# Rating the Energy Performance of Fenestration Systems in Commercial Buildings - A New Approach

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## Abstract

The National Fenestration Rating Council is well recognized for developing uniform consensus standards for determining the energy performance of fenestration products. A new rating procedure is being developed that addresses the specific needs of the non-residential building community that is entitled the Component Modeling Approach. This procedure utilizes validated thermal performances of fenestration system components and a standardized algorithm to determine standardized building envelope energy performance ratings during the design stage.

### Introduction

Fenestration products and systems have a significant impact on the energy performance of buildings. Overall, fenestration products contribute about 30% of the overall building heating and cooling loads with an annual impact on the overall energy use within the U.S. of some 4.7 Quads (4.7 quadrillion BTU's).

In 1989, the National Fenestration Rating Council was formed by a representatives from the fenestration industry, state energy officials from California, Oregon and Washington and the Department of Energy. The purpose of this new organization was to develop standards for determining the energy performance of fenestration products; and to develop and administer a certification and labeling program to verify and communicate product performance. Since its inception, NFRC has successfully developed consensus standards for U-factor, Solar Heat Gain Coefficient, Visible transmittance, Condensation Resistance and Air Leakage.

Prior to the formation of the National Fenestration Rating Council, there was not a single, credible method for determining the energy performance of windows, doors, skylights or curtain wall systems. While there had been considerable advancements glazing performance and materials technology, there was little or no application of these technologies in the fenestration industry.

There are a number of reasons for this failure, including:

- Relatively little industry marketing of new technologies (due to the inability of the industry to "fairly" market energy efficient technologies);
- The increase in material costs ($$) for energy efficient technologies;
- A lack of requirements and/or lack or enforcement for fenestration performance in building energy codes;

- The inability to enforce energy code requirements for fenestration products, where applicable;
- The lack of understanding about potential energy savings from these advancements.

Since the adoption of NFRC ratings for U-factor and SHGC in the International Energy Code Council in 1994; the residential fenestration market has seen an incredible growth in the development and use of high performance components, including; low-e glass, warm edge spacers and thermally efficient framing materials. This market transformation is exemplified by the increase in the use of low-e glass use in residential windows; which has more than doubled since 1991 (from 28% to almost 60% of the market for new windows).

In 1999, NFRC developed a Site-Built program to assist in the development of a national rating program for fenestration systems installed on commercial buildings. The program was required in the state of California in 1991 and in some cities (such as Seattle, Washington). It has been shown to provide consistent, reliable and uniform energy performance ratings for curtainwall and storefront products; and is an especially useful tool for determining compliance to local energy codes. Nevertheless, the NFRC Site-Built program has not successful in transforming the commercial arena.

Further studies by NFRC reveal that, while the technical standards were still applicable, there were marketplace barriers that restricted the success of the Site-Built program. Some of these barriers include:

- Marketplace players - unlike the residential market; where production follows whole product application; the commercial market in the U.S. utilizes several parties for production and installation of fenestration systems on commercial building envelopes; including frame suppliers, glazing suppliers and glazing contractors (installers).
- Customer relationships - in the commercial market in the United States, the relationship between architect/specifier and the fenestration product supplier is very close with, in some cases, a total dependence on fenestration suppliers to provide thermal performance information. This practice typically results in energy performance based upon center-of-glass only data; ignoring the framing effects altogether. In other cases simple default values are applied. Finally, due to economic pressures, poor code enforcement and the disconnect between builders and eventual building occupants, we see that initial high performance fenestration specifications left on the contractors floor; in favor of inexpensive commodity systems. .
- In addition, the NFRC Site-Built program did not address the needs of the non-residential community on issues of preliminary project bidding needs, project customization and the preparation of systems during mock-up testing.

## Objective of New Approach

There is a great potential for market transformation within the commercial fenestration marker. The current penetration of low-e glass in the nonresidential (commercial) building market (in 2003) was estimated at only 30%; which is half the market penetration of the residential market. This provides the evidence that there is a tremendous un-tapped potential for improving the energy efficiency of the glazing systems in nonresidential buildings.

Glazing areas in nonresidential construction (other than industrial) is typically greater than residential buildings; and office buildings tend to have a large carbon footprint due to their cooling loads. Studies have shown that - if the installed high-rise office (nonresidential) glass area in 2003 (estimated at 421 million square feet) had achieved the same level of high performance glazing as the residential market - annual energy savings would be 5.8 million BTU's.

## Methodology

In 2002, NFRC began having task group meetings to review the potential for a new rating system for site-built fenestration products. Eventually, the Component Methodology Approach (or CMA) began to take shape.

CMA builds upon some of the early successes achieved by NFRC; specifically the Spectral Data Library (also call the International Glass Data Base or IGDB). After NFRC adopted standards for measuring glass performance (specifically transmittance, reflectance and emittance); a verification program was set up to allow for the industry to govern itself. After submitting measurements from a spectrophotometer to NFRC (now administered by Lawrence Berkeley National Laboratory or LBNL) the data was checked for mathematically anomalies (or errors) and submitted for a peer review. After the peer review was completed, the performance data for each verified glass was listed in a Spectral Data Library and posted on-line for all to use. In this way, window manufacturers wishing to obtain certified ratings from NFRC would have their simulator obtain the correct glass data from the library and use it in approved simulation tools; including LBNL's WINDOW[1] and THERM[2].

The idea of an easily accessible library of glass data seemed to be applicable to other window components as well; specifically, spacers and frames. Each component supplier could be responsible for providing the heat transfer characteristics of the individual extrusions or lineals through NFRC approved software tools and an established base of accredited simulators. Component libraries could then be established and made available for use in developing whole product ratings. We know that this method is accurate because it is the basis for how WINDOW operates.

## The Component Methodology Approach

We know that existing software tools could be used to develop a calculation of the overall product performance; however, it would be unwieldy to perform a simulation on each separate product configuration. How then can we simplify the system so a rating methodology can be developed that does not require continual application of WINDOW and THERM software?

One simplified approach would be to prove the theory that it is possible to build a simulated product from components that utilizes logarithmic interpolation, to determine the overall performance of the fenestration product or system.

It has already been determined that center-of-glass performance and product size are very close to linear; allowing for linear interpolation of product performance (U-factor, SHGC, VT) of various size products as an option in NFRC standards (NFRC 100, 200). While these ratings cannot be used for certification, they certainly provide additional information to manufacturers and consumer alike. In addition, a paper by Dr. Curcija on the Component Modeling Approach[3] showed that a linear relationship exists for different glazing systems within the same frame. The biggest question that needed to be answered is the effect of the spacer on the entire system. This same paper also indicated that there is a logarithmic relationship on the overall performance of a product that can be calculated utilizing their effective conductivity ($K_{eff}$).

The way CMA simplifies the rating is to take the frame conductivity (as determined by computer simulation); and establish a best and a worst cases for the potential glass to be installed and for the spacer to be used. By establishing the boundaries of performance for that framing system and establishing the appropriate log curves we can provide a graphic calculation of overall performance of that frame system. NFRC has approved a technical standard[4] that applies this logic as follows:

Total of four best/worst or B/W configurations is defined. These configurations are assembled from two different glazing options at the extreme of the thermal performance and two spacer configurations at the extreme of thermal performance. The following are four Best and Worst configurations:

b1 in Table 5.6.1: Best glazing with Best spacer
b2 in Table 5.6.1: Best glazing with Worst spacer
w1 in Table 5.6.1: Worst glazing with Best Spacer
w2 in Table 5.6.1: Worst glazing with Worst Spacer

**Table 5.6.1.** Template for Reporting Component U-factors

| | Frame | | | |
|---|---|---|---|---|
| | w1 | w2 | b1 | b2 |
| $U_f$ [W/m$^2$K] | | | | |
| $U_e$ [W/m$^2$K] | | | | |
| *PFD [m]* | | | | |

Where Center of Glass: $U_c$ = is defined and Where Spacer: $k_{eff}$ = is defined
Quantities w1, w2, b1, and b2 are defined in Reference [3].
For each individual product, total fenestration product U-factors shall be reported for the specified configuration at the model size, as shown in Table 1 of NFRC 100. The calculation of this total product U-factor is done using procedure detailed in Reference [3].

Does this methodology work? The short answer is yes. The paper published by Curcija[3] (et. al.,) proves the accuracy of this approach by comparing the ratings developed by this methodology to pure computer simulation.

## Conclusions

The Component Modeling Approach holds great potential and promise for addressing the needs of the various stakeholders in the commercial building arena for energy performance ratings.

## Summary

NFRC's success in the residential fenestration market confirms that having a widely accepted and standardized tool for product comparison; as well as a standardized method for communicating that performance to consumers and building code officials; enhances the market transformation for high performance products. A rating program that meets the needs of the nonresidential marketplace can succeed in transforming that market.

## References


1. WINDOW 4.1 "A PC Program for Analyzing Window Thermal Performance of Fenestration Products," Lawrence Berkeley National Laboratory, 1994.

2. THERM5 – "A PC program for Analyzing Window Thermal Performance of Fenestration Products," Lawrence Berkeley National Laboratories, 2003.

3. "Component Modeling Methodology for Predicating Thermal Performance of Non-Residential Fenestration System," Curcija, et al, University of Massachusetts, 2003.