According to EPA, WaterSense has helped consumers save 125 billion gallons of water and \$2 billion in water and energy bills. There are more than 4,000 plumbing products in the market today under the WaterSense label.

To read more about the 2011 EPA WaterSense awards, visit http://www.epa.gov/watersense/partners/watersense_awards.html.

USGBC Awards Target Field

Target Field, home of the Minnesota Twins, was awarded a Leadership in Energy & Environmental Design (LEED) Silver certification for green operations and maintenance by the US Green Building Council (USGBC) for 2011. Target Field was previously honored in 2010 with a LEED Silver certification in new construction, and becomes the first professional sports venue to achieve LEED certifica-

tion in both categories. Target Field features include a Pentair capture and reuse system for rainwater, which has generated over 686,360 gallons of purified water, and recycling and conversion for generated waste into energy. Target Field delivered 741.3 tons of trash to the Hennepin Energy Recovery Center, adjacent to the Field, for conversion into heat energy for service levels and hot water. Reduction in electrical use is another hallmark of the stadium complex, which is 23% more efficient than other buildings in its ENERGY STAR® category. In terms of maintenance, 73% of cleaning compounds used at the stadium meet USGBC LEED standards, qualifying it as a green cleaning program. To read more about Target Field, go to http://www.bizjournals.com/twincities/blog/sportsbusiness/2011/12/target-field-adds-another-green-accolade.html and http://hometownsource.com/2011/12/13/target-field-is-firstpro-sports-facility-to-be-certified-for-construction-and-operations/.

IN PRACTICE

A Window On High Performance Fenestration: An Interview With Stephen Selkowitz

Energy Design Update®

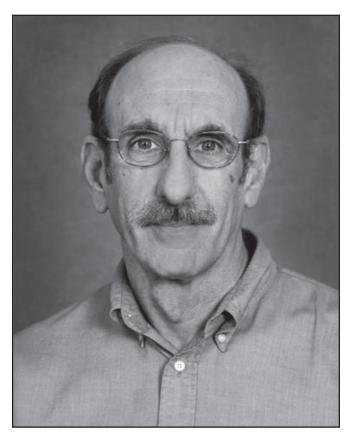


Figure 10. Stephen Selkowitz serves as Department Head for Building Technologies, Environmental Energy Technologies Division, at Lawrence Berkeley National Laboratory. Photo courtesy Stephen Selkowitz and Lawrence Berkeley National Laboratory.

Windows are a big player in any building's performance and aesthetics. Builders today searching for that ideal window product – especially for a high performance home – face a daunting array of material and technical combinations. As technology keeps rapidly updating, how can a construction professional make a confident decision in both material choice and technology, to garner desired performance?

Energy Design Update interviewed Stephen Selkowitz, of Lawrence Berkeley National Laboratory (LBNL), in Berkeley, California (see Figure 10), to get an expert opinion on upcoming window advancements, options, and best resources for residential building. Selkowitz heads the Building Technologies Department at LBNL, which works closely with industry to develop efficient technologies for buildings that increase energy efficiency, and improve the comfort, health, and safety of building occupants. Visit the Department online at http://btech.lbl.gov/btfd.html.

EDU: What energy efficient window developments are you seeing?

There are two general directions in which window performance is changing. The first is more highly insulating windows; the second trend is windows with better solar control. Most of the window world, over the last 20 years, has gone to a Low-E, double-glazed, gas-filled window which reduced heat loss by a factor of about 2 from existing windows. While this is a more efficient product, it represents a plateau in energy performance. The next step for the industry is to reduce heat loss by another factor of 2, essentially cutting heat loss in half. If you do that, you get to the point where windows break even in winter (heat loss = solar gain), or even become net energy gainers.

Back in the 1970s and 1980s, passive solar homes required specific window placement to optimize performance. These homes often adopted a south-facing strategy by orienting almost all windows to the south, so that windows capitalized on solar gain. This was touch and go in terms of actual energy performance. Spaces could get overloaded by solar heat gain on mild days and transition seasons, and views might be compromised if the best view was to a non-south orientation.

Given the next efficiency leap, windows today can be freed from these constraints. With the latest high



Figure 11. The NFRC label discloses performance factors for each individual window. Visible transmittance, air leakage, U-factor, and solar heat gain coefficient (SHGC) ratings all enable determination for an optimal window performance choice. Learn more about the NFRC label at http://www.nfrc.org/label.aspx.



Figure 12. The same dynamic effect of smart glass is available by operating shades, awnings, or blinds for retrofits. In Europe, blinds and shades are viewed as the first defense against solar heat gain, rather than being relegated as a decorative feature, like here in the US. Image from http://www.simplyshutters.co.uk/exterior_shutters.php.

performance window, even on a northern exposure, the small amount of energy picked up during the day can compensate for any small heat loss at night, during heating season. Windows can be more safely placed where they are needed, offering a lot more architectural and design freedom.

The main reason people have windows in houses is for light and view. New window technology will provide these without an energy penalty. Daylighting should not be taken for granted. Daylighting is important, though frequently under estimated in residential construction. While a home with no windows might seem to avoid certain heating and cooling loads, the lighting consumption in that home would double with no natural light.

To realize the major reduction in heat loss, there are three or four technology pathways to follow with different costs and different degrees of market readiness. Many manufacturers are using triple- or quad-glazing, with new Low-E and gas combinations. Newer technologies like aerogels or vacuum glazings are still in the R&D pipeline. There are different optimal pathways, depending on housing type, climate, orientation, and on whether the project is new or retrofit construction. It is also important to note that these options focus on the insulating glazing unit – the overall window properties include the effects of the window sash and frame. NFRC ratings for both heat loss (U value) and solar

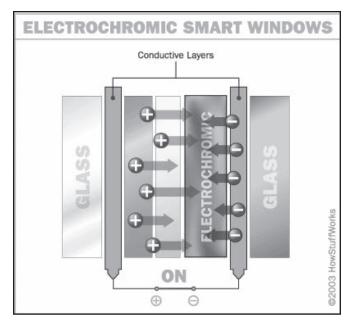


Figure 13. Electrochromic glass technology uses a small electrical signal to change a window glass's opacity, from translucent to transparent. The change in opacity controls the amount of light and solar gain allowed through the window. Image from http://home.howstuffworks.com/home-improvement/construction/green/smart-window4.htm.

heat gain (SHGC) are given for the whole window unit (see Figure 11).

In much of the US, solar control, and therefore cooling loads, are important contributors to building energy use. You can reduce over half of the solar gain with spectrally-selective glazing, which is a well established product and is offered by most manufacturers. However, you can't get much below 0.25 solar heat gain coefficient (SHGC), and 0.3 visible light transmittance (VLT) without making windows darker. Remember, people want windows for light and view. Darker glass will interfere with this. What can you do to further reduce the solar load? A major technological strategy that will address this challenge is variable transmission, available as part of the window with "smart glass". Smart glass encompasses advances like electrochromic and thermochromic glazing, which allow for dynamic change in glass properties. For 25 years, we have thought that this is a promising technology, and today it is getting closer to market viability, in cost, application, and availability. Variable transmission via smart glass allows for optimal views and solar transmission in winter, and can darken to shut down solar heat gain in summer. During the day, a window can darken to block heat from the sun, and then lighten later in the day to capitalize on the evening view. This process

can be automated or manual, and should have a lifetime of many years.

The same dynamic effect of smart glass is available by operating shades, awnings, or blinds for retrofits (see Figure 12). In Europe, blinds and shades are viewed as the first defense against solar heat gain, rather than being relegated as a decorative feature, like here in the US. You can avoid air conditioning in some climates, and greatly reduce sizing in others, by smart use of solar block drapes, internal or external shades, etc. Europeans have been doing this a long time, and results show that you can cut 80% to 90% of a home's window solar gain with external window covering systems.

EDU: What are your favorite new technologies for enhancing energy performance in windows?

The big news on the cooling side is dynamic window technology: solutions like thermochromic, photochromic, and electrochromic glazing and motorized

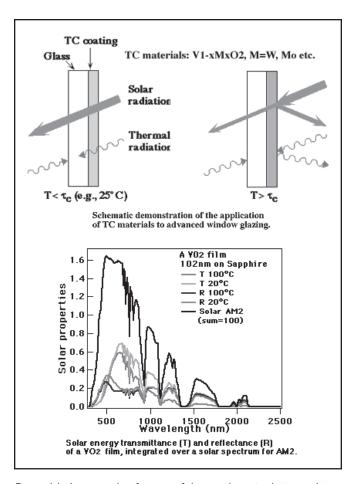


Figure 14. An example of a type of thermochromic glazing and its effects when applied to a window. Image from http://pubs.acs.org/doi/abs/10.1021/ed083p393.

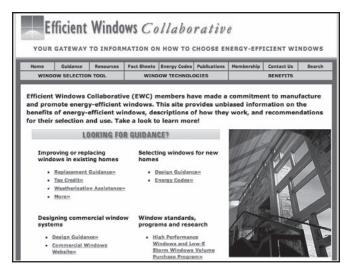


Figure 15. Selkowitz recommends the Efficient Windows Collaborative as a resource tool for window decisions. Go to http://www.efficientwindows.org/.

shades and blinds. Electrochromic glass technology uses a small electrical signal to change a window glass's opacity, from translucent to transparent (see Figure 13). The change in opacity controls the amount of light and solar gain allowed through the window. Electrochromic is preferable for energy control, as it is the most responsive, offering fully dynamic control of the window's glazing at any time. Thermochromic, which relies on heat to alter the glazing opacity, works well in some applications, though not as controllable (see Figure 14). The claim with thermochromic is that the glass unit will be cheaper. All of the dynamic glazing, or smart glass technology, is expensive now, but prices will go down. These advances have been coming for a while. Two electrochromic manufacturers are currently building new plants, which will increase output and size, and reduce prices. I expect to see more window product options for both electrochromic and thermochromic in 2012.

Developments on the solar control side that are running parallel with dynamic glass technology are the introduction of additional motorized and automated shading systems. These allow for instant external or internal shading of windows, and thereby greatly reducing solar heat gain and cooling energy requirements. If you think about the control technology underlying today's home entertainment systems and smart meters, that same control technology can automate the operation of shades and blinds available off the shelf from Europe. The infrastructure to control smart glass and automated shading attachments is there for the market to adopt.

EDU: What are your window recommendations for a high performance home?

The key issues are to invest in energy efficiency and thermal comfort. Pay attention to the details of each room. What is the room's orientation? Will there be a heat gain or loss problem? Who's in the room? At what time of day is the room predominantly used? Is there a need for ventilation? What attachments will be involved in the window? You want the window itself to provide most of the necessary thermal integrity; shading and sun control can be optimized further via attachments like shades and blinds.

One of the best opportunities to optimize total home performance through windows, which is often forgotten, is to use different glass on different orientations. West facing rooms might justify investment in electrochromic glazing, while northern exposures might be fine with simple triple-glazed, Low-E technology. There is no reason why you shouldn't do that. This type of optimization is something builders don't often do – they will focus on colors and grid patterns, but don't often educate consumers on available glazing options you can select. While a glass package that varies by orientation means extra attention on the contractor's part, to ensure proper window placement, potential performance gains make it worth the extra effort.

EDU: What are some of the best available tools to enable effective window choices?

A starting point is to be sure to select a window with energy ratings from the National Fenestration Rating Council (NFRC) and look for ENERGY STAR® windows that are appropriate for your climate zone.

One of the best Web sites for a builder or homeowner to look at is the Efficient Windows Collaborative site (see Figure 15). Visit http://www.efficientwindows.org/. This Web site grew out of a book, and offers specific data on 250 different climates and cities, as well as design guidance, energy code access, and window performance data and research. A builder or homeowner can obtain a great handle on what works well for his or her location. The Efficient Windows Collaborative also allows access to RESFEN, a simulation tool that calculates heating and cooling impacts of each window in your specific house. Additional software tools accessible through the site include WINDOW, THERM, and HOME ENERGY SAVER.

Another valuable site is Window Attachments (http://www.windowattachments.org/), which looks at window attachments – things like films, external shades, awnings, screens, etc. While the information is more qualitative for general attachment types and applications, it is useful to devise a full window performance plan. Energy savings data is in development to be available for this site at a later date.

EDU: What is your advice for someone looking to optimize their window purchase, both in performance and cost effectiveness?

Evaluating what people should do when it comes to selecting windows can become a complex question. If I were buying a new home today, what would I look for? Windows are truly a capital investment, my best advice is to invest as much as possible so as to maintain the windows' and home's performance as long as you can. Unlike light bulbs or appliances, which get repurchased every 5 to 10 years, windows may last between 30 and 50 years. This means you're stuck with the energy consequences for a long time. A window's long life means you should invest to the absolute maximum that you can because you'll feel the economic effects for many years. Buying windows every 40 years also means the consumer does not have a lot of pragmatic experience. In my opinion, the amount of money spent on windows and their long-term energy cost impact justifies the extra time needed for consumer research into the efficiency options. A homeowner or builder should treat the selection process seriously as an investment, beyond even the energy part.

For me, the real question is whether or not the extra marginal cost is worth the benefit it brings. Taking a baseline window expenditure, for example \$5,000, if you spend \$8,000, how much benefit does the additional \$3,000 bring you in performance? How you view the problem and frame it, the value proposition issue, is really important. In addition, the benefits of purchasing energy efficient windows extend beyond you and your home. Value intangibles, like enhancing energy security and placing less stress on the grid, should be evaluated in a cost-benefit analysis. While this is also true for any other building system, this scenario is unique, in that windows have a long life time, and are also involved in building aesthetics. Before purchasing, research possible state, government, and utility programs that can help defray first costs. And, if you are really short on funds, invest an extra \$1,000 in better windows and make your granite countertop 10 sf smaller.

EDU: How do you address life cycle costs for replacement windows?

One of the big issues is always how you do the accounting. When you do accounting for a retrofit, and include labor costs to tear out the old windows and put the new ones in, you almost always see a long 20- to 30-year payback. Payback calculations have an appropriate use in some places, but they can also be misleading in others. I would argue that windows bring additional hard-to-quantify value, such as views, daylight, and amenities. The question becomes when is it important and appropriate to look at replacement windows purely through cost numbers? When the decision takes the form of a public policy mandate, such as new codes or standards, these cost-benefit numbers need to be calculated. In new construction, the marginal cost of going from a double-pane to upgrade to a triplepane unit are modest, especially with the energy savings involved. Even in the retrofit market, a value proposition can look positive if you are buying a house with a 30-year loan. If spending money for new windows will offer a net positive monthly return on investment over those 30 years (e.g., mortgage plus utility bills are cheaper on a monthly basis with new windows), then it is a good investment. If people switch to thinking about it this way, that makes more sense. While window sales sites may offer all of the savings numbers, I would argue that you go beyond these numbers, and ask what makes sense for the long-term benefit of the home, and for your thermal comfort.

Our thanks to Stephen for his time and expertise. At LBNL, Selkowitz has managed a building science research and development program encompassing Windows and Daylighting, Lighting Systems, Simulation R&D, Commercial Building Performance, Demand Response Research, and High Tech Buildings. Selkowitz has over 30 years of experience in building energy performance and sustainable design, with an emphasis on research, design, and development of energy efficient technologies, systems, and design practices. Projects range from basic materials research for glazing and daylighting, development of energy simulation tools for integrated building design and operations, and from near term demonstrations of emerging technologies, to research for "net zero energy" buildings. In addition, Selkowitz speaks frequently on building energy efficiency, and is the author of over 170 publications, and holds two patents. Visit the Building Technologies Department at LBNL online at http://btech. lbl.gov/.