
# Issues paper for Policy pathway for windows and other glazed areas

## (Working document)

# Introduction

Significantly improving energy efficiency remains a priority for all countries. Recent meetings of the G8 and the G20 leaders as well as the IEA Ministerial reaffirmed the critical role that improved energy efficiency can play in addressing energy security, environmental and economic challenges.

To support governments with their specific energy efficiency policy measures, the IEA proposed under the G8 Gleneagles plan of action, a set of 25 Energy Efficiency Policy Recommendations. The recommendations draw on extensive on-going IEA technical/economical/policy modelling, review of international policy experience and dialogues with stakeholders, focusing on 25 areas across seven priority categories: buildings, appliances, lighting, transport, industry, power utilities and cross-sectoral activities. Together, these measures set out an ambitious roadmap for improving energy efficiency on a global scale and will lead to significant cost-effective energy savings and carbon dioxide reduction.

The IEA acknowledges that simply making recommendations to countries is not enough. Usually, countries know what to do, but not necessarily how to do it. To fill the "know-how'' gap and to make sure that each of the 25 IEA Energy Efficiency Policy Recommendations is successfully implemented, the IEA secretariat is developing a series of Policy Pathways.

The Policy Pathway publications provide details and guidance to policy-makers and relevant stakeholders on the essential steps needed to successfully implement policies that reflect the IEA 25 Energy Efficiency Policy Recommendations. Based on direct experience, published research and expert workshops, the Pathways also provide insight into the types of policies adapted to the specific policy context(s) of different countries, so that each country derives the maximum benefit from energy efficiency improvements. Ultimately the Policy Pathway Publications aim to support countries in their endeavours to achieve greater energy efficiency improvements.

This particular pathway focuses on policies to improve the energy performance of windows and glazed areas. It is based on the analyses of lessons learned from the implementation of existing policies for windows, as well as planned policies in IEA and non-IEA Member countries. It documents the elements, steps and milestones (*i.e.* the pathway) necessary to successfully implement policies for more efficient windows. Its aim is to help countries implement effective programmes within the context of their national policy frameworks by offering advice and opportunities to benefit from the experience of others.

The final publication will include a detailed pathway comprising of four stages (plan, Implement, monitor and evaluate) and ten critical elements to be defined during the workshop to support the development and the implementation of policies for more efficient windows.

The upcoming IEA workshop on windows and glazed areas which takes place on July 6th at the IEA headquarters in Paris, is a unique opportunity for the IEA secretariat, policy makers, experts and manufacturers from all over the world to analyse existing windows policies and to work together on a detailed pathway for a successful implementation of these policies. The workshop is also an opportunity for all of us to learn more about planned policies and lessons learned from the implementation of the existing ones in South Korea, the US, Australia, New Zealand, the EU and other APEC countries.

## Policies for window energy performance

Windows are a source of heat loss, solar gain and daylight; therefore, they play an important role in the energy demand and the indoor climate of buildings. However, the energy performance of a window cannot be isolated from the performance of a building as a whole. Especially in hot climates where excessive solar heat gains may lead to the increase of cooling needs. Hence, the impact windows have on the heating and the cooling demand can't be analysed without considering the climate, the building type, the shadings, the proportion of glazed areas as well as the thermal and optical performances of the windows, glazing and their orientation.

A holistic approach that considers the energy performance of a building as a whole and specifies thermal and optical performance requirements for windows and glazed areas is essential to reduce the impact windows have on the energy consumption of a building. Thus, from a policy perspective, requirements for energy efficient windows are usually included in building energy codes. The requirements vary according to the climate, shadings, window orientation and percentage of glazed areas and frames.

In addition to the requirements included in buildings energy codes, some countries have implemented energy labelling schemes for windows on either a voluntary or mandatory basis. Furthermore, by July 2012, countries like South Korea will implement a mandatory labelling scheme and MEPS for fenestration systems.

### *Parameters included in window Energy rating labels*

Several countries have already implemented Energy rating labels for windows and glazed areas. However, parameters considered for the labelling scheme vary among countries. Based on a literature review, the following thermal and optical performances of a fenestration system are the ones usually included in the rating scheme:

- Thermal transmittance coefficient or heat transfer coefficient (U-value) is a measure of the heat transfer characteristics of a fenestration product under specific environmental conditions. When the interior-exterior temperature difference is multiplied by the projected fenestration product area, this yields the total heat transfer through the fenestration product by conduction, convection and infrared radiation. The U factor is the heat transmission in a unit time through a unit area of a test specimen and its boundary air films, induced by a unit temperature difference between the environments on each side in W/m2.K
- Solar transmittance coefficient (g value) or solar heat gain coefficient (SHGC) is defined as the ratio of the solar heat gain entering the space through the fenestration product to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and that portion of the absorbed solar radiation which is then reradiated, conducted or convected into the space.
- Light transmittance (τv) or visible transmittance (VT) is defined as the ratio of the visible light entering the space through the fenestration product to the incident visible light. The visible light entering a space is weighted by the photopic response of the eye.
- Energy Performance indices (EP) for heating (cooling) is the annual sum of the monthly contributions of the seasonal weighted average for the seasonal utilisation factor method, from the window to the energy need for space heating (cooling). More specifically, the

energy performance is defined as the sum of the net heat loss/gain through the window per the projected window area per month. It's expressed in kWh/m2

- Daylight potential (DP) indicates the windows potential to supply a building with daylight. It depends on the visible transmittance, the view factor from the glazing to the sky and the glazing to window area ratio
- Air leakage (include definition, standard/methodology used for its measurement)
- Noise transmissibility (include definition, standard/methodology used for its measurement)

## *Methodologies to rate window energy performance*

In most countries, window energy performance is rated based on a simulation method. Due to the high cost of physical testing few countries only require the rating to be validated by physical testing. In this case, a small portion of window products are tested to demonstrate congruence with a simulation or become the representative performance of a group of window products. The calculated window rating is then put into a larger building envelope performance calculation to enable energy code compliance.

The computer simulation and physical testing may be based on international recognised standards such as:

| | Parameter | Description | ISO standard |
|---|---|---|---|
| Glazing | Ug | Heat transfer coefficient | ISO 10077-1 |
| | Gg | Solar energy transmittance | ISO 9050 |
| | Tvis,g | Visible transmittance | ISO 9050 |
| | EPh,g | Heating Energy Performance | ISO 18292 |
| | EPc, g | Cooling Energy Performance | ISO |
| | DP | Daylight potential | |
| Windows | Uw | Heat transfer coefficient | ISO 10077-1 |
| | Gw | Solar energy transmittance | ISO 9050 |
| | Tvis,w | Visible transmittance | ISO 9050 |
| | EPh, w | Heating Energy Performance | ISO 18292 |
| | EPc, w | Cooling Energy Performance | ISO 18292 |
| | DP | Daylight potential | |

Regarding test procedures/protocols usually countries/regions adapt the international/regional standard to their climate conditions and building design. However, the methods for calculating U-value in the window product standard provide U-value variations by as much as 20 %. While energy building codes are developed at national/local level and most of them use default values for window performance or only glazing values for the fenestration system.

## *Different parameters that impact window energy performance*

Windows play an important role in the energy performance of a building, as part of the building envelope. It is therefore desirable to control heat gain/loss, visual transmittance and noise transmissibility to reduce the need of cooling/heating and artificial lighting. However, since windows are part of the building as a whole system, the impact windows have on the energy performance of the building might be negative/positive depending on the climate, the building type and the window design.

### *Climate impact*

To better understand the impact of each parameter of window energy performance, we conducted a thermal building simulation for a commercial building of 200 m2, 2 floors in different climate zones with different structure and window design.

As we can see from Table 1, for the same window configuration and same orientation, the impact on the heating and cooling load vary largely for different climate zones.

| Climate zone | Heating Load (kWh/m2) | Cooling load (kWh/m2) |
|---|---|---|
| Cold climate | 74 | 21 |
| Moderate climate | 56 | 46 |
| Hot Climate | 40 | 59 |

Table 1: Impact of the climate

### *Design impact*

Using the same example, we looked at:

- The impact of the window orientation and the proportion of glazed area for each orientation. Table 2 shows the results of the thermal simulation, we see that the impact of window orientation and % of glazed area is more important in summer time than in winter time, and for some orientations the needs may double between hot and cold seasons.

| %of glazed area | Climate zone | North | | South | | East | | West | |
|---|---|---|---|---|---|---|---|---|---|
| | | Heating load (kWh/m2) | Cooling load (kWh/m2) | Heating load (kWh/m2) | Cooling load (kWh/m2) | Heating load (kWh/m2) | Cooling load (kWh/m2) | Heating load (kWh/m2) | Cooling load (kWh/m2) |
| 40% | Cold | 72 | 18 | 71 | 23 | 71 | 19 | 71 | 24 |
| | Hot | 39 | 54 | 39 | 62 | 39 | 58 | 39 | 65 |
| 80% | Cold | 74 | 11 | 70 | 30 | 72 | 17 | 73 | 35 |
| | Hot | 40 | 38 | 38 | 71 | 38 | 56 | 39 | 80 |

Table 2: Impact of windows orientation and % of glazed areas

- The other parameter that has an impact on the role of windows in building energy performance is shading. Considering different shading options (0%, 10%, 30% and 60%) for

the same building design and window orientation, we see that an increase of shading has a greater impact in summer time than in winter time, particularly in a hot climate.

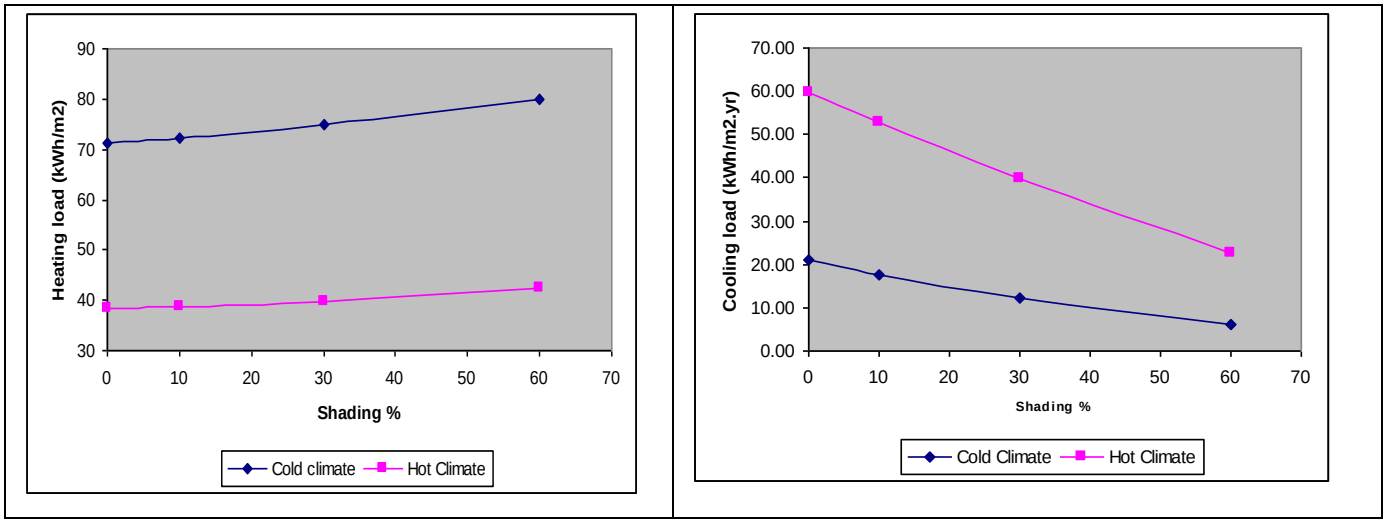



Figure 1: Impact of the shading

- Using the same building with the same window characteristics and orientation, modifying only the % of glazed area, we see in Figure 2 that this leads to an increase in both the heating and cooling load. However, the increase of the cooling load is much greater, particularly in a hot climate.

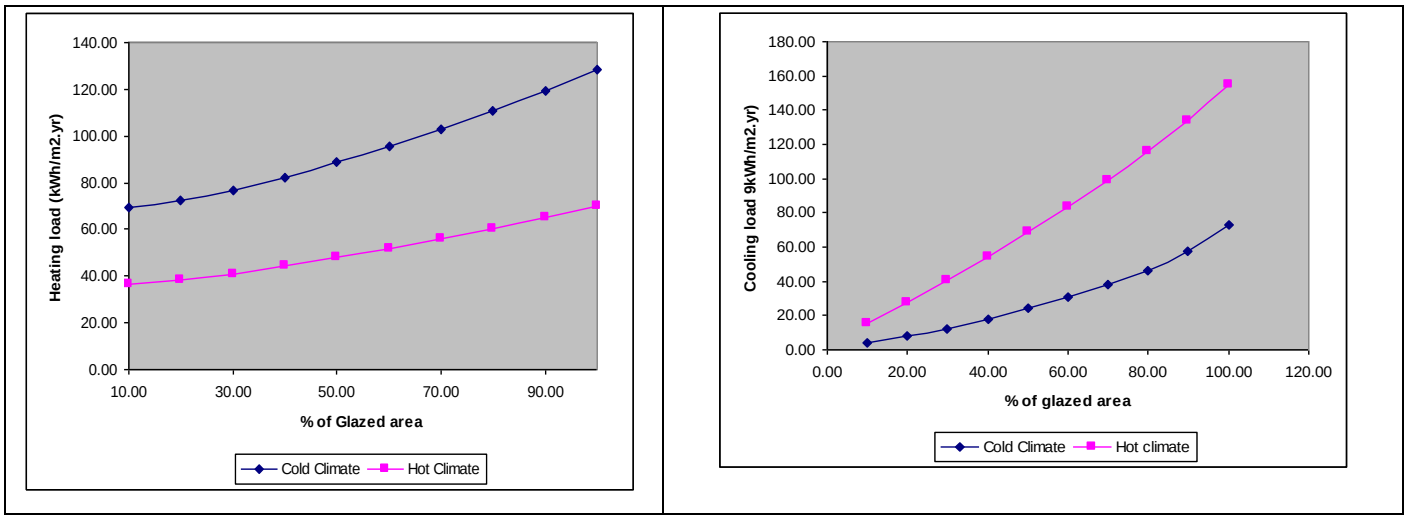



Figure 2: Impact of the % of glazed area

- Finally, the quality of the window frame also has an impact on the window performance. For the same building design with same window orientation and glazing but different window frame quality, we see that the low frame quality increases the heating loads, particularly in cold climates because of the increase in air leakage.

| Frame quality | Cold Climate | | Hot climate | |
|---|---|---|---|---|
| | Heating load (kWh/m2.yr) | Cooling load (kWh/m2.yr) | Heating load (kWh/m2.yr) | Cooling load (kWh/m2.yr) |
| Low | 88 | 18 | 48 | 56 |
| Medium | 74 | 40 | 21 | 59 |
| High | 71 | 40 | 21 | 60 |

Table 3: Impact of window frame quality

The parameters described above and their impacts are usually considered in the building energy codes.

### *Thermal and optical performance impact*

When the optimum design option has been selected, the next step is to select a window from a manufacturer's catalogues. Usually two parameters are considered in this final selection; the U-factor and the Solar Heat gain Coefficient (SHGC).

The impact of the U-Factor is greater in winter time, particularly in cold climates as we can see in Figure 3.

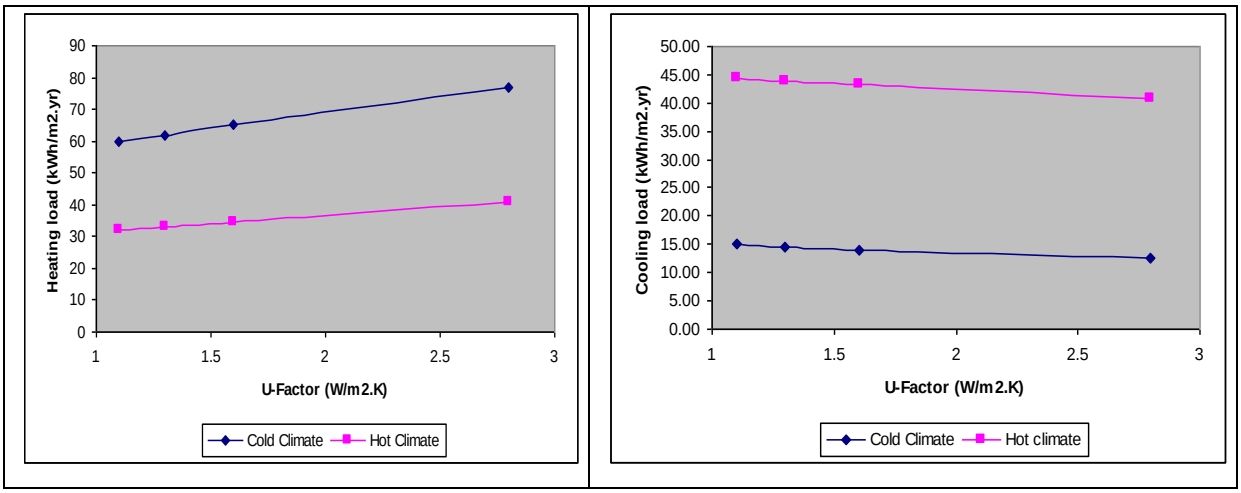



Figure 3: Impact of the U-Factor

The increase of SHGC has a huge impact in summer time in hot climates, and a small impact in winter time even in cold climates, as we can see in Figure 4.

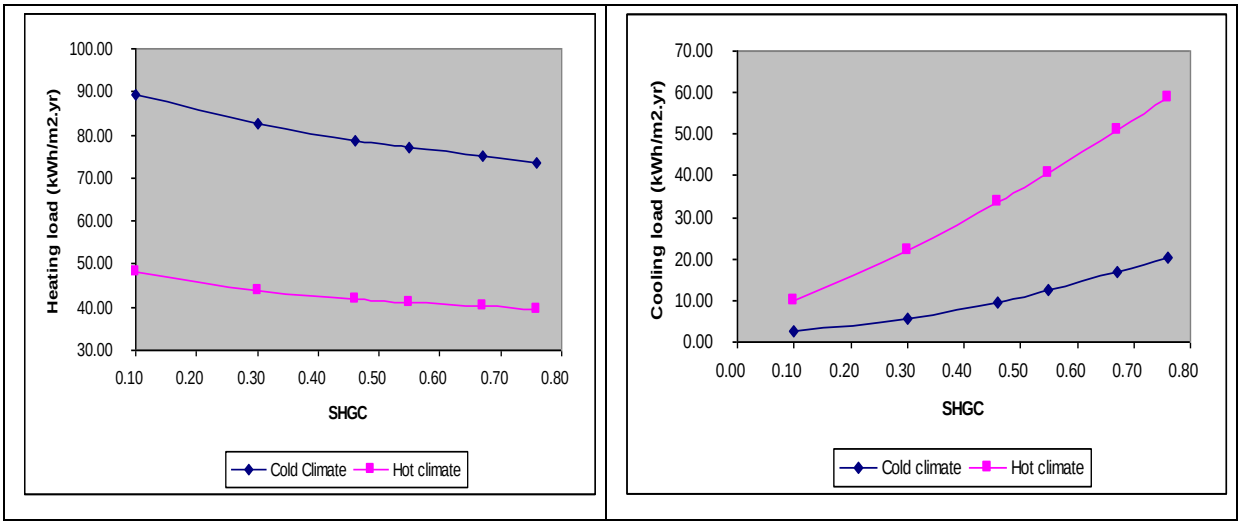



Figure 4: Impact of SGHC

When looking to the combined impact of U-factor and SHGC, we see that in both cold and hot climates the combination of the two factors reduces the heating needs while the impact on cooling needs is lower, Table 4

| | | | Cold climate | | Hot Climate | |
|---|---|---|---|---|---|---|
| | U-factor (W/m2.k) | SHGC | Heating load (kWh/m2.k) | Cooling load (kWh/m2.k) | Heating load (kWh/m2.k) | Cooling load (kWh/m2.k) |
| Single glazing | 5.8 | 86 | 99 | 20 | 53 | 61 |
| Double glazing | 2.8 | 76 | 71 | 21 | 39 | 60 |
| Triple glazing | 1.8 | 68 | 64 | 19 | 34 | 55 |

Table 4: Combined impact of U-factor and SHGC

The thermal and optical parameters described above are usually addressed in the energy performance label; furthermore, some countries include minimum requirements for each parameter.

## *Issues to discuss*

Analyses of the existing policies demonstrates that climate and building design parameters as well as the thermal and optical performance of the window itself are the key element that influence the impact of windows in the energy performance of a building. Based on the literature review, the climate and design parameters are addressed in building codes where the building is considered a unique system and the window thermal and optical performance by labelling and Minimum Energy Performance requirements (MEPS) schemes.

Therefore, the main issues to discuss during the workshop are:

- The effectiveness of the policy package (building energy codes to address the climate and design impact) and the MEPS & labelling scheme to address the thermal and optical performance of the window from a building energy performance perspective and the cost.
- Is this policy package sufficient to reduce the negative impact of windows and glazed areas on the energy performance of buildings?
- Are complementary policies needed? If yes, which ones?
- Based on lessons learned in different countries, what are the main elements to consider when implementing this policy package?
- Shall the policy package be mandatory or voluntary?
- How can the compliance of the design parameters be checked?
- How the compliance of window thermal and optical performance rating be checked?
- Shall we consider other environmental aspects such as embodied energy and waste when recommending a policy package for windows? Has this impact been quantified? Which methodology is used to quantify it?
- How do we raise awareness about the impact of windows on building energy performance?
- What are the market failures and the barriers for more efficient windows and how to overcome them?
- How to implement a window policy package to improve building energy performance? What are the necessary milestones to consider?

**Windows policies in South Korea**

**Prepared by Yungrae KIM**

## Overview

Aiming to enhance the energy efficiency of equipment and facilities, the Republic of Korea as the 10th largest energy importer has been operating three energy efficiency management programs; including the Energy Efficiency Labelling program, the Certification Program for High Efficiency Energy Equipment and the e-Standby Program.

The Energy Efficiency Labelling program has been implemented since 1992 as a mandatory scheme which covers 23 products including clothes washers, air-conditioners and refrigerators. Among the covered products, window sets are considered key equipment for energy saving in apartment buildings as they account for as much as half of the wall area in many these buildings. With a seven times lower insulation value than that of walls, window sets account for 20 ~ 45 percent of total energy loss in buildings. On such grounds, window sets have been designated as target a product for the Energy Efficiency Labelling program since July 2012.

## Status of Korea's Energy Efficiency Programs

- **Certification Program for High Efficiency Equipment**

Pursuant to the tentative regulation, "Regulation on the Operation of High Efficiency Equipment," the current window labeling program recognizes products having a heat transmission coefficient lower than 2.632 W/m2· K for insulation performance and lower than a 2nd grade for sealing.

- **Building Design Criteria**

| Classification | | Central region | South region | Jeju Island |
|---|---|---|---|---|
| Direct exposure to outdoor air | Apartment buildings | 2.1 | 2.4 | 3.1 |
| | Others | 2.4 | 2.7 | 3.4 |
| Indirect exposure to outdoor air | Apartment buildings | 2.8 | 3.1 | 3.7 |
| | Others | 3.2 | 3.7 | 4.3 |

- **Range of Coverage**

The program applies to window products to be sold as combination units of glass and frame in pursuant to KS F 3117 which take up more than $1m^2$ of a window area in buildings exposed to outdoor air.

Currently in the Korean market, window sets supplied to construction companies as combination units of glass and frame account for 20~30 percent while the rest (70~80 percent) is constituted by glass and frame supplied separately to construction companies.

- **Time of Application**

The program for window sets is a mandatory scheme which is applied by MEPS and the Energy Efficiency Labeling Program (1st – 5th Grade) targeting combination units of frame of glass and this program is scheduled to come into force from July 2012.

- **Method of Measurement**

An energy efficiency grade will be determined using the heat transmission coefficient measured in accordance with KS F 2278 and the degree of sealing measured according to KS F 2292.

- **Criteria for Energy Efficiency Grades**

| R | Air-Leakages | Grade |
|---|---|---|
| R≤ 1.0 | 1st Grade | 1 |
| 1.0＜R≤1.4 | 1st Grade | 2 |
| 1.4＜R≤2.1 | Over 2nd Grade<br>(1st Grade or 2nd Grade) | 3 |
| 2.1＜R≤2.8 | n/a | 4 |
| 2.8＜R≤3.4 | n/a | 5 |

R= heat transmission coefficient ($W/(m^2 \cdot K)$)

- **MEPS (Maximum heat transmission coefficient): 2.4 W/m2· K**

The manufacturing and sales of products not meeting the MEPS shall be prohibited, and fines of up to 20 million KW will be charged for violations.


- **Distribution of Energy Efficiency Grade**

| Classification | 1st Grade | 2nd Grade | 3rd Grade | 4th Grade | 5th Grade |
|---|---|---|---|---|---|
| 900 model | 45 (5.5%) | 180 (19.6%) | 324 (35.9%) | 261 (28.7%) | 90 (10.3%) |

- **Post Management of Equipment Under The Energy Efficiency Program**

After notification has been given regarding energy performance, the product is purchased at a retail outlet by KEMCO staff accompanied by representatives of consumer associations. The energy performance and an energy label of the product shall be verified through energy tests conducted by a government designated laboratory.

700 million KW have been allocated for post-management for 197 models of 23 product items including refrigerators, washing machines, air-conditioners, and dish-washers.

## Windows policies in the US

## Prepared by Bipin SHAH

### Policies Implemented-Labels and Minimum Performance

The United States has four primary voluntary and mandatory policies for energy saving windows

| | Residential | Commercial |
|---|---|---|
| **Mandatory** | International Energy Conservation Code (IECC) | American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) 90.1-2007 |
| **Voluntary** | ENERGY STAR Windows Program | US Green Building Council-Leadership in Energy and Environmental Design |

### Residential, Mandatory: International Energy Conservation Code, IECC

The IECC, the most common mandatory, residential energy policy directly referencing window energy ratings and is updated every three years with the 2009 version being the latest. In the US, each state government considers adopting the IECC 2009 and making it state law for building energy performance. In addition, the US Government bases federal funding to the states based on their energy code adoption and implementation. IECC is used in nearly every US state. The IECC requires maximum U-factors and SHGCs by climate type provided by participating with the National Fenestration Rating Council's window rating program. Each residential window must display an NFRC label on its glass surface enabling performance confirmation.

### Residential, Voluntary: ENERGY STAR Window Program

The ENERGY STAR Windows program is the most common voluntary, residential policy referencing window energy ratings. It also references maximum U-factors and SHGCs by climate type. ENERGY STAR provides a distinct label for each qualified product so consumers can easily identify and confirm the window products qualification for the program.

### Commercial, Mandatory: American Society of Heating, Refrigerating, and Air-conditioning Engineers 90.1-2007

ASHRAE 90.1-2007 is the most common commercial building energy policy making reference to window energy ratings. Like IECC, state legislatures consider ASHRAE 90.1 adoption for the building energy policy. Maximum U-factors and SHGCs are listed in the policy by climate. In addition, the user may use alternative building energy simulation to comply with the policy, but must also use NFRC window energy ratings to determine compliance. ASHRAE 90.1-2007 references NFRC window energy performance, but for commercial projects, label certificates stating the U-factor and SHGC are provided for each project, not on each window.

### Commercial, Voluntary: US Green Building Council Leadership in Energy Efficient Design (LEED)

The US Green Building Council (USGBC) LEED program is the most common voluntary commercial building energy program in the US. LEED makes reference to ASHRAE 90.1-2004 as a mandatory requirement for its energy and atmosphere requirement. LEED applicants need to show their

ASHRAE 90.1 window energy compliance by providing a window energy performance certificate as mentioned in the ASHRAE 90.1 requirements above. The USGBC issues certificates for each successful LEED applicant.

**Policy Requirements**

- **IECC**

The IECC requires energy ratings from the National Fenestration Rating Council, NFRC. This non-profit, technical, consensus based organization provides a comprehensive energy rating system for window manufacturers to fairly and accurately rating window energy performance. The IECC directly references NFRC 100 (U-factor rating) and NFRC 200 (SHGC and VT ratings). The only alternate rating method is using the window performance default tables within the IECC. Over 800 US, European, Canadian, and Asian window manufacturers rate nearly 3 million product types for potential sale in the US and other economies.

- **ENERGY STAR Windows Program**

The ENERGY STAR Windows Program is the most common voluntary energy policy for residential windows. This program requires NFRC 100/200 ratings and the full NFRC certification process. The program lists U-factors and SHGC requirement based on climate type across the United States. The US Government develops the criteria by working with technical consultants and considering stakeholder input (manufacturers, efficiency advocates, and others.) The ENERGY STAR windows program is well established with nearly all NFRC rated manufacturers participating. This program enables the consumer to easily identify energy efficient window products by simply selecting window products displaying the label. In addition, the US government offers tax credits for ENERGY STAR qualified window products and many US power utilities offer rebates and incentives based on the program.

Nearly all NFRC rated window manufacturers participate in the ENERGY STAR window program. In addition, 90% of more of manufacturers selling window products in the US participate with NFRC. Therefore, ENERGY STAR and NFRC are nearly ubiquitous throughout the US.

- **ASHRAE 90.1-2007**

The ASHRAE 90.1-2007 requires window ratings per NFRC 100/200 or specific defaults within the standard. The SHGC and U-factor requirements are listed by window frame type (metal, nonmetal) and by climate zone. The standard also limits the window to wall ratio to 40% if using the simple, prescriptive path for compliance. Users may consider a full building energy simulation if window to wall ratios greater than 40% are used.

- **USGBC LEED**

The USGBC's LEED program requires numerous measures to ensure good environmental and energy performance. Window energy policy is embedded in the energy and atmosphere requirement by referencing ASHRAE 90.1-2004. As described in this document, ASHRAE 90.1 references NFRC 100/200 for window energy performance rating and requires maximum U-factors and SHGCs by climate zone. This is a mandatory requirement and the user may also achieve a higher LEED rating or score by exceeding the ASHRAE 90.1 minimum criteria.

This voluntary program has over 21,000 approved projects; however, limited NFRC ratings exist for commercial projects. This implies LEED applicants are using alternative methods to comply with the LEED energy and atmosphere requirement. Anecdotally, LEED market penetration is estimated to be less than 5% of commercial projects.

## Barriers to the implementation of policies for more efficient windows and lessons learned.

As discussed, the residential market enjoys nearly complete penetration of both mandatory and voluntary window ratings. Limited barriers exist. For commercial buildings, however, the primary barrier is the window industry's limited acceptance of the present NFRC commercial window rating program. Some reasons the industry cite are expense, time, complexity, and lack of code official understanding. NFRC release a new energy rating program for commercial products in January 2010. The program has moved slowly through the marketplace and met with limited success thus far. Efforts are underway across the US to implement this promising new program.

## Compliance checking

Building energy codes are enforced by state and local government agency or contractors. For residential homes, compliance checking is done at time of framing during the construction process. Code officials note the U-factor and SHGC on the window product by looking at the NFRC label affixed to the window product. For the ENERGY STAR window program, the US government uses the NFRC database to confirm all ENERGY STAR window program applications so compliance is 100%.

For commercial projects, the code official requests the window energy rating certificate for a commercial project. Anecdotal evidence indicates many different documents are accepted for window energy compliance other than the required NFRC label certificate. Efforts are underway to change and improve this practice, improved code compliance, and increase NFRC label certificate activity. LEED applicants must submit evidence of ASHRAE 90.1-04 compliance, but it is unknown if actual NFRC label certificates are submitted. It is unlikely they are submitted properly based on the limited commercial rating activity observed by the NFRC.

## Other Information

The NFRC has license agreements with Australia, South Africa, and a pending arrangement with India. The NFRC also is referenced in Canadian building energy codes.

# Windows policies in the EU

## Prepared by Diana AVASOO

### Energy saving potential in EU

One of the most important aims within the global community is the reduction of energy consumption, and thereby the reduction in CO2 emission; considered by many to be a vital prerequisite to the reduction of the harmful effects of climate change. Ensuring that fenestration products are selected on the basis of an optimized energy performance in their specific environment will have a significant impact on achieving that goal. The accumulated additional energy loss through poorly selected fenestration products, over their lifetime, is truly enormous, and any steps that can help reduce that loss must be taken as soon as possible.

A Thermie report presented to the European Commission in 1996[1], showed an energy saving potential of approximately 310 TWh in the 15 EU member States if windows were upgraded to low emissivity double glazing. The report also showed that 60 % of the dwellings in EU-15 were single glazed. The report highlighted the hidden energy saving potential that could be achieved with more energy efficient windows. Since the publication of the Thermie report another 12 countries have joined the European Union. The windows available on the European market today have twice as good insulation value as low emissivity double glazing mentioned in the Thermie report. Our assumption of the energy saving potential compared to this study is very low.

The existing dwelling stock in EU-27 amounts to approximately 230 million dwellings (UN Economic commission for Europe 2004). The total window area in these dwellings is approximately 2500 million square meters. The amount of windows in the non-residential sector is approximately equivalent to windows in the residential sector.

The energy saving potential in the residential sector is minimum 250 TWh if the average energy saving per window area is 100 kWh per year. This is based on the assumption of an average window area of 11 %. The table below demonstrates that three times that figure can be saved by simply reducing the heat loss when converting from single glazing to an **A** rated window. It should also be noted that further energy can be saved when the room temperature can be lowered and the weather-stripping improved.

[1] Major energy savings, environmental and employment benefits by double-glazing and advanced double-glazing technologies, Contract No XVII/7001/90-8

[2] Based on 4000 degree days = Southern Sweden and several central European countries

TABLE 1 ENERGY SAVING (KWH/M$^2$,K)2 WHEN UPGRADING WINDOWS TO ENERGY RATE A – G (SWEDISH RATING)

| Window type and U-value | | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|---|
| | U-value | ≤0,9 | 1,0 | 1,1 | 1,2 | 1,3 | 1,4 | 1,5 |
| Single glazed | 4,0 | 310 | 300 | 290 | 280 | 270 | 260 | 250 |
| Double glazed | 2,9 | 200 | 190 | 180 | 170 | 160 | 150 | 140 |
| Triple glazed | 1,9 | 100 | 90 | 80 | 70 | | 50 | 40 |

Cooling is the area in which energy consumption is accelerating the most. Energy efficient windows with solar controlled glass can reduce a building's heat load from solar heat transfer by up to 72 per cent, whilst maintaining good daylight transmittance. Higher reduction can be obtained at the cost of lower daylight transmittance. Energy efficient windows have the potential of greatly reducing energy consumption currently used for cooling both in residential and commercial buildings.

TABLE 2 SOLAR HEAT TRANSFER THROUGH 1 M2 GLASS – SOLAR INTENSITY 800 W

| Glass type | Heat loss U-value | Hear transfer Watt/m$^2$ | Index |
|---|---|---|---|
| Single glazed | 5,4 | 688 | 100 |
| Double glazed | 2,9 | 608 | 88 |
| Triple glazed | 1,9 | 544 | 79 |
| Double glazed Solar control + LE | 1,1 | 288 | 42 |
| Triple glazed Solar control Low Emissivity glass | 0,7 | 192 | **28** |

Table 2 shows that there is a huge energy saving potential in buildings with cooling demand.

A higher awareness when designing windows in commercial or non-residential buildings can reduce the cooling demand dramatically. A report presented in 2007[3], states that by 2020 between 15 and 85 million tonnes of CO2 annually can be saved if there was a greater use of solar control glass in residential and non-residential building in the EU.

[3] Impact of Solar Control Glazing on energy and CO2 savings in Europe, TNO Report 2007-D-R0576

Modern glass with neutral tint and with low emissivity coating provides solar shading on sunny days and reduces heat loss during the heating season. Window energy rating can be used as a tool to reduce cooling demand.
The Swedish window energy label includes information of glass heat transfer coefficient. That is all information needed for evaluating the cooling demand of a particular building. Professional buyers of building designers simulate the building energy balance, heating and cooling demand with various computer tools. The only in data that these tools require for calculating heating and cooling demand are the U-value and the g-value. G-value is the total solar heat load through glass.

## History

Between years 2000 and 2003 The Swedish Energy Agency participated in a SAVE Project titled European Window Energy Rating System (EWERS). The objective of this Project was to develop the basis for a European window labelling and rating system. Eight countries participated in the Project.

The aim of EWERS was to increase the use of energy efficient windows by helping consumers, dealers, architects and other decision makers to choose the most energy efficient windows for their application. The labelling and registration process was a tool to drive the market to improve the products and reduce overall energy consumption.

After three years research by eight specialists and scientists we agreed on a formula for the calculation of windows energy balance, upon which the rating could be based. However, this formula gives different results depending on climate. It is based on windows installed in a small one family house and does not consider that windows are installed in all types of buildings. If the window installation zone and the orientation of the window is known, and provided no shading is used, the window energy balance can be calculated. However, if the windows are sold across the country or even exported; the energy balance on the window label will be misleading. Consumers can, for example, be misled when they import an A rated window from a country with mild climate into a country with cold climate.

The EWERS project started with Phase 1 for establishing the base information for windows that remains constant regardless of location within the EU. The base information required was: thermal resistance, radiation properties and air permeability. These are basic physical characteristics for windows that are unaffected by the location of the window.

Phase 2 was planned for more professional buyers, such as architects etc. This phase was concerned with establishing performance data for windows in relation to climate and location within the EU. It used the information collected under Phase 1 to set up a rating method for the net energy impact of windows in a given climate.

The conclusions of the EWERS project were that a reliable and easy to understand rating system is needed. Four out of the eight countries that participated in EWERS decided to implement and evaluate window energy rating in their countries as a pilot project and exchange experiences. Below we describe the current status of these projects and we have chosen to give a more detailed picture of the Swedish project as it is well established and very successful.

## Window Energy Rating - Sweden

Despite a good window standard compared to most other European countries, Sweden still has approximately 40 million windows with ordinary double glazing. The energy saving potential in Sweden is 8 TWh if all double glazed windows in the residential sector were upgraded. This equals to approximately 5 % of the energy used in the building sector. The building regulations for existing buildings are only advisory and contain no obligation to replace double glazing with better windows. The window selection is therefore very often a matter of comparing prices. Particularly the professional buyers tend to buy the cheapest windows as they represent the builder and not the tenant who will pay the heating- and electricity bill.

Another 7-8 TWh can be saved if the windows in the non-residential sector were upgraded. Changing windows involves many professions and this creates jobs. In Sweden it is estimated that each building effort creates three other.

## Pilot project 2006-2008

In 2005 the Swedish Energy Agency decided to follow up the EWERS project with a pilot project for energy rated windows. However, the journey has been long and troublesome due to difficulty in finding volunteers. The idea was presented to the Wooden window manufacturer's organisation, to all manufacturers of wooden, PVC and aluminium windows, to the glass industry and other related groups early in 2005. We had several well attended meetings but the organisation and their biggest members fought against the whole idea. The methods used by manufacturers for marketing their windows are not very sophisticated. Between 25 and 40 per cent rebates are offered on high tariff prices. Very often low U-values are promised but in reality the low U-value is that of the glazing unit and not that of the entire window. Window manufacturers, who are accustomed to selling windows to customers who were happy to receive a rebate and to not ask questions, were very worried when they heard about our intentions to introduce window energy rating. Suddenly the windows energy performance would be transparent. To them, transparency of the windows energy performance was more a threat than a new and positive marketing tool.

However, 10 small and medium size manufacturers decided to join the project and signed a voluntary agreement with the Swedish Energy Agency.

European window manufacturer's organisations contacted the European Commission already during the EWERS project expressing their concern with energy rating of windows. During the Swedish pilot project, some international window manufacturers prohibited their subsidiaries from participating in the pilot project. These actions convinced the Swedish Energy Agency even more that window energy rating and labelling is necessary.

In January 2006 the Swedish Energy Agency signed a voluntary agreement with ten window manufacturers. The agreement included a commitment to develop, rate, label and promote energy labelled windows during a two year period.

The ten manufacturers were small or medium size manufacturers with both wooden and PVC windows. Their share of the Swedish window market was 25 %. Two of them were Finland's biggest wooden window manufacturers and four were PVC window manufacturers. The dominating wooden window industry in Sweden was suddenly challenged by imports from Finland and from PVC windows.

## Energy rating procedure

The aim of the pilot project was to:

- reduce the Swedish energy consumption
- increase the installation of energy efficient windows
- encourage window manufacturers to develop and promote windows with low U-values
- provide buyers with documented correct and reliable information of windows energy performance

The window energy label is, as are the energy labels on white goods, purely a marketing label. It communicates energy efficiency in a very simple way. You don't have to be an engineer to understand that item **A** is more energy efficient than item **C**. This part of the voluntary agreement, to use the same label as for white goods, was easy to accept by the participants. The difficult part was the rating method. Among the ten licensed window manufacturers we had two from Finland and several with window licences from Germany. For cross border trading it would be beneficial to have a uniform international labelling system, rather than separate national systems.

## U-value or Energy Balance

The need to assess the energy performance of windows has become even more evident after the implementation of the European Building Energy Performance Directive.

It must be acknowledge that, in terms of energy consumption and saving, there is a significant difference between household windows and other electricity consuming products such as household white goods. Windows are transparent and heat is transferred during the wintertime from the inside of the building to the outside of the building, and vice versa during the summertime. The challenge therefore is to find a simple rating system that the consumer finds easy to understand and compare.

We studied the window energy balance developed during the EWERS project and found it difficult to communicate to both window manufacturers and to consumers. Furthermore, it was not interesting for professionals as they are looking at the buildings overall energy balance and not that of windows. The buildings energy balance is depending also on how the building cumulates heat and many other parameters. One of these parameters is universal - the U-value.

The International Standards Organisation, ISO, has developed standards for calculation of window and glass U-values. These standards have become European standards. They are used by all window manufacturers in the world. The most complete calculation method for U-value is regulated by EN-ISO standard 10077-2 and the determination of a U-value for windows in laboratories is regulated by EN-ISO standard 12567-1. Irrespectively of continent, building type, orientation, climate, window configuration etc., the U-value of a window, that is the heat transfer through a construction, is the same all over the world. We subsequently agreed not to complicate things and to use the U-value as a rating method for windows. Therefore, we found that there was no need to complicate the comparison of windows by introducing calculation methods that very few people could understand. This was understood and appreciated by all parties.

Below you can see the rating levels set by the window manufacturers. The levels are, somewhat surprisingly, lower than the ones anticipated by the project leaders:

Table 3 Swedish window rating scale

| Energy rate | U-value, W/m$^2$,K |
|---|---|
| A | ≤ 0,9 |
| B | 1,0 |
| C | 1,1 |
| D | 1,2 |
| E | 1,3 |
| F | 1,4 |
| G | 1,5 |

## Determination of U-value

There are four methods for calculating U-value in the window product standard EN 14351-1. Depending on chosen method, the U-value can vary as much as 20 %. This discrepancy is not acceptable as for example a windows with a tested U-value of 1,5 can obtain U-value 1,2 depending on the chosen calculation method.

Neither the laboratory test nor the theoretical calculation methods take air-leakage into account. Air leakage has significant impact on the window energy performance.

Apart from the test and calculation methods in the EN standard 14351-1, there are other methods for determination of U-values. One of these is the ISO standard *15099:2003 Thermal performance of windows, doors and shading devices that is used by countries outside Europe*.
A single test and calculation method valid and accepted worldwide would solve many of the problems that this project faced from start. The problems were mainly discussions with window manufacturers that refused to test their windows according to the EN standard 12567-1or calculate the U-values according to the more complete calculation method in EN-ISO10077-2.

Experiences from the Finnish rating system showed that there may be a discrepancy between a U-value from laboratory tests and a calculated U-value. In order to avoid uncertainties and provide a robust and reliable rating, the Energy Agency and the manufacturers agreed the following:

a) Each manufacturer had to test two of their windows in test laboratories according to the EN-ISO standard 12567-1.

b) The U-value of the same windows should then be calculated according to the EN-ISO standard 10077-2. The reason was to calibrate the windows and see if the discrepancy between tested and calculated windows was significant. If this was not the case, then it was enough to let an accredited or certified National body to calculate the U-value of the windows in the future. Laboratory tests are very expensive and time consuming as many countries have very few approved window testing laboratories.

c) The U-value for all other windows of the manufacturer should then be calculated according to the EN-ISO standard 10077-2. The simplified method of calculating U-values, EN-ISO 10077-1 or tabulated calculation methods were not accepted as these methods exclude components that can have impact on the U-value.

d) The protocols from the certified laboratories were sent to a third party for control and approval.

e) The approved windows obtained master copies of labels and data sheets. The rated windows were published on the web site.

## Credibility of label

In order to reduce risk for cheating with the rating system, three different labelling methods were selected.

The label shows the energy rate, the U-value of a complete window, the daylight transmittance and the solar energy transmittance (g-value) of the glass. These figures provide engineers and architects with necessary input data to their climate design tools for calculation of the building energy balance.

Each window model was given a unique product code connected to the frame, configuration and glass combination.

In order to secure the credibility of the label, it is locked by the advertising agency and cannot be manipulated in a computer. As a second security, the label is inserted in a product data sheet that can be downloaded from the project home page www.energifonster.nu.

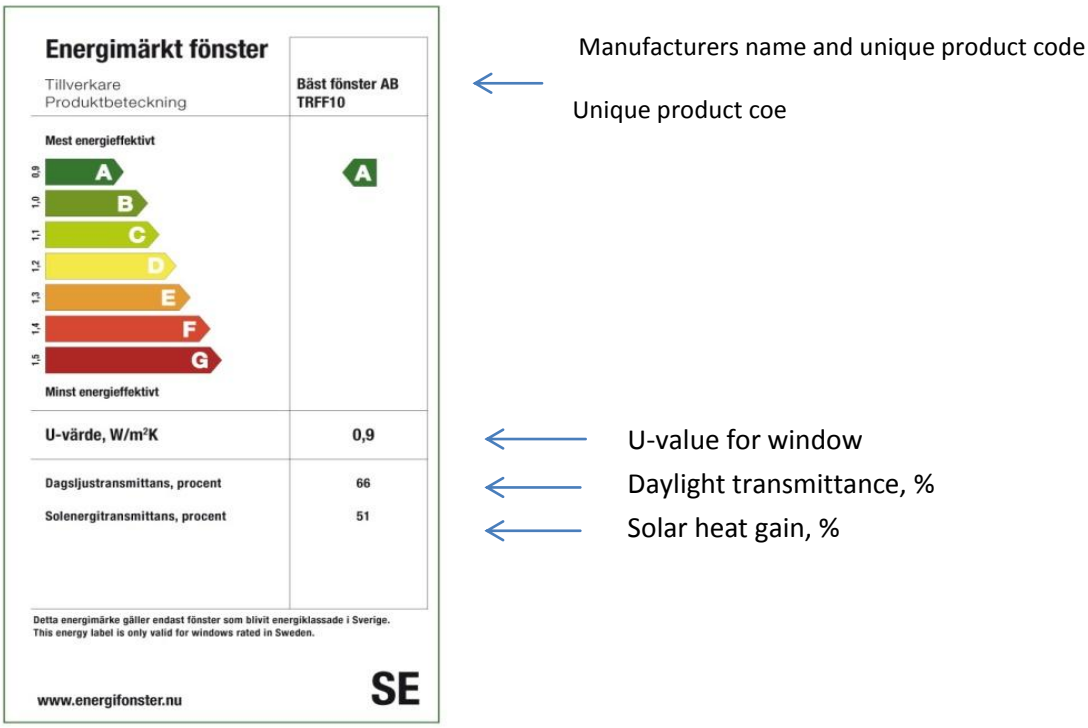



*Figure 3 The Swedish window label*

The consumers and other buyers can visit the home page and download the product sheet seen below and study the glass combination. This product sheet is also important after the delivery of each window to the customer. The customer can, using the product sheet, compare the delivered window glass with the window they ordered and paid for.

The label of the energy rated window

The glass combination specifying distance between glass panes, gas filling, type of spacer, i.e. all parameters that have impact on the glazed part of the window.


*Figure 4 The Swedish product data sheet*

As a third security, we produced a small, permanent label to be placed on the window frame or the casement. The label is very difficult to remove. This label will make energy declaration of buildings much easier as engineering consultants will be able to easily identify the windows energy performance only by looking at the label. The label below says “Energy rated window” and has the Swedish Energy Agency’s logo on in order to give legitimacy. Also the web-site address is on the label, in case more information regarding a particular window is needed.


*Figure 5 Permanent window label*

The label above shows that the particular window was **A** rated in 2008 and the U-value was 0,9 W/m$^2$,K. If the rating scale had to be changed in the future, the house owner or the inspector could for example see that the U-value is 0,9 and means a B rating for year 2013.

The U-value is a universal constant and the rating scale can easily be changed along with lower U-values introduced on the market.

### Labelling procedures

The window configurations, materials (wooden, PVC, Aluminium, Steel and combination of these), vary from country to country. Windows are sold in different ways:

- annual agreements with one-family house producers
- annual agreements with building material dealers
- public procurements
- procurement from entrepreneurs and real estate owners
- direct sales to one-family house owners or builders
- direct sales to multi-dwelling house owners

Most of the manufacturers are big industries that build a window from scratch. They have their own saw mills; make their own timber profiles etc. Others buy PVC or aluminium profiles and make windows. They produce windows in standard sizes but these are glazed with different glass units and obtain different ratings. To glue labels on each window can lead to mistakes that, in the long run, can lead to complaints from customers.

One must also consider the cost implications. Printing labels that go with every produced window will increase manufacturing costs by approximately 0.5 € per window. Furthermore, it is not environmental friendly to print all these labels.

During the project we therefore agreed to put only the small labels (figure 5) on the frame. The manufacturers are provided with a protected original of their label (figure 3) and their product sheet (figure 4). The original copy can be used for printing the label as a display material, in brochures, in their home page, advertisements etc. They can, if they want to, stick a label on each window. This was, we found, a smooth, cheap and still reliable system. The small, permanent, labels are provided by EQ Windows in order to control that the right type of labels are used. For example a manufacturer without A rated windows cannot order A labels.

### Credibility of the project

In order to maintain the high profile of the window energy rating, we organised an Ethics Council. The Swedish Energy Agency bought energy rated windows by proxy and sent them to the National Testing Institute for tests.

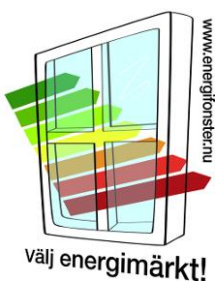
Two of the manufacturers had deliberately deceived the customer by selling windows with higher U-value than ordered by the customer. The windows were analysed by the testing institute and there was no doubt that this was a deliberate deception. The Ethics Council gathered and decided to expel these manufacturers from the pilot project in order to maintain the reliability of the project and also for warning against others from trying the same.

The Swedish Energy Agency arranged a press meeting and informed the public about the misuse of the rating and that two members left the project.

### Dissemination

We started by giving the project an identity:

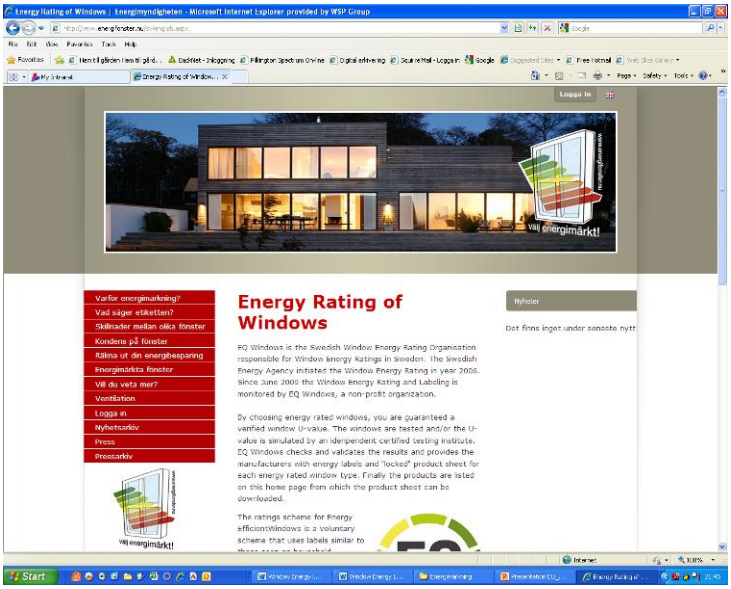




1 Logo that everyone used in their advertising

(Text under logo: Choose energy labeled!)

2 Home page with the domain name [www.energifonster.nu](http://www.energifonster.nu) (nu in Swedish means now)




The home page has a calculator where consumers can calculate the energy saving and economy of the window upgrading. They can find general information about windows and about energy rated windows. An important information is the product data sheet for each rated window that can be downloaded and, if necessary, compared with delivered windows. The homepage contains also important information about ventilation and external condensation. The window manufacturers and their sales teams can log in and download power point presentation, printed material, advertising material and other useful information.

3-Easy to recognise, specially designed leaflets, brochures and exhibition material etc.


Very little money was spent on common advertising as good relations with the press resulted in hundreds of positive articles. The window manufacturers themselves advertised with the logo saying that their windows were labelled. Also television and radio broadcasted interviews with the Swedish Energy Agency.

We arranged seminars for buyer groups and also participated as speakers in many seminars promoting energy rated windows. We had common stand in several trade fairs exhibiting one window from each manufacturer. It was interesting experience to see competitors side by side. For visitors it was excellent to have all information and all types of windows gathered in one stand.

An important part of the dissemination was education of all energy advisors working in the municipalities. These were our ambassadors as they are the people who daily answer questions from consumers. We also educated the manufacturers' sales staff in energy efficiency policies, the role of energy efficient windows in buildings energy balance and indoor comfort, window and glass physics and the advantages of energy rated windows.

Information about the project reached countries outside Sweden. We have been contacted by window manufacturers and Universities that want to implement energy rating systems in France, Turkey, Estonia, Latvia and many more countries.

During the period November 2008 and November 2010, the web site has been visited by 56 339 visitors from 70 different countries. The visitors were as far as from China, Japan, USA, Canada and Brazil. The majority of the visitors are from the EU-27 countries.

### Phase 2 of the pilot project – 2008 - 2010

Seven months after the project started, we were approached by the biggest window manufacturer in Sweden who wanted to join the pilot project. After voting, we accepted to extend the project and open it for all manufacturers that wanted to join in. With the participation of this new member, the manufacturers' share of the market increased from 25 % to 50 %. The project became suddenly both a success for the members but also a threat for those who were not members.

By the end of the pilot project period, the energy rating of windows was well known by many professional buyers. The window manufacturers were very pleased with the outcome. It also triggered market completion amongst manufacturers to be the first to produce a new window with low U-values. Also, the Swedish Energy Agency was satisfied with the way the market accepted the energy rating and decided to support the project for another two years. However, this time the manufacturers had to invest more money and effort in the project. All nine manufacturers from the previous phase and 5 new manufacturers joined Phase 2. The market share of these amounts to 85 % of the Swedish window market. They represent all four Nordic countries. The members are both wooden window manufacturers and PVC window manufacturers

### EQ Windows – energy and quality rated windows

EQ stands for Energy and Quality rated windows.

Credibility and Reliability were the words of honour. However, the Swedish Energy Agency felt that buyers may equate "Reliable U-value " with "Good Quality Window". The manufacturers were asked if they were prepared to invest time and money in expanding the energy rating scheme with quality system. They all accepted to test their windows to meet certain quality standards. Since windows manufactured and sold in Sweden, at the time of the project start, did not need to be CE marked, the quality tests were those required for CE marking with certain minimum levels (higher than the minimum levels in the CE marking) for each quality standard. In addition, the manufacturers had to

give their customers 10 years guarantee for all window functions and provide documentation on how to install and maintain their windows. Other voluntary qualities were: Environmental friendly treatment and contents, ISO 9000 quality system and ISO 14000 environmental control system.

All energy rated windows in Sweden had to be quality tested for all qualities requested. Most of the energy rated windows had already required tests and the others had their windows tested in National approved test laboratories.

Windows that passed all the tests and fulfilled all other requirements were provided with the energy label that also had the EQ mark.

Of course, these extra tests have financial implications, which make it more difficult for smaller manufacturers to join. However, the aim of the rating is to reduce energy consumption in Sweden and therefore the products must meet the minimum energy requirements. For example, the tests showed that many windows were not air tight or even rain-tight. The U-value test or calculations don't take into account air leakage which is another source of energy loss. Windows that leak air, leak energy and also let noise in.

The introduction of the EQ marking was very well received by consumers and by professional buyers. "At last we have a reliable system for good quality windows" they expressed. Buyers and 85 % of the window providers in Sweden were satisfied. . A quality marking of windows is important as windows have many weak points that shorten their lifetime and also, as explained above, increase the energy loss.

Unfortunately, one importer of windows from Poland claimed that he should become member as he had CE marking. He could not give us any proof of this CE marking or show any relevant test protocols and therefore was denied to become a member. He started to complain to various authorities.

Instead of jeopardising the whole project, we decided that the project should continue without the Swedish Energy Agency's' support. Therefore, in June 2009, the EQ Windows – Energy and Quality Rated Windows organisation was registered. The chairman of the board and project leader, is Diana Avasoo, glass and window expert at WSP Environmental, an international consultancy agency. Diana Avasoo was also the Swedish Energy Agencys' project leader for the window rating projects since year 2000. The EQ Windows board decided to withdraw the EQ marking until the legal questions about what was possible to demand in a voluntary rating system were sorted out

## Market transformation

There are many ways of transforming a market towards more energy efficient products:

A) The easiest and quickest is to give incentives such as energy grants for choosing energy efficient windows. However, this is also an expensive and short lived method. Unless grants are not given over a long period of time, people continue to buy the cheapest windows when the grants are removed.

Between years 2004 and 2008, the Swedish government introduced a grant system for windows in one-family houses when installing windows with U-value of 1.2 or better. This incentive stimulated production of windows with U-value 1.2 W/m2K and the availability of these increased rapidly. On the other hand, there was no ambition to develop windows with even better insulating properties.

Many window dealers and manufacturers with a window range of higher U-values, convinced the buyers to buy windows with higher U-value and offering them rebates of the same amount as the Government grants. Another argument was that they could never save energy for the money they pay for a lower U-value.

B) Technology procurement is a long term method and suitable when the needed technology is not available on the market. In Sweden technology procurement for energy efficient windows was carried out in 1991 and 1995. The winning windows had U-value of 0.8 W/m2K. Despite massive marketing efforts by the Swedish Energy Agency, very few were installed. The manufacturers were waiting for market demand before investing in new production lines for energy efficient windows. The market was looking for products that did not exist or were extremely expensive and “clumsy”. The sales staff and the distributors found it difficult to explain the benefits of energy efficient windows or even what U-value is. The technology procurement failed because of the above mentioned reasons but most of all because of the window manufacturers’ attitude. Most of them are “carpenters” and convinced that the market is happy to buy the cheapest windows available.

C) A third method is to change human behaviour through information and advice, is also a long term solution and requires manpower and advertising.

D) The fourth method is the one we are describing here: Make energy visible by rating and labelling windows. The green, yellow and red arrows are well known. They are very educational and show that some products are more energy consuming than others. The concept has been successful and the evidence is the table below. Within four years the market has been transformed from U-values of 3.0 and 2.0 W/m2K, to much lower U-values. Furthermore, 65 % of the windows sold by 85 % of the manufacturers are energy rated.

Table 4: Sales statistics – Energy rated windows 2006-2009

The sales figures below are provided by the manufacturers that participated in the pilot project and reflect 85 % of the Swedish window market

**Sales of energy rated windows in Sweden as a % of total sold windows**

| Year | U-value ≤ 0,9 | U-value 1 | U-value 1,1 | U-value 1,2 | U-value 1,3 | U-value 1,4 | U-value 1,5 | % of total |
|---|---|---|---|---|---|---|---|---|
| 2006 | 0 | 0,05 | 0,96 | 15,6 | 5,1 | 0,87 | 1,9 | 24,5* |
| 2007 | 2,3 | 0,07 | 1,8 | 49,6 | 42,4 | 1,1 | 1,4 | 98,7* |
| 2008 | 0,93 | 0,14 | 2,2 | 35,3 | 18,5 | 1 | 3 | 61,1 |
| 2009 | **2,4** | **0,22** | **7,6** | **45,8** | **8,2** | **0,58** | **0,15** | **65** |
| | | | | | | | | **77**** |

Comments:

2006 Pilot project starts with 10 window manufacturers = 25 % of the market

2007 Sweden's biggest manufacturer joins the project and energy rates all their windows

2008 Phase 2 with 5 new and large window manufacturers = 85 % of the market
2 small manufacturers live the project

2009 65% of windows sold by members are energy rated.
Windows with U-values 1,2 or lower increase and windows with higher U-values decline

* Please note that the percentage figures cannot be added as each column shows the energy rated windows only and not all windows produced by the members.

****77,0%** of window with U-value 1,5 and below are energy rated.

## Monitoring the project

The Swedish pilot project must be considered as a great success bearing in mind that we dealt with 14 angry competitors. Most of it was thanks to a good teamwork between the officer from the Swedish Energy Agency and the project leader.

We had several well organised meetings with seminars and workshops. In addition we had frequent contact through e-mail and phone.

We encouraged the manufacturers to expose their energy rated windows in joint stands. It was wonderful to see 14 competitors under the same roof "selling" energy rated windows. They also financed joint advertisements.


*Figure 6 Photo from joint exhibition. The heading on the roll-up display says: "Ask for the label!"*

Windows are not quite as simple to select on the basis for their energy performance as refrigerators, pumps or automobiles. A credible, easy to understand and cost-effective window energy performance rating system can reduce the European energy consumption for heating by more than 400 TWh.

Implementation of a reliable energy rating system that is easy to understand by consumers, quickly adopted by the manufacturers is urgently needed throughout Europe if the European CO2 emission reductions are to be met. The rating system must be monitored and controlled by independent bodies and have enough financial strength for dissemination. Houses with passive heating and cooling have been built in at least 25 years. Simple and reliable solutions exist but they are not commonly used. The results are well documented but need to be known by many more.

The discussions we had within the EWERS project were all very technical. The missing point was that window energy rating is a marketing tool. It will compete with other items that people will spend money on: Trips abroad, a new kitchen, Bubble pool etc. Windows must become more attractive. Therefore other, emotional qualities have to be lifted up. Therefore we have used arguments like:

- Better indoor comfort
- You can sit close to the window without or with very little downdraught
- You can have bigger windows without discomfort
- You can choose a smaller heating device or no heating system at all etc.

*Figure 7 Comfort close to big window*


*Figure 8 Drawings with messages type "Chose energy rated windows!" used in advertisements and on the web-site*

For professional buyers we had other arguments: When there is no risk for downdraught even without heating devices under the window, then you can build new buildings or refurbish old ones at

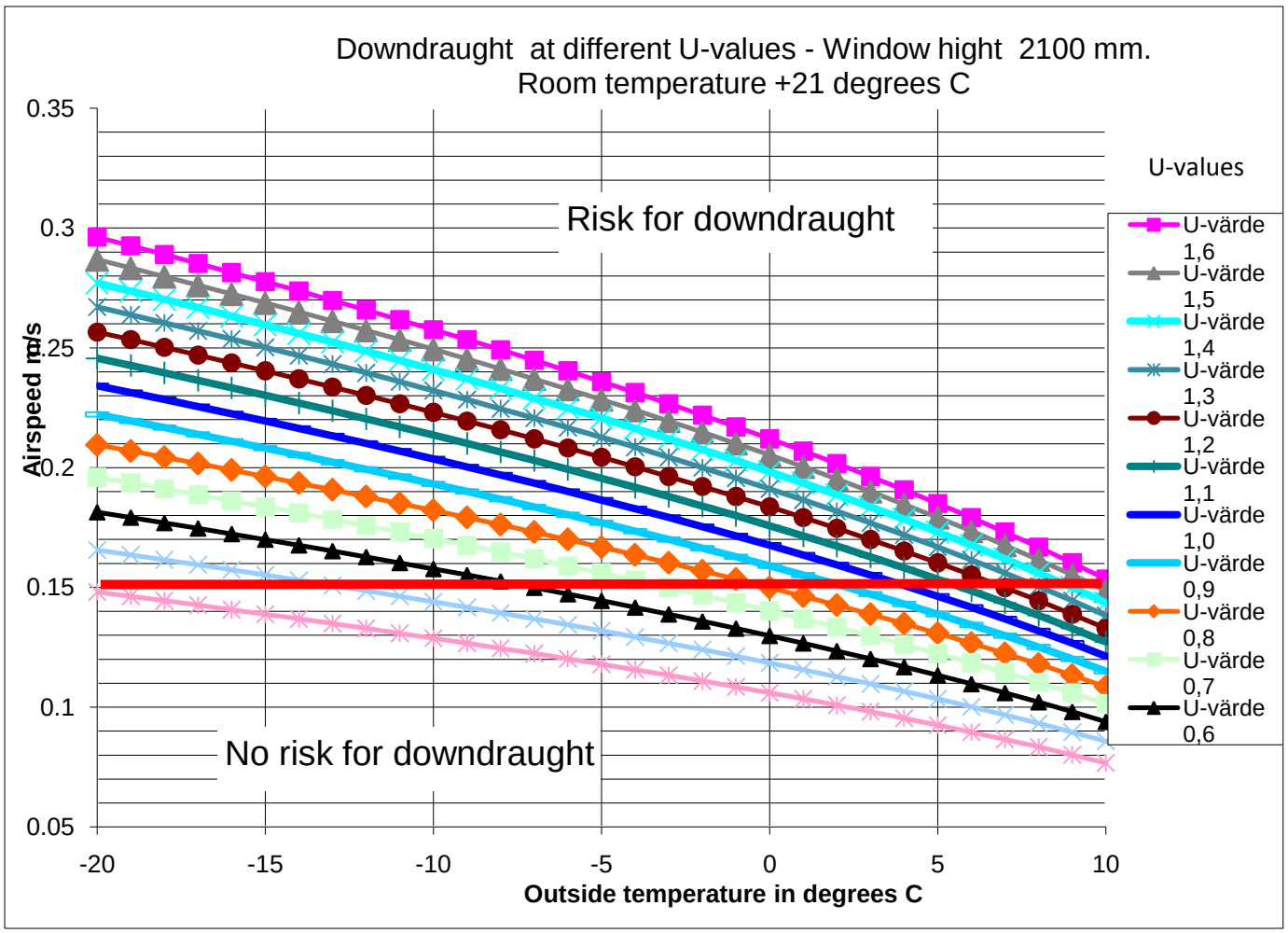



*Figure 9 Diagram showing risk for downdraught, WSP Environmental, Gothenburg*

lower costs when choosing energy efficient windows. You save the costs for installation of heating devices.

Figure 9 above shows risk for downdraught at various U-values and outdoor temperatures. The thick red line across the figure is drawn at 0,15 metres/second air speed. Above this speed, people suffer from discomfort as the air movements decrease the perceived room temperature.

A combination of good indoor comfort and low indoor temperature can be obtained at $U_g$-value (glass U-value) of 0,8 when the temperature outside is zero degrees. Under this temperature even lower U-values are required. This is for a window height of 2100 mm and without any heating device under it. For other window sizes the figures vary.

For buildings with cooling demand we used arguments from interesting research reports:

Swedish children (maybe also European children?) are losing one year's study because their classrooms are too warm. In fact in Sweden, during spring and autumn, the sun goes up at 4 o'clock in the morning and heats up the class rooms. The pupils come to a hot class 8 'o'clock a.m.

The consequences of overheated class rooms but also of all other working places are: Declining focus and declining efficiency.[4] Declining efficiency means financial loss. Other negative consequences shown in another study by D.P. Wyon are increasing accidents in industry.

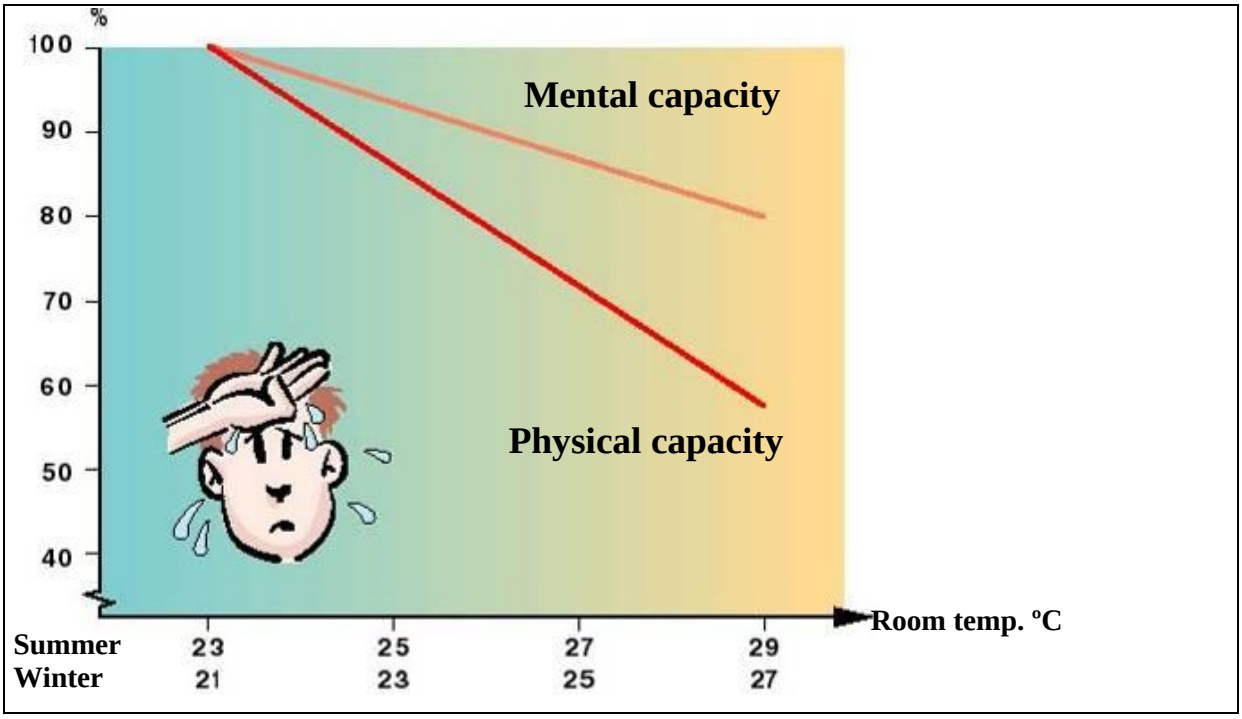



*Figure10 Indoor air temperature and discomfort*

The different temperatures in figure 10 show that in the summertime we tolerate two degrees higher indoor temperature than in wintertime because we wear lighter cloths.

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3 The effects of indoor air quality on performance and productivity, D.P. Wyon, International Centre for Indoor Environment and Energy, Technical University of Denmark

Changing to energy rated windows with low U-values and low solar heat transmittance in Swedish schools has resulted in good indoor climate all year round. After changing windows, the schools that we studied did not have to install cooling systems. The schools reduced both energy consumption and also their maintenance costs, as windows do not need frequent maintenance as a cooling system.

## Energy Rating 2010-2011

The window manufacturers were very disappointed when the Swedish Energy Agencys involvement in the project ceased. They felt that running the project as a Window manufacturing group will not have the same credibility as when a governmental body was supervising it.

Two of Sweden's biggest window manufacturers, with a market share above 60 %, are members of EQ Windows. These are concerned that the criteria for obtaining a window energy rating could be regarded by competition authorities and other manufacturers as a mean to limit competition.

The group was not sure if the criteria agreed by the Agency during phase 1 was against any regulations. For example were we forced to accept CE marking as basis for window energy rating? The methods used for calculation of U-values for CE marking result in 20 % discrepancy compared to the method accepted in the original criteria.

The above mentioned arguments were discussed in board meetings and we decided to freeze the project until we have rating criteria and methods that are acceptable by authorities and still are robust and reliable. This is unfortunate as many local and international window manufacturers with sales in Sweden contact us and want to rate their windows. They are upset that the rating is closed for others than the 14 already rated manufacturers.

EQ Windows have contacted the Swedish Technical Research Institute, SP, and gave them the assignment to establish a technical advisory group. The group, representing environmental organisations, consumer organisations, researchers, builders etc., will define criteria for energy and quality rating of windows. The energy and quality rating will be certified can then be provided by accredited bodies. The present time schedule is end of 2011 for approved criteria and opening of the rating system early in 2012.

## Lessons learned

Lessons learned from the EWERS project were:

- Good marketing and tutorial skills are needed before consumers can learn to identify the national energy balance of each window. Until then, consumer ratings based on energy balance should be accompanied by a Health Warning: '*valid only for the specific window configuration specified in the rating system and for climate zone xx*'.
- Strong lobbying exists from bodies that fight against energy efficient windows
- It is necessary to bear in mind that the labelling should be viewed as a consumer information system and not for building design
- The label should contain data needed for professionals to simulate the building energy demand for heating and cooling
- Severe control of window performance data is necessary in order to maintain a reliable rating system

- Consumer information needs to be kept simple

Lessons learned from the Swedish pilot projects were:

- Experience from other rating systems run by the industry itself show that they don't work.
- A mandatory rating system would speed up product innovation and market transformation towards energy efficient windows. Perhaps under the EU Directive 2010/30/EU for energy related products and also later under the Eco Design Directive.
- The methods for calculating U-value in the window product standard and for CE marking are not reliable as the U-value can vary as much as 20 %. For example a C rated window can be B or even A rated in the Swedish system depending on the chosen method. An important factor such as air-leakage is not taken into account when calculating or testing windows U-value.
- The product standard for windows should be opened for revision soonest possible and the work should focus on windows energy performance.
- A frequent market control system is necessary as it is extremely difficult to identify the window properties by just looking at it. Once a window is energy rated, the same window can be produced and sold with higher U-values. Elements that have impact on energy performance are normally invisible: Gas filling, spacers, PVC or aluminium frames chambers etc.
- The purpose of the labelling is to make energy visible to people that are not technicians. We believe that it is important to regard the project as a marketing project rather than as a technical project.
- The window manufacturers are not self-going. Continuous contacts are needed in order to stimulate product development and marketing of energy rating.

## Conclusions

The Swedish Energy Rating System has been very successful. Some of the good results are due to

- A governmental part guaranteed reliability
- A rating system that is easy to understand for manufacturers and for consumers.
- A well-recognized label of the same type as the previous label for white goods.
- Full explanation of the label and the rating on a product sheet spread by manufacturers or by downloading on the project web-site.
- A repeated message that the rating and labelling is robust and reliable.
- Spreading information about Life Cycle Cost calculation, LCC. Education of energy advisors and professionals in LCC calculation and provided tools for that.
- The window performance is provided by certified laboratories and by EU accepted notified bodies.
- All windows are tested or calculated in the same size as the one recommended in the European Product Standard for windows, 1230 x 1480 mm. All quality tests are performed according to European product standard for windows.
- Careful monitoring of the rating procedures and third party control of provided information.

Phase 1 of the project was evaluated by independent consultants. The outcome of this evaluation was:

- The energy rating has resulted in lowered heating and cooling demand in Swedish buildings
- The energy rating has strengthened the participating manufacturers' competitive position

- Consumer information has improved but there is still demand for increased information about the window energy rating and the information must be clearer
- Project leading and project implementation has been very well executed
- The socio-economic benefits have exceeded costs

The window manufacturers are prepared to invest money and effort and continue to rate their windows according to the Swedish system until a pan European system has been established. They express a strong wish to have a moral support from the Swedish Energy Agency. They fear that the credibility of the rating will reduce without the agency's support.

The Swedish window manufacturers, both the ones with rated windows and many others, express a strong wish to rate their windows and hope that EU will introduce a mandatory rating system. Otherwise, there is a risk that many other groups will introduce their own rating systems. Many different types of window ratings will split and confuse the market. A good example is voluntary environmental labelling and the rating systems introduced in Europe and presented below.

## Window Energy Rating - UK

### History

British Fenestration Rating Council (BFRC) was established in 1999 with the assistance of the DETR, Department of the Environment Transport and The Regions, and the major trade associations from the window industry. They initiated the EWERS project because of a clear need for a rating system to impartially measure and asses the thermal efficiency of windows. WER, Window Energy Rating, was launched in March 2004 immediately after the end of the EWERS project. More details of the organization, and how a window company can have its products rated, are given on the website http://www.bfrc.org/

The rating system was the one developed by EWERS that is on an energy balance for a window in a fictive building. The balance for the window for the heating season is described below:

$$q_{net} = \eta_g (g_w) G_{sol} - (U_w + L_w)(\overline{T}_{i,setpoint} - \overline{T}_e)t \quad (1)$$

Where:

$q_{net}$ = the net heat load in MJ (per $m^2$ window)

$\eta_g$ = utilisation factor for solar heat gain [-],

$G_{sol}$ = total amount of solar radiation on vertical surface for an average orientation in the heating period in MJ ($m^2$ window)

$T_{i,setpoint}$ = is the average setpoint temperature of the room at the inside of the window in °C

$T_e$ = is the average outdoor temperature in the heating season in °C

t = time of heating season in Ms

For orientation of solar radiation an average orientation (equal average between north, east, south and west) is used.

e climate data - daily or monthly data

To derive the constants A and B for a specific climate zone the following procedure is followed:

1. Derive the season length in accordance with EN 832:1998 [3] and as described more precisely in paragraph 4.1 of EWERS document 'Development of energy rating method. Part 2 – Discussion document' [4].
   In short: Use the reference building parameters (see Section 4) to derive daily heat gains and losses. The heating season is cut off where 96% of the annual heating demand is reached (cutting off 2% at the beginning and 2% at the end)
2. Derive:

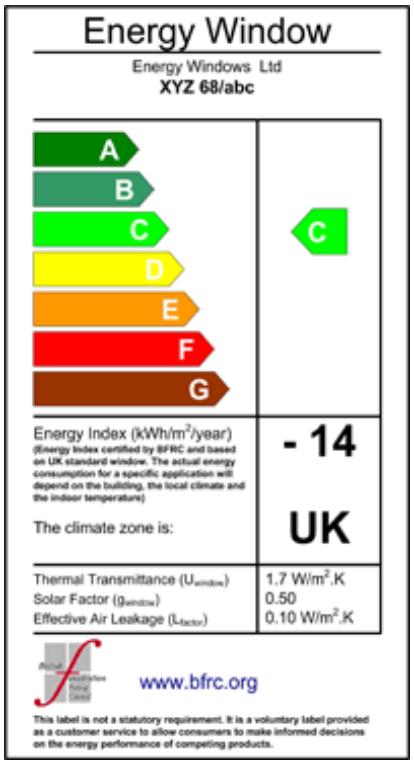
- the total amount of solar radiation on a vertical surface for an average orientation in the heating period, $G_{sol}$,
- the average outdoor temperature in the heating season, $T_e$
- the length of heating season, t

using the heating season length and hourly climate data of the climate zone.

3. Derive the utilization factor in accordance with EN 832:1998 [3] using the reference building and $G_{sol}$, $T_e$ and t.

4. Calculate A and B using $T_{i,setpoint}$ from the reference building and the above calculated utilization factor $\eta_g$, $G_{sol}$, $T_e$ and t.

Etc.




To explain how the energy balance works is very complicated and takes several pages. The window manufacturers and the consumers see only the ready label with a rating on. There is no explanation on how to interpret the label seen on the left. On the home page there is a brief explanation saying that a minus figure means energy loss per square meter window are per year.

Compared to U-value, the energy balance is misleading as the windows orientation, shading, type of building it is going to be installed in and the actual climate zone is not known. Furthermore, the air leakage is a standard figure as the windows are not tested in a laboratory.

A window with 1,7 in U-value has ha heat loss of approximately 130 kWh/year. There is little sun coming in rainy and cold winter days and all winter nights. Even if the energy from the sun is a heat gain, there is still a lot of down-draught and cold radiation from a cold window surface.

With a cold glass, there is no possibility to reduce indoor air temperature and save even more energy.

Limitations in the BFRC Rating:
The BFRC Rating refers only to the standard BFRC sample size - this is the same sample size used in both the relevant European Standards and in the Building Regulations. It is not possible to provide a BFRC Rating for any other specific style/shape or configuration of window. The BFRC Rating refers only to the general orientation of windows in UK homes. It is not possible to provide a BFRC Rating for a specific house or orientation of window. The BFRC Rating refers to the general UK climate zone. It is not possible to provide a BFRC Rating for a specific and local climate zone in the UK.

**BFRC rating procedures**

1. A BFRC Certified Simulator produces an assessment report* of the window.

2. A BFRC Independent Agency ensures the window company has a satisfactory quality management system, approves the Certified Simulator's report and informs BFRC.

3. BFRC authorize, and inform the window company of, the product's Rating and give permission to them to use labels. BFRC place the product on the database on its website.

* The Certified Simulator's report gives an assessment of the BFRC Rating, which takes into account U value, g value and L value (air leakage). The U value would normally be produced by the Simulator using approved software, the g value comes from the glass manufacturer and the L value from testing to BS 6375. The U value simulation is performed for a window to the standard GGF configuration, and the result can be applied to all products of other configurations using the same system/profile.

Although a window system or frame in itself cannot gain a BFRC Rating, it would probably be in a system/window company's interests to have an assessment report done for a window using his

profile, and incorporating a standard insulating glass unit. A BFRC Certified Simulator would probably charge about £800 for this. This could be repeated using different glazing variants in the same window at about £60 per variant.

The benefit to the systems supplier is that the one report could then be used by his customers as part of their evaluation by a BFRC Independent Agency.

**BFRC and Energy Saving Trust**

The energy saving recommended certification mark was developed by the Energy Saving Trust to distinguish the most energy efficient products on the market.

Only products that meet the strict requirements will be endorsed and given the certification mark. The certification scheme is managed by the Energy Saving Trust and backed by the Government. The energy saving recommended logo is strongly supported by marketing campaigns and is widely recognised by consumers as signposting the most energy efficient products available in the marketplace. The BFRC has worked with the Energy Saving Trust to enable suppliers of suitable BFRC rated products to apply for endorsement by the scheme and use of this prestigious mark on their product. Manufacturers and suppliers who achieve a BFRC rating of 'C' (or above) are eligible to apply to the Managing Agent of the energy saving endorsement scheme for approval to use the logo and to be listed on the energy saving recommended database. If a manufacturer or supplier's product achieves a 'C' (or above) rating then the BFRC provides a WER label to this effect. The holder of the WER label contacts the Managing Agent of the energy saving endorsement scheme for an Application Pack. This is a simple 4-page form that is completed and returned with:


- • The relevant BFRC Rating labels.
- • A copy of the last Annual Return made to the Registrar of Companies.
- • Copies of up to date certificates for Product Liability Insurance and Employers Liability Insurance.
- • A copy of the procedures which monitor the quality of the product
- • A commitment to annually report sales of the endorsed product.

The Managing Agent completes the rest of the process and if successful manufacturers and suppliers are given permission to use the energy saving recommended logo.

Scheme members benefit through the large-scale publicity that is carried out by the Energy Saving Trust to support and publicize the scheme. They benefit from the support of a multi-million pound advertising campaign including posters, press, PR and below- t he-line activity throughout the year and during the energy saving week promoting the energy efficiency message and directing consumers to the website.

## Current activity

Because of the association with Energy Saving Trust and the Energy Efficiency Recommended accolade many forward thinking window companies are aiming initially for a C-rated window product to allow them to carry the EER logo also. More information at http://www.est.org.uk/

D-rated windows provide a lower cost alternative although still above the minimum for regulatory compliance. B-rated windows allow companies to differentiate products with superior thermal properties. Some windows have achieved A-ratings status with a triple glazed window. Presently, A-rated windows are extremely expensive and therefore, triple glazed windows are fare away from becoming standard in the UK.

## Window Energy Rating - Denmark

### History

The Danish trade organisations and the Danish Energy Authority signed a voluntary energy labelling agreement for windows for the period 2004 until 2006. The Danish Energy Authority supported gave the trade more or less free hands to design the Danish energy rating system and to implement it among their members. The results are therefore much different from the outcomes from EWERS. The Danish Energy rating label, see Figure 2, was much different from a traditional Eco Design label. There were three levels of rating, A-C. Denmark had already an energy rating system for multiple glazing units (MGU) rated A-C based on the energy balance of the glass according to a method developed in Danish Technology Institute. The window rating system was based on the combination of a frame with a certain U-value and a glass unit that is A-rated:

A rated windows = frame configuration U-value below 0,18 W/m$^2$K + A rated glass unit.
B rated windows = frame configuration U-value of 0,18 - ≤ 0,20 W/m$^2$K + A rated glass unit.
C rated windows = frame configuration U-value of 0,20 - ≤0,22 W/m$^2$K + A rated glass unit.


*Figure 1*
*Danish label 2004-2006*


*Figure 2*
*Danish logo for energy rated windows*

The project was evaluated by an independent consultancy agency. The results were that the rating system was not working as expected by Energistyrelsen, the Danish Energy Agency and was stopped in 2006.

### New rating system

The Danish Window Industry signed an agreement with the Danish Energy Agency that commits the window industry to energy rate their windows. The aim is to increase sales of windows that are more energy efficient than required in the Danish building regulations 2010 (BR-10). The voluntary agreement is in force since January 2011.

The rating is based on a window energy balance for a window installed in a one-family house with a standard window size. The formula for calculating this energy balance is explained in a report by the Denmark University, DTU, and in a 28 page report presented by the window industry, www.vinduesindustrien.dk.

| Energiklasse | Energitilskud $E_{ref}$, kWh/m2, jf. pkt. 4 |
|---|---|
| A | $0 \leq E_{ref}$ |
| B | $-17 \leq E_{ref} < 0$ |
| C | $-33 \leq E_{ref} < -17$ |
| D | $-55 \leq E_{ref} < -33$ |
| E | $-60 \leq E_{ref} < -55$ |
| F | $E_{ref} < -60$ |

The 2010 building regulations demand that all new windows in new and in existing buildings shall have C rating or better. From 2015 the lowest rating must be B or better.

The window industry provides a certificate for each rated window. The certificate can be downloaded from the project homepage [http://energivinduer.dk/certifikatet](http://energivinduer.dk/certifikatet).


Energimærkningscertifikat nr. _____
for facadevinduer

vinduer

Virksomhed:

Produktsystem:

Energiklasser for produktsystem

Energiklasse Eref | Klasse | Mærkning

Standardprøvning

Limlinie | Kategori | Mærkning

Energidata for produktsystem

Standardrude:

Er vinduessystemet underlagt kontrol

Det attesteres hermed at:

Dette certifikat er gyldigt til: 01.02.2013

The certificate gives the window energy balance value and the U-value for window and glass. However, it does not give information on how the window was glazed. This means that the window manufacturer can use any type of glazing and this will be difficult for a customer to discover. The alternative glazing can change the window U-value and energy balance.

The certificate says that the manufacturer is capable of calculation the windows energy rating and that the documentation is controlled once a year by a third party.

The window manufacturers are not allowed to put labels on their windows. They can only use the green logo. The only identification is the certificate on the left.

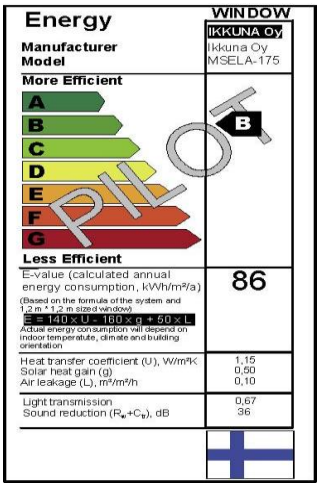
## Window Energy Rating - Finland

### History

Finland introduced 2004 a pilot in project with a slightly different calculation method for the energy balance than the one developed within EWERS project. The project was supported by the Ministry of Trade and Industry, Ministry of the Environment, Finnish Real Estate Federation, Motiva (governmental) and the national testing institute VTT Building and Transport. The criteria to be applied in the labelling were established in co-operation between Motiva, the Technical Research Centre of Finland (VTT) and the Finnish window manufacturing industry.

The basis of the window energy balance was the same as the method developed by EWERS. However, the EWERS energy balance method gives a negative figure = energy loss. The formula in Finland was modified so the result was a positive figure.

The label in the pilot phase of the project was the same as the one agreed within the EWERS project.




Eight Finnish window manufacturers with total sales of approximately 75 % joined the rating system.

### Present rating

After a two year pilot period (2003-2005) and evaluation, the energy rating is now fully implemented. One of the important outcomes of this pilot study was: “Do not try to use the system to find out actual energy consumption of a specific window of a house. This will lead to a complicated system which will not help buyers to select windows. If buyers don’t understand the system they will not use it”.

The rating is now owned by the Wood window manufacturers association. The manufacturers pay a small fee to VTT for the calculation of U-values and presenting the results on a home page http://www.energiaikkuna.fi/. There is no other activity such as marketing of the rating, informative homepage or even marketing by the window manufacturers.

In 2011 the rating system was modified and the A rating was extended to A+ and A++.

The rating for A is now 84-65 compared to 84 according to the old rating. The figure is the E-value in kWh/m2a. A+ has 64-45 and A++ ≤44.

At the same time a new label has been introduced:


## Window Energy Rating - other European countries

As far as we know, there is no other window energy rating system in Europe. EQ Windows in Sweden have been approached by several window manufacturers in the three Baltic countries, a manufacturer in France and some others interested to learn more about a window rating system. We believe that they have not fulfilled their intentions because of the costs involved and the lack of governmental support.

The Norwegian Energy Agency ENOVA has introduced a window recommendation site, http://www.enovaanbefaler.no/sitepageview.aspx?sitePageID=1541 where they display energy efficient windows with U-value of 1,0 W/m2K or lower.

## Windows policies in other APEC countries including New Zealand and Australia

**Prepared by Bipin SHAH**

APEC economies are in various state of fenestration testing and rating. Most mature economies have some form of testing and rating programs. Developing economies have minimal activity. The testing and rating of window products will lead to a fair and competitive market, enable new technologies to emerge, ensure building energy codes have a standard to reference, and enable professional and layman consumers to make an informed purchasing decision.

Window energy ratings include three primary energy measures: U-factor, SHGC and air leakage. U-factor is the thermal transmission from the inside of a building to outside.

The lower the U-factor, the better the window performs during heating periods. The SHGC or solar heat gain coefficient (gvalue in many energy codes and window standards) is the amount of infrared heat allowed into a building from the sun.

The lower the SHGC, the better the window performs during a cooling season. Air leakage (uncontrolled) through cracks and openings of fenestration system increases heating or cooling loads when outdoor air entering the building needs to be heated or cooled. Air leakage is typically expressed as an air flow rate. Several standards exist throughout the APEC economies to measure these values. Some are common to several economies, but none is common to all. Ideally, one set of harmonized standards among APEC economies would eliminate the barrier and promulgate trade of energy efficient windows.

The most effective window rating systems involve both computer simulations and physical testing of window products to determine the energy indices. This provides a cost effective solution for manufactures to rate their products. Computer simulations are widespread in several APEC economies and many are validated by physical testing of the indices as a major quality control step. A physical test involves putting the entire window product into a testing laboratory to measure the heat flows and calculate the U-factor and SHGC. These validated window energy indices enable the most competitive markets and lead to ever increasing efficiencies as manufacturers compete to improve their products.

In most APEC economies, these energy rating indices are simply calculated manually using common thermal and optical properties. Many building energy codes allow this simple calculation and do not reference any available standard or measurement document. This practice does not lead to accurate ratings, good building energy performance, or induce competition. Energy savings windows will not typically become widespread in these economies without more accurate and independent ratings and testing methods.

Building energy code presence and enforcement are necessary to make reference to a window rating and testing method. In many APEC Economies, a policy or building energy code makes reference to specific, common window ratings methods. This fundamental step underpins any window energy rating and testing program an APEC economy might consider.

Below is a summary of the testing and rating of window in APEC economies. The table notes if the economy employs any testing or rating and comments on the enforcement within the economy. Enforcement of any energy code, either advanced or minimal, is crucial to fomenting energy savings windows in any economy. Even advanced APEC economies, with widespread use of testing and simulation methods, may suffer from poor enforcement. In addition, poor enforcement eliminates

the motive for manufacturers to pursue ratings, develop better products, and reduce national energy consumption from buildings.

| APEC Economy | Testing and rating method | | Enforcement |
|---|---|---|---|
| AUS | No | Yes | Simulation required by building energy code |
| BD | No | No | NA |
| CDA | Yes | Yes | Limited enforcement, provincial authorities do not require except British Columbia |
| CHL | No | No | NA |
| PRC | Yes | Yes | Limited enforcement |
| HKC | No | No | Generic U-factors and SHGC used for wall OTTV calculation in energy code |
| INA | No | No | Generic U-factors and SHGC used for wall OTTV calculation in energy code |
| JPN | Yes | Yes | Limited enforcement on window energy performance measurement. Performance rating limted to U-value only. New calculation standard developed, JIS A 2102-1 |
| ROK | Yes | No | Enforcement limited |
| MAS | No | No | Generic U-factors and SHGC used for wall OTTV calculation in energy code |
| MEX | No | No | Generic U-factors and SHGC used for wall OTTV calculation in energy code |
| NZ | No | No | NA |
| PNG | No | Yes | Follow Australian Building energy code practices |
| PE | No | No | NA |
| RP | No | No | NA |
| RUS | Yes | No | Limited |
| SIN | No | No | Generic U-factors and SHGC used for wall OTTV calculation in energy code |
| CT | Yes | Yes | Limited enforcement |
| THA | No | No | Generic U-factors and SHGC used for wall OTTV calculation in energy code |
| US | Yes | Yes | Residential program nearly 100% effective. Commercial program available, but limited enforcement restricting full implementation |
| VN | No | No | Generic U-factors and SHGC used for wall OTTV calculation in energy code |

In the table above, only the US, Canada, Australia, China, Chinese Taipei, and Papua New Guinea use window simulation methods. In addition, only the United States and Canada require the rating be validated by physical testing. These simulations enable manufacturers to showcase advance window technologies and local and state government to enforce building energy codes making references to these simulation methods.

Simulation methods consistently rate window products also Computer simulation of U-factor and SHGC may be based on internationally recognized standards such as *ISO 15099-Thermal Performance of Windows, Doors and Shading Devices — Detailed Calculations* or other standards. Some window ratings are based on similar standards such as ISO 10077-*Thermal performance of windows, doors and shutters —Calculation of thermal transmittance*. These standards, however, are

not compatible and lead to differing ratings. A new effort is underway to integrate these two standards.

An ISO meeting scheduled in September 2011 will address this concern. APEC economies are encouraged to monitor or participate in this effort.

Canada, China, Chinese Taipei, Korea, Japan, Russian Federation, and the United States are the only APEC economies deploying a physical test method as part of a rating. Physical testing is expensive, time consuming, and only rates one version of a window product. Simulations on a computer enable numerous ratings since components (glazing, spacers, and frames) may easily be modified. Physical testing is usually done on a small portion of window products to demonstrate congruence with a simulation or become the representative performance of a group of window products. Physical testing is not a practical method for widespread implementation of an energy saving window program.

Finally, the remaining APEC economies simply make a manual calculation of the window rating as instructed by the relevant energy code, if present. This calculation relies on common material properties and may use look up tables for some window configurations. The window rating calculated is then put into a larger building envelope performance calculation to enable energy code compliance. This method is frequently referred to as the overall thermal transmittance value or OTTV.

Some economies break it down further using both envelope thermal transmittance value, ETTV, and roof thermal transmittance value, RTTV, calculations in their codes. This simplified building envelope energy calculation method is not likely to promote optimized thermal performance of the building envelope as it may lead to poor performing windows with highly insulating walls. OTTV also requires U-Factors, Solar Heat Gain Coefficients for the proper calculation. Currently most economies use default values or only glazing values for the fenestration system. OTTV, RTTV and, ETTV currently do not consider air leakage effect which can be substantial energy loss for some buildings. OTTV is perhaps a good intermediate step prior to a full window energy rating method since its estimates may be reasonable, but it will not enable manufacturer to compete fairly, allow for consistent calculation among different users, or enable high performance products to be recognized properly. This method will likely limit energy saving windows proliferation. Alternatively, economies should consider the adoption of minimum energy performance criteria for windows in addition to a total OTTV. One key benefit will be to ensure improved comfort near window spaces that can have additional energy savings by avoidance of thermostat adjustments.

## Policies and Programs to Promote Energy Savings through Advanced Fenestration Technologies in APEC Economies

APEC economies have a variety of policies or building energy codes to mandate energy saving window use. Beyond those policies, voluntary programs also help to enforce energy saving window use. Voluntary programs may also serve to compel consumers and businesses to consider above minimal energy code window use.

Policies may be written by the government, developed by trade associations, written by consultants, or written by third parties and then mandated by local, state, or federal authorities. Any policy developed in an APEC economy must be vigorously enforced by local authorities, typically building code department's within the APEC economy government. Enforcement dictates how diligent a window manufacturer may purse the mandated window rating mandated by code. Even where advanced energy saving window policies are present, such as the United States, actual compliance

may be nearly absent if enforcement is lacking. In the commercial window market in the United States, this is largely true. Limited enforcement has led to slow development of a competitive commercial window market.

The United States Green Building Council has developed the *Leadership in Environmental and Energy Design* or LEED for new and existing commercial and residential buildings. This program is being used throughout the world and several APEC economies have experience LEED activity. Energy savings windows may be promulgated as a result of this activity. In LEED, the energy and atmosphere section of the program requires compliance with the ASHRAE 90.1-2004. This code requires NFRC rated window products. APEC economies with no viable building energy code or window rating activity may benefit from the presence of this activity to demonstrate better window performance to the local economy. LEED had also been referenced in some APEC economies by local and state governments.

The ideal policy for any APEC economy would be a fully developed building energy code making reference to internationally recognized energy saving window ratings methods with vigorous enforcement. Some APEC economies have evolved this way such as the US, Canada, and Australia. Most other APEC economies have instituted a basic building energy code making reference to simple window energy rating calculation methods.

The table below compares various policies and programs throughout APEC economies.

| APEC Economy | Policy | Program | Enforcement |
|---|---|---|---|
| AUS | Residential and commercial building code | Various green programs | Widespread adoption of policy and programs |
| BD | None | None | NA |
| CDA | Residential and commercial building code | ENERGY STAR window, USGBC LEED activity | Limited |
| CHL | Residential building energy code | Limited commercial programs | Limited |
| PRC | Residential and commercial building energy code | Limited commercial programs | Limited |
| HKC | Commercial building energy code | Limited commercial building energy efficiency programs | Limited |
| INA | Commercial building energy code | None | Limited |
| JPN | Commercial and residential building energy code | New high performance window incentive program | Increasing |
| ROK | Residential and commercial building energy code | Building component energy labelling program | Increasing |
| MAS | Commercial building energy code | None | Limited |
| MEX | Commercial building energy code | None | Limited |
| NZ | Residential and commercial building energy code | Various commercial and residential programs | Limited |
| PNG | See Australia | See Australia | Using Australian Codes |

| | | | |
|---|---|---|---|
| PE | None | None | NA |
| RP | Commercial building energy code | None | Limited |
| RUS | Commercial building energy code | None | Limited |
| SIN | Commercial building energy code | Commercial building energy efficiency program | Limited |
| CT | Commercial building energy code | Limited and developing green building programs | Limited |
| THA | Commercial building energy code | None | Limited |
| US | Residential and commercial building energy code | Numerous voluntary building energy efficiency programs | Residential program nearly 100% effective, commercial program still developing and not fully enforced |
| VN | Commercial building energy code | None | Limited |

**Market Assessment of Climate Appropriate Efficient Window Technologies**

APEC Economies consume over 60% of the world's energy and constitute $31 trillion in GDP or about half of the world's $58 trillion economy[1]. Within these APEC economies, buildings consume about 70% of all electricity making building energy performance the primary method to achieve good energy conservation. Designing energy efficiency buildings is important to conserve energy in this growing part of the world.

In a typical residential or commercial building, about 25% of the energy passes through the windows. Commercial buildings in cooling only climates, typical in the APEC region, may consume for more energy as a result of the energy load imposed by windows.

Below is a table noting gross domestic product per person in each APEC economies. This common economic indicator reflects the developmental state of an economy. The table lists the presence of a rating or testing method, program or policy, and then estimates the potential for energy efficient window products to promulgate. Energy saving window promulgation will depend upon the energy efficient infrastructure present in an economy. The rating and testing method are fundamental to establishing the window's energy performance. A program, voluntary or mandatory, and a policy such as a building energy code, is to establish a fair, competitive marketplace where energy saving windows will spread.

Climate comments are included as well. The policy or program adopted by an economy will factor in this variable by listing climate zones for large economies crossing several latitudes (hot to cold ranges) and may factor in humidity levels (arid or tropical). Climate zones are declared by grouping heating degree day and cooling degree day values to typify large areas

of an economy. For example, the United States ASHRAE 90.1 uses eight climate zones spanning all fifty states. In economies of limited size or existing in uniform national climates, simple energy intensity (energy consumed per unit area per year) may be required since climate will not vary significantly. Considering climate will be essential for the best use of energy savings windows.

| APEC Economy | GDP/per | Rating or testing method | Program or policy present | Climate considered by policy or program | Potential for efficient window technologies development |
|---|---|---|---|---|---|
| AUS | $41.300 | Yes | Yes | Yes | High |
| BD | $50.300 | No | No | No | Low |
| CDA | $39.600 | Yes | Yes | Yes | High |
| CHL | $15.500 | No | Yes | Yes | Medium |
| PRC | $ 7.400 | Yes | Yes | Yes | High |
| HKC | $45.600 | No | Yes | Yes | Medium |
| INA | $ 4.300 | No | Yes | Yes | Medium |
| JPN | $34.200 | Yes | Yes | Yes | High |
| ROK | $30.200 | Yes | Yes | Yes | High |
| MAS | $14.700 | No | Yes | Yes | Medium |
| MEX | $13.800 | No | Yes | Yes | Medium |
| NZ | $28.000 | No | Yes | Yes | Medium |
| PNG | $ 2.500 | Yes | Yes | Yes | High |
| PE | $ 9.200 | No | No | No | Low |
| RP | $ 3.500 | No | Yes | Developing | Low |
| RUS | $15.900 | No | Yes | Yes | Medium |
| SIN | $57.200 | No | Yes | Yes | Medium |
| CT | $35.800 | Yes | Yes | Yes | High |
| THA | $ 8.700 | No | Yes | Yes | Medium |
| US | $47.400 | Yes | Yes | Yes | High |
| VN | $ 3.100 | No | Yes | Yes | Medium |

If an APEC economy has a rating and testing method and a policy or program in place, it is more likely energy saving window technologies will proliferate. APEC economies lacking these fundamentals are unlikely to experience any widespread application of energy saving windows.

Based on the estimates in the table above, the economies listed here have a high propensity for market application of energy saving windows. Most of these economies have well developed infrastructure and high GDPs.

- AUS: Australia
- CDA: Canada
- PRC: China
- JPN: Japan
- PNG: Papua New Guinea

- CT: Chinese Taipei
- US: United States

The next tier of APEC economies, having moderate potential for adoption of energy saving windows, may be able to increase the energy saving window application potential primarily by adopting a rating and testing method. Many of these economies may have a policy or program in place, but without a specific window testing and rating method, the policy or program cannot guarantee good window performance.

- CHL: Chile
- HKC: Hong Kong, China
- INA: Indonesia
- MAS: Malaysia
- MEX: Mexico
- NZ: New Zealand
- RUS: Russian Federation
- SIN: SingaporeT
- THA Thailand
- VN Viet Nam

The final tier of APEC economies has significant challenges ahead of them. Without a energy saving window rating and testing method, or building energy programs or policies, the chance for widespread adoption of energy saving windows is poor. These economies need to consider the adoption of existing energy ratings in other economies as well as policies and programs appropriate for their needs. These APEC economies may also consider developing their own ratings, policies, and programs, but this will prolong their adoption of energy saving windows. The pattern in most APEC economies has been to consider widely available rating technology and program or policy documents for adoption with modification. Without the necessary energy saving window infrastructure, poorly performing products are likely to dominate the market place. The final tier of APEC economies includes:

- BD: Brunei Darussalam
- PE: Peru
- RP: Philippines

**Conclusion**

Energy saving windows may spread in an APEC economy when the necessary infrastructure is in place. A good window energy rating and testing method can enable manufacturers to rate products, help efficient windows compete fairly in the market, and allow energy policies and programs to make direct reference to these ratings. A few APEC economies have established comprehensive window energy rating and testing systems, but most have not. To accelerate the adoption of energy saving window technology, economies may wish to consider the following recommendations:

- Work with other APEC economies toward adoption, with modification, of existing energy saving window testing and rating programs. Many APEC economies have successfully pursued this path and have more quickly achieved a functioning energy saving window

environment. The National Fenestration Rating Council (NFRC) has worked with Australia and Canada to help implement a window energy rating system.

- Work with other APEC economies to develop or adopt existing building component energy policies or programs to enable energy saving windows in the marketplace. Frequently, building energy programs and policies are written by third parties such as trade associations. These groups are eager to work with national, state, or local governments to help them adopt their documents.