by Steve Andrews

Low-e glass gives designers greater flexibility due to reduced solar transmission, greater insulation value, and reduced fabric fading.

SHOPPING FOR SUPERWINDOWS

How to sort through the high-performance options to pick the right window for your project

The last time you shopped around for windows, chances are you scrutinized for durability, ease of operation, a tight fit, economy, and good overall service—from delivery to guarantees. Since 1985, however, a host of energy performance options have probably been added to your shopping list.

Low-emissivity coatings that significantly cut heating and cooling costs are available from every major wood window manufacturer. Heat Mirror—a low-e film suspended between two panes of glass—can provide even greater savings. A few manufacturers now offer units filled with a gas called *argon* that further cuts heat loss. By the early 90's, windows that are both low-e coated and gas-filled may have captured over 50 percent of the market.

In Europe, you can buy R-10 windows today; Geilinger is a Swiss building company that makes a 3-inch wide glass unit with such low heat losses that the homes don't require heating systems. Colorado-based Alpen Inc. can match that performance—with one layer of low-e coated glass, two layers of Heat Mirror film, and argon in all three air spaces. But, products with a more modest R-4 rating—twice as effective as standard double-glazing—still represent a quantum leap, the biggest breakthrough in windows since double glazing was first patented in 1865.

When shopping for energy efficiency in windows, there are five factors to consider: the type of glazing (including coatings and films); air space between glazings, and any gas added to it; losses from edge spacers; frame losses; and air infiltration. Here's an update on each of these features, with a look to new directions.

Glazing Products

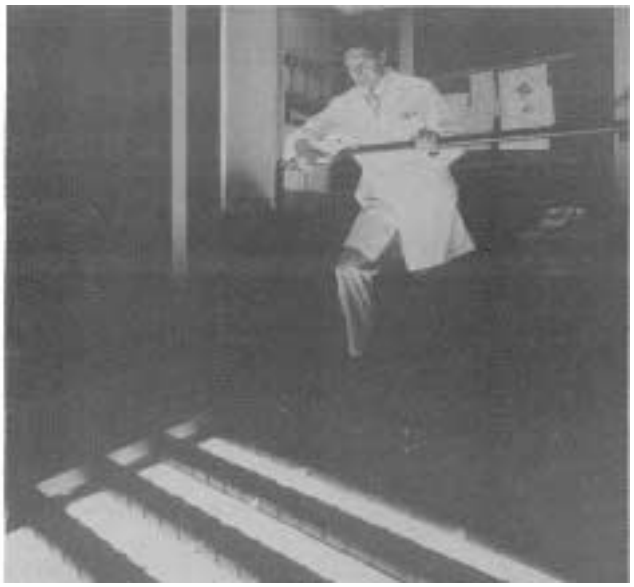
Last year, 13 percent of all double-glazed windows made in the U.S. had low-e coated glass, according to PPG's residential market manager William F. Uhl, Jr. This year, Uhl says low-e should capture 21 percent of the market, and grow to 50 to 60 percent by the end of 1991. Crestline currently ships 25 to 30 percent low-e at present, Hurd is up to 30 percent, and Andersen tops the list with low-e on nearly 70 percent of residential sales. This is an impressive showing, considering that low-e first appeared in this country back in 1981.

Manufacturers attribute the popularity of low-e to the technology's four key features: low energy bills, increased comfort, decreased fabric fading, and reduced problems with wintertime condensation. The atoms-thin metallic low-e coatings achieve these results through precise design and engineering. Layers of metal oxides and silver are either magnetically deposited on glass inside a vacuum chamber ("sputtered" on) or are applied to glass while it is still being fired ("pyrolitic"). The low-e coatings block radiant heat loss and warm up the inner surface of double glazing.

To the chagrin of some manufacturers like Andersen, sputtered coatings are also known as "soft-coat" low-e. Those who make it wish this name would fade away, since the phrase can imply a disadvantage when compared to pyrolitic, also known as "hard coat." While sputtered coatings can degrade in the open air and do have about a 6-month shelf life, they should last in

the window as long as the insulated glass seal holds. With one exception (Pella's Glaverbel), sputtered coatings tend to offer a higher insulating value over pyrolitic coatings (R-3.2 vs. R-2.6 in a standard double-glazed window). The biggest R-value gain from low-e still comes from applying the sputtered coating to a film (Heat Mirror) suspended between double glass, yielding an R-4 unit.

In addition to reducing heat loss, low-e coatings cut down on the amount of solar energy transmitted through glass. That detracts from low-e's overall savings during the heating season but it's a plus for cooling climates. While conventional double glazing transmits about 75 percent of the solar energy that hits it, the figure for most low-e coatings is closer to 55 to 65 percent. By tinkering with the coating design, manufacturers can achieve a much greater reduction for cooling climates. Heat Mirror 66 and Andersen's High-Performance Sun Glass admit only 34 and 28 percent, respectively, of the sun's heat energy. (Heat Mirror 55 and 44 films reduce solar gains even further.)



An atoms-thin metallic coating is magnetically deposited onto a pane of glass in a vacuum chamber. This "sputtering" process will yield a soft-coat low-e window.

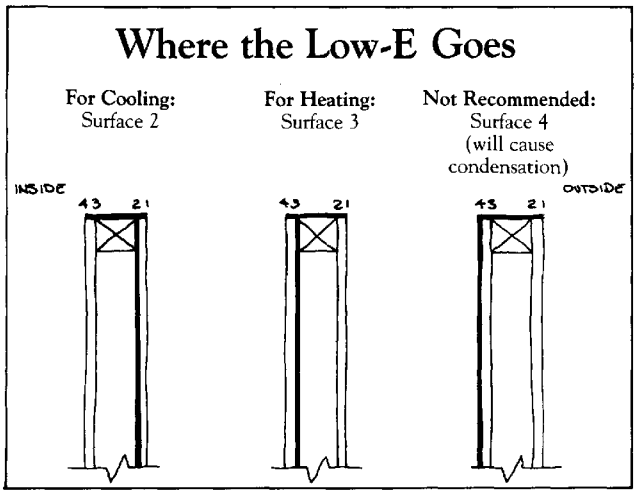


Figure 1. *The low-e coating must be placed on the correct surface or it will not provide the desired energy savings.*

From Miami to Sacramento, adding low-transmission low-e glass to a well-insulated home can allow significant downsizing of air conditioning equipment. To ensure the cooling benefit as advertised for hot climates, make sure the low-e coating is on the *inner side* of the *outer* pane of glass, called surface 2 (see Figure 1). How about mixing high-transmission low-e glass on the south side with lower-transmission low-e on the east and west? Ideally, this makes sense, especially in climates with both heating and cooling loads. (For commercial projects, this strategy is very effective.) But as a practical matter, mixing the two can lead to confusion during ordering and installation. One thing is certain: Don't mix glazing types (for example, clear and low-e) on the same elevation, or you may wind up with contrasting tints.

There are some issues not related to energy performance—such as changes in levels of light and color—that can affect low-e windows. PPG says their Sungate products reduce visible light by about 10 percent and have a slight blue tint. Indeed, all low-e products will drop the indoor light levels a bit, except for the greater shading produced by some coatings designed for cooling climates, the average person would not notice. By contrast, the color issue is one which tends to bother some potential buyers.

In fact, there have been a number of complaints that low-e glass can look either discolored or tinted, depending on the angle of the sun and the height of the windows. One window fabricator has a disclaimer sheet for buyers to sign which states "we will not be responsible for any haze, variation, pinholes, coating scratches, coating voids or any other coating problems..." with the low-e coating. While you may not get an entirely satisfactory answer, go ahead and ask the color question before you buy from a supplier. Look at a few actual installations to answer the color question for yourself.

A footnote to the color issue: If the coating is nearly invisible to the naked eye, how do you know you get what you pay for? According to Tim Johnson, a researcher at the Massachusetts Institute of Technology, the best way is to hold a cigarette or piece of chalk next to the glazing. With double glazing, you should see four reflections. The low-e coating will make one look blue while the others remain white.

The cost of upgrading to low-e varies with different manufacturers, dealers, and locations (see sidebar). Andersen claims that 8 percent is a fair estimate of their low-e upcharge. Marvin headquarters suggests allowing $1.25 more per square foot of low-e window ordered. Hurd charges about 20 percent more for windows with Heat Mirror film. These costs should come down as low-e technologies become increasingly-automated and refined.

Air Spaces and Argon Gas

Buying double glazing with a proper air space is essential to good window performance, especially with low-e. The optimal air space is between 5/8 and 1 inch (See Figure 2). If a salesman claims that their 3/16-inch air space is all your low-e window really needs, switch window companies.

Comparison Shopping

Dealer	Double Glazed	Low-e	R-value	Cost of Upgrade	Percent	Time
Anderson	$2853	$3068	R-3.0	$215	8%	6-8 wks.
Pella	$3254	$3840	R-3.2	$586	18%	5 days
Hurd	$2413	$2977	R-4.0	$564	20%	4 wks.
Anderson (#2)	$2627	$2837	R-3.0	$210	8%	3 wks.
Marvin	$3320	$3754	R-3.57	$434	13%	3 wks.
Caradco	$2493	$2668	R-3.1	$175	7%	4 wks.

Adventures in Window Shopping

For a 1000-square foot superinsulated addition with 12 windows and one skylight, what would be the *total price difference*—including any differences in heating and cooling system costs-for upgrading from double glazing to a high-performance glass? Obviously, the price will vary from one location and climate to another, as well as with the competitiveness of the market and how often you let your window distributor beat you at racquetball. Since the addition described here is a real one that is now being built in Denver, the costs listed below apply only to that market.

Four wood-window dealers, carrying five different lines of windows, were asked to bid on a 12-unit window order. All units were to come clad in white, with 2x6-inch jamb extensions. Sizes for the assortment of fixed and casement units were specified, with a total glass area of 115 feet, equivalent to 11.5 percent of the addition's floor area.

Hurd was selected for two reasons. First, when you consider that the average wood window has an insulating value of less than R-2, use of Heat Mirror film allowed the biggest performance improvement (double) for the money spent. Second, since the addition will be located on a suburban corner, the sound-insulating quality of a suspended film offered additional value.

While the Hurd option increased costs by $564, there were some HVAC savings. Heat Mirror enabled the designer to cut heat loss in the two-story garden-level structure by about 2700 Btus per hour at design temperature. That eliminated one in-the-wall electric convector heater in a large room, which saved $125 to $150 (installed cost).

A footnote: "It seems on every job, the material that gives me the most grief is windows," a local builder told me. This job was no exception. Hurd promised delivery in three to four weeks, but took five, and would have taken six had it not been for my concerted protest. So there's more to good windows than an R-4 rating. ■

R-Value and Air Spaces			
	1/4-inch	1/2-inch	3/4-inch
Clear	1.7	2.0	2.1
Low-e soft-coat	2.3	3.2	3.3
Low-e hard-coat	1.9	2.5	2.6

Figure 2. *The R-value of double glazing depends on the width of the air space. Beyond about 1/2 inch however, there is little gain.*

Filling the air space between two panes of an R-3 low-e window with argon gas will increase the insulating value to about R-4. Argon is an inert gas that insulates better than air. Since it's a byproduct of the welding industry, argon is cheap—about 3 to 4 cents for enough to fill up a typical 2x4-foot window. Lawrence Berkeley Laboratory has experimented with other types of gas materials, but alternatives such as krypton gas—now we're really talking "Super" windows—cost a lot more than argon for the modest improvement they achieve. Manufacturers who now offer argon-filled windows or glazings include Alpen Inc., PPG, Crestline, and Marvin Windows.

The one nagging doubt about gas-filled windows has been durability: Will the gas leak out? Europeans have been using gas-filling technology for a decade. MIT's Tim Johnson reports that the problems they had initially were partly due to poor filling techniques and partly to leakage through the seals. Johnson says a new gas-filling technology is soon to be adopted by "a major U.S. window manufacturer."

One major player in this area is PPG. Early this year, it introduced its OptimEdge product, an argon-filled *welded* glass unit, which eliminates all spacers and sealants by fusing the two panes of glass at the window edge. With a low-e coating specially designed to withstand the welding process, PPG expects a major window manufacturer to pick up the OptimEdge line this summer. That will put them in elite company, since only Hurd, Crestline, Marvin and Pella currently have products with a comparable rating (R-4 or better).

Andersen is apparently the next window company that will commit to gas-filling its low-e windows. As this article goes to press, the company's official line is that it is still "experimenting" with gas-filling, and wants to make sure it will conform to the company's 20-year guarantee. In fact, a fair number of their current products going out the door are rumored to be gas-filled already! Next time you're in an Andersen showroom, check up in the corner for a little node sticking down inside the sealed unit (the gas port). Word has it that Andersen won't publicize its new move until all the old conventional low-e stock has been moved. The gas is reportedly going to be added at no cost to the buyer.

A 16x30-inch bathroom window may have an insulating value as much as one-fifth lower than a 36x60-inch picture window with otherwise identical specs.

Edge Losses

When you've finally found a good R-4 window at a competitive price, brace yourself for the bad news: It probably isn't an R-4 after all. The typical metal edge spacer is a big heat loser. While the center-glass area may be performing as advertised, the edges significantly drag down the overall rating. The smaller the window, the worse the impact of the "edge effect." A 16x30-inch bathroom window may have an insulating value as much as one-fifth lower than a 36x60-inch picture window with otherwise identical specs. Tim Johnson states that in a 3x4 foot low-e window with argon fill—or a Heat Mirror unit—as much as 50 percent of the heat loss through the glass can be blamed on the edge effect.

Window manufacturers have been researching materials to overcome this problem, both to improve energy performance and to reduce condensation problems around the perimeter. Fiberglass spacers would help, but they are still in the experimental stages. PPG's new OptimEdge eliminates the metal spacer; but glass is almost as poor an insulator as metal. Manufacturers have yet to bring to the market any significant new products or processes to reduce edge losses.

The Frame Factor

Perry Bigelow, an energy-conscious Chicago-based builder (Bigelow Homes), complains that he can't believe some of the performance numbers generated by window manufacturers. "How can you take a glass rated at R-3.5, stick it in a thin wooden frame, and then claim it has an R-value of R-4 or better? That's nonsense."

Bigelow is right. The problem dates back to the days when wood-frame window manufacturers were allowed to increase the R-value rating of their single-glazed windows roughly 20 percent to allow for the insulating benefit of the wood frame.

Whenever you see a standard double-glazed window rated above R-2—and many of them do (Marvin, R-2.32; Pella, R-2.43)—it is this "framing factor" that usually makes up the difference. But once a manufacturer installs a low-e product with an insulating value of R-3 to R-4, the frame will no longer have a positive effect on the window; to the contrary, it may actually be dragging down the insulating value. In this case, the practice of adjusting the R-value upwards because of the wood frame should be discarded.

Crestline says its low-e glazing provides an R-3.6, which goes up to R-4.5 when filled with argon gas. How then can the total window be rated as R-5? Watch out for "framing claims" when combined with high-performance glass. LBL's Steve Selkowitz said that ASHRAE is working on a new standard that will end this shell game. The standard should be available in 1989.

There have been some legitimate attempts to actually boost the R-value of window frames by redesigning them or using new products. At least one Canadian company manufactures *fiberglass* frames. Owens-Corning made some insulated fiberglass frames several years ago that were held back just before they were to appear on the market in 1986, due to corporate takeover battles. It will be reintroducing the product shortly and will be looking to combine it with a high-performance glazing material. A few other manufacturers—including PPG and its Sunsash system—are eyeing new framing concepts for sash material, but manufacturers are tight-lipped about what they're doing or when they will have something ready to go.

The argon gas cannot leak out of PPG's new Optimedge insulating glass, which has the two panes welded together. The low-e units are rated at R-4 and will be available soon.

Air Infiltration

A number of European windows are designed to make replacement of weatherstripping a straightforward job. By contrast, most American wood window manufacturers have little to say about replacement of weatherstripping. Too bad...especially for sliders and double-hungs. Not that homeowners want to replace weatherstripping very often; but it would be nice to give them the option.

At the same time, tightness test results can be quite impressive. The industry standard still quoted in today's brochures is .50 cubic feet per minute (cfm) of air per lineal foot of sash crack, with the equivalent of a 25 mph wind on the outside. Andersen shows a listing between .04 cfm (for compression seals on casements and awnings) and .25 cfm (sliding seals for horizontal sliders). Hurd reports a range between .04 and .12 cfm, while Pella ranges from .03 to .15 cfm. Their numbers are typical for good wood windows. Also, much of the weatherstripping used on casements and awnings today appears to be quite durable. Next time you visit a home you built ten years ago, check the vinyl-bulb weatherstripping for rebound and integrity; it will probably still look reasonable.

Ask your window manufacturer how their windows are selected for testing. Are they picked regularly and at random? Caradco and Andersen make this claim. Not everyone does. Tightness tests by third parties haven't always been as positive as the catalog listings would lead you to believe. There aren't any foolproof answers to this one.

Star Wars Windows

At the 1988 NAHB convention in Dallas, researcher Steve Selkowitz told builders what they may see on the market in another 5 to 10 years. The list of fancy future windows being developed in federal laboratories is impressive:

Evacuated glass. Two panes of glass are held apart by small glass beads welded to them. The edges are welded together and the air within the thin space is sucked out, creating a vacuum. Samples produced at the Solar Energy Research Institute (SERI) have shown remarkable R-values: R-10 or better. One SERI researcher claimed that if any window manufacturer ever seriously pursued this technology, it could be on the market in as little as two years.

Aerogel. This "transparent insulation" is a thick, lightweight, silica material made up of microscopic air pockets that are nearly small enough to hold single molecules of air in a way that virtually eliminates air conduction. The material also blocks radian heat loss. This gives aerogel an incredible insulating value—about R-20 per inch. Unfortunately, samples developed to date are all translucent, not transparent. An aerogel window would probably use a sandwich material, with protective glass or plastic coatings on either side.

Electrochromic glass. An electric charge is applied to thin metallic coatings or films on glass, changing its optical properties. Depending on the current's directions, the film can reduce or increase solar transmission, or reduce radiant heat loss. "Smart" glass for smart houses? If your client has a few extra dollars in the budget, you can contact Taliq Corp. (Sunnyvale, Calif.) and buy a "smart window" today; plan on shelling out a mere $2,500 for a 3x8-foot unit.

These three types of glass aren't likely to enter the residential market in fewer than five years, barring the return of a major energy crisis. But don't be surprised if the next major glazing breakthrough comes from this short list.

Yet even without Star Wars glass, the case can be made that the best performing wall in most climates is actually a window. In fact, researcher Selkowitz reports that an R-6 or R-8 window facing in any direction can, because of the solar gain, outperform virtually any insulated wall design in nearly all climates. With several windows on the market that reach or approach that mark, the glass industry is getting closer to giving you optimal energy performance. Now if they could just knock an extra 5 percent off the next order... ■

Steve Andrews is a Denver-based residential energy consultant and freelance writer.