Southwest Energy Efficiency Project

Saving Money and Reducing Pollution through Energy Conservation

Policies and Programs for Expanding the Use of High Efficiency Fenestration Products in Homes in the Southwest

Howard Geller

Prepared for

U.S. Department of Energy
Building America Program

Through the

Midwest Research Institute
National Renewable Energy Laboratory Division

September 2004

2260 Baseline Road, Suite 212 • Boulder, CO 80302 • tel: 303-447-0078 • fax: 303.786.8054 • www.swenergy.org

Preface

This report on windows and other fenestration products is one in a series of technical briefs being prepared by the Southwest Energy Efficiency Project (SWEEP) in support of the U.S. Department of Energy's Building America Program. Its intended audience is energy efficiency policy makers and program managers in the southwest region. Feedback from all readers on the form and content of this report are welcome. A companion report, "Windows and Window Treatments" is aimed at builders and design professionals. It includes information on the energy and economic performance of different types of windows and window treatments in the southwest region. Both reports are available for downloading at www.swenergy.org.

Introduction

Inefficient windows (aluminum frame, double pane clear glass) can account for 25-55% of the energy use for space heating and cooling, and cost $190-380 per year in energy bills, in a standard 2,000 square foot air conditioned home in the Southwest. The energy cost associated with windows is highest in very hot regions such as Arizona or southern Nevada (Kinney 2004). Use of better quality windows (vinyl frame and spectrally selective "low-E" coating) can cut the energy use and cost associated with windows by 50-65%, and do so very cost effectively. The energy bill savings will pay back the incremental cost in moving from inefficient to efficient windows in 3.3 to 6.2 years (Kinney 2004).

Use of spectrally selective, low-E windows will also provide a significant reduction in summer peak electricity demand in air-conditioned homes in the Southwest. It is estimated that this savings, relative to a home with aluminum frame, double pane clear windows, is 1.0-1.5 kW in the southern tier of the region; e.g., in Phoenix and Las Vegas, and 0.5-0.8 kW in the northern tier; e.g., in Denver and Salt Lake City (Kinney 2004). Thus, high performance windows are also very beneficial to electric utilities that are confronting high peak demand growth, declining load factors (the ratio of average-to-peak power demand), and in some cases overloaded transmission and distribution lines. In a new home, this reduced demand can also lead to downsized air conditioning units.

There is potential to further lower energy use and cost associated with windows by employing well-designed shading devices especially in the southern tier of the southwest region, and automated shutters throughout the region. But these features are more difficult to justify strictly on a cost-benefit basis than use of high performance windows.

This report addresses the policy and program options for increasing the adoption of high performance windows in both new construction and existing homes in the southwest region. It complements a companion report on the energy and economic performance of various window and window treatment options (Kinney 2004).

Market Status

A recent market study indicates that 5.7 million residential-type windows were sold in the Mountain region in 2003, 9.1% of all windows sold nationwide (AAMA/WDMA 2004).[1] About 61% of these windows were used in new construction, and the remaining 39% in remodeling or replacement applications. This market study also indicates that 58% of the residential-type windows sold in the Mountain region in 2003 included a low-E coating, compared to a nationwide low-E market share of 56%. According to this study, the low-E market share is significantly greater in the Southwest and other Mountain states than in the Southeast or South Central states.

[1] The Mountain region includes the southwest states of Arizona, Colorado, Nevada, New Mexico, Utah and Wyoming, as well as the states of Idaho and Montana.

Nationwide, the low-E share of the residential windows market increased from 47% in 2001 to 56% in 2003. Likewise, the fraction of residential windows obtaining an ENERGY STAR® rating increased from 34% in 2001 to 41% in 2003. In addition, low-E coatings are more commonly used in wood and vinyl frame windows (59% market share in 2003) than in aluminum frame windows (39% market share).

There are no data on ENERGY STAR market share or use of low-E coatings by frame type for the Mountain region alone. But growth in the number of ENERGY STAR new homes constructed in the region in recent years no doubt has influenced the market for low-E, ENERGY STAR windows. One expert on energy-efficient construction in the region estimates that 80% or more of ENERGY STAR new homes include low solar gain low-E windows. But approximately half of these homes still contain inefficient, non-thermally broken aluminum frame windows rather than vinyl or wood-frame windows (Townsend 2004).

Fenestration Efficiency Rating and Labeling

It is possible for builders and consumers to evaluate the energy performance of different fenestration products and determine appropriate efficient products for their situation using the energy performance label adopted by the National Fenestration Rating Council (NFRC—www.nfrc.org). A sample of the current label is shown below. It includes the U-factor, solar heat gain coefficient (SHGC), visible transmittance, and air leakage for each labeled product. Over 80% of windows now include the NFRC label (AAMA/WDMA 2004). This means the ratings were assigned using standardized test procedures at accredited and certified testing facilities.

Figure 1. Sample NFRC label

The NFRC rating and labeling program ensures that builders and consumers obtain reliable energy performance data. The International Energy Conservation Code (IECC) and its predecessor, the Model Energy Code, require that fenestration products be rated in accordance with the NFRC test procedures (or use a table of defaults as the only

acceptable alternative). However, the NFRC ratings and label do not ensure that a fenestration product is energy efficient, just that it has been tested and rated in accordance with industry norms.

The ENERGY STAR program identifies what are generally considered to be well-performing fenestration products (www.energystar.gov). To achieve the ENERGY STAR designation, a window, door, or skylight must have U-factor and SHGC ratings below specified maximum values. These values are based on the overall fenestration product (glass and frame) and vary according to climate zone (see Figure 2). Fenestration products must have a SHGC of 0.40 or lower to qualify as ENERGY STAR in the southern tier of the region (including in Las Vegas, Phoenix, and Tucson). In the northern tier that includes Cheyenne, Denver, Reno, and Salt Lake City, ENERGY STAR fenestration products must have a U-factor below 0.35 but there is no maximum SHGC requirement. Albuquerque and Santa Fe are in an intermediate zone (called the north/central zone in Figure 2) where the maximum U-factor is 0.40 and maximum SHGC is 0.55 in order for window and doors to qualify as ENERGY STAR.

ENERGY STAR Qualification Criteria WINDOWS AND DOORS		
Zone	**U-factor**	**SHGC**
Northern	≤ 0.35	Any
North/Central	≤ 0.40	≤ 0.55
South/Central	≤ 0.40	≤ 0.40
Southern	≤ 0.65	≤ 0.40

ENERGY STAR Qualification Criteria SKYLIGHTS		
Zone	**U-factor**	**SHGC**
Northern	≤ 0.60	Any
North/Central	≤ 0.60	≤ 0.40
South/Central	≤ 0.60	≤ 0.40
Southern	≤ 0.75	≤ 0.40

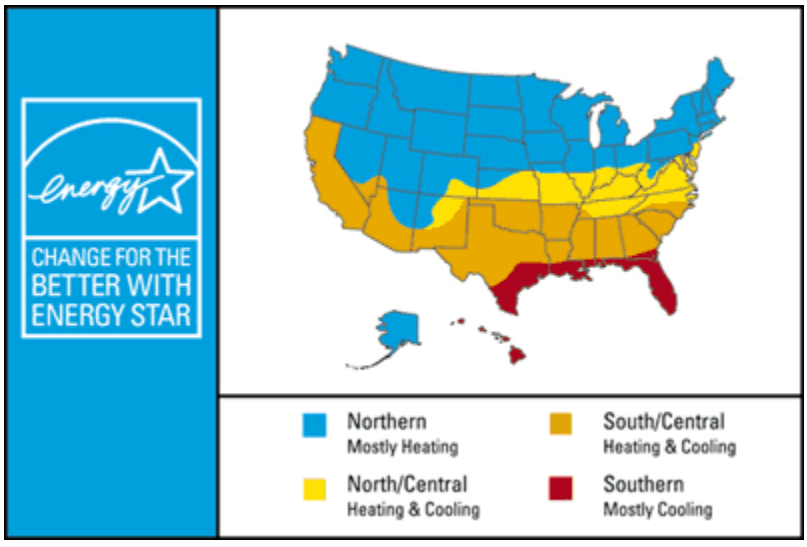

Figure 2. ENERGY STAR Window, Door and Skylight Qualification Criteria

Promoting the purchase and use of ENERGY STAR fenestration products is a reasonable rule of thumb in most parts of the country. ENERGY STAR is a national "brand" with relatively high and growing awareness and acceptance among builders and consumers. But in parts of the Southwest where there are both significant heating and cooling loads, and where peak electricity demand is a serious concern, a more refined approach than simply promoting ENERGY STAR is desirable. In particular, use of low SHGC (less than 0.40) glazing, also known as spectrally selective or "low-E2" glazing, is beneficial to consumers and utilities even in air conditioned homes in Colorado, northern New Mexico, or Utah (Kinney 2004).

In very hot locations such as Las Vegas or Phoenix, an even lower solar gain is highly desirable (Gohman 2004). Newer low-E glazing products are now available with a SHGC of 0.20-0.30 at only slightly higher first cost compared to traditional low-E products. Promoting these lower SHGC levels will lead to lower peak electric power demand and lower cooling bills for consumers. In short, state and utility energy efficiency program managers in the Southwest should use the ENERGY STAR brand, but with refinements to the basic concept of promoting ENERGY STAR fenestration products as part of their energy efficiency and DSM programs.

Regional, State, and Utility Programs

There have been some remarkably successful regional, state, or utility programs aimed at increasing the adoption of ENERGY STAR fenestration products in the residential sector. The program implemented by the Northwest Energy Efficiency Alliance (NEEA) is perhaps the most successful and well-known effort. In short, NEEA spent $1.8 million over a three-year period (1998-2001) to increase the market share for energy-efficient residential fenestration products in the Pacific Northwest. The market share for ENERGY STAR windows (U-factor 0.35 or less) increased from 10-15% when the project began to 70% by the end of 2001, exceeding the project's goal (Jennings, Degens and Curtis 2002).

The NEEA program worked collaboratively with window manufacturers, dealers, builders, and the manufactured home industry in the Northwest. Manufacturers based in the Northwest were signed on as ENERGY STAR partners. Some manufacturers were given financial incentives of $20,000 to $80,000 per year for up to two years to co-fund their marketing efforts. Window distributors and retailers also were signed up as partners. A total of 13 manufacturers and 287 distributors, retailers, and component manufacturers became partners by 2001. In return for becoming an ENERGY STAR partner, these companies received technical assistance on how to meet the ENERGY STAR specifications at least cost, training for sales staff, marketing materials, inclusion in the program's promotional efforts, and awards for leadership in ENERGY STAR window production or sales. The program did not include any financial incentives for consumers (homeowners and renters), and did minimal direct marketing to these end users.

The NEEA program demonstrated the ability to transform the windows market on a regional level by using the ENERGY STAR brand and working "upstream" with

manufacturers, distributors, and vendors of fenestration products. Surveys in the Northwest showed that relatively few consumers (e.g., homebuyers and remodelers) were aware of ENERGY STAR windows throughout the three-year effort. The program was successful in part because it helped manufacturers reduce the cost for producing ENERGY STAR windows through technical assistance and economies of scale (Jennings, Degens and Curtis 2002). In addition, the program paved the way for an energy code change that requires use of relatively efficient windows (U-factor less than 0.40) in all new homes built in Washington state.

The NEEA approach and experience is not unique. A similar program significantly increased the market share for low solar gain windows in a portion of Texas. The Texas Window Initiative was sponsored by American Electric Power Company (AEP), a major utility operating in central and southwestern Texas, during 2000-2001. It featured education and training for windows manufacturers, distributors, retailers, builders, and contractors (Tribble et. al. 2002). In this case, some mass media advertising was done as well. The goal was to increase the market share for ENERGY STAR windows, which in this region means a SHGC of 0.40 or less. It was estimated that only 2-3% of windows sold for the residential market met the ENERGY STAR criteria prior to the program. The market share for low solar gain ENERGY STAR windows in the AEP service area reached approximately 25% by the end of 2001 (Zarnikau and Campbell 2002). Builders that participated in training sponsored by the Initiative reported that 47% of the windows they were buying were ENERGY STAR.

Like what happened in Washington state, the Texas Window Initiative paved the way for Texas to adopt the International Energy Conservation Code (IECC) which requires the use of low solar gain fenestration products in most of Texas. Adoption of the IECC in 2001 has spawned a high level of compliance with the code's SHGC requirement.

An evaluation of the AEP program estimated that the two-year program stimulated the sale of ENERGY STAR windows that saved 8 MW of peak demand and about 325 GWh of electricity over a 20-year product lifetime (Zarnikau and Campbell 2002). These are "gross" energy savings values that do not take into account the likely market share for energy-efficient windows in the absence of the program (so-called free riders). Given the low market share for ENERGY STAR windows prior to the program in Texas, net savings might be around 260 GWh and 6.4 MW (author's estimate). Using typical avoided costs in the Southwest of $115/kW-yr and $34/MWh, the net energy and peak demand savings would be worth about $13.5 million over 20 years.[2] Assuming an incremental cost of $1.25 per square foot for the ENERGY STAR windows, the cost of the more efficient windows stimulated by this program was about $5 million while the program itself cost about $1 million. Thus, the program was very cost-effective with an overall benefit-cost ratio of approximately 2.3.[3]

---

[2] This estimated benefit is net present value using a 6% real discount rate for discounting future benefits. The cost effectiveness estimates were performed by the author, not by the program managers or evaluators.

[3] This estimate ignores the "market transformation" effect of the program. Including an estimate of this effect would increase the program's cost effectiveness.

In California, utilities have provided incentives to stimulate the adoption of high performance windows and window treatments for a number of years. The incentives have typically been $1 per square foot and are offered to homeowners and landlords installing replacement windows in owner-occupied as well as apartment buildings (see www.fypower.com). High performance windows must have a low-E coating and meet a SHGC requirement of 0.40 or less in hotter climate zones in the state. One utility, the Sacramento Municipal Utility District, offers low-interest loans to residential customers who purchase ENERGY STAR windows with SHGC $\leq$ 0.40 and U-factor $\leq$ 0.40. In addition, a few utilities in hotter parts of the state have offered a $1 per square foot incentive for installation of window shade screens on east, west, and south-facing windows.

Efficient Window Programs in the Southwest

There is only one incentive or promotion program aimed specifically at encouraging the adoption of energy-efficient windows in the Southwest at the present time. The Colorado Springs, CO municipal utility offers a rebate of up to $200 to customers who purchase ENERGY STAR windows and doors (U-factor $\leq$ 0.35).[4] This incentive is not available for new construction.

In Tucson, AZ, the electric utility provides incentives to builders to encourage the construction of new homes that are energy efficient (Kinney, Geller and Ruzzin 2003). In the past, the gas utility has had an energy efficiency program for new homes as well. These programs have been very successful; most new homes built in Tucson are now ENERGY STAR performance or better (Rald 2004). In turn this has led to use of low solar gain windows in most new homes although approximately half of new homes in Tucson still use inefficient metal frame windows (Rald 2004). The new homes programs sponsored by the utilities facilitated the adoption of the IECC in Tucson which requires all windows to be low solar gain (SHGC $\leq$ 0.40). The new energy code took effect in mid-2004.

There is also a very active ENERGY STAR new homes program in southern Nevada (metropolitan Las Vegas area). This program involves builder training and vigorous promotion, but not financial incentives. It is estimated that around half of new homes built in the Las Vegas area in 2004 will qualify as ENERGY STAR, up from about 10% market share in 2001. This achievement is influencing fenestration products. An in-depth study of new construction practices completed in 2003 showed that most ENERGY STAR new homes built in southern Nevada include low solar gain windows (SHGC $\leq$ 0.40), while standard new homes in the Las Vegas area had an average SHGC of 0.58 (Makela and Britt 2003). This study also showed that 81% of windows used in ENERGY STAR homes have inefficient metal frames. For comparison, over 95% of windows used in standard homes have metal frames.

[4] See Colorado Springs Utilities web site, http://www.csu.org/residential/rebates/energy_efficiency/index.html

As of summer 2004, Utah Power was planning an incentive program to promote the construction of ENERGY STAR homes as well as energy-efficient multi-family housing in Utah (Bumgarner 2004). Builders will be required to use low solar gain (SHGC $\leq$ 0.40) windows in order to qualify for a rebate.

Fenestration Requirements in Building Energy Codes

The 1998 (and subsequent) International Energy Conservation Code (IECC) allows builders and contractors to choose between prescriptive and performance-based paths to meet compliance. Prescriptive values are simpler to understand and use than performance-based values, and most builders choose to meet the prescriptive requirements. However, the performance-based path is an option that offers a builder greater flexibility in home design.

The IECC specifies that fenestration products used in hotter climates (defined as those with less than 3,500 heating-degree days) have a SHGC of 0.4 or less – both in the prescriptive and performance compliance paths (IECC 2003). In the southwest states covered by SWEEP, this requirement applies in southern Arizona including metropolitan Phoenix and Tucson, southern Nevada including metropolitan Las Vegas, and southern New Mexico. The requirement does not vary with size of the home or amount of fenestration area.

The IECC's U-factor requirements vary by climate and depend primarily on the quantity of windows (ratio of square footage of window rough opening to opaque wall) installed in the home. The U-factor requirements also can be "traded-off" or reduced by the use of greater insulation. The simplified path in the IECC is described in Table 1 as a function of heating degree-days (HDD). It is for home designs with no more than 15% of the wall

Table 1. IECC Prescriptive Fenestration Requirements by Climate Zone

Zone (HDD)	Maximum U-factor	Maximum SHGC
0 – 499	Any	0.40
500 – 999	0.90	0.40
1,000 – 1,999	0.75	0.40
2,000 – 2,499	0.65	0.40
2,500-2,999	0.60	0.40
3,000 – 3,499	0.55	0.40
3,500 – 3,999	0.50	Any
4,000 – 5,499	0.45	Any
5,500 – 5,999	0.40	Any
6,000 and above	0.35	Any

area containing windows. For single-family homes with window area greater than 15%, the IECC contains more rigorous U-factor requirements.

A number of states and municipalities in the Southwest have adopted the 1998 or a subsequent version of the IECC (Kinney, Geller and Ruzzin 2003). Texas adopted the IECC in 2001 and, as mentioned above, this significantly affected the Texas windows market. A market study in the Dallas-Fort Worth area showed that about 84% of windows installed in new homes in 2002 were low solar gain (RLW Analytics 2002). In addition, the cost increment for low solar gain ENERGY STAR windows dropped significantly after the code took effect and the market expanded (Makela 2004). Recently, the 2003 version of the IECC was adopted by the state of New Mexico, the city of Denver, and the city of Phoenix. However, some jurisdictions in the region still have outdated energy codes (e.g., Nevada).

There is precedent for adopting additional window efficiency requirements as part of building energy codes. In particular, Georgia adopted a 0.40 maximum SHGC requirement statewide as of Jan. 1, 2004. This requirement would have applied in most but not all of the state if the IECC was adopted without amendment. The state's Department of Community Affairs is partnering with the Efficient Windows Collaborative to educate code officials, window distributors, and window retailers about the window energy performance requirements of the new code (Tribble 2004).

The IECC also prescribes simplified SHGC and U-factor requirements for replacement windows and other fenestration products. Figure 3 shows the replacement window requirements for counties and states in the SWEEP region.

Unfortunately, these replacement window provisions in the IECC are not well known.[5] Furthermore, it is unlikely that many window distributors and vendors knowingly comply with this requirement. In general, code enforcement occurs only in new construction and major remodeling projects where a building permit is required.

The 2004 IECC Supplement

The newest version of the IECC, which has been published as the 2004 Supplement version, radically alters the code by removing all window-to-wall area limitations, effectively allowing unlimited glazing. This version also contains other simplifications to make it easier for builders and building code officials to use. One simplification is many fewer climate zones. A positive aspect of the simplifications and removal of window area calculations is that builders can no longer make a trade-off to allow the use of poorer performing windows in exchange for installing fewer of them. No matter how many windows that are installed, they have to meet the prescriptive or performance requirements. The new IECC window requirements are summarized in Table 2.

[5] A number of building energy efficiency experts in the southwest region were unaware of this provision.

Package	Maximum Window U-factor	Maximum Window SHGC
A 0-1,999 HDD	0.75	0.40
B 2,000-3,499 HDD	0.50	0.40
C 3,500-3,999 HDD	0.50	NR
D 4,000-5,999 HDD	0.40	NR
E 6,000 & above HDD	0.35	NR

"NR" means no requirement is specified in this package.

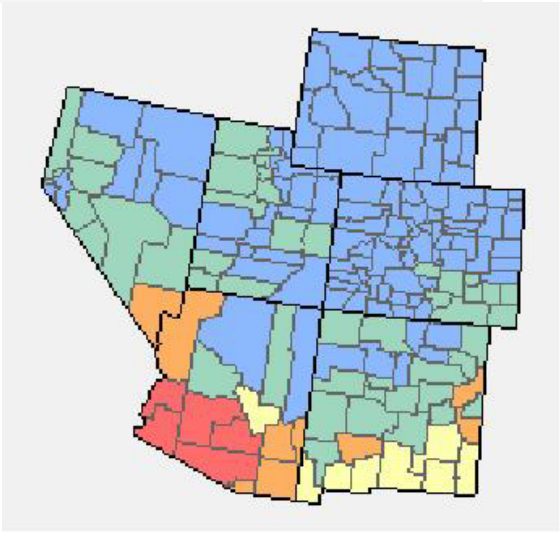

Figure 3. Replacement Window Requirements in the IECC for the Southwest States

Table 2. 2004 IECC (Supplement Version) Prescriptive Fenestration Requirements

Climate Zone (No longer based upon HDD)	Window U-factor	Skylight U-factor	Window & Skylight SHGC
1	1.20	0.75	0.40
2	0.75	0.75	0.40
3	0.65	0.65	0.40
4 except "Marine"	0.40	0.60	Any
5-8	0.35	0.60	Any

Unfortunately, the regions with a maximum SHGC coefficient are still very limited. In the Southwest, they only cover southern and western Arizona (including metropolitan Phoenix and Tucson), southern Nevada (including metropolitan Las Vegas), and southern New Mexico. The maximum U-factor of 0.35 applies in nearly all of Colorado, Utah, and Wyoming, along with northern Nevada.

One negative aspect of unlimited glazing is that high glazing area homes are allowed to use worse performing windows than allowed in earlier versions of the IECC. For example, the requirement in each of these zones is taken from the old 15% window-to-wall area tables in the IECC. Under the old IECC, at 25% glazing area, the U-factor requirement would be more stringent than the numbers shown here.

The new version of the IECC still allows an energy performance trade-off between windows and other parts of the building envelope. But the model code also institutes maximum fenestration performance caps (U-factor and SHGC) that cannot be exceeded in any circumstance. These caps help maintain the integrity of the code. For southern climates less than 3,500 HDD, where cooling is the primary consideration, the maximum SHGC is 0.50. For heating-dominated climates where U-factor is the primary consideration, the maximum U-factor is 0.40.

Resources

There are a number of organizations that could assist with efforts to expand the adoption of energy-efficient fenestration products in homes in the southwest. The Efficient Windows Collaborative (www.efficientwindows.org) is a public interest organization, funded primarily by the U.S. Department of Energy, which promotes the adoption of ENERGY STAR windows. The Collaborative conducts training on energy-efficient windows for manufacturers, builders, utilities, and code officials, and sponsors a regional initiative to promote efficient windows in Florida and other Southeast states. The Collaborative also maintains a useful web site that includes comparisons of energy costs for different window options by city (EWC 2004).

The ENERGY STAR windows program is another potential resource. In 2004, the program decided to focus its efforts on increasing ENERGY STAR window market share in the southern portion of the country given that this is where the market share is lowest. The program and its contractors plan to work with larger window manufacturers and national retailers to support marketing efforts and encourage increased sales of ENERGY STAR-qualifying products in hotter states. The ENERGY STAR program hopes that utilities will co-fund these marketing efforts (Karney 2004).

The U.S. Department of Energy supports R&D on efficient window technologies as well as promotion and dissemination efforts such as the Efficient Windows Collaborative. Windows R&D is based at Lawrence Berkeley National Laboratory (LBNL) where researchers are developing new products that go beyond basic ENERGY STAR windows in terms of energy performance. For example, researchers at LBL are working on a sealed low-E window that includes an automated blind between the glass panes. This product is

designed for climates with high cooling loads and peak electric demand problems. There are opportunities to demonstrate and test new products such as this one in the Southwest, in cooperation with DOE and LBNL (Selkowitz 2004).

Leading manufacturers of energy-efficient low-E glass and fenestration products might be willing to co-fund efforts to promote use of ENERGY STAR and other efficient fenestration products in the Southwest. A leading glass manufacturer provided seed money for the Texas Windows Initiative, for example. Also, some companies are interested in funding state or regional web sites promoting the use of high efficiency fenestration products (Zarnikau 2004).

For assistance with building energy codes, the Responsible Energy Codes Alliance (RECA --**www.RECA-codes.org**) is a consortium of energy efficiency professionals, product and equipment manufacturers, and trade associations with expertise in the adoption, implementation and enforcement of building energy codes nationwide. Also, the Building Codes Assistance Project (BCAP – **www.bcap-energy.org**) provides free assistance to states and municipalities in their efforts to adopt and implement both commercial and residential energy codes.

Policy and Program Recommendations for the Southwest

Research, Development and Demonstration

Home construction levels are very strong in much of the Southwest; there are builders constructing energy-efficient, high quality homes in each of the SWEEP states. Some are committed to building all ENERGY STAR homes or homes with even better energy performance. There are good opportunities to demonstrate new fenestration technologies throughout the region, working collaboratively with product manufacturers, research organizations such as LBNL, and these leading builders.

We urge state energy agencies and utilities to demonstrate and co-sponsor field testing of innovative fenestration technologies such as the sealed windows that contain an automated blind, a new technology being developed by LBNL mentioned above. Other new and emerging fenestration technologies that merit demonstration and testing include automated shutters and “smart” windows whose solar gain and other properties can be varied using a switch. One promising smart window technology employs an electrochromic coating, but other smart window technologies are under development as well (Carmody et al. 2004). The performance of these technologies including their energy savings should be carefully studied in occupied homes in different climate zones.

Once a new fenestration technology is commercially available and shown to be technically and economically feasible, it can be promoted to architects, builders, contractors, and others involved in housing construction and retrofit. Persuading several progressive production builders to adopt new technologies like exceptionally energy-efficient windows can go a long way toward accelerating wider adoption of the new product.

Utility Incentive Programs

Utility-funded energy efficiency and load management programs, also known as demand-side management (DSM) programs, are expanding in some parts of the Southwest such as in Nevada and Utah. These programs include incentives for households and businesses that purchase and install energy-efficient devices that save electricity at less cost than the utility's marginal cost for supplying electricity. At the present time, only one utility in the region (the municipal utility in Colorado Springs, CO) offers incentives for energy-efficient windows or other energy-saving fenestration products.

We urge electric and gas utilities in the Southwest to provide incentives for high efficiency fenestration products as part of their DSM programs. Given that the market share for ordinary ENERGY STAR fenestration products is increasing due to the growing acceptance of ENERGY STAR homes as well as through the adoption of the IECC, we recommend that utilities consider offering builders, contractors and/or homeowners incentives for fenestration products that perform better than what is needed to achieve the ENERGY STAR designation. Incentives could be offered for fenestration products used in both new homes and the replacement market.

In the hotter portion of the Southwest (i.e., areas with less than 3,500 heating degree days), incentives could be offered for very low solar gain low-E windows with a SHGC of 0.20-0.30 and better quality frame (i.e., wood or vinyl). In a companion report, SWEEP showed that these "high end" windows offer significant additional energy savings and peak electric demand reduction potential compared to ordinary low solar gain low-E windows (Kinney 2004). Furthermore, the SWEEP analysis showed that such windows are cost-effective in very hot areas such as Phoenix or Las Vegas. Minimizing the solar heat gain would also improve occupant comfort in rooms with large window area (Gohman 2004).

In the cooler portion of the region (i.e., areas with more than 3,500 heating degree days), incentives could be offered for windows with a U-factor less than 0.35 (the ENERGY STAR window requirement) as well as low solar gain (SHGC of less than 0.40) in air conditioned homes. The SWEEP technical report showed that these windows are cost effective throughout the southwest region (Kinney 2004). The low solar gain requirement will ensure electricity savings during periods of peak electric demand in the summer.

Utilities in the Southwest should also consider offering incentives for other technically and economically feasible but greatly underutilized fenestration products. These include insulating curtains or shutters especially in heating-dominated parts of the region. Promotion of low solar gain low-E windows along with insulating shutters or curtains in air conditioned homes in Denver, Salt Lake City and similar areas will benefit both utilities (by reducing peak power demand) and consumers (by reducing both heating and cooling bills). In cooling-dominated portions of the region, utilities should promote greater use of awnings, solar shades, or retrofit films that reduce solar gain.

Education and Promotion Programs

State energy agencies, utilities, and other entities interested in promoting greater energy efficiency in the Southwest should consider implementing programs to promote energy-efficient fenestration products in a manner similar to the successful NEEA effort and the Texas Window Initiative. These programs provided technical assistance, training, and marketing support to fenestration manufacturers, distributors, retailers, builders, and contractors. Marketing support such as cooperative advertising and sales staff training is especially needed and encouraged (Karney 2004).

In the southwest region, it would be logical to attempt such efforts at the state or multi-state level based on climate conditions. A hot climate window initiative could be organized in Arizona, southern New Mexico, and southern Nevada (in particular parts of those states with less than say 3,500 heating degree days). The initiative could be funded by a combination of state energy agencies and local utilities, with the possibility of additional support from the Efficient Windows Collaborative or ENERGY STAR windows program. Both ENERGY STAR and "ultra low" solar gain (SHGC = 0.20-0.30) products could be promoted, in part by working with the ENERGY STAR and other energy-efficient new homes programs that exist in places like Las Vegas, Phoenix, and Tucson.

Likewise a colder climate window initiative could be organized in metropolitan Denver and other Colorado Front Range cities, Salt Lake City, the mountain communities, and Wyoming. Once again the initiative could be funded by a combination of utilities, state energy agencies, and other parties. Here the aim would be to transform the market to ENERGY STAR (U-factor $\leq$ 0.35) but also low solar gain (SHGC $\leq$ 0.40) in air conditioned homes, as well as promote use of insulating shutters or curtains. In both cases, a state or regional initiative should track market shares for ENERGY STAR and very low solar gain products before, during, and after the initiative is implemented.

Another education and promotion opportunity relates to the fact that for optimal energy performance, different types of windows should be installed in air conditioned homes in regions with both significant heating and cooling loads (e.g., in much of Colorado and Utah). Energy agencies or utilities could sponsor training for builders, fenestration manufacturers, and distributors about proper window selection based on building orientation and whether windows face north, south, east, or west. This training also could cover the use of shading devices in building designs to minimize solar gain and cooling loads, as well as use of insulating shutters or curtains to minimize heat loss in the winter. In addition, the energy agency or utility could publicize and promote builders and contractors who routinely implement these optimal window selection and shading practices.

Codes-Related Activities

In states, counties or cities that have adopted the IECC, utilities, state energy agencies, and energy efficiency advocates could encourage compliance with the fenestration

requirements that apply to the replacement market as well as to products going into new homes. This means publicizing the requirements through information dissemination and meetings with builders, building contractors, and window fabricators, distributors and vendors. While it may not lead to 100% compliance with the IECC requirements for the replacement market, it is likely to have a significant impact. In addition, information and training regarding fenestration products and code requirements could be offered to building code inspectors.

Conclusion

There are a number of ways for state and local energy officials and utilities to increase the use of high performance fenestration products in both new construction and existing homes in the Southwest. As part of their energy efficiency programs, electric and gas utilities can provide incentives to builders, contractors, and/or homeowners who purchase energy-efficient windows and doors. In particular we recommend promoting adoption of ENERGY STAR products, but with some additional requirements.

In the hotter portion of the region, we suggest providing incentives for products with very low solar gain (SHGC of 0.20-0.30) as well as a moderate or low U-factor. In the cooler portion of the region, we suggest providing incentives for products with a U-factor less than 0.35 (the ENERGY STAR window requirement) as well as low solar gain (SHGC of less than 0.40) in air conditioned homes. Products meeting these criteria offer significant energy and peak electric demand reduction potential, and are cost-effective for consumers and utilities. In addition, utilities should consider offering incentives for insulating curtains or shutters especially in heating-dominated parts of the region, and shading devices including awnings, solar shades and retrofit films in cooling-dominated portions of the region.

State energy agencies, utilities, and other organizations should consider implementing education and promotion programs to increase the adoption of energy-efficient fenestration products in the Southwest, as was done very successfully in the Pacific Northwest and Texas. These programs provided technical assistance, training, and marketing support to fenestration manufacturers, distributors, retailers, builders, and contractors. Marketing support can include cooperative advertising and sales staff training. If such programs are implemented, it is important to track market shares for energy-efficient fenestration products before, during, and after the initiative.

Energy agencies or utilities also can sponsor training for builders, contractors, and fenestration manufacturers and distributors about proper window selection based on building orientation and whether windows face north, south, east, or west. Builder and contractor training can include use of shading devices to minimize solar gain and cooling loads, as well as use of insulating shutters or curtains to minimize heat loss in the winter. In addition, the energy agency or utility could publicize and promote builders and contractors who routinely implement these optimal window selection and shading practices.

Another program opportunity relates to the replacement window requirements in the IECC. State and local energy agencies, utilities, and energy efficiency advocates can encourage compliance with these requirements in states, counties or cities that have adopted the IECC. This can be done by publicizing the requirements through information dissemination and meetings with builders, building contractors, and window fabricators, distributors and vendors.

State energy agencies and utilities also can demonstrate and co-sponsor testing of innovative fenestration technologies such as automated shutters, sealed windows that contain an automated blind, and "smart" windows whose solar gain and other properties can be varied using a switch. The performance of these technologies including their energy savings should be carefully studied in occupied homes in different climate zones. Once a new fenestration technology is commercially available and shown to be technically and economically feasible, it can be promoted to architects, builders, and contractors.

References

AAMA/WDMA 2004. *Study of the U.S. Market for Windows, Doors and Skylights*. Schaumburg, IL: American Architectural Manufacturers Association and Des Plaines: IL: Window and Door Manufacturers Association.

Bumgarner, J. 2004. Personal communication with Jeff Bumgarner, Director of Energy Services, PacifiCorp, Portland, OR, April 20.

Carmody, J., S. Selkowitz, E.S. Lee, D. Arasteh, and T. Willmert. 2004. *Window Systems for High-Performance Buildings*. New York, NY: W.W. Norton & Co.

EWC. 2004. Window Selection Guide. Washington, DC: Efficient Windows Collaborative. www.efficientwindows.org/selection.cfm.

Gohman, C. 2004. Personal communication with Charles Gohman, Conservation and Engineering Manager, Arizona Department of Commerce, Phoenix, AZ, July 9.

IECC. 2003. *International Energy Conservation Code 2003*. Country Club Hills, IL: International Code Council, Inc.

Jennings, J. P. Degens, and G. Curtis. 2002. "Residential Windows in the Northwest: A Market Transformation Success Story." In *Proceedings of the 2002 ACEEE Summer Study on Energy Efficiency in Buildings*. pp. 2.147-156. Washington, DC: American Council for an Energy-Efficient Economy.

Karney, R. 2004. Personal communication with Richard Karney, ENERGY STAR Program Manager, U.S. Department of Energy, Washington, DC, Sept. 17.

Kinney, L., 2004. *Windows and Window Treatments*. Boulder, CO: Southwest Energy Efficiency Project.

Kinney, L., H. Geller, and M. Ruzzin. 2003. *Increasing Energy Efficiency in New Buildings in the Southwest: Energy Codes and Best Practices.* Boulder, CO: Southwest Energy Efficiency Project.

Makela, E. 2004. Personal communication with Eric Makela, Britt/Makela Group, Inc., Greenleaf, ID, June 10.

Makela, E. and M. Britt. 2003. In-Field Residential Energy Code Compliance Assessment and Training Project. Carson City, NV: Nevada State Energy Office. www.energy.state.nv.us/news/SPCodesProjectFinalReport.pdf

Rald, C. 2004. Personal communication with Carl Rald, Energy Program Coordinator, City of Tucson Energy Office, Tucson, AZ, June 9.

RLW Analytics. 2002. *High Efficiency Residential Windows Baseline Study*. Sonoma, CA: RLW Analytics.

Selkowitz, S. 2004. Personal communication with Stephen Selkowitz, Director of Windows and Daylighting Research, Lawrence Berkeley National Laboratory, Berkeley, CA, June 9.

Townsend, B. 2004. Personal communication with Brad Townsend, Environments for Living Program, Phoenix, AZ, Aug. 5.

Tribble, A. 2004. Personal communication with Alison Tribble, Efficient Windows Collaborative, Washington, DC, June 7.

Tribble, A., K. Offringa, B. Prindle, D. Arasteh, J. Zarnikau, A. Stewart, and K. Nittler. 2002. "Energy Efficient Windows in Southern Residential Windows Market." In *Proceedings of the 2002 ACEEE Summer Study on Energy Efficiency in Buildings*. pp. 2.227-241. Washington, DC: American Council for an Energy-Efficient Economy.

Zarnikau, J. 2004. Personal communication with Jay Zarnikau, Frontier Associates LLC, Austin, TX, June 10.

Zarnikau, J. and L. Campbell. 2002. *The Window Market in Texas: Opportunities for Energy Savings and Peak Demand Reduction*. Austin, TX: Frontier Associates LLC.