency, durability, and convenience makes it a strong contender for best value in the industry.

For Dave Veldhuizen, who builds low- and zero-energy homes in Eugene, Ore., it's hard to beat the practicality of U.S.-made fiberglass windows. "Integrity windows cost less than half as much as [superinsulated] European windows, and they don't require a six-month lead time when ordering." In fact, Marvin guarantees delivery to the local distributor within 10 days for all of its Integrity windows and doors, including special sizes.

There are two options for fiberglass windows: all

fiberglass and fiberglass-clad wood. Full fiberglass models offer the best value of the two, while the clad models offer the timeless look of real wood on the interior of the home. Clad models also tend to offer the more high-end glazing options, like triple-pane glass, while all fiberglass has glazing options for every climate as well.

Clad windows are the most expensive category, but they offer an unmatched combination of interior wood, energy-efficiency, and low-maintenance. Aluminum and fiberglass are both superdurable outdoors, and each has its slight advantages. Aluminum offers more options, while fiberglass has the edge in overall strength and value. Both offer a wide range of near-weatherproof color coatings, which are bonded to the cladding during its manufacture. Vinyl cladding is less expensive than the other two but has the performance and durability problems associated with all-vinyl and some vinyl-wood composite windows mentioned earlier.

To be sure your clad windows are top-quality, check to see that there is no wood exposed to the outdoors, and check the specs to compare coatings between various brands. Look for a third-party rating.

SELECTING THE RIGHT GLAZING PACKAGE

The glass, called glazing, is the other critical component in your window package. While manufacturers tend to pick a frame material and stick with it, they offer a wide range of glass configurations and coatings, all of which have a big impact on energy efficiency. In fact, the top U.S. window manufacturers get their glass from just a few factories, who specialize in combining the high-tech coatings, films, spacers, and gases that go into today's glazing units.

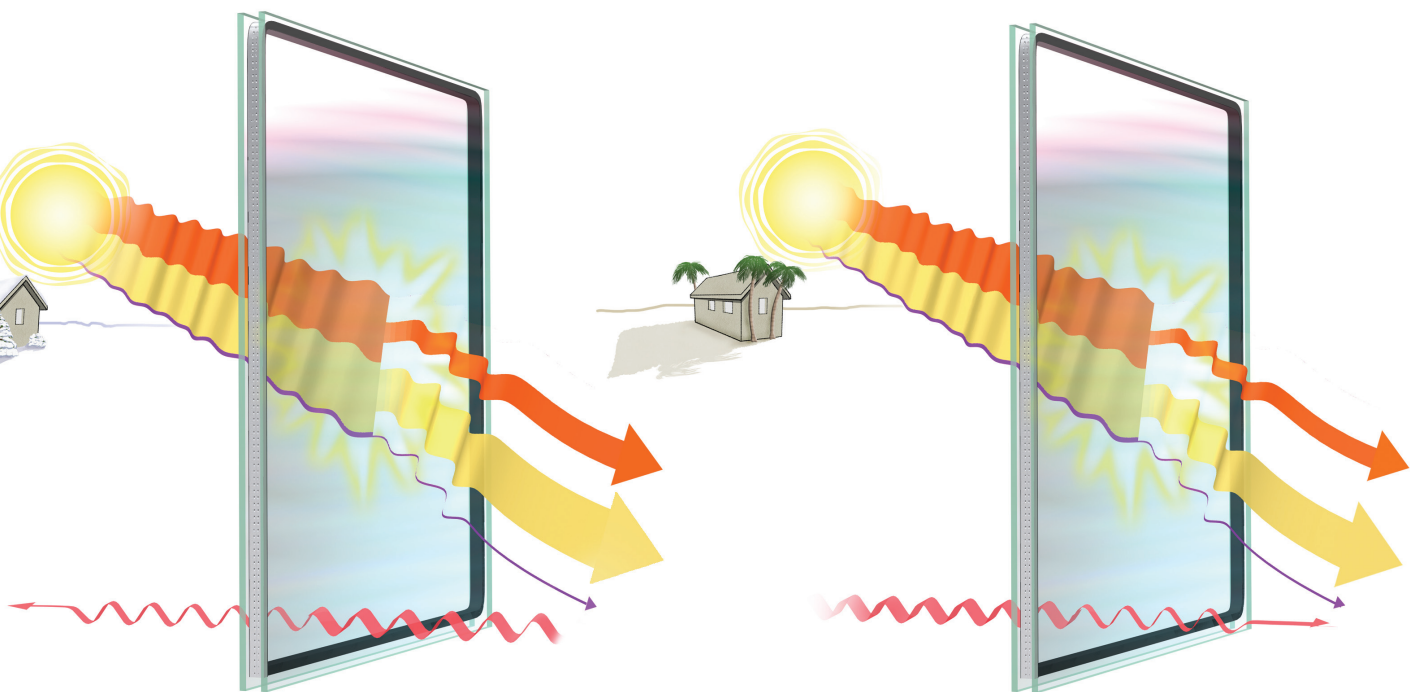
Two-pane insulated units are now standard, and that step alone has taken windows from a U-Factor of about 1 for a single-pane window to roughly U-0.50. Adding inexpensive low-e coatings and argon gas between the panes can take a two-pane window up to a U-Factor of 0.3, which will meet the Energy Star standards for all regions.

While low-e coatings help to stop solar radiation,

they can also reflect heat back into the house. So they affect both solar heat gain and the overall insulating ability (U-Factor) of the window unit.

The next big step up is adding a third pane, which can lower the window's overall U-Factor by another 50 percent. Some designers and builders of low-energy homes have relied on European triple-pane windows as part of a superinsulated building envelope. However, these window packages are traditionally cost-prohibitive for many clients. Double-pane windows and domestic triple-pane units can offer performance at less expense. Still, experts advise finding more cost-effective ways to improve a building's thermal envelope before going to three-pane units.

"As we start building more airtight and insulated homes, triple-glazed will start to make more sense," Risinger predicts. "Here, we aren't quite there yet."



LOW-E COATINGS

Manufacturers strive to create insulated-glass units that block most UV rays, admit maximum light, and manage heat from infrared rays in a way that's most advantageous to the home's climate and orientation. They achieve this by applying very thin metallic coatings to precise surfaces within the glazing unit. Low-e coatings adjust the window's SHGC in order to help meet the performance demands of the home.