Sustainable Energy Development Office
Government of Western Australia

Particular Element Testing of *AccuRate* v0.93 *Beta*

Prepared on behalf of the Sustainable Energy Development Office

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Particular Element Testing of *AccuRate*

1. Background

In 2002, the Nationwide House Energy Rating Scheme (NatHERS) management group agreed to fund a major upgrade of the CHENATH computation engine that resides within the NatHERS accredited software.

CSIRO, the owners of CHENATH, were contracted to increase the tool's capacity to more accurately model building energy performance, in particular, CSIRO were asked to improve the ventilation modelling to better reward good design practice in hot humid climates.[1]

As a result of the upgrade, the NatHERS Technical Advisory Committee is currently reviewing a beta test version of the software, named *AccuRate*.

The Sustainable Energy Development Office tested the software in regards to two particular issues. Firstly, the software was analysed to determine whether the ventilation modelling is appropriately rewarding house designs. Secondly, the sensitivity of the model to the addition of a gas bayonet point was determined. This was a result of anecdotal evidence in Western Australia suggesting that the addition of a gas bayonet point is having a disproportionate effect on house energy ratings.

2. Natural Ventilation Modelling

2. 1 Method

The difference in the predicted energy consumption of houses using the simple and the new network ventilation model were tested. Results were simulated for a sample 50 houses in the two ventilation modes. All other variables were kept constant. The predicted energy use was not area adjusted.

The absolute error of the total predicted energy use (MJ/m^2), the star ratings and the percentage change in the total energy use between the natural and simple ventilation modes were calculated. Analysis was also carried out on the relative change to heating and cooling energy requirements in the different ventilation models.

The sample of houses was split into climatic categories to further determine the impact on predicted energy consumption between the two ventilation modes. Houses in the northern climates included Brisbane, Townsville, Port Headland and Darwin, while the southern climates included Melbourne, Perth, Esperance and Ballarat. Houses from Brisbane were removed from the northern climate set to produce the tropical climate set. Finally, houses from the northern climates with high cross ventilation, as assessed from the given house plans, were tested in the high ventilation data set.

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[1] Delsante, A., *AccuRate Review of Modifications*, CSIRO, presentation given on 8 December 2003.

Number of sample houses in each climatic category

Total	48
All Northern	18
Southern Climates	30
All Tropical	11
High Ventilation Houses	8
SW and Perth	7

2.2 Results and Discussion

The summary statistics on the first three variables are shown below in Table 1.

No houses in the sample had a predicted increase in energy use using the new network ventilation model. The average percentage change in the total energy use was a reduction of 15% with an average increase in star rating of 0.6. The largest reduction in energy use was 55%.

The houses with the lowest reduction in absolute energy consumption were based in Melbourne with medium to low cross ventilation, whilst the houses with the largest reduction were based in the northern climates with high cross ventilation.

Due to the fact that the absolute energy consumption of houses varies in different climate zones, using star ratings as an indicator best compares the relative change in energy consumption. Star ratings increased by 1.1 for houses built in the northern climates as opposed to a 0.3 increase in southern climates. This indicates a half a star relative gain for the northern climates. High ventilation rate designs increased, on average, by 1.5 stars, with the largest increase being an additional 3 stars to a well-designed "Troppo" house in Townsville.

Table 1: Difference between predicted energy consumption and star rating of 50 houses of network ventilation and simple ventilation models.

Change in Total Energy (MJ/m^2)	Mean	Median	Max	Min	St Dev
Total Average	-48.1	-22.4	-1.1	-247.5	63.6
All Northern Climates	-97.4	-97.5	-5.2	-247.5	80.4
Southern Climates	-17.4	-13.1	-1.1	-46.3	13.4
All Tropical Houses	-78.6	-43.3	-5.2	-226.2	82.3
High Ventilation Houses	-144.4	-154.8	-19.7	-247.5	85.0
Star Ratings					
Total Average	0.6	0.5	3.0	-0.5	0.8
All Northern Climates	1.1	0.8	3.0	0.0	1.1
Southern Climates	0.3	0.0	1.5	-0.5	0.5
All Tropical Climates	0.9	0.5	3.0	0.0	1.1
High Ventilation Houses	1.5	1.5	3.0	0.0	1.1
% Change in Energy					
Total Average	-14.9	-7.6	-0.4	-55.2	16.9
All Northern Climates	-25.5	-23.4	-1.0	-55.2	21.0
Southern Climates	-8.3	-6.3	-0.4	-47.0	9.3
All Tropical Climates	-15.8	-6.6	-1.0	-47.3	17.1
High Ventilation Houses	-30.9	-38.7	-3.7	-48.8	19.2

On average the new ventilation model led to a decrease in heating energy and a decrease in cooling energy consumption (Table 2). However, the heating energy required increased as a proportion of the total by 4.7%, whilst the cooling energy decreased by 4.7% (Appendix A).

The effect of the natural ventilation model on the heating load was slightly more significant in southern climates with a mean reduction of –3MJ/m^2. However, on average the percentage load of heating increased by 3% whilst the percentage load of cooling decreased by 3%. The standard deviation for these differences is significant and, as a result, drawing conclusions on this basis is problematic.

In the northern climates the change is characterised by a larger decrease in cooling loads, and minor changes in heating loads. The results indicate a greater reduction in the cooling load in high ventilation houses when isolated in comparison to all tropical or northern climate houses.

The proportion of energy required for latent cooling remains relatively constant, in southern climates, at 3-4% of the total. In northern climates, it increases slightly on average from 20.3% to 21.7% of the total, with the median and maximum also being larger. The maximum latent cooling load was 33% with the network ventilation model.

Table 2: Absolute error between predicted heating and cooling energy consumption (MJ/m2) of 50 houses in network ventilation and simple ventilation models.

Change in Heating Energy (MJ/m2)	Mean	Median	Max	Min	St Dev
Total Average	-1.9	-0.4	5.1	-15.6	3.8
All Northern	0.0	0.0	1.5	-2.2	0.7
Southern Climates	-3.1	-2.5	5.1	-15.6	4.4
All Tropical	0.1	0.0	0.4	0.0	0.1
High Ventilation Houses	0.0	0.1	0.4	-1.0	0.4
Change in Latent Cooling Energy					
Total Average	-4.3	-1.5	18.2	-42.0	12.7
All Northern	-7.9	-7.2	18.2	-42.0	19.8
Southern Climates	-2.1	-1.5	4.2	-16.1	3.5
All Tropical	1.9	7.8	18.2	-24.4	16.2
High Ventilation Houses	-10.1	-17.1	17.2	-40.7	21.4
Change in Sensible Cooling Energy					
Total Average	-41.9	-19.1	6.5	-230.9	56.5
All Northern	-89.5	-76.3	-8.9	-230.9	67.4
Southern Climates	-12.3	-10.7	6.5	-39.1	11.2
All Tropical	-80.6	-60.5	-18.6	-209.3	69.1
High Ventilation Houses	-134.4	-122.0	-36.7	-230.9	70.3
Change in Total Cooling Energy					
Total Average	-46.2	-19.8	10.7	-247.7	64.6
All Northern	-97.5	-98.0	-5.2	-247.7	80.5
Southern Climates	-14.4	-12.8	10.7	-46.1	13.8
All Tropical	-78.7	-43.3	-5.2	-226.6	82.4
High Ventilation Houses	-144.4	-154.5	-19.7	-247.7	85.1

3.3 Conclusions

Given these figures it could be expected that ratings of houses in all climate zones will increase on average by half a star, the northern climate zones by 1 star and well ventilated houses in the northern climates by 1.5 stars. However, given the small sample size of the houses tested, the error and deviation from the mean is high. Notwithstanding this, analysis of individual houses at the extremes indicates that the model is behaving as expected.

At present houses in the Building Code of Australia allows houses in climate zones 1, 2 and 3 a 3.5 star rating as opposed to a 4 star rating, due to ineffectual natural ventilation models in the current software. The 0.5 star increase produced by these results would appear to indicate that the changes to the software rectify this problem.

It also appears as though the natural ventilation model will most probably lead to a slight increase in the predicted proportion of energy used in heating and a reduction proportion of the energy used in cooling in southern climates. However, the absolute value of both loads will, in all likelihood, decrease.

Cooling loads in northern climates were reduced in the network ventilation model and well-ventilated houses appear to be rewarded appropriately. The model predicts that an average of 22% of the total energy load will be contributed to latent cooling.

2. Sensitivity to Addition of a Gas Bayonet Point

2.1 Methods

The model was tested for sensitivity to the addition of a single gas bayonet by adding one point to the main living area. The difference between the original rating without a bayonet point and with a bayonet point was then compared.

2.2 Results and Discussion

The addition of a gas bayonet point reduces the average star rating by minus half a star. Whilst there is a slight variation between the effects on different climates, in general all climate zones are affected in the same manner.

The largest change, a loss of 1.5 stars, was seen in three houses located in Melbourne. The greatest change to houses in the northern climates was a one star loss. In southern climates the addition of one bayonet point has the potential to alter the rating by the same magnitude as the new network ventilation model.

Table 3: Difference between predicted energy consumption and star rating of 50 houses without and with a gas bayonet point (without minus with).

Change in Total Energy (MJ/m^2)	Mean	Median	Max	Min	St Dev
Total Average	-27.3	-26.2	94.3	-89.8	26.7
All Northern	-24.5	-24.2	94.3	-89.8	40.0
Southern Climates	-29.1	-26.4	-8.6	-80.6	14.0
All Tropical	-27.0	-29.1	94.3	-89.8	49.2
High Ventilation Houses	-23.5	-25.9	94.3	-89.8	54.6
SW and Perth	-25.8	-20.2	-8.6	-51.0	14.0
Star Ratings					
Total Average	0.4	0.5	1.5	0.0	0.4
All Northern	0.4	0.5	1.0	0.0	0.3
Southern Climates	0.4	0.5	1.5	0.0	0.5
All Tropical	0.5	0.5	1.0	0.0	0.4
High Ventilation Houses	0.4	0.5	1.0	0.0	0.3
SW and Perth	0.3	0.5	0.5	0.0	0.3
% Change in Energy					
Total Average	-10.0	-9.9	22.6	-39.4	7.8
All Northern	-7.1	-8.0	22.6	-21.4	9.4
Southern Climates	-11.7	-10.9	-4.6	-39.4	6.2
All Tropical	-5.4	-8.1	22.6	-13.1	10.4
High Ventilation Houses	-5.7	-8.4	22.6	-12.8	11.7
SW and Perth	-9.5	-8.4	-6.0	-12.8	2.6

The dependence on construction type was also investigated. While the wall type that appears to have the greatest drop with the addition of a gas bayonet point is timber flooring and brick veneer cladding, this data set also has the largest variance. The results are summarised in Table 4.

Table 4: Difference between the star rating of 50 houses without and with a gas bayonet point (without minus with) for different construction types.

Floor Type	Wall Type	Average	Standard Deviation
CSOG	AAC200	0.3	0.3
CSOG	BV	0.2	0.3
CSOG	C150	0.8	0.4
CSOG	CAV	0.3	0.3
CSOG	WB	0.4	0.2
TIMB	BV	0.9	0.6
TIMB	C150	0.5	-
TIMB	WB	0.3	0.3

AAC200	Autoclaved Aerated Concrete Blocks 200mm
BV	Brick Veneer
CAV	Cavity Brick
CSOG	Concrete Slab on Ground
C150	150mm Concrete Block
TIMB	Timber
WB	Weatherboard

The relationship between high, medium and low ventilation houses was also investigated. The reduction in stars for each was on average 0.4, 0.5 and 0.23, showing no clear relationship between infiltration and ventilation. This indicates that the new network ventilation modelling has not exacerbated this problem.

2.3 Conclusions

The effect of adding a gas bayonet point to a house appears disproportionately large, especially in southern climates. The danger is that rather than bearing the cost of installing a flued gas heater, that clients will opt to install electric heating appliances. The infiltration rate currently used needs to be reviewed.

APPENDIX A

Simple Ventilation Model

% Heating Energy	Mean	Median	Max	Min	St Dev
Total Average	45.4	61.3	91.3	0.0	34.8
All Northern	7.1	0.4	32.9	0.0	10.8
Southern Climates	69.1	74.0	91.3	15.8	19.9
All Tropical	1.0	0.0	5.4	0.0	2.1
High Ventilation Houses	4.0	2.0	17.5	0.0	5.9
% Sensible Cooling Energy					
Total Average	44.5	35.9	83.6	6.5	26.4
All Northern	72.6	75.8	83.6	50.6	9.5
Southern Climates	27.0	23.7	67.2	6.5	16.3
All Tropical	77.4	79.0	81.3	69.7	3.8
High Ventilation Houses	77.9	79.4	83.6	61.3	6.9
% Latent Cooling Energy					
Total Average	10.2	3.2	30.3	0.5	9.4
All Northern	20.3	20.3	30.3	10.5	5.1
Southern Climates	3.9	2.3	19.5	0.5	4.6
All Tropical	21.6	20.4	30.3	13.3	4.9
High Ventilation Houses	18.1	19.6	21.2	13.1	3.3
% Total Cooling Energy					
Total Average	54.6	38.7	100.0	8.7	34.8
All Northern	92.9	99.6	100.0	67.1	10.8
Southern Climates	30.9	26.0	84.2	8.7	19.9
All Tropical	99.0	100.0	100.0	94.6	2.1
High Ventilation Houses	96.0	98.0	100.0	82.5	5.9

Network Ventilation Model

% Heating Energy	Mean	Median	Max	Min	St Dev
Total Average	48.4	64.6	92.9	0.0	33.7
All Northern	13.0	0.7	55.8	0.0	19.1
Southern Climates	70.3	75.0	92.9	16.8	18.5
All Tropical	1.8	0.0	9.8	0.0	3.8
High Ventilation Houses	7.5	3.8	33.2	0.0	11.2
% Sensible Cooling Energy					
Total Average	41.4	31.9	76.7	6.8	24.3
All Northern	65.3	72.7	76.7	32.6	13.7
Southern Climates	26.5	22.6	69.0	6.8	16.1
All Tropical	72.9	73.7	76.7	67.0	3.2
High Ventilation Houses	71.1	74.0	76.7	50.4	8.7
% Latent Cooling Energy					
Total Average	10.3	5.0	33.0	0.4	10.2
All Northern	21.7	23.0	33.0	9.8	6.5
Southern Climates	3.2	2.1	14.3	0.4	2.8
All Tropical	25.3	25.3	33.0	17.2	4.3
High Ventilation Houses	21.4	22.3	26.3	16.4	3.5
% Total Cooling Energy					
Total Average	51.6	35.4	100.0	7.1	33.7
All Northern	87.0	99.3	100.0	44.2	19.1
Southern Climates	29.7	25.0	83.2	7.1	18.5
All Tropical	98.2	100.0	100.0	90.2	3.8
High Ventilation Houses	92.5	96.2	100.0	66.8	11.2

Absolute Error between network and simple models

Change in Heating Energy (MJ/m2)	Mean	Median	Max	Min	St Dev
Total Average	-1.9	-0.4	5.1	-15.6	3.8
All Northern	0.0	0.0	1.5	-2.2	0.7
Southern Climates	-3.1	-2.5	5.1	-15.6	4.4
All Tropical	0.1	0.0	0.4	0.0	0.1
High Ventilation Houses	0.0	0.1	0.4	-1.0	0.4
Change in Sensible Cooling Energy					
Total Average	-41.9	-19.1	6.5	-230.9	56.5
All Northern	-89.5	-76.3	-8.9	-230.9	67.4
Southern Climates	-12.3	-10.7	6.5	-39.1	11.2
All Tropical	-80.6	-60.5	-18.6	-209.3	69.1
High Ventilation Houses	-134.4	-122.0	-36.7	-230.9	70.3
Change in Latent Cooling Energy					
Total Average	-4.3	-1.5	18.2	-42.0	12.7
All Northern	-7.9	-7.2	18.2	-42.0	19.8
Southern Climates	-2.1	-1.5	4.2	-16.1	3.5
All Tropical	1.9	7.8	18.2	-24.4	16.2
High Ventilation Houses	-10.1	-17.1	93.6	-40.7	21.4
Change in Total Cooling Energy					
Total Average	-46.2	-19.8	10.7	-247.7	64.6
All Northern	-97.5	-98.0	-5.2	-247.7	80.5
Southern Climates	-14.4	-12.8	10.7	-46.1	13.8
All Tropical	-78.7	-43.3	-5.2	-226.6	82.4
High Ventilation Houses	-144.4	-154.5	-19.7	-247.7	85.1

% Point Change in Proportion of Total

% Change in Heating Energy	Mean	Median	Max	Min	St Dev
Total Average	4.7	2.2	39.0	-4.7	7.9
All Northern	5.9	0.3	25.7	0.0	8.7
Southern Climates	3.9	3.6	39.0	-4.7	7.4
All Tropical	0.8	0.0	4.7	0.0	1.7
High Ventilation Houses	3.5	1.8	15.7	0.0	5.3
% Change in Sensible Cooling Energy					
Total Average	29.7	25.7	61.3	-7.7	18.7
All Northern	45.0	50.0	61.3	13.2	13.5
Southern Climates	20.2	18.8	58.1	-7.7	14.7
All Tropical	51.2	52.7	60.4	36.7	7.0
High Ventilation Houses	53.0	55.4	61.3	29.3	10.1
% Change in Latent Cooling Energy					
Total Average	-34.4	-33.4	-4.7	-64.4	17.8
All Northern	-50.9	-51.9	-36.7	-64.4	7.8
Southern Climates	-24.1	-21.1	-4.7	-59.6	14.1
All Tropical	-52.1	-54.5	-36.7	-64.1	7.8
High Ventilation Houses	-56.5	-56.4	-45.0	-64.4	6.2
% Change in Total Cooling Energy					
Total Average	-4.7	-2.2	4.7	-39.0	7.9
All Northern	-5.9	-0.3	0.0	-25.7	8.7
Southern Climates	-3.9	-3.6	4.7	-39.0	7.4
All Tropical	-0.8	0.0	0.0	-4.7	1.7
High Ventilation Houses	-3.5	-1.8	0.0	-15.7	5.3