Supplementary Submission to Productivity Commission Public Enquiry into Energy Efficiency

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Summary

A submission to this enquiry by the Commonwealth Department of Environment and Heritage/ Australian Greenhouse Office (submission #69) offers comments on my previous submission (#28) and also provides some new information.

This submission addresses, among other issues, a number of statements and assertions made by DEH/AGO.

The key question(s) asked in submission #28 was,
"*what evidence exists to demonstrate a causal connection between the construction elements of a dwelling (eg thermal insulation, materials, shading, etc) and relevant aspects of energy-efficiency?*" similarly *"what evidence exists to demonstrate the integrity of NatHERS (and related) HERS".*

The DEH/AGO submission provides no substantive new information to answer these questions.

Comments on DEH/AGO submission #69

"NatHERS has <u>never</u> claimed that the energy use figures calculated in the course of a rating measure actual energy use (i.e. the energy measured at the meter)." #69P2

While NatHERS (or at least those speaking for the scheme) perhaps has never made such a claim directly, the clear and unequivocal implication of employing a rating scheme is that houses with a higher rating will have reduced energy use compared with houses of a lower rating. Examples abound (even from reputable organizations) of NatHERS descriptions that to a normal person would convey this impression.

"NatHERS Software…..House Energy Rating Schemes (HERS) are being introduced throughout Australia to encourage improved design that will reduce energy consumption and improve thermal comfort in houses, providing Australians with a better environment both inside and outside their homes…….… Energy-efficient design can result in a home that is up to five degrees cooler in Australia's warm summer, and reduce energy costs by as much as 40%. By reducing the energy consumed it will also reduce greenhouse emissions…….." (CSIRO 2004)

*"House Energy Rating Schemes (HERS) are being introduced throughout Australia. The aim is to reduce residential energy consumption and increase thermal comfort by encouraging improved building envelope design….**...**NatHERS and BERS actually simulate the operational energy use in a home……HERS tools rate buildings in terms of average energy consumption per square metre."* (AGO 2004)

"Would the heating and cooling energy used by a real house with a real family acting in the same way as NatHERS equal measured energy consumption?" #69P6

This question misses the point of my first submission and criticisms of the NatHERS scheme. I have never made such a claim. At best a NatHERS rating is a *performance indicat*or. A good indicator is generally accepted as having the following characteristics,

- *Highlight some key issue(s)*

Reflect something basic and/or a fundamental policy objective

- *Be easily understood*

Be accepted by stakeholders as a vital sign of success of policy (or symptom of trouble).

- *Be measurable and meaningful*

Be amenable to practical data collection and analysis to demonstrate statistical validity.

- *Have interest and appeal*

Indicates, for example, the advantage of one product/design over another.

Applied to NatHERS ratings, the ranking of houses should therefore indicate some measurable quantity (not necessarily actual energy consumption).

"…the purpose of NatHERS star ratings is to indicate to consumers that one house will use less energy than the other, <u>all other things being equal</u>" #69P4

A main difficulty in addressing such a statement is that, from its inauguration in 1992, substantive objectives in meaningful terms, of what a NatHERS rating indicates has never been clearly articulated. The statement above may be read as some sort of aim however the rider "*all other things being equal*" is meaningless and nonsensical. Everyone with a rudimentary knowledge of built-environment psychology knows that human behaviour, activities, etc, is contingent upon context. As a simple example, a family living in an insulated house with small windows will most certainly behave very differently (with energy use implications) compared with living in a house designed to open to the outside environment. A HERS rating, however, assumes the same behaviour and "judges" the houses accordingly.

Elsewhere Isaacs (DHE#69 Attachment A) offers another version of an aim "*[NatHERS] provides a rating of the energy-efficiency of the external fabric of a house for its climate conditions…..*". Elsewhere DEH/AGO (#69p1) suggests another "[it]*…measures the inherent thermal performance of the building shell <u>all other things being equal</u>"*. Even taking these "aims" on face value they are each conceptually and fundamentally different.

In the context of the Building Code of Australia (BCA) a substantive end is perhaps clearer. NatHERS rating provides a verification method against the objective "*To reduce greenhouse gas emissions by efficiently using energy"*. But as pointed out previously (see submission #28) in this context "efficiently using energy" is a contested phrase.

Elsewhere one can find suggestions that the NatHERS rating (by producing energy-efficient houses) addresses the issue of reducing peak summer loads due to air-conditioners (eg *"….energy efficiency in buildings (both new and through energy efficiency requirements for refurbishments) can contribute to future reductions in peak power demand"* DEH/AGO #69:P11). Since no study specifically addressing this issue has been published, (and my experience suggests such a claim is doubtful) data in a recent report prepared for the AGO (ABSA 2004:11) gives a tentative clue on

the matter. Participants in a workshop to assess AccuRate simulated the performance of a simple house together with a number of changes. The Energy Load(s) for heating and cooling (MJ/m2) and peak energy demand (kW) were reported. The plot of these results (see Figures 1A&B below) shows there is NO correlation between an AccuRate rating based on the sum of heating & cooling requirements or cooling load only and likely peak (cooling) electricity demand.

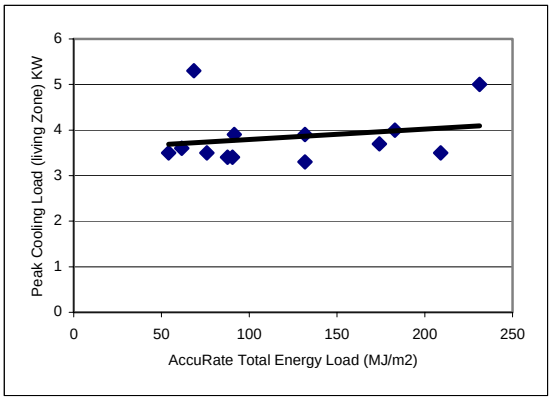

Figure 1A: AccuRate Total Energy Load (Rating Scale) vs Peak Cooling Demand
(N=13, R^2 = 0.049)

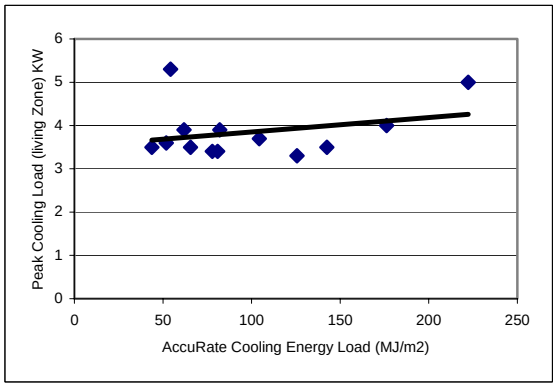

Figure 1B: AccuRate Energy Load Cooling vs Peak Cooling Demand
(N=13, R^2 = 0.049)

Good policy-making demands that regulations have clear objectives and are based on sound science. Science, as a method of acquiring knowledge, is founded on the values of objectivity, neutrality and rationality. Scientific theories, or theory-like statements such as regulations, (as opposed to pseudo-science and non-science) should be capable of falsification, refutation and testing. The DEH/AGO submission almost suggests that NatHERS as a scheme is not capable of testing, or in any case, such testing would be very (too) expensive. Given the central place of NatHERS in the implementation of Government policy, its development (including testing & validation, typically 50-80% of total costs) has been chronically under funded compared with the additional costs imposed on new house construction by regulation whose justification is based almost entirely on the use of the software (estimated at an average of $997/dwelling or $M781 Australia wide for the period 2004-2010 (ABCB 2002)).

"The energy modelling performance of NatHERS is consistent with the international BESTEST program." #69P6

The IEA BESTEST procedure is known as an inter-model validation. That is, aspects of a computer programs operation are compared with other programs (not against "real" results). It involves comparing the candidate program with the results from a set of "reference" programs, for a series of variations of a simple building (essentially a test cell) 6 m x 8 m x 2.7 m. In particular it assesses the ability of a program to model aspects of heat transfer associated with the building fabric, basic thermostat controls and mechanical ventilation. While such tests are an

important aspect of software development quality control they do not address the issue of the accurate simulation of real situations. It is also important to note that,
1) the IEA BESTEST procedures conducted on NatHERS (Delsante 1995a) and AccuRate (Delsante 2004) involve aspects of the simulation engine only and NOT the scheme as a whole,
2) the IEA BESTEST procedure has NO tests for ground-coupling effects. In other words the important heat flow to floors (slab-on-ground or suspended) in NatHERS or AccuRate has not been subjected to any tests of validity,
3) the IEA BESTEST procedure has NO tests for natural ventilation modelling to be introduced into AccuRate, therefore this new component has not been subjected to any tests of validity.

"Work to verify the capacity of computer modelling [NatHERS] to predict temperatures within a house has been undertaken." #69P6

The work referred to (Williamson 1984) involved monitoring the internal temperatures (and external climate) of free-running houses in a number of locations during 1977-78. It is acknowledged as the first attempt anywhere to construct a comprehensive data set for empirical validation of thermal performance software. As part of the project, software developers/users were invited to submit their software to validation. CSIRO, Division of Building Research (DBR) ran tests of the program ZSTEP, then under development. The output of program ZSTEP (a predecessor of the NatHERS simulation engine CHENATH[1]), together with other programs, was compared with the temperature measurements. The project did not involve forming objective judgements about the appropriateness (or otherwise) of a program. However, on the basis of a visual examination of results, most informed judges concluded that the program ZSTEP was acceptably accurate for the time. In the intervening 25 years or so major changes/modifications/additions have been made to that software. As well the science of computer software validation has developed greatly. To claim this work validates the CHENATH simulation engine (and by implication NatHERS) brings to mind the story of George Washington's axe[2]. Just to illustrate how times (and computers and programs) have changed, the ZSTEP program tested in the project operated on a CDC Cyber 76 similar to the one shown below.

[1] During the 1980s after changes to ZSTEP the software was called CHEETAH. In turn, CHENATH is an enhanced version of CHEETAH and AccuRate is described as a greatly enhanced version of the CHENATH simulation engine
[2] George Washington's axe - Young George Washington is said to have cut down his father's cherry tree with an axe. The axe is supposedly on display in an (unverifiable) American museum, although, having had both its handle and its head replaced several times, no part of the original axe remains.

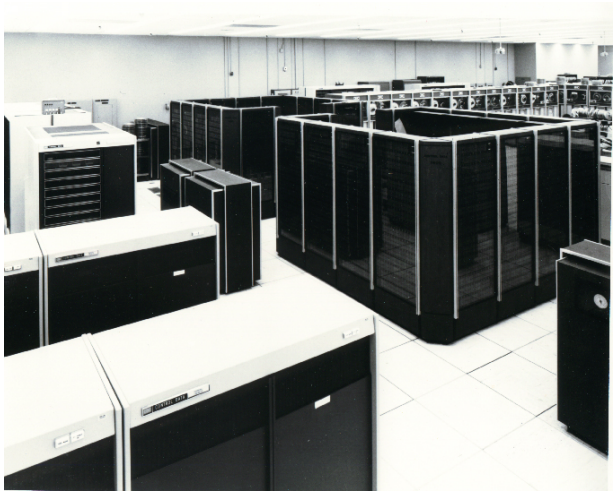

Figure 2: CDC Cyber 76 similar to one operated by CSIRO circa 1979-81 when ZSTEP was tested

While I have no doubt that the software engine is as good as could be under the circumstances, the fact remains, that the current version of the simulation engine, upon which the entire NatHERS scheme stands or falls, has not been the subject of comprehensive empirical validation[3]. Empirical validation against IEA test cell data was carried out in 1995 (Delsante 1995b) with the following conclusion,
"While this work produced useful results….. it is important to remember that the test cells are very simple lightweight buildings, and in particular do not test any of the CHENATH enhancements…..Nevertheless the overall performance of the program is pleasing……" P18

More importantly however, is that there is no evidence that the scheme (that is the software with all its built-in variables, assumptions, etc) operates to fulfil some stated objectives.

For interest, a prophetic recommendation of Williamson (1984) was (following legal opinion given to AHRC),
"All newly developed thermal performance computer programs should be subject to thorough evaluation. The provisions of the various Trade Practices Acts and Consumer Protection Acts may in fact preclude the publication of results from computer studies unless the program has been thoroughly validated by comparison with monitored conditions". P3.

"…..regulation of the thermal performance of houses influences the consumption of about 9 percent of total energy consumed in Australia." #69P10

Energy consumption figures and GHG emission statistics are notoriously difficult to pin down. While I would expect DEH/AGO to have a good handle on the data, this figure would appear erroneous and an overstatement of the relative importance of the house energy-efficiency regulation.

[3] An issue of some alarm is that only one CSIRO officer has detailed knowledge of the software engine. Risk management principles suggest such a situation is far from ideal.

ABARE figures show that residential energy consumption, taking Australia as a whole, accounts for around 11.9% of total consumption (393 PJ of a total of total consumption 3307 PJ) in 2001-02. (ABARE 2004)

[Other estimates (easily found on the internet) give similar, but also very different estimates of residential energy consumption :
"*In the current financial year (1998), the household sector will account for about 373 PJ of delivered energy, or about 11.5% of the national total.*" George Wilkenfeld and Associates 1998)

"How much energy is used by appliances in households?
Quite a lot. With 7 million households in 2001 and a good standard of living, Australia's residential energy consumption is a significant proportion of the national total (around 40%)". (AGO 2003) *underlining by author*]

Space heating and cooling accounts for around 41% (heating 40%, cooling 1.2%) of household delivered energy use (see Table 5 below). It follows therefore that "the regulation of the thermal performance of houses" influences around 4.8% (41% of 11.9%) of total secondary energy (not 9% as stated).

Table 5. End Use Share of Energy Use and Emissions, All Household Energy, 1990 and 1995

	1990					1995					
	Share of PJ	Share of CO_2-e	PJ	kt CO_2-e	kg CO_2-e/GJ	Share of PJ	Share of CO_2-e	PJ	kt CO_2-e	kg CO_2-e/GJ	Change 90 to 95
Space heating	40.0%	12.6%	127.1	6281	49	40.1%	12.8%	142.2	6663	47	11.9%
Space cooling	1.2%	2.4%	3.9	1184	304	1.2%	2.4%	4.3	1230	287	10.1%
Refrigeration	9.1%	17.6%	28.8	8756	304	8.9%	17.5%	31.7	9097	287	10.1%
Lighting	4.2%	8.0%	13.2	4005	304	4.1%	7.9%	14.4	4122	287	9.1%
Water heating	26.2%	27.7%	83.3	13800	166	26.6%	27.9%	94.3	14498	154	13.2%
Cooking	7.7%	9.3%	24.4	4631	190	7.8%	9.4%	27.6	4877	177	13.0%
Major appliances	5.3%	10.2%	16.7	5064	304	5.2%	10.1%	18.3	5240	287	9.6%
TV, video	2.4%	4.6%	7.6	2307	304	2.4%	4.6%	8.4	2394	287	9.9%
Miscellaneous	3.9%	7.6%	12.5	3808	304	3.8%	7.5%	13.6	3896	287	8.4%
All energy (a)	100.0%	100.0%	317.5	49837	157	100.0%	100.0%	354.7	52017	147	11.7%

Source: GWA (1997) (a) Emissions from wood use exclude CO_2

Note: From George Wilkenfeld and Associates, 1998

A similar analysis in terms of GHG emissions for 1999 shows that the residential sector (stationary energy) contributes around 11.8% of Australia's end-use emissions (see Table 7.3 below)
Of this total, residential heating & cooling accounts for around 18%. (heating 15% & cooling 2% - see Table 8.11 below). Therefore "the regulation of the thermal performance of houses" accounts for around 2.1% (=11.8%*18%) of total emissions.

[A report by ABCB (2002:32) that does not acknowledge the source of data gives a comparable result, "*Residential buildings accounted for 9.7% of Australia's net greenhouse gas emissions of 503.3 Mt CO_2-e in 1990, of which 13% was from space conditioners. It follows that space conditioners accounted for 1.25% (=9.7% x 13%) of net total emissions.*" P32.]

Table 7.3 Allocation of emissions to end use sectors (1999).

End use sector	Emission allocation ($Gg\ CO_2$-e)						Share of total (%)
	Stationary energy	Transport energy	Industrial process	Biosphere[c]	Waste	Total	
Agriculture, forestry and fishing	7 621	6 559	–	130 566	–	144 746	27.6
Mining: non-energy	12 801	2 464	–	–	–	15 265	2.9
Mining: export energy	25 382	733	–	–	–	26 115	5.0
Manufacturing	116 258	7 238	10 409	–	6 327	140 231	26.8
Construction, water, etc	5 684	4 018	–	–	2 109	11 812	2.3
Commercial/institutional	46 536	670	–	–	3 254	50 460	9.6
Residential[a]	62 827	34 777	–	–	4 766	102 370	19.5
Other[b]	5 400	24 681	–	2 914	–	32 995	6.3
Total	282 509	81 140	10 409	133 480	16 456	523 993	100.0

a Includes travel to and from work and travel for private purposes by PMVs.

b Includes combustion of solvents, military energy use, unallocated freight and passenger transport and land use change not allocated to agriculture.

c Biosphere includes agriculture and land-use change and forestry sector emissions and removals.

Table 8.11 Residential sector—FC emissions by end use by energy type (1999).

	FC emissions ($Gg\ CO_2$-e)					Share of emissions (%)
	Electricity	Natural gas	LPG, petrol	Wood, coal	Total	
Space heating and cooling	4 025	4 409	490	2 220	11 145	17.9
Water heating	13 676	2 764	345	–	16 785	26.9
Cooking	2 511	376	82	–	2 969	4.8
Appliances	26 230	–	–	–	26 230	42.1
Lighting	5 182	–	–	–	5 182	8.3
Total	51 624	7 549	917	2 220	62 310	100.0
Share of emissions (%)	82.9	12.1	1.5	3.6	100.0	–

Source: GWA & ES (2002)

Note: Tables 7.3 & 8.11 taken from Wilkenfeld and Associates and Energy Strategies, 2003

"Some experimental work is available in Australia for verifying the performance of NatHERS against actual measurements……. actual measurements necessary to prove the validity of NatHERS modelling … have not been undertaken." #69P5

These statements in the same paragraph appear contradictory.

"Use of house energy rating systems has in fact delivered real and significant energy efficiency savings." #69P1 and "NatHERS is a suitable tool for energy modelling of houses for regulatory purposes." #69P9

The only evidence offered for these claims seems to be contained in Attachment A. Here it is suggested *"While the rating scheme is not perfect the effects of its use are leading builders and designers to take positive steps to improve their houses."* In other words, the application of rating tools produces preconceived results in terms of requirements for insulation, weather-strips,

window areas, etc. If producing these results was the instrumental aim of HERS then there are much simpler (and cost-effective) ways to achieve this end.

The issue of concern here is that regulations (and HERS) tend to take on a life of their own, often leaving rationality, innovation in design, and possibly social interest behind. The danger is that sub-optimal outcomes will result from adherence to inappropriate one-dimensional regulation. Tenbrunsel et al (1996) argue that this sub optimality is due to a tendency for regulations to direct attention to themselves and their compliance and away from the underlying objective of the regulation. Industry discourse tends to focus on how to meet the standard, rather than a focus on how to optimally deal with the underlying issue(s).

The following illustrates the one-dimensional aspect of the current building regulations aimed at reducing heating and cooling energy consumption.

From data presented above the total (Australia wide) residential delivered energy consumption for heating and cooling is around 160 PJ *(180 PJ primary energy)* in 2001-02. *(393*41%)* and 8.7 Mt of CO_2-e. (Note, new houses would account for only a small faction of this amount). Each new house constructed in Australia involves, on average and including an allowance for infrastructure, around 1200 GJ of embodied energy and a corresponding 68 T of GHG emissions (personal communication S. Pullen, UniSA). Assuming approximately 120,000 new houses are built in Australia in a year, the embodied energy total is approximately 145 PJ *(primary energy)* and 8.2 Mt of CO_2-e. Policies to encourage a reduction of embodied energy, not so much affected by the vagaries of human behaviour, would therefore seem to have the potential of achieving greater overall energy-efficiency than the current approach.

Climate Change – CO2 Concentrations and Earth Temperature (PowerPoint slide)
I am somewhat surprised that this slide continues to be displayed. While the source of the slide is given as CSIRO 2002, the original (temperature change component) is derived from Mann, et al (1998). The Intergovernmental Panel on Climate Change (IPCC) adopted this work as central evidence to demonstrate an adverse anthropogenic influence on climate. However, a recent examination of this work by McIntyre & McKitrick (2003) has thrown serious doubts on its validity. A re-analysis of the Mann et al. data (see Figure 2 below) shows a very different climate change pattern, with high temperatures in the decade 1400-1500, which suggest that statements by the IPCC such as "*It is very likely that the 1990s was the warmest decade, and 1998 the warmest year, of the instrumental record. Extending the instrumental record with proxy data for the Northern Hemisphere indicates that over the past 1,000 years the 20th century increase in temperature is likely to have been the largest of any century, and the 1990s was likely the warmest decade"* (IPCC 2001:48) and "*Reconstructions of climate data for the last 1,000 years also indicate that this 20th century warming was unusual and unlikely to be the response to natural forcing alone*." (IPCC 2001:51) are questionable.

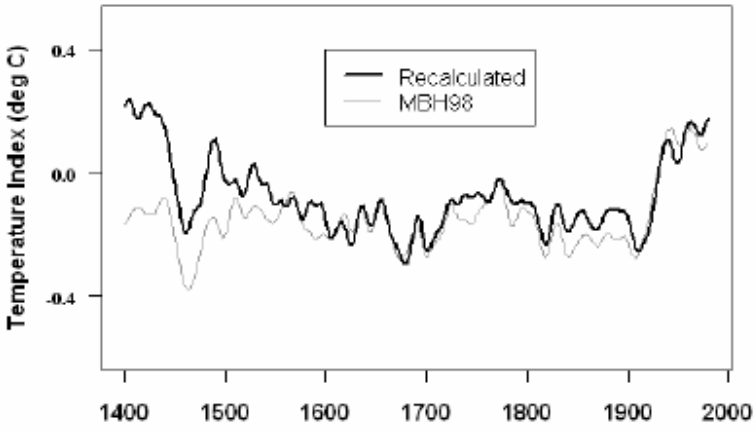

Figure 2. Northern Hemisphere temperature reconstructions: MBH98 and MM05 emulation of MBH98 using (a) centered principal components; (b) archived version of Gaspé series. Both series smoothed.

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