The Progress Toward Energy Efficient Fenestration Products in California

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Natural market forces, building energy efficiency standards and utility programs all contribute to moving the fenestration industry forward to more efficient products. From the mid 1970s to the late 1980s, California's industry moved from single to dual glazing due to the interplay of the three influences. In 1989 the California Energy Commission began a process that would result in (1) more efficient products being required by the standards and (2) a rating and certification program that would allow consumers to make educated choices. The process was successful because there were enough parties motivated to support the adoption of the new standards to overcome the influence of parties motivated to resist the changes. Among the most supportive groups were the utilities in California. The level of their support for future energy efficiency initiatives will depend in large part upon the details of the electric industry market structure to emerge from the California Public Utilities Commission. Given the restructuring of the electric industry and the shift in emphasis from standards toward market forces, there may never be another critical mass of support for a major leap forward in California building standards for cost effective, energy efficient fenestration products.

HOW ENERGY EFFICIENCY TECHNOLOGIES ARE IMPLEMENTED WITHIN THE FENESTRATION INDUSTRY

Examining energy efficiency measures for past and future market penetration levels includes understanding the impacts of natural market forces (including research and development of new technologies), state and federal building and appliance standards, public agency programs, and utility programs. Each contributes to moving the industry forward and the interplay of the various forces will have differing degrees of success in different markets. The past twenty years in the fenestration market in California provide a useful illustration of the connection between building standards and the advancement of energy efficient products.

BACKGROUND

In the 1970's the standard California window was a single glazed aluminum frame slider. The market did not demand more. It is not that more efficient options weren't available. Dual glazing was already common in some markets in North America. Vinyl windows were very common in Europe and wood windows on the East Coast. But only a few builders in California offered the increased energy efficiency and comfort afforded by dual glazing. Some manufacturers, recognizing the benefits of higher profit-margin products, were looking for a market in California; but it was small and slow to grow.

The energy crises of the 1970s raised energy consciousness and, starting in 1978, the state Building Energy Efficiency code[1] recognized the improved effectiveness of dual glazing. This technology was suggested by the existing American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE) Handbook of Fundamentals but was specifically accepted in the code process as the result of the cooperation between the fenestration industry, builders, the California Energy Commission and other interested parties.

Since the code is based on the performance of the whole building, it was often cheaper to install more efficient equipment elsewhere in the building. Further, the new standards were not uniformly understood or enforced. The fenestration industry's products did not advance much initially as a result of the state's early building efficiency standards.

During the 1980's utility demand side management (DSM) programs and public agency programs caused changes in the incremental costs of efficiency technologies. Utility retrofit DSM programs contributed so much to the progress of fenestration technologies chiefly because residential rates in California have been relatively quite high. Utility new construction programs contributed because they lowered critical first costs of quality products for builders. This made dual glazing the standard almost throughout the state and transformed some markets so that a wider variety of efficient fenestration technologies was available. Many retailers were encouraged to begin stocking dual glazed products due to the increased demand created by the utility programs, and this in turn lowered the costs faced by builders. Dual glazing ceased being a ''specialty'' product but other energy efficient fenestration technologies were still not common. Manufacturers

who had more efficient product had a tough sell in much of the California market. The lack of a uniform method of comparing the performance of competing products impaired the speed of progress.

Public agency programs (eg., Federal Farm/Home loan programs and Housing and Community Development programs) had little effect on the level of efficient technology available in California at that time since most ''change outs'' offered were simply from single to dual glazing. Natural market forces did little to promote progress in fenestration performance. Except for the retrofit and high end custom home market, consumers had virtually no ability to exercise choice; the builder had already chosen for them (usually based on first cost) by the time they saw the home. In essence, the industry in California was moving forward very slowly, but was ripe for a profound shift[2].

Starting about 1990, the Commission began a two pronged effort to make energy efficiency gains through better fenestration. On one front, the Commission worked with the industry and other states to develop a uniform window rating and certification program. Concurrently the Commission modified its standards to make the most cost-effective fenestration products the basis against which other products are evaluated.

UNIFORM RATING AND CERTIFICATION PROGRAM

Under the California Building Energy Efficiency Standards in effect until 1992, all dual glazed windows were considered to have a U-value of 0.65 whether the frame was wood, metal, metal with a thermal break or vinyl. This discouraged manufacturers from developing truly higher performing products. As the Commission considered setting the standard at the most cost-effective technology and allowing credit for higher performing (lower U-value) products, it became very apparent that a credible means of distinguishing between levels of performance was needed to allow builders, building officials and consumers to differentiate between low and high performance products.

In late 1989, representatives from state energy offices, national window manufacturing firms and associations, glazing manufacturers, national labs and the U.S. Department of Energy formed an association called the National Fenestration Rating Council (NFRC) to establish fair, credible rating and certification procedures for the energy attributes of fenestraton products. Prior to the creation of the NFRC, window manufacturers could rate the thermal performance of their products by:

(a) pulling a U-value associated with a generic product description off a table in the ASHRAE Handbook of Fundamentals (ASHRAE 1989, 27.16–17),

(b) calculating a U-value through the use of Lawrence Berkeley Laboratory's (LBL) *WINDOW* program (LBL 1987),

(c) testing a product using the American Architectural Manufacturers Association's (AAMA) test method (AAMA 1988), or

(d) testing with the American Standards and Test Methods (ASTM) procedure (ASTM 1987).

Manufacturers could also choose to test either a small window or a large window, with bug screens on or off, and with a ''production line'' sample or a ''hand tuned'' prototype.

There were plausible arguments for either size and each rating procedure, but manufacturers tended to choose the combination that would show their products in the best light compared with the competitions' products. Consumers and building inspectors had no stable yardsticks with which to measure all competing products. Some states already required testing using one specific procedure but they still had problems. They made exceptions for alternate sizes. It is alleged that manufacturers ''gold plated'' and hand tuned their products in the test labs to gain the lowest possible U-value during testing. No one really held the test labs or the ''certification'' agencies fully accountable.

Initially, the Energy Commission considered a proposal to establish its own fair, accurate and credible rating and certification program for California[3]. The Commission advanced a proposal to the industry, as did at least two manufacturers[4]. Other states, DOE and manufacturers of higher performing products persuaded California to join with a national effort that was beginning to grapple with the same issues. The newly formed NFRC included window manufacturers' associations, manufacturers of all types of fenestration products, testing labs, state and federal energy offices, architects and other specifiers, manufacturers of glazing and other fenestration related products, and public interest groups. The Commission, along with its partners in the effort, invested significant time, effort and money to develop a universal procedure for rating (with U-values) all windows (NFRC 1991), and a certification program to ensure that each rating advertised as meeting the requirements of NFRC ratings, actually does. Now any building official anywhere in the state can tell by simply comparing the U-value on the NFRC label against the U-value in the building compliance documentation whether a window has the level of performance required.

COST-EFFECTIVE STANDARDS

As directed by its legislative mandate, the Energy Commission establishes building standards that not only reduce the wasteful use of energy, but also are shown to be cost-effective compared to historical practices. The mandate only requires that the standards be cost-effective in total and only that the building elements of the standard package be set at cost-effective levels, not the *most* cost-effective level. However, during the revision for 1992, the standards were set at or very near the most cost-effective level for each building element.

The process included establishing assumptions for hourly weather, base case building descriptions and costs and performance of available technologies. Each step of the procedure was an open public process. In particular, window manufacturers in California provided costs and performance specifications for the products they offered, and suggested additions and modifications to the lists once the Commission published a draft.

In order for California to adopt building standards that recognized the newer fenestration technologies, many influences had to be aligned. First, there had to be a significant range of performance among competing technologies. This was satisfied by the competition between aluminum, wood and vinyl frames, as well as the new low-emissivity glazings. Second, there had to be a way to quantify the effects of each technology on energy performance. The rating procedure under development by the NFRC along with the existing building energy performance software approved by the Energy Commission satisfied this requirement. The other essential element was sufficient support from affected parties to outweigh the inertial influence of those who would rather not see any change. Examination of the influence of each of the affected parties (see Table 1) allows us to understand why the process of incorporating high efficiency fenestration technologies was successful in the 1992 round of standards revisions[5].

Window Manufacturers. One feature of the fenestration industry that emerged most clearly during the standards revision process was that the industry was deeply, and seemingly irreconcilably, divided. A few California manufacturers stated that they are not *aluminum* window manufacturers, but *window* manufacturers, and whatever the market wants they'll make, including more efficient products. But, to a large degree the industry in California was initially split into those that made aluminum windows with 1/4″ spacers, and those that offered more energy efficient products. Most of the former resisted the changes mightily and, after initial sidelining, the latter fought hard for the changes. Early in the process the general influence of the industry was against change. Once the high efficiency product manufacturers became involved, the negative influence was generally neutralize.

The likely reason that the high performance manufacturers' involvement came on rather slow is that they assumed the new standards would be adopted and effective without them having to weigh in. In addition to the technical/analytical support of building standards development and enactment, there is an equally important politcal constituent which they were slow to recognize.

Builders. The building community was also basically neutral on the issue. Considering that the building industry generally opposes code changes that increase first costs of homes, this may seem surprising. There are two apparent reasons for their neutrality: (1) the revisions proposed would allow builders to have more assurance that they get what they pay for, and (2) the building industry was more intently focused on other changes in the standards that had the potential to raise first costs much more than the changes proposed for fenestration. In the end, the greatest concern they expressed was that the standards should not rely upon rating and certification procedures under development by a new national organization unless the Commission could be certain that the procedures were ready and reliable, and the Commission would monitor the situation to ensure NFRC's reliability.

Consumers. Consumers were little involved in the public process of revising the standards. This is not unusual. To a certain degree, public interest groups acted as surrogates for the consumer though each had another perspective to support. In essence, the consumer influence was also neutral.

Building Inspectors. Building inspectors, represented by the California Building Officials (CALBO), were unsupportive of the changes proposed. Since part of the change was a fenestration rating and labeling system that would allow them to tell at a glance whether or not a product complied, they had a strong reason to be supportive. On the other hand, under the previous requirements, few windows had to be checked for anything other than whether they were dual glazed or not—an even simpler inspection task. Further, it was never clear to many in the inspection community that the new system would not require *them* to verify that the U-value on the NFRC label was the U-value that the window should have. The building inspectin community was unsupportive, but except for a very few, it was not actively so.

Building Materials Manufacturers. Insulation manufacturers had felt for a long time that the window industry was getting a ''free ride.'' To be used in construction in California, insulation has to be tested, labeled and certified to the state for R-value. The insulation manufacturers argued

Table 1. *Influences on the Incorporation of Fenestration Technologies into Standards*

Influence	Positive	Negative
Manufacturers	Desire to gain recognition for Superior Technology (gain market share) Uniform single rating system	Desire to avoid showing their product(s) in a bad light relative to Superior Techs. (keep mkt. share) Desire to avoid additional capital investment and compliance costs
Home Builders	Decrease the cost of more efficient technologies Long run increase in choices of technologies	Raise the cost of minimum technology for compliance
Consumers	More comfort Lower energy bills Lower cost, better information and greater choice of efficient equipment at time of replacement or addition	Higher first-cost of home
Building Inspectors	Less work Less complexity	Additional work Added complexity
Manufacturers of other building technologies (eg., insulation)	Level playing field for evaluation of impacts of technologies	
Legislature and other govt. entities	Cost-effective means of reducing wasteful use of resources Preservation of economic assets for investment in other segments of economy (long-run) Stabilization of economy Increase in ‘‘local’’ jobs	Allocation of economic assets to a government designated purpose rather than a market chosen alternative Decrease in ‘‘local’’ jobs Time and effort spent developing standards
Environment	Less reliance on off-site energy Air quality improvements	Air quality impacts of importation of ‘‘exotic" materials
Utilities	Lower peak demand, less capacity needed Reliability for measurement and evaluation (and therefore, return on investment) for DSM expenditures	Lower sales Higher baseline for energy efficiency programs

that allowing manufacturers to claim that all dual glazed windows had a U-value of 0.65 was unfair. They also pointed out that since California has a whole building performance requirement, fenestration products and insulation compete head to head. They strongly supported the proposed standards for fenestration products.

Other Government Agencies. The California Building Standards Commission (CBSC) was divided. Some were concerned that the new rating system was untried, incomplete and was possibly taking the place of an oversight function that should, they argued, rightly stay within the Commission. Others were persuaded by the argument that it was the industry itself that had created the NFRC and the industry had compelling reasons to ensure its success. They also felt that the case for the cost-effectiveness of the standards was strong. The members of the CBSC who questioned the proposed revisions were more outspoken than those who

supported them, so during the process the CBSC seemed unsupportive. Yet in the end, those who supported the changes outnumbered the negatives and the Building Standards Commission approved the standards.

Environmental Groups. The Natural Resources Defense Council (NRDC) was a strong supporter from the first consideration of improving the standards. They focussed most of their attention on other aspects of the proposed code revisions and the analysis supporting the revisions, but their advocacy was clearly a positive influence.

Utilities. Perhaps the strongest and most valuable allies in the process were the utilities. Although it is the utilities' business to sell electricity, there is a culture within the California utilities of promoting energy efficiency. This influence coupled with the substantial profit incentive with which the CPUC provided them for DSM programs with measurable energy efficiency impacts, made the utilities strong advocates for the proposed revisions of the standards. The utilities in California had been providing incentives to builders and consumers to install more energy efficient windows. It was very much in their interest to have the Commission develop or recognize a fenestration rating and certification system that could provide them with a higher level of assurance that they were getting the performance they paid for.

The final influence (not shown on the table) is the culture of the state agency with primary responsibility for energy efficiency standards. At the time of the 1992 revisions to the California Building Energy Efficiency Standards, the Commission had had a greater than ten year history of developing pacesetting standards, of drastically reducing the energy consumption of buildings and appliances through cost-effective standards and cooperation on DSM programs. In the mid 1970s California had one of the highest per capita energy usages in the nation; by 1993, it had fallen to 46th in the nation. Both candidates for governor in 1990 pledged that the Commission would continue to reduce the energy use of buildings by 5% each code revision cycle. This explicit support of the administration reinforced the Commission's own culture which was, perhaps, the strongest influence for adopting standards recognizing new fenestration technologies.

Because the standards in California (and the utility programs that built upon those standards) recognize improvements that save energy, new glazings, new frame designs and high performance spacers are now all available in the California market. Because California's standards rely on the NFRC's rating and certification procedures, the pre-1992 average window, with a nominal U-value[6] of 0.65 and an actual[7] of about 0.88, has all but been replaced with newer designs and combinations of technology that achieve an actual 0.65 U-value.

CONCLUSION

Lessons learned from the process in California may have only limited application elsewhere, but certain points are important:

(1) National, state or local codes must rely on technologies that are readily available, though not necessarily equally available universally.

(2) Development and adoption of standards that promote high efficiency products are more likely with broad support from (at least, some of) the industries affected.

(3) To be effective at moving a market or industry toward energy efficient products, the code must rely on a system that makes it easy for consumers, inspectors and promoters (eg., utility DSM providers) to distinguish between high and low performing products, and

(4) There must be significant financial and/or other incentives (eg., comfort) for buyers to seek high performance products[8].

However, much of the history lesson is no longer even fully applicable to California. The world has changed. The Energy Commission, like virtually every other state or federal institution, is looking toward ways of encouraging the *market* to reward energy efficiency and away from 'easy' reliance on (1) increased stringency in standards and (2) utility rebates. Solutions such as the NFRC rating and certification programs are excellent means of partnering with the industry to achieve a market solution. Once manufacturers test and label products, consumers can compare the relative energy performance of competing products, along with other attributes, such as price, aesthetics, ease of operation and apparent durability.

It is unlikely that there will be another junction of influences necessary to undertake a revision to the fenestration portion of the California energy efficiency standards as major as the 1992 standards. Additionally, even though DSM programs in general had very positive benefit/cost ratios from society's perspective, and were tending to deliver even more for less (Hadley, Hirst 1995), California investor-owned utilities have cut their DSM budgets drastically. Besides the fact that they feel a need to reduce expenses to help keep their rates as competitive as possible, they also face uncertainty about whether they will be able to recoup investments in energy efficiency. Instead of rebates and marketing dollars for builders, they are offering no- or low-interest loans to customers for energy efficiency upgrades. These programs can be viewed as serving customer retention purposes at least as much as energy efficiency. One possibility being considered by utilities that may reverse this influence and make utilities

more, rather than less, concerned about the efficiency of windows is the prospect of becoming providers of services, such as thermal comfort, for a monthly fee[9]. Their incentive to keep costs down would then make them strong advocates of energy efficiency again.

If a nearly united fenestration industry made a strong argument to the Commission that a change in the standards was needed to promote cost effective energy efficiency technologies, and that such changes would either meet the market test or have little in them to cause any of the above groups to oppose it, there could be another round of advances as significant as the 1992 revisions incorporated into the standards.

However, with (a) real energy prices falling, (b) energy bills being split (unbundled) into fixed and smaller variable (avoidable) portions[10], and (c) the fenestration market doing reasonably well at providing a range of efficient products, state code bodies are not likely to initiate such an undertaking in the near future.

ENDNOTES

1. Part 6, Title 24, California Building Code.

2. Influences leading to this condition include: residential energy bills were high, utilities were relying heavily on fenestration to achieve energy savings, Oregon and Washington were realizing both energy efficiency advances and problems from referencing a test of performance rather than a default table for generic products, Lawrence Berkeley Laboratory and others in California were promoting the value of energy efficient fenestration products, and some national and regional manufacturers were porting improved product lines from other markets into California.

3. Presented to the California window industry, December 1989 in a paper by Nehemiah Stone.

4. Glen Barth of Rylock Windows and Ray Bjerrum of Merzon Windows each advanced alternative plans.

5. Testimony from the advocates for the various participant groups is part of the docketed files *92-RSB-1* and *92-WIN-1* in the dockets office at the California Energy Commission.

6. Any dual glazed window, regardless of frame type or design, was considered to have a U-value of 0.65 before the 1992 code changes.

7. Based on NFRC 100-91 rating procedure.

8. If, for example, builders find a much larger price difference than performance difference between high performing and low performing fenestration products, they will choose the low performing product and make up the energy difference with less expensive upgrades in insulation or heating equipment.

9. This concept has been widely discussed and was specifically one of the topics at a Southern California Edison focus group on January 20, 1995.

10. One of the near-certainties to come out of the restructuring of the California electricity industry, and therefore not unlikely other states and other energy industries, is an unbundling of rates in energy costs and delivery costs. Only the energy costs would vary by amount of usage, so a much smaller percentage of the residential energy bill will be avoidable through energy efficiency. Ergo, fewer energy efficiency ‘‘upgrades’’ will be cost-effective.

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