Household Energy Rating: Questioning the Current Direction

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Abstract

Greenhouse gas emissions are only one of a plethora of environmental impacts that buildings have on the environment, however they are currently the focus of much attention as Australia attempts to achieve its Kyoto target. The process of Housing Energy Rating (HER), in which the envelope of the house is simulated to produce predictions of heating and cooling energy, is gaining momentum as a method for reducing residential greenhouse gas emissions. This paper questions the underlying aims of HER, concluding that current tools assist assessors/regulators but are of little use to building designers. It also questions the focus on heating and cooling energy and through a case study of warm climates, highlights alternative routes to achieving reductions in household greenhouse gas emissions. These routes are to broaden the scope of greenhouse gas assessment and to refocus on design-phase assessment rather than post design/compliance assessment.

1. INTRODUCTION

The state of environmentally responsible building design at the beginning of the 21st century is such that there are a comprehensive set of theoretical approaches, design strategies and technical solutions available to the architect. These environmentally responsible solutions are put forward in an ever increasing library of literature on the subject. More telling than the literature are exemplar environmental buildings that have been constructed, proving that significant advances towards sustainable architecture are possible. Not only are they possible today, but texts show that many of the solutions have been in existence for decades (Skurka and Naar, 1976). Despite this evidence that environmentally responsible design is possible, there remains precious little implementation of solutions that would help achieve this goal.

There are several barriers, directly and indirectly related to building designers, causing this lack of implementation (Wittman, 1997). The underlying barrier is the perception of the complexity and value conflict produced by the vast range of environmental issues associated with the design of the built environment. From the results of her survey Wittman states, '…the essential problem underlying the identified barriers (to sustainable architecture) is a lack of consensus as to the significance and relevance of environmental problems in general...' (Wittman, p7). This notion of lack of consensus as a cause for inaction is a theme that appears in other recent research on the topic (Lavery, 1998).

The implicit hypothesis of the research, from which this paper is drawn, is that architects and other building designers require assistance to deal with this complexity and value conflict presented by environmental issues. Designers need to be able to assess the environmental consequences of their design decisions, during the design process, that is, at the time that they are making the decisions. Building Environmental Assessment (BEA) tools are a method proposed for achieving this. (Watson, 2001)

The focus of this paper is Household Energy Rating (HER) and HER Schemes (HERS) as a method of reducing greenhouse gas (GHG) emissions associated with the residential building sector. The scope of environmental considerations therefore is limited to GHG emissions from residential buildings. However, the implications drawn are pertinent to all types of environmental impact, all types of buildings and to the development of BEA tools in general.

2. BACKGROUND

Residential Greenhouse Gas Emissions in Australia

In 1997 Australia signed the Kyoto Protocol in which it agreed to constrain greenhouse gas emissions to a level of 8% above 1990 levels, by the year 2010. The Australian Greenhouse Office (AGO) published in 1999 a report on GHG emissions in the residential sector (AGO, 1999). Some summary charts from this report are presented below. There are 5 scenarios presented in the charts. The basic difference between them being the standard of the building envelope. The HE+ scenario assumes 5 star HER for all new dwellings plus improvements to existing building stock through an aggressive ceiling insulation retrofit program. The minimal intrusion into overall household GHG emissions is a sobering picture to environmental designers who may assume that they can have an impact through the passive design of their houses. The impact on heating and cooling emissions is not much better.

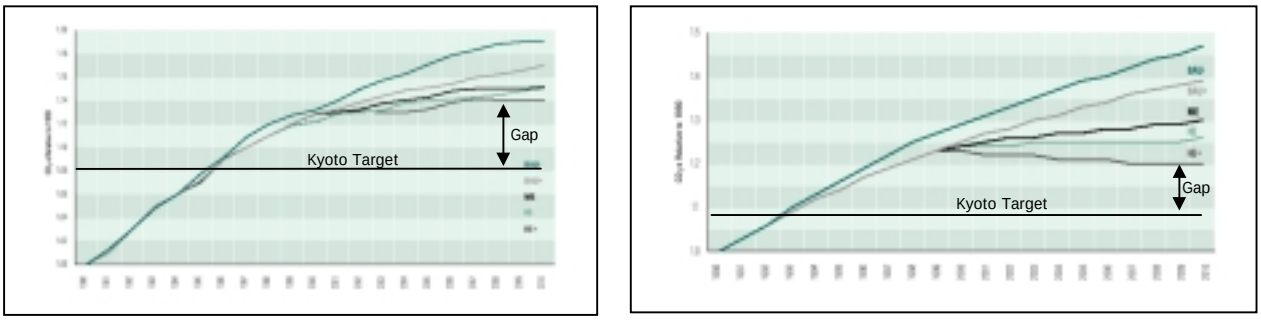

Figure 1: Residential Greenhouse Gas Projections to 2010, for overall household emissions (left) and emissions associated with heating and cooling (right). (AGO, 1999, p22 & 28)

Household Energy Rating Schemes (HERS)

HER tools in use in Australia presently assess only that part of the household energy use associated with heating and cooling during the operational phase of the building's life. The calculations undertaken to make an assessment are based on input that describes to the tool the characteristics of the envelope of the house, as well as its layout and orientation. HER tools are, therefore, assessing heating and cooling performance based on these factors only, and omit consideration of plant efficiency, and user characteristics.

There has, in fact, been little correlation found between the results produced by HERS and the measured results of actual houses. These technical problems with HERS have already been identified in work by others and this will not be taken further in this paper (Williamson, 2000).

There is increasing use of HERS as a code compliance tool throughout Australia. A range of related tools exist; Building Energy Rating Scheme (BERS), in Queensland, ACTHERS, in the ACT, NatHERS, intended for national use but used mainly in NSW and FirstRate, in Victoria. Brisbane City Council (BCC) and Maroochy Shire Council (MSC) are two major local governments in warm climate regions that have recently included the BERS as one of two options for gaining approval under their energy codes. The other option being a deemed-to-satisfy approach which contains some very basic prescriptive envelope measures (BCC, 2000)

The CSIRO makes the following statements regarding the role of HERS, and their product NatHERS in particular:

> …encourage improved design… …reduce energy consumption and improve thermal comfort in houses.
>
> NatHERS has been developed by the CSIRO to provide quick, comprehensive and effective assessment of house design in an easy-to-use format.
>
> The NatHERS software is an invaluable tool for the architect and builder, providing easy assessment of designs and an additional service to clients.
>
> *(CSIRO)*

These statements reveal the underlying objectives of HER as being essentially twofold. The first is to create more environmentally responsible houses, at least in relation to energy and thermal comfort. The second is to assist in the assessment of houses, that is, to check whether they really are more environmentally responsible.

These objectives in turn contain some underlying assumptions.

- That an HER tool can be used by the house designer to assist in design decision-making and therefore improve the environmental performance of the design.
- That the criteria upon which an HER tool makes an assessment are a reasonable indicator of environmental

performance of the house.

Both of these underlying assumptions will be challenged in the following sections of the paper.

3. H.E.R. AS ASSISTANCE TO DESIGN DECISION-MAKING

The first of the underlying assumptions stated above is that HER assists designers in making decisions during the design process. Figure 2 illustrates that the most important decisions relating to saving energy are made at the earliest stages of the design process. The question is, can HER tools provide assistance at these early stages? The answer is that in a speculative manner they probably can, but to use them as intended, many of the design decisions need to have already been made.

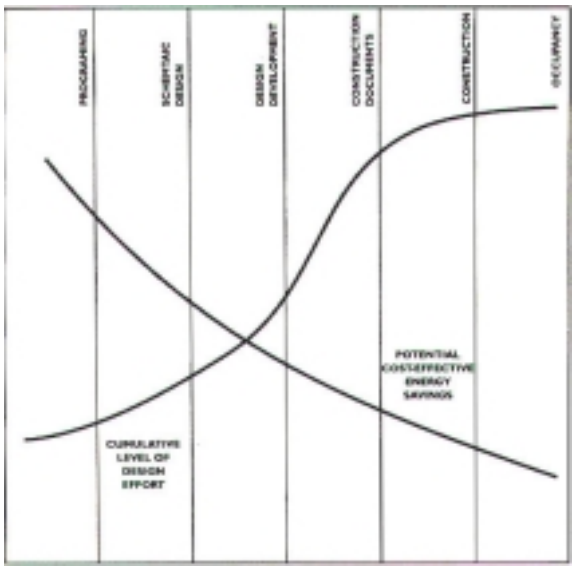

Figure 2: Energy Saving Measures and the Design Process (Wilson et al, 1998)

The architectural design process is a relational one, in which many disparate individual elements are brought together to form an overall entity that is greater that the sum of its parts. Tools, such as HER in its present form, do not recognise this relational characteristic of design and consequently are of little benefit to the designer. They are essentially atomistic, isolating household heating and cooling energy from the rest of the gamut of architectural considerations. This characteristic of HER is exactly what makes it appealing for use as a regulatory assessment tool. Having individual aspects of a design isolated makes for easy compliance assessment. The assessor can check one aspect of the design at a time (Lawson, 1997). The designer however requires the opposite to this, that is, to be able to consider and relate many aspects simultaneously. Seen as a design tool HER is unrealistic and would tend to lead to unimaginative solutions (Williamson, 2000). It limits, rather than expands the potential solution sets for the designer. For regulation, however, quantitative criteria are preferable so that a simple test of compliance, preferably numerical, may be made (Lawson, 1997).

In terms of the mass housing market HER doesn't necessarily assist in environmental design. What it can assist in is assessing the least-cost scenario, for achieving the level of performance for code compliance. For example, a designer finds that compliance may be achieved by either adding extra insulation or by adding shade devices to windows. The task then is not to attempt to assess which would be the more beneficial environmentally, but which of the two options adds the least to cost.

What we have with the use of HER as a regulatory tool is a classic case of the tail wagging the dog, and there is very little in HER in its present form that attempts to create change in the dog itself.

4. H.E.R. AS INDICATOR OF ENVIRONMENTAL PEFORMANCE: A CASE STUDY OF HER IN WARM CLIMATES

The second underlying assumption of HER is that it is based on a reasonable set of environmental performance criteria. This assumption comes into question when a more holistic environmental approach is taken, encompassing building life cycle considerations. Even when household operational energy is the scope of consideration there must be doubt as to the relevance of the rating being made. An investigation of the breakdown of household energy consumption reveals the extent to which HER has the potential to impact upon household GHG emissions.

In Queensland, as figures 3 and 4 show, because of the climate, the issue of the narrow scope of HER is exaggerated. Only 6.34% of household GHG emissions are associated with heating and cooling in this state. The biggest contributors to GHG emissions by far, are hot water and electrical appliances. The building envelope theoretically therefore can only reduce emissions, at the absolute most, by 6.34%. This is evident by referring back to figure 1, which revealed that even the most optimistic scenario relating to implementation of efficient building envelopes, does not get residential emissions near to the target of 8% above 1990 levels.

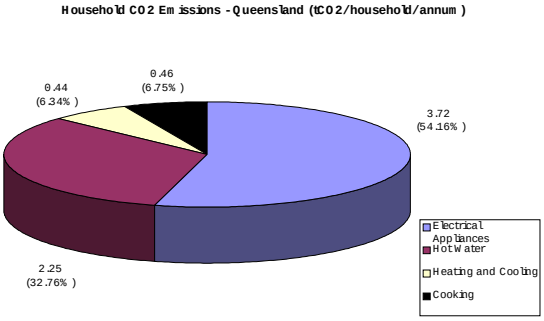

Figure 3: Breakdown of average Household CO2 emissions for Queensland (based on data from AGO, 1999)

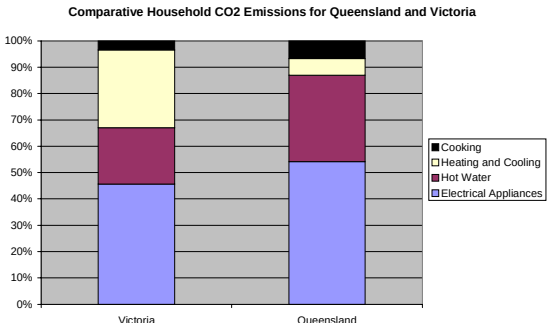

Figure 4: Comparative household CO2 emissions for Queensland and Victoria (based on data from AGO, 1999)

5. ALTERNATE ROUTES TO HOUSEHOLD GREENHOUSE GAS SAVINGS

An Example of an Environmental Prototype House

An environmental prototype house, built on the Gold Coast in 1999 has been monitored over a period of a year (Watson and Hyde, 2000) and has produced results that further highlight the problems with HER, but also begins to suggest some beneficial directions forward.

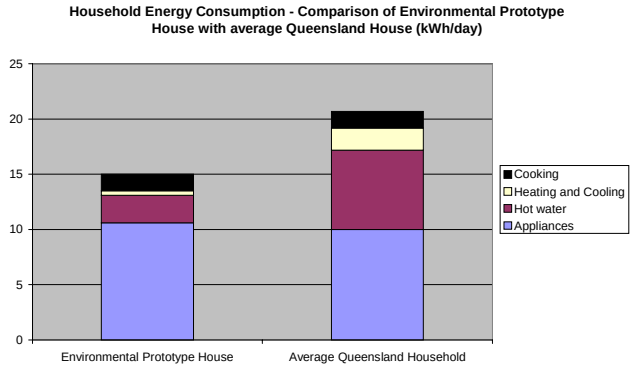

Figure 5: Household energy consumption comparison of Prototype Home with the Qld average.

In this case, through sound passive design of the house, it's envelope, orientation and layout, reductions in heating and cooling energy use have been made (refer figure 5). However, as figure 5 reveals a greater reduction was made by the simple installation of a solar hot water system. There was a lot of design effort and material expense that went in to producing the reduction in heating and cooling energy through the design of the house as compared to the act of designing-in and installing the solar hot water system. Through a BERS simulation the house scored a 4 star rating, equivalent to a heating and cooling energy consumption of 76.8MJ/m^2 of conditioned floor area per year (Hyde and Watson, 2001). The house is not mechanically conditioned, so the results from monitoring show that the actual figure is far less than the simulated estimate. Since these results were compiled the family has installed a photovoltaic (PV) system. The resulting reduction in household GHG emissions will obviously be significant.

Means and Ends – Alternative Fuel Sources

The underlying problem with present HERS, that the above example highlights, is that they rate energy consumption and not GHG emissions. Fundamentally this is an issue of the assessment of means and ends. The overall aim must be to reduce GHG emissions, as this is the actual environmental impact. Reducing energy consumption is just one means to the end that is the reduction of GHG emissions. The use of alternative, non-GHG producing energy sources is another. A deficiency in HER at present therefore, is the lack of allowance for alternative fuel sources. Two houses of exactly the same design could have vastly different GHG emissions if one were to be heated by Natural Gas and the other by electricity produced by a coal fired power station. A HERS simulation would attribute the two houses with the same rating.

The issue of household GHG emissions could be likened to a leaking bucket. There are many holes to plug and they are of differing sizes. The sensible thing to do would seem to be to first patch up the largest holes. This approach is recognised by, for example, the current government rebates available to households to install alternative energy sources such as solar hot water, or PV systems.

Local governments, through their role as building approvers, only have a limited scope for imposing regulation regarding household energy measures. This is why building envelope issues have been the first to come under

consideration. However, it does not seem out of the question that alternative energy systems could be regulated. The MSC in fact does equate the installation of a solar hot water system to 1 star on the BERS which is used to gain approval in that jurisdiction. A broader perspective reveals that there are many other environmentally friendly technologies that local government could be regulating. Low water flow devices are one example.

The advantage with GHG reduction measures such as solar hot water is that there is a much higher level of certainty that it will actually result in a reduction in GHG emissions in comparison to envelope strategies. There are not issues of system efficiency and user variables that swamp the intended thermal properties of a house design (Williamson, 2000).

Design-Phase Environmental Assessment

The other direction that GHG assessment and environmental assessment in general should take, is towards being included in the early stages of the design process. Here the term design process is used in it's loosest sense, as there is a recognition that by far the largest percentage of the new housing market is provided by large mass producing housing companies, with little specific design input into individual houses.

As a route to address the mass housing market, rather than placing a regulatory hurdle at the end of the design process, the introduction of incentives, to improve housing models from the concept stage would seem to be a beneficial approach. Incentives could be structured to focus on the entire package of the house, to include appliances, hot water and the building envelope itself.

In terms of assisting in the traditional design process, work continues (Watson, Cheshire and Hyde, 1999), on an environmental briefing process that attempts to lock in environmental performance criteria for an individual project. The aim is to create beneficial relationships between the critical environmental design strategies from an early stage in design. The example given in figure 6 relates to solar hot water and PV.

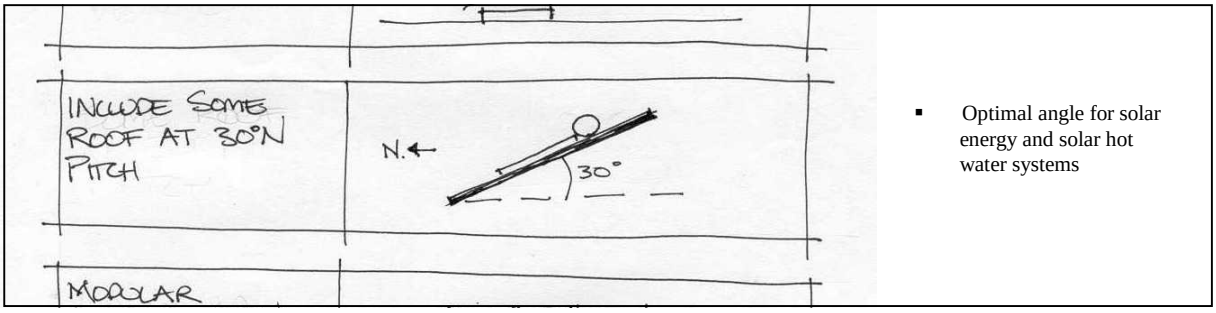

Figure 6: Extract from Environmental Briefing Document showing environmental strategies for solar hot water/PV

Another example of a new tool intended for use by designers in the design phase is the ESD Office Fitout Guidelines, produced by the QLD Dept of Public Works (2000). Although this tool is specifically for use with office buildings, there is no reason why the underlying model of the tool could not be transferred to housing. The tool consists of a series of issue-related guidelines for environmental performance and a series of checklists directed at each stage of the design process. A housing tool based on this model, is something that could be used by architects for individual designs and by the mass housing market in the development of their standard models.

6. CAVEAT

Despite the arguments put forward here this is not a total rejection of HER. This paper has focused on the singular aim of reducing GHG emissions. The issue of thermal comfort has been left aside. The argument presented in this paper should certainly not be taken to mean that the design of the building envelope can be dismissed as irrelevant. Good thermal design of buildings is a fundamental architectural quality that should be encouraged as part of an overall approach to sustainable building design. The environmental qualities determined by the building envelope go much further than just thermal comfort and the resulting energy savings.

Perhaps the truly beneficial role of HERS as a regulatory tool should be realised as that of raising the minimum standard of house design such that the poorest thermally designed houses are not built. There is no doubt that a HER encourages improved thermal design which in turn means that a house at least has the potential to perform better thermally and hence reduce energy consumption, even if in reality because of other factors this does not occur. In the warm climate of Brisbane we find that there are a lot of climatically unresponsive houses being built based on construction techniques from cooler climates. HER could certainly have a role in arresting this inappropriate development.

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