CONFERENCE PAPER

NO. 22 (1996)

TOWARDS A WINDOW ENERGY RATING SCHEME FOR AUSTRALIA AND NEW ZEALAND.

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From: WINDOW INNOVATIONS '95,
A World Conference on State of The Art Window
Technologies For Energy Efficiency in Buildings
5-6 June 1995, Toronto, Canada

The research reported in this paper was funded by the
Architectural Aluminium Association of New Zealand,
the Energy Efficiency Conservation Authority and Unisearch
(University of New South Wales)

ISSN: 0111-7505

Towards a Window Energy Rating Scheme for Australia and New Zealand

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1. Introduction

Thirty percent of Australia's primary energy is used to heat, cool and light buildings[1]. Australia is highly dependent on fossil fuels and building energy efficiency is one of the few options enjoying widespread support which is immediately available for reducing greenhouse emissions. In contrast to Australia, New Zealand relies largely on renewable hydroelectricity as its primary energy source. However environmental problems caused by inundation and some vulnerability to drought have focused much attention on demand-side management in New Zealand also. To underpin new standards for energy efficiency in the building envelope, the selection process for windows in Australia and New Zealand will be assisted greatly by the advent of a new Window Energy Rating Scheme (WERS).

The Window Energy Rating Scheme will rate and label window products in terms of their energy impact in both residential and commercial construction. It must be understandable to the specifier and homeowner and advantageous to industry. At the time of writing, this scheme is under development by the Solarch group and researchers at the Building Research Association of New Zealand (BRANZ) under contract to the Australasian Window Council (AWC). A subcommittee of the AWC, the Energy Working Group, is steering WERS. A combination of modelling using WINDOW 4.1, VISION 4.0 and FRAME 3.1, along with guarded hot box tests in both countries, will establish solar and thermal performance for glass and frame combinations. The project has the backing of industry, Australia's Commonwealth Scientific & Industrial Research Organisation (CSIRO), and the national energy administrations of both countries. These are the Department of Primary Industries and Energy in Canberra and the Energy Efficiency and Conservation Authority in Wellington. These bodies have matched industry's funding to make the development of WERS possible.

The new rating scheme will be incorporated into the Australia's Nationwide House Energy Rating Scheme (NatHERS), into New Zealand's Home Energy Rating Options (HERO) and into the Commercial Building Energy Code for both countries. The scheme has strong technical links to the National Fenestration Rating Council and to current research under the International Energy Agency's *Task 18* project on advanced windows.

This paper outlines the industry, energy, building and cultural backgrounds to WERS and describes some likely options for its final form. Some similarities and differences between the context of WERS and the context of Canada's Energy Rating (ER) system and the United States' National Fenestration Rating Council (NFRC) project are discussed.

2. The AWC - a peak body for the window-products industry in Australasia

The new Australasian Window Council, which is the fully described in another paper at this conference [2], is steering the Window Energy Rating Scheme. The overall mission statement of the Australasian Window Council is "to develop, implement and manage an industry-wide quality assurance system for the window products industry in Australia and New Zealand". As in most countries, the impact of new window technology in Australia and New Zealand is emphasising quality accreditation, environmental impact, standards initiatives and consumer demands for greater comfort. Independent credible benchmarks are needed to assess claims about window energy performance - hence the development of the unified WERS for Australasia. This is but the first of a number of quality assurance-related projects that the AWC will coordinate. It is an example of the strategy of integrating exemplary energy performance into the quality assurance programs to complement non-energy issues such as wind and rain penetration, glazing safety standards, materials and finishes. Because of their consultative development process, WERS and other initiatives of the AWC will be owned by industry as much by government.

3. Housing, demographics and climate in Australia and New Zealand: background

Most housing in Australia and New Zealand is detached single-storey and therefore climate-dominated in terms of internal conditions. The most common construction form in Australia is external brick veneer with a timber frame and plasterboard (drywall) internal linings and partitions. Concrete slab-on-ground predominates except on steep sites. In New Zealand, wood framing is also the most common although the exterior cladding is more likely to be wood-based than brick. Passive solar design is promoted widely although genuinely practised by only a minority of architects and builders.

The climates of both countries are, while largely temperate, also extremely diverse. These climates range from tropical (Northern Australia and the far North Island of New Zealand), through warm temperate in mid-latitude coastal regions, to inland continental, to alpine in the interior of both islands of New Zealand and in the Southeast Australia. Tasmania and some parts of the New Zealand's South Island have a maritime cool/cold temperate climate. Table 1 gives indicative heating and cooling degree days for both countries and compares them with the locations selected for the NFRC's Annual Energy Rating studies and the Canadian Energy Rating development. The geography of New Zealand is such that in travelling 150 kilometres, one could pass through most of these climatic zones. With the increasing level of tourism in alpine areas comes an increasing desire for thermally efficient window systems. In Australia high population growth is occurring in Canberra, the federal capital as it diversifies from its original government-sector base. Canberra has a cool temperate climate of clear frosty winters and hot dry summers, and the nearby Southern Highlands of New South Wales are becoming a dormitory area for the greater Sydney region.

Low energy prices in New Zealand, the temperate climate, restrictions in available glazing rebate widths and a culturally low expectation for the level of human thermal comfort, coupled with the relatively high price of insulating glass, mean that long payback periods have deterred the installation of insulating glass in around 90% of the country. Obviously when higher priorities are placed on thermal comfort, noise abatement, condensation resistance and aesthetic requirements the equation can tip in favour of high-performance windows. These comments also apply largely to Australia. It should be noted that the vast majority of Australian (and New Zealand) homes do not have whole-house air-conditioning and many do not have central heating. In summer, many people rely on ventilation, night cooling, shades, etc to limit summer discomfort. However, a small cooling load is an indicator of good summer performance, even if it is hypothetical.

4. Market trends for high-performance windows

In Australia the use of insulating glass is rising steadily, especially in cool temperate areas, ski towns and office buildings. Meanwhile the great importance of solar-control glazing in cooling-dominated applications has spurred interest in 'cool daylight' single or double glazing whose good solar heat rejection can be more beneficial than a very low U-value. The insulating glass market in New Zealand is currently small, with an emphasis on reducing heating loads. Aluminium frames are not yet available in thermally-broken form, yet still have a 90% market share. Thermally 'improved' aluminium frames are just becoming available in Australia. The total combined window market for Australia and New Zealand is about 2.1 million units/year, of which about 10% is double-glazed, primarily in new construction. The use of u-PVC (vinyl) in window frames is a relatively recent event and market acceptance is still low, with the main limiting factor being consumer suspicion in the expectation of UV embrittlement of PVC that is exposed to the sun. There is little market data so far on the long-term performance of PVC in either country. Wood frames hold up to 30% of the overall Australian window market but only 5% in New Zealand.

New Zealand has a new Building Code which demands a certain maximum thermal transmittance through building envelopes of all new construction. Currently the Building Code is performance-based rather than prescriptive which allows energy-efficient cladding elements to be used in conjunction with poorer components in order to meet the specification. In Australia, the states and territories are free to adopt or ignore nationally-developed energy codes; some enforce mild mandatory standards [Victoria and Australian Capital Territory (Canberra)] while others favour an advisory approach only. However the greenhouse response strategies of both countries will increasingly determine whether a regulatory or voluntary approach is taken to building energy codes.

The development of the NatHERS for Australia is at an advanced stage and is described in another paper at this conference [3]. Because of the coordination between that project and WERS, Australia has the opportunity to achieve a rigorous and well integrated standard for envelope efficiency in residential construction. The same comments apply to New Zealand (HERO teamed with WERS) and to commercial buildings in both countries.

5. Choice of building models for WERS

Residential model

At the time of writing, the New Zealand house model for the WERS development is under consideration. For Australia, a 'generic' house plan has been developed by the Nationwide House Energy Rating Scheme (NatHERS) project for use in thermal/energy simulation studies. This HERS house plan has a floor area of about $160m^2$ ($1720\ ft^2$) and has three types of spaces, ie., day/living areas, night/bedroom areas and service areas, i.e. laundry/bath/toilet. Roughly 50% of the floor area consists of day/living areas. Windows make up 25-30% of the longer facades and approximately 15% of the shorter sides. This design is typical for houses built after about 1970 in the eastern states of Australia. It has been chosen to represent neither the best nor the worst in terms of energy efficiency. The house energy performance can be simulated for any orientation. No internal shading devices will be assumed in the simulations, nor are curtains allowed for in terms of additional night-time insulation. However eaves will be assumed, in keeping with typical construction practice. The generic plan can be modified at will by varying building elements, eg., framed floor replaced with slab-on-ground, addition of mass internal partitions, changing the pattern of use of the building, changing insulation levels in the walls, ceiling and floor, etc. It is likely that this generic HERS house plan will be the base building model for all the Australian WERS analyses. A decision to this effect will ensure compatibility between the two schemes, and fast-track user acceptance of WERS. The thermal modelling software to be used is the CSIRO-developed CHENATH (CHEETAH for NatHERS) which is a PC-based dynamic program based on the ASHRAE response-factor method.

A parametric sensitivity study will determine the factors which most affect house energy performance (and therefore the window energy performance). It is expected that the study will produce results that will be somewhat different to the results available from studies carried out in North American and other largely heating-dominated climates.

We note from the NFRC results [4] that predicted heating and cooling energies increase monotonically as window size is increased, for all seven cities. The immediate message to the consumer from this is that, 'the bigger your windows are, the more you'll pay for heating and cooling'. In Australia the window industry hopes to sell more product by demonstrating that bigger windows can reduce heating bills and simultaneously improve thermal comfort. Genuine passive solar design helps to make this possible. Of course some windows which are net-gain in one locality will be net-loss in another, depending on cloud, etc, and cooling energies can increase slightly as windows get bigger.

Commercial model

Two previous energy simulation studies have been carried out for commercial buildings in Australia. These are:

i) Building Energy Efficiency and Thermal Performance Standards for Australia (ERDC Report 1547), and

ii) National Stringency Analysis study for the Commercial Building Energy Code (CBEC) project

Similar models were used for both these studies. The building is three storeys high, with one interior zone and four perimeter zones oriented in the cardinal directions on each storey. Building models of this type in single-storey configuration have been used in previous studies [5, 6, 7]. The model is very versatile and powerful, allowing the study of a number of parameters affecting energy consumption.

The perimeter zones are modelled to be 5m (16 ft) deep and 30m (98 ft) wide. Corner walls are considered to be adiabatic (no heat flow across them) to isolate the effects of external walls and windows in a single orientation. Floors are modelled as carpeted 150mm (6-inch) concrete slabs, considered to be typical in commercial buildings. Each zone is modelled with its own HVAC system equipped with an enthalpy-controlled economiser to enable energy analysis on a zone-by-zone basis. Minimum outside air is set in accordance to Australian Standard AS 1668 at 10 L/s/person (21 CFM/person). Heating and cooling are made unavailable outside scheduled hours, again standard practice in Australia. DOE-2.1E is to be used as the simulation tool.

Since the major objective is to quantify and correlate the energy performance of different window systems, it is sufficient to use the single-storey configuration of this model for the WERS runs. Using this type of model will also ensure compatibility with future energy efficiency standards derived from the CBEC studies and/or the ERDC report.

6. Selection of window 'menu' for WERS development

Table 2 gives glazing and whole-window data for a range of windows which span a wide range of performance. The baseline glazing is single-pane clear with an unbroken aluminium frame. At the other extreme, window type 7 - vacuum glazing, is the subject of IEA Task 18's Project B5, led by Australia[8]. In all cases an appropriate frame type was chosen for each glazing. Although vacuum glazing is not yet on the market, the WERS team believes that the scheme should include near-market advanced glazings, not just what is available today.

7. Options for the WERS rating label

The first phase of the WERS development program involved a review of current schemes for energy rating and labelling of windows in Canada [9] and the United States [4]. Several alternative schemes for the WERS label format are under consideration These include:

1. Heating and cooling numbers
2. Solar thermal parameters
3. Star rating, derived from one of the above.

Heating and cooling numbers can include the Canadian ER method, where the ER is the net energy gain or loss of the window system, which when multiplied by the duration of the season gives the total heating or cooling energy consumption per square metre that is attributable to the windows. Alternatively, relative indices can be used to rank the energy impact of windows. This system is used by the NFRC in the form of the Fenestration Heating Ratio (FHR) and the Fenestration Cooling Ratio (FCR). These differ from the Canadian ER numbers in that they are dimensionless numbers which express the relative improvement in annual heating or cooling energy due to a given window, relative to the base-case window. At the time of writing, industry is being consulted through AWC Energy Working Group meetings to arrive at an outcome which is both workable for the manufacturer, understandable to the consumer and leads to real energy and comfort benefits. Alternatively, the U-value, solar heat gain coefficient, visible transmittance, damage-weighted transmittance, etc could be modelled and/or simulated and displayed on the label. Software or application literature, specific to the climate where the window would be installed, would then be required to help interpret the energy impact of the window.

8. Can window rankings be independent of climate?

The Canadian and US simulations show that, for the most part, the rankings of the various windows are independent of climate for both heating and cooling performance. However this generalisation breaks down for more temperate climates where cooling is as important, or more so, than heating. It has been found that FHR rank changes *do* occur for the milder climates where heating demands are lowest (Miami, Seattle and Phoenix). In contrast, FCR ranks seem to be genuinely independent of climate. Climates with high loads (either heating or cooling) tend to show the least deviation in rankings. Conversely, low-load climates are not as clear-cut. It is also clear that parameters such as window distribution, thermal mass and occupant usage have an impact on window performance. The milder the climate, the more pronounced is this impact.

Although inhabited regions of Australia and New Zealand have heating degree day (HDD) values ranging from zero to more than 4000 (base 18°C) [~ 7200 HDD base 65°F], most areas are below 2000 HDD (base 18°C) and the majority of the population lives in temperate to cool-temperate climates, where we must be wary of rank changes should we adopt an FHR/FCR-type rating system.This problem will probably mean that the simplistic FHR/FCR approach will not work for temperate Australia and New Zealand climates unless appropriate weighting factors are applied.

Table 1. Comparison of definitive Australian and New Zealand climates with US climates used in the NFRC Annual Energy Performance studies and some Canadian climates used in the CANMET ER development.

Location	HDD18C	CDD18C	CDD24C
Adelaide, South Australia	1007	584	83
Alice Springs, Northern Territory	618	1668	
Brisbane, Queensland	232	1228	161
Canberra, Australian Capital Territory	2160	241	13
Darwin, Northern Territory	0	3450	1304
Hobart, Tasmania	2062	37	0
Mt. Buffalo, Victoria	3398	0	0
Melbourne, Victoria	1423	244	8
Perth, Western Australia	665	811	139
Sydney, New South Wales	743	556	15
Auckland, New Zealand	977	134	0
Wellington, New Zealand	1806	61	0
Christchurch, New Zealand	2455	30	1
Invercargill, New Zealand	3007	9	0
Toronto ON	4257		
Quebec PQ	5296		
Ottawa ON	4532		
Boston MA	3126		54
Denver CO	3418		27
Madison WI	4246		10
Miami FL	123		604
Phoenix AZ	733		967
Seattle WA	2853		0
St. Louis MO	2694		178

HDD18C = Heating Degree Days to base 18°C (64°F)
CDD18C = Cooling Degree Days to base 18°C (64°F)
CDD24C = Cooling Degree Days to base 24°C (75°F)

Table 2 Spectrum of current Australasian window products with their performances.

Window type	Glazing description	Frame description	Total U-value W/m^2K ($Btu/h.ft^{2°}F$)	SHGC =TSET	SC = b
1	Single clear	Alum., no thermal improvment	6.0 (1.1)	0.84	0.96
2	Single solar control laminate with low-E	Wood	3.3 (0.58)	0.31	0.35
3	Double clear	Alum., improved	3.5 (0.62)	0.66	0.75
4	Double (clear + low-E)	Alum, improved	2.7 (0.48)	0.63	0.72
5	Double (clear + low-E) with Argon fill	Wood	1.8 (0.32)	0.60	0.68
6	Double (reflective tint + low-E)	Wood	2.1 (0.37)	0.18	0.21
7	Double (low-E + low-E) evacuated *(not yet on market)*	Wood	0.8 (0.14)	0.53	0.60

9. Funding and delivery of WERS

As mentioned in the introduction, WERS is a joint effort of academia, industry and government in both countries. The overall cost of the first phase - delivery of the draft methodology for energy rating of windows - is about A$170,000 (US$125,000). The implementation phase will follow and will be funded by industry. The WERS team plans to deliver a pilot scheme for Canberra by July 1, 1995 with other areas to follow during the second half of the year.

10. Conclusions

It is expected that the strategies and workplan descibed here will result in:

- a rigorous independent system for quantifying the energy impact of windows in Australia and New Zealand;
- window products being selected with the knowledge that they are part of a system - the building;
- enhancement of quality assurance programs for the benefit of industry and the consumer;
- reductions in greenhouse emissions, particularly from coal-fired electricity, once windows and glazings selected using the scheme begin to penetrate the market in both new and retrofit products; and
- a framework for public education of the benefits to be gained from emerging advanced glazing technologies.

11. References

1. Greene, D.A. *A Greenhouse Energy Strategy: Sustainable Energy Development for Australia,* Deni Greene Consulting Services, North Carlton, Victoria, Australia, 1990.
2. Michael G. Hutchins, Paul D. Robinson, Peter R. Lyons and John A. Ballinger. *From Laboratory to Marketplace: A Strategy for the Successful Application of Advanced Glazings.*Proc. WIC '95.
3. John Ballinger, Deborah Cassell, Deo Prasad and Peter Lyons. *The integration of window labelling into the Nationwide House Energy Rating Scheme (NatHERS) for Australia.* Proc.WIC '95.
4. Crooks et al. *NFRC Efforts to Develop a Residential Fenestration Annual Energy Rating Methodology,* Proc.WIC '95.
5. Pacific Northwest Laboratory, *Recommendations for Energy Conservation Standards and Guidelines for New Commercial Buildings*, PNL-4870, Pacific Northwest Laboratory, Richland, Washington, October 1983.
6. Berkeley Solar Group, *Regression Equations for ASHRAE Standard 90.1 Envelope Calculations*, Berkeley Solar Group, Berkeley, California, April 1986.
7. Wilcox, B.A., *Development of the Envelope Load Equation for ASHRAE Standard 90.1*, ASHRAE Transactions, Vol. 97, Part II, 1991.
8. R.E. Collins, T. Simko, G.M. Turner, J-Z Tang and J.D. Garrison. *An Overview of The Technology of Vacuum Glazing.* Proc. WIC '95.
9. Enermodal Engineering Limited, Waterloo, Ontario, Canada. *Development of a Cooling Energy Rating System for Windows - Final Report, For Use in Conjunction with CSA A440.2* April 1993.

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