

March 28, 2003

Mr. Richard Karney, P.E.
Manager, Energy Star Program
Forrestal Building
U.S. Department of Energy
1000 Independence Avenue
Washington, DC 20585

Re: DOE Energy Star Windows

Dear Mr. Karney:

Following please find my comments in response to your February 11, 2003 letter. By way of background, I have extensive experience on the subject of energy codes, legislation, and regulations for buildings. For most of the past 30 years I have been a Subcommittee Chairman, Vice Chairman, and Chairman of the 60 person ANSI/ASHRAE/IESNA Standard 90.1 Committee. This is the committee that sets the national minimum energy standards for commercial and high rise residential buildings, as set forth in the 1992 Federal Energy Policy Act.

In my practice as a consulting engineer over the last 40 years I constantly evaluate energy issues for private sector residential and commercial building owners and occupants. I am a registered professional engineer in 49 states, have been active in many technical and professional organizations, and have participated in building code proceedings.

My comments focus mainly on the technical basis for the DOE analysis and conclusions. DOE is now placing importance on "reducing cooling energy requirements and maximizing peak load savings."

It is essential to understand that even though the ENERGY STAR window program may be voluntary, it does and will set the de facto minimum standards for commerce in both the residential and small commercial market. As I am sure you know, about half of all commercial buildings are 5,000 square feet or less and many use residential construction techniques and products. Thus, the de facto minimum standards for windows will also apply to a significant fraction of commercial buildings. In paragraph 2.1 of the analysis DOE made this exact assumption when it says that **all** window sales move to the minimum ENERGY STAR criteria.

This ENERGY STAR window program will also apply to residential townhouses and low-rise multifamily residential buildings. However, the IECC requirements for these buildings are not the same as those for one and two family dwellings. According to RECS, almost one quarter of all households are in multifamily buildings. There were no analyses of these residential buildings. Thus, the DOE analysis must consider these important segments of the residential window market.

All of the DOE references to the window U factor requirements in IECC are to the IECC Chapter 6 Simplified Prescriptive Requirements. See Table 6 in the DOE analysis. The window U factor requirements in Chapter 5 "Residential Building Design by Component Performance Approach" are not the same as those in Chapter 6, but will still achieve compliance with IECC. Also, the Systems Analysis in Chapter 4 of IECC will also determine compliance with window performance that differs from that assumed in the DOE analyses. Thus, the DOE description and characterization of the IECC window requirements is incorrect, incomplete, and misleading.

By not comparing the ENERGY STAR window requirements with the IECC window requirements on consistent climate data, the results are not consistent, since the DOE Table 6 shows IECC window values that do not apply across the entire ENERGY STAR climate zones.

It is reasonable to expect that many ENERGY STAR windows will be used in commercial and high-rise residential buildings. Therefore, evaluations and comparisons with the requirements in IECC Chapter 8 and ANSI/ASHRAE/IESNA Standard 90.1-2001 should also be made, since both are widely used.

In the IECC Chapter 5 Component Performance method the SHGC (502.1.5) shall not exceed 0.40. However, that value is based on "the area weighted average" and includes "the effects of any permanent exterior solar shading devices." Thus, the windows alone do not require a SHGC of less than 0.40 if there is any exterior shading. The area weighting can also allow very high SHGC on the South side and very low SHGC on the North side, and still achieve IECC compliance. Therefore, any comparisons between the SHGC of the windows alone in the ENERGY STAR window program and the minimum requirements of the IECC are neither correct nor consistent.

The DOE analysis apparently assumes that every residential building will be built to just meet the minimum requirements of the IECC Simplified Prescriptive method for the purpose of calculating energy and demand savings. It does not consider that (1) the IECC requirements can change in future years, (2) buildings will be built to comply with other chapters of IECC, and (3) most buildings will be built to higher levels of performance than the absolute minimum required by IECC. In other words, DOE calculates savings compared with the worst possible buildings that can be built under IECC. Such an assumption is not rational or realistic. For most new buildings the products that just meet the minimum IECC requirements are often not even available or always used.

Paragraph 1.2 of the February 2003 DOE Evaluation assumes and concludes:

"The lower a window SHGC, the more it lowers the building's cooling energy use, including peak power electricity use."

That statement is fundamentally flawed for several reasons, so that the conclusions reached are not reliable or correct.

First, it assumes that air conditioning is installed and used. Second, it assumes that every window is subjected to solar heat gain at the time of the electric peak, which never happens. Third, it assumes that even those windows that may be subject to solar heat gain are experiencing the maximum gain at the same time as the electric peak. Fourth, it assumes that the peak power electric use occurs in summer. Fifth, it assumes no influence from either interior or exterior shading. Sixth, it assumes that the peak solar heat gain is coincident with the peak electric load. Seventh, not all residential air conditioning is electric or operates on peak.

Eighth, it assumes a single central electric air conditioning unit serves every house. Lastly, while not specifically mentioned in the quotation, lower SHGC increases the heating energy requirement.

In many residential buildings the air conditioning is not used at all times. Thus, there is no impact from ENERGY STAR windows on peak power use if the air conditioning is turned off.

For the second point, windows tend to be equally distributed among all facades of residential buildings. Thus, only those windows that face the sun coincident with the time of the electric peak will benefit. There is no peak power benefit for all other windows. Yet, all windows will likely be ENERGY STAR, if for no other reasons than consistency and appearance and they are likely to be the only ones available. Having low SHGC on the north side will never provide any significant benefit.

There are many houses that are now supplied with electricity on time of use electric rates, and they adjust their use of appliances and air conditioning accordingly. Thus, at least some homeowners minimize or do not use air conditioning during peak hours. More and more utilities have implemented automated demand response programs that give homeowners lower electric rates in return for the ability to automatically turn off or cycle air conditioning units to reduce peak power electricity use. However, it must be remembered that demand response is done by the utility at the time of their choosing, which is not necessarily the same time as the peak cooling load in the houses. These were obviously not considered or evaluated, and must be to determine the extent to which cooling is actually used during peak power electricity use.

To support the fourth comment, there are some major utilities that experience winter peaks. For example, PP&L serves more than a million and a quarter customers in much of central Pennsylvania and has consistently been a winter peaking utility for decades. Thus, ENERGY STAR windows will not benefit PP&L or its customers for peak summer electricity.

On the fifth point, there will be some shading for many, if not most windows, which will reduce the solar heat gain below that from the SHGC alone. There is often shading from overhangs, porches, adjacent buildings, vegetation, and interior devices such as shades, drapes, or blinds. Thus, it is not reasonable to compare ENERGY STAR windows with those not having any shading. For example, over the years DOE has promoted exterior shading, and especially the use of deciduous trees for the purpose of reducing summer cooling loads and increasing winter passive solar heat gains.

According to Table HC4-1b in the 2001RECS, just over half of all houses have large trees that shade the home. Thus, to not consider any exterior shading from trees alone makes the analysis and conclusions in the DOE Evaluation very questionable.

Sixth, the peak electric load on residential buildings often does not occur at the same time as the peak power electricity use. As one common example, my local electric utility is PECO Energy Company, which serves a million and a half customers. They have Night Service Riders available that provide huge discounts for off peak electric demands that exceed on peak demands. On peak hours are from 8 AM to 8 PM on Monday through Thursday, and from 8 AM to 4 PM on Friday. While the Riders are not available for one and two family dwellings, they are available and are used by the vast majority of the apartment owners. The extensive documented experience shows that the peak electric demands occur during off peak hours. Of course, this is why apartment owners employ the Night Service Rider. Therefore, the assumption that the peak cooling load and peak electric demand in residential buildings occurs at the time of the electric utility peak power use **is not always valid.**

Peak power electricity use for almost every utility company occurs on Monday through Friday, and usually tapers off on Friday afternoon as business and industry finishes their workweek. Thus, the peak power electricity use of houses is likely to not be coincident with the utility peak power use on at least three of every seven days.

In some parts of the country with high CDD, evaporative cooling is the predominant method for supplying cooling to houses. In other areas, cooling is provided by gas absorption air conditioning. Some buildings are cooled using thermal storage cooling systems with compressors that operate during off peak hours. In these cases, even though cooling is provided, there is no benefit for ENERGY STAR windows on peak power electricity.

Many houses are not served by a single central cooling system. Some houses and many apartments have room by room heating and cooling systems. Some have two or more central cooling systems. In any of these cases the impact of solar heat gain will not always impact all of the cooling systems and thus will not have the peak power impact that it would for houses with a single central system.

According to Table HC4-1b in the 2001 RECS, 20% of all air conditioned households used their central air conditioning only a few times, 15% used it quite a bit, and 34% used it all summer. For those houses with room air conditioners, 17% used them only a few times, 6% quite a bit, and another 6% all summer. The Table also shows that 2.5% of the houses with air conditioning never used it. Thus, any assumption that all air conditioned houses use their cooling systems all or most of the time is contradicted by the RECS data.

In recent years, and for the foreseeable future, the price of heating fuels has increased far more than electricity. Thus, in climates requiring heating, and especially where cooling may not be used constantly, the total cost of cooling plus heating can increase with low SHGC windows.

Therefore, it is clear that only a very small fraction of ENERGY STAR windows will be capable of reducing peak power electricity use, and even then, the reduction will not always be nearly as much as assumed. There can be no technical or economic justification for reductions of peak power electricity use at all for the majority of ENERGY STAR windows, and substantially reduced justification for all remaining ENERGY STAR windows.

The use and acceptance of the DOE proposed climate zones is far from settled. There have been no completed peer-reviewed publications with these proposals. Even if they are proposed to the IECC there is no assurance they will be adopted, and they could be substantially modified or withdrawn. DOE has repeatedly approached ASHRAE to adopt their climate zone proposals, and ASHRAE has not been satisfied with the DOE climate proposals. DOE could have, but did not submit a formal continuous maintenance proposal to ASHRAE, which would have required a formal and public response. Thus, despite claims by DOE, their climate zone proposals do not have any formal or informal acceptance or use outside of DOE.

There are several footnotes and references that are not readily available, so it was not possible to review them and examine their accuracy, reliability, and relevance to this analysis. For some of the references the organization or publisher is not shown, making it extremely difficult to find the reference and determine its validity.

Footnote 4 references an ASHRAE symposium paper on window energy use. Reference to the ASHRAE Transactions shows that formal written questions posed to the authors of this paper were never answered. The information from this reference was used for the ENERGY STAR analysis, and the methodology and assumptions used are not shown or described to allow independent evaluation and verification. For example, it is not known how energy calculations can be averaged, or how the proxies were determined.

Indeed, the ASHRAE paper in Footnote 4 concludes by saying, "there is still much that can be done to improve the accuracy of this database" and then in an appendix it lists 15 areas where these improvements are needed. If the authors of this fundamental reference believe that much is still to be done, then how can DOE not only rely on this work, but also use it as the basis for further analyses and conclusions?

An in depth review of the ASHRAE paper is likely to show that the assumptions, calculations, and conclusions are not proper or relevant for the purposes in this analysis. For example, it assumes only a perfectly square 1,540 square foot single story house and use of the 1993 Model Energy Code, and not the 2000 IECC.

Paragraph 2.4 opens with a discussion on "Electric reliability and gas pricing in times of high demand." It makes the unsubstantiated statement:

"reducing the SHGC of windows will reduce peak-cooling loads **dramatically**, which in turn reduces electricity consumption, utility bills, and power-plant pollution emissions."
(Emphasis added)

Peak cooling loads by definition occur at most for a few hours on a few days each year, or usually less than one percent of the hours. Thus, during peak cooling loads, there cannot be too much in the way of reduced electricity consumption or reduced electric cost or power plant emissions, since peak cooling loads do not last that long. Moreover, electric reliability is a function of the design and maintenance of the electric generation, transmission, and distribution systems, and not the cooling loads. Since only a few percent of all electric generation is from gas, and most of that is sold at predetermined prices, and it is used for few hours, the influence of gas pricing in times of high demand is not significant.

The NFRC900 database was never intended to determine the average reduction in peak electric demand. Since there is no description of how this reduction was determined and what assumptions were made, there is no way to know whether these calculations meet any engineering standard of care that is generally accepted in the industry.

Table 3 shows the results of the undocumented assumptions and calculations. It shows an average peak reduction of 0.25 kW per home. This conclusion is not supported, nor is it realistic or reasonable.

In existing homes, the air conditioning unit will likely not be replaced and the size not reduced when new windows are installed. In new homes, the use of ENERGY STAR windows may or may not result in reducing the capacity of the air conditioning unit compared with IECC compliant windows.

Residential air conditioning units are sized and designed not only to operate at full capacity during peak load times, but also to allow the room temperatures to float up by three degrees above the thermostat setting. See page 28.2 of the 2001 ASHRAE Fundamentals. During peak cooling load times residential air conditioning units intentionally operate at full load continuously, and until the cooling load is reduced, and the thermostat setting can be satisfied. Therefore, during peak load conditions, even though the solar heat gain may be reduced by ENERGY STAR windows, the electric **peak demand will not be reduced.**

It is also not possible to achieve the claimed 4,612 MW reduction unless every house in the climate zone from New Jersey to California had their peak cooling load and peak electric demand occurring at the same time. The probability that the entire climate zone would experience peak cooling and solar heat gains at the same time is so remote as to be impossible.

Not addressing incremental first costs for ENERGY STAR windows is simply unacceptable. For those houses without air conditioning or those who choose not to use it all the time, any incremental first cost is an unnecessary burden, since there is no reduction in cooling cost, and there are increases in heating cost. Thus, ENERGY STAR windows could prove to be both a premium first cost and a premium operating cost, which is the opposite of what the ENERGY STAR program should be doing.

The use of average fuel costs in Table 4 is not appropriate or correct. Using average fuel costs by climate zone is not correct or representative. Fuel costs vary widely even within climate zones. Gas costs for houses can vary by 25% within a few miles, due to different rate structures by different utilities. Electric costs can vary by much more for the same reason and also due to different rate structures in the same utility. The Energy Information Administration publishes extensive detailed cost data for each utility that shows these wide variations. Thus, what may be justified for one family may not be justified for another family in the identical house across the street.

The use of average fuel and electric costs is also not applicable since they include customer and meter charges and they do not reflect the incremental or decremental costs due to declining and inclining block rates. Thus, the proper evaluation of the energy costs for changes in window properties must be based on the cost of the changes in energy use, and not the average cost of energy.

Contrary to the statement below Table 4, the spreadsheet provided does not recalculate the energy consumption. Almost every value in the spreadsheet is precalculated and fixed. Thus, it is not possible to determine how the values shown in the spreadsheet were calculated, nor is it possible to recalculate the results.

The Annual Energy Cost Savings in Table 5 is a simple average of the cities selected, with each city weighted equally, without consideration of the population or housing starts or energy costs. The savings shown are compared with some estimates of what the prior window performance practices were assumed to be. No comparison is made with windows that comply with IECC. If such a comparison were made using all of the assumptions and calculations in this analysis, the savings for ENERGY STAR windows would be \$8.00 per house per year or less. If the comparison were made with the current ENERGY STAR windows, the savings would be less than \$7.00 per house per year.

Therefore, in comparison with current ENERGY STAR window criteria and widely adopted and enforced building energy codes, the energy cost savings using the most extreme and unrealistic assumptions amount to a few dollars per house per year. Claims are also made for improved comfort and reduced condensation, with no quantification or determination of the benefits. DOE should use the extensive peer-reviewed scientific literature on these subjects to quantify changes in comfort and condensation, so consumers and the industry can judge the extent of the benefits.

In 5.1 there is a mention of the option to do tradeoffs of various energy related features in IECC, such as HVAC equipment and windows. However, that option does not exist in Chapter 6 of IECC, which is probably the most commonly used since it is the simplified approach. A tradeoff option exists in Chapter 5, but is limited to only envelope elements, and even that is rarely done. The only option that allows the tradeoffs described in 5.1 is IECC Chapter 4, Systems Analysis, which is virtually never used because it is so complex and expensive. Thus, this statement is misleading.

The analysis described in Appendix A for existing buildings relies on the data in the ASHRAE paper and goes on to describe even further assumptions and calculations, without providing either the references or the data. Therefore, it is not possible to review or critique such important issues as the weighting factors or the assumptions made about the assumptions.

Table A.1 indicates the source of data as the 1997 RECS. However, it does not say what specific pages or tables in RECS were used as the source of the values. Table CE3-2c on page 159 of RECS shows Total Electric Air Conditioning consumption as 0.42 quads. Yet, Table A.1 shows Total Electric Air Conditioning consumption as 1.34 quads.

Table A.2 could not be verified because the underlying data and assumptions were not provided. However, it is very curious that the Table shows that applying the 2000 IECC window requirements to **all** existing houses over the next 40 years will result in an **increase** in heating energy use. A conclusion like this should certainly have been explained and justified.

The analysis described in Appendix B for new buildings also relies on the data in the ASHRAE paper and goes on to describe even further assumptions and calculations, without providing either the references or the data.

Table B.3 could not be verified because the underlying data and assumptions were not provided. However, it is also very curious that the Table shows that applying the 2000 IECC window requirements to **all** new houses will result in an **increase** in heating energy use. A conclusion like this should certainly have been explained and justified.

Appendix C says cooling energy is expressed in kWh/yr in the spreadsheets, yet the spreadsheets show Btu/yr. The spreadsheets show a source energy conversion factor, however, that factor cannot be accurately or correctly applied nationally or even regionally. Consumers buy kilowatthours of electricity, not Btu of electricity. Thus, energy use and energy savings for electric cooling should be expressed in the units actually used.

The use of source energy is also not correct or valid, both on a national basis, and especially on a regional or local basis. Nor can source energy the way it is used here correctly reflect emissions or other power plant related issues. In some regions and states all or most electricity is generated by hydroelectric plants. In other regions and states a large fraction of the electric generation is nuclear. There is a growing amount of generation from wind turbines. There is also dramatic growth in the use of cogeneration and distributed generation with very different energy and emissions characteristics. Many states are using system benefits charges to promote and subsidize residential solar photovoltaic electric systems. These latter technologies are being extensively advocated and promoted by DOE. Source energy does not accurately or adequately reflect these increasingly and widely used technologies, and should be dropped.

If source energy is going to be used for electricity, it must also be used for other heating and cooling fuels such as oil and gas. What is measured at the meter does not begin to reflect what it takes to deliver these forms of energy to the consumer. The source energy includes the burdens from processing, distribution, transmission, storage losses, and the energy left in the ground because it is not practical or economical to extract it.

Relying on and analyzing SHGC alone is not sufficient or correct. The basic design premise for sizing and designing residential air conditioning assumes the use of inside shading. Otherwise, with peak cooling loads and no inside shading, the house will not be able to achieve or maintain comfort. Some reasons are:

"Direct application of procedures for calculating cooling load due to heat gain for flat glass (discussed in Chapters 29 and 30) results in unrealistically high cooling loads for residential installations"

as shown on page 28.2 of the 2001 ASHRAE Fundamentals. Thus, Window Glass Load Factors (GLF's) are shown in ASHRAE, and with separate values for one and two family detached residences and for multifamily residences. Also see the load calculation procedures from the Air Conditioning Contractors Association, which are used extensively for residential buildings.

The analysis spreadsheets showing calculations do not contain the basis for many of the assumptions and calculations. Thus, it is not possible to see or understand how DOE conducted their analysis or to review and provide responsible comments on the methods or results.

Some locations have no building energy code at all. Others use earlier or later versions of IECC or its predecessors. Still other locations have their own building energy codes that are more or less stringent than IECC. Therefore, any reasonable analysis of the impact of the ENERGY STAR window program must look at the building codes actually in use.

One must also consider the extent to which the ENERGY STAR criteria will increase the cost of windows to the point where the cost becomes a deterrent to window replacement. If that is the case, then far more energy savings are lost because homeowners retain their existing inefficient windows.

There is a great inconsistency in the entire analysis. Climate data and energy analyses were examined for several dozen locations, yet energy cost data was presented for only five regions, and first cost data were assumed to be the same everywhere.

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The DOE analysis does not make proper comparisons with IECC. It uses references that may not be technically or practically correct or relevant. It does not show the assumptions and calculations for most of the conclusions, or provide references showing them. What is most important, the DOE analysis does not justify and support the results and conclusions.

While there is much to be said for simplicity, one always faces the complexity versus compliance dilemma. Regardless of the level of complexity selected, whatever is done must be done correctly and completely. The DOE Evaluation does not.

In conclusion, there are so many technical errors and practical problems with the DOE Evaluation that are beyond quick or easy fixes. I believe DOE has an obligation to employ rigorous engineering and economic analyses in developing ENERGY STAR criteria. The comments above show that there are fatal flaws and serious omissions in the engineering analyses, and no economic analyses. There must be a sound basis for setting the requirements for ENERGY STAR windows. What has been done so far does not provide that basis. Therefore, it is absolutely essential that the DOE evaluation be done over from the beginning, using technically correct information and generally accepted engineering practices. Anything less will substantially diminish the credibility of DOE and ENERGY STAR and all of their programs in the building industry and among consumers.

Very truly yours,

LAWRENCE G. SPIELVOGEL, INC.

/s/

L. G. Spielvogel, P.E.

LGS:jca

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