Study of the Effect of Temperature Settings on AccuRate Cooling Energy Requirements and Comparison with Monitored Data

Final Report

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CONTENTS

EXECUTIVE SUMMARY

In order to validate the heating and cooling energy requirements predicted by 2nd Generation NatHERS rating tools and in particular the AccuRate rating tool, a comparison was made with detailed monitoring of heating and cooling energy data for six suburban Adelaide houses over two years.

After allowing for the appliance energy performance, the study demonstrated the ability to utilise AccuRate in determining the monthly heating requirements. However, AccuRate, initially under predicted the cooling energy consumption.

In an attempt to identify the quantum of change necessary to closely match the AccuRate prediction with the monitored cooling energy use, the temperature set points used in AccuRate for cooling energy evaluation were varied. The results demonstrate that a better match with monthly monitored results is possible from realistic adjustments to the thermostat settings.

Having identified the size of the adjustment necessary, a workshop of nationally recognised thermal comfort experts was held in Adelaide in December 2007 to investigate a theoretical basis for establishing new cooling trigger temperature settings for AccuRate. The expert panel identified two additional aspects of thermal comfort that could be applied to the Chenath cooling methodology and recommended the testing of specific changes.

The results for Adelaide demonstrate that this new methodology and these specific temperature settings provide more realistic values for use in AccuRate cooling energy estimations in comparison with monitoring data.

The study is, however, based on a statistically small sample and highlights the need for extensive national energy consumption data collection and monitoring research. The study identifies that further validation of the cooling aspects of 2nd Generation NatHERS tools will require extensive research into both air conditioner performance and usage patterns during hot peak demand periods.

1. BACKGROUND AND INTRODUCTION

In a previous report completed earlier (Saman et. al. 2007), comparisons were made between the heating and cooling requirements, simulated using AccuRate Version 1.1.2.0, and the monitored electrical energy consumption for heating and cooling appliances used in six Adelaide homes over a two-year period. Separate models were generated for each house using the standard weather data file (CLIMAT16) and a modified file, using recorded weather data for the monitoring period. The monthly heating energy demands when using the recorded weather data agreed reasonably well with the monitored data after allowing for the thermal performance of the heating appliances employed. However, considerable differences were evident when comparing the corresponding cooling data. In order to investigate the likely causes of the differences, this process was repeated using Version 1.1.3.1 of AccuRate. Models generated using this new version of AccuRate were then simulated using two different thermostat settings for cooling. The first was the default setting, which consisted of a cooling thermostat setting of 25ºC and a trigger temperature of 27.5ºC. The second setting was a cooling thermostat of 22ºC and a trigger temperature of 27.5ºC. This second setting effectively meant that after being cooled to 22ºC, the temperature of certain zones had to reach 27.5 ºC before simulated cooling was applied by AccuRate. This represented an unrealistic domestic cooling situation; therefore it was decided to investigate the impact of applying different cooling trigger temperatures to the same models. The results of this investigation form the basis of this report.

In the previous work, comparisons were made between AccuRate Version 1.1.3.1 data generated using both thermostat settings and the monitored data, which demonstrated that, especially during winter months, AccuRate provided a realistic estimate of energy consumption, based on actual weather data. AccuRate appeared to underestimate actual cooling energy requirements in harsher summer months, with a closer match obtained using the lower thermostat setting of 22ºC in the milder cooling months, even though an unrealistic trigger temperature was used. An assessment of the impact of maximum daily temperature on daily monitored energy use and load predicted by AccuRate, revealed a tendency for a larger difference at higher ambient temperatures, further highlighting the impact of variations in air-conditioner performance and perhaps also the limitations in the AccuRate model, especially during extended periods of elevated temperature. Further comparison between the daily AccuRate and monitoring data demonstrated the difference between the time pattern for heating and cooling requirement, as predicted by AccuRate, and the actual pattern of air-conditioner usage. Comparisons between monitored load profiles on SA peak electricity demand days, in both summer and winter, and profiles generated by AccuRate using both standard and measured weather data files highlighted this fact, showing little similarity between modelled and monitored load profiles, as expected. Comparison between individual energy use patterns for seemingly similar houses showed large variations in peak demand and total energy use, which exemplified the impact of user behaviour on energy use.

Considering the monthly and yearly totals, it was found that on average, after adjusting the thermostat temperature setting, AccuRate results compared reasonably well with the monitored data for the energy used for heating, especially in relation to monthly totals and the combined average energy consumption for all houses. This indicated that, on a macroscopic level, AccuRate performed well as a predictive energy rating tool.

On the other hand, the AccuRate predictions of cooling energy use in the Mawson Lakes homes were significantly lower than the monitored values. New analysis was therefore undertaken in an attempt to establish the quantum of change necessary to improve the correlation to within reasonable bounds of error. This analysis involved determining the impact of introducing new AccuRate "cooling parameters", which are listed below:

1. (a) 22ºC, (b) 27.5ºC, (c) 22.5ºC
2. (a) 23ºC, (b) 27.5ºC, (c) 25ºC
3. (a) 25ºC, (b) 27.5ºC, (c) 25ºC

Where in each of the three cases listed above, the sequence of three numbers respectively represent:

a) Cooling thermostat temperature setting. The cooling is turned off when this temperature is reached,
b) Temperature that triggers cooling, if cooling was not on in the previous hour,
c) Temperature that triggers cooling, if cooling was on in the previous hour.

It should be noted that the actual trigger points in 2nd Generation NatHERS software are considered after calculating the impacts of a range of thermal comfort effects including air movement, temperature and humidity.

Results were compared with the monitored data and the previously used default cooling parameters of (a) 25ºC, (b) 27.5ºC and (c) 27.5ºC (Note: these parameters follow the same format as those listed above). For the purposes of this report, all cooling parameters such as those listed above will be abbreviated as follows: e.g. 25, 27.5, 27.5. This new analysis is confined to cooling energy use at the new thermostat settings and has no impact on AccuRate heating estimates which will also be included in the results.

A summary of basic details of monitored and modelled houses is given below in Table 1.

Table 1: Summary of House Details

House No.	Star Rating	Air-conditioner Type	COP (heating)	EER (cooling)	Conditioned Area (m^2)	Persons
1	4.1	Ducted RCAC	3.13	2.58	84.7	3
2	4.1	Evaporative	0.808	8	79.1	2
3	4.0	Ducted Cooling	0.718	3.57	153.4	2
4	4.7	Ducted RCAC	3.2	2.69	153.2	3
5	4.2	Split RCAC	2.77	2.45	104.8	3
6	3.4	Ducted RCAC	3.21	2.87	180.2	5

Note: Houses 2 and 3 used gas for heating, the rest used Reverse Cycle Air Conditioners (RCAC) for heating.

The results from the first report (Saman et.al., 2007) on the comparison between the monitored heating and cooling data, after allowing for the heating/cooling appliance thermal performance (COP/EER) and the AccuRate predictions for the 6 homes using the default cooling temperature settings (25, 27.5, 27.5), are given in Table 2 for the two years of investigation. The results are given with and without House 3 where, due to untypical occupant behaviour, heating use was extreme and skewed the small sample.

Table 2: Monitored and AccuRate Default Heating and Cooling Energy Use 2002-03 and 2003-04

2002-03 House	Monitored (kWh/y) Heat	Monitored (kWh/y) Cool	Monitored (kWh/y) Total	AccuRate - Default (kWh/y) Heat	AccuRate - Default (kWh/y) Cool	AccuRate - Default (kWh/y) Total
1	390	497	887	1116	306	1422
2	3396	566	3962	3308	174	3483
3	15117	1901	17018	4736	1000	5736
4	857	1665	2521	1042	774	1816
5	864	810	1674	1310	412	1722
6	2124	2139	4263	1563	1382	2945
Ave with Hse 3	3791	1263	5054	2179	675	2854
Ave excl. Hse 3	1526	1135	2661	1668	610	2278

2003-04 House	Monitored (kWh/y) Heat	Monitored (kWh/y) Cool	Monitored (kWh/y) Total	AccuRate - Default (kWh/y) Heat	AccuRate - Default (kWh/y) Cool	AccuRate - Default (kWh/y) Total
1	665	333	998	1289	301	1590
2	3927	550	4477	3852	170	4022
3	17804	1380	19184	5626	976	6602
4	1494	1158	2652	1246	754	2000
5	992	731	1723	1532	376	1908
6	2258	1584	3842	1800	1312	3111
Ave with Hse 3	4523	956	5479	2557	648	3206
Ave excl. Hse 3	1867	871	2738	1944	582	2526

2. RESULTS AND DISCUSSION

2.1 COMPARISON BETWEEN ACCURATE AND MONITORED DATA

The results of the latest analysis are given below in Table 3 and show that on average, the cooling parameters 23, 27.5, 25 give the best cooling correlation in both 2002-03 and 2003-04.

Table 3: AccuRate Heating and Cooling Predictions with new Thermostat Settings

2002-03 kWh COP modified	22,27.5,22.5 Heating	22,27.5,22.5 Cooling	22,27.5,22.5 Total	23,27.5,25 Heating	23,27.5,25 Cooling	23,27.5,25 Total	25,27.5,25 Heating	25,27.5,25 Cooling	25,27.5,25 Total
House 1	1119	889	2008	1117	573	1690	1117	446	1563
House 2	3315	393	3708	3309	282	3591	3309	224	3532
House 3	4774	2162	6936	4748	1662	6410	4740	1354	6094
House 4	1046	2006	3052	1043	1342	2386	1042	1082	2125
House 5	1312	1198	2509	1310	759	2069	1310	605	1915
House 6	1567	2926	4493	1565	2118	3682	1564	1772	3336
Ave with Hse 3	2189	1596	3784	2182	1123	3305	2180	914	3094
Ave excl. Hse 3	1672	1482	3154	1669	1015	2684	1668	826	2494

2003-04 kWh COP modified	22,27.5,22.5 Heating	22,27.5,22.5 Cooling	22,27.5,22.5 Total	23,27.5,25 Heating	23,27.5,25 Cooling	23,27.5,25 Total	25,27.5,25 Heating	25,27.5,25 Cooling	25,27.5,25 Total
House 1	1293	776	2069	1290	521	1811	1290	422	1711
House 2	3868	356	4224	3859	268	4127	3853	220	4074
House 3	5677	2041	7718	5646	1573	7219	5634	1309	6943
House 4	1254	1862	3116	1250	1265	2515	1248	1042	2290
House 5	1538	1029	2566	1535	692	2227	1534	552	2086
House 6	1805	2591	4396	1802	1994	3796	1800	1689	3490
Ave with Hse 3	2573	1442	4015	2564	1052	3616	2560	872	3432
Ave excl. Hse 3	1952	1323	3274	1947	948	2895	1945	785	2730

Table 4 below summarises the results showing predicted AccuRate average annual energy use as a percentage of the monitored data, excluding data for House 3.

Table 4: Percentage difference between Monitored Data and AccuRate for the various cooling parameters, 2002-03 and 2003 - 04

	Cooling Paramet	Heating	Cooling	Total
2002/03	22,27.5,22.5	9.5%	30.6%	18.5%
	23,27.5,25	9.4%	-10.6%	0.8%
	25,27.5,25	9.3%	-27.3%	-6.3%
	Default	9.3%	-46.3%	-14.4%
2003/04	22,27.5,22.5	4.5%	51.8%	19.6%
	23,27.5,25	4.3%	8.8%	5.7%
	25,27.5,25	4.2%	-9.9%	-0.3%
	Default	4.1%	-33.1%	-7.7%

Other sections of this report consider the results in more detail in attempting to understand the reasons behind the improvements and to make suggestions for future refining work. The analysis included in sections 2.2-2.4 has been based on data for the year 2002-03.

2.2 DETAILED ANALYSIS OF RESULTS

To smooth out as much as possible behavioural impacts by individual household occupants, total average monthly heating and cooling energy use, calculated from both the monitored data and the AccuRate predictions, for the various cooling parameters were plotted. See Figure 1 (excluding House 3) & Figure 2 (including House 3). Note that for cooling, House 3 occupants did not have such extreme behaviour as they did for heating. The following is immediately evident from the figures below:

- The default case of AccuRate shows by far the worst match for cooling energy consumption,
- Though overall cooling parameter 23, 27.5, 25 is, as indicated above, the best predictor it shows a better fit in November, February and March than for the other months and 22, 27.5, 22.5 is better in December and January.

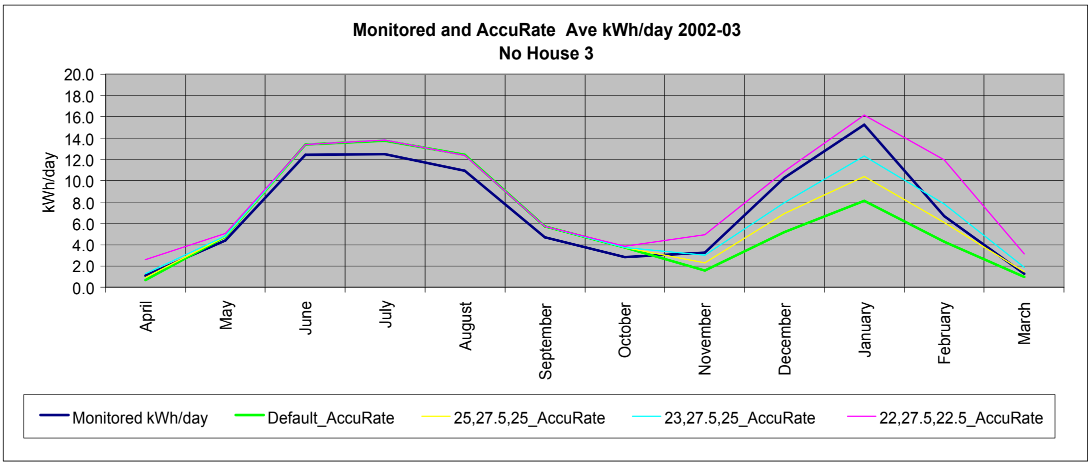


Figure 1: Monitored and AccuRate Monthly Average Energy Use for the Different "Cooling Parameters" (excluding House 3)

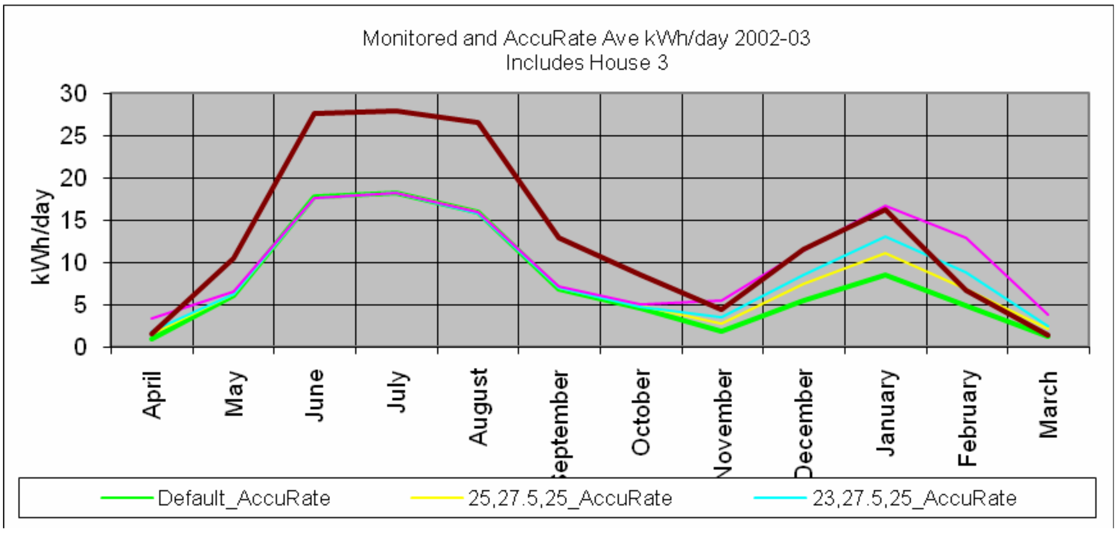


Figure 2: Monitored and AccuRate Monthly Average Energy Use for the Different "Cooling Parameters" (including House 3)

An attempt was made to determine the reasons behind the better match for cooling parameter 23, 27.5, 25 in November, February and March and 22, 27.5, 22.5 for December and January respectively. A first step was to consider the ambient temperature variation over the summer. A plot of maximum temperatures for the summer of 2002-03 is shown below in Figure 3.

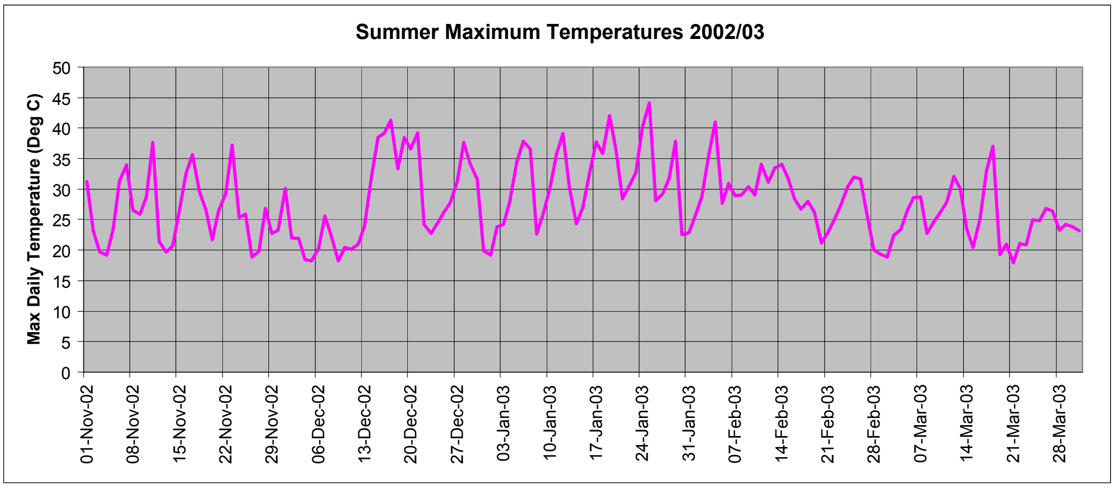


Figure 3: Daily Maximum Ambient Temperatures November 2002 – March 2003

It can be seen that December and January were consistently hotter than the other months. In fact there were only three isolated days having maxima above 35ºC in February and March and two in November. On the other hand there were many more consecutive days with temperatures over 35ºC in the other two months.

It is noted that Houses 3, 4 and 6 (all of which have ducted air conditioners) showed the best match between monitored data and AccuRate 23, 27.5, 25 for November, February and March and AccuRate 22, 27.5, 22.5 for December and January. House 4 is shown as an example in Figure 4.

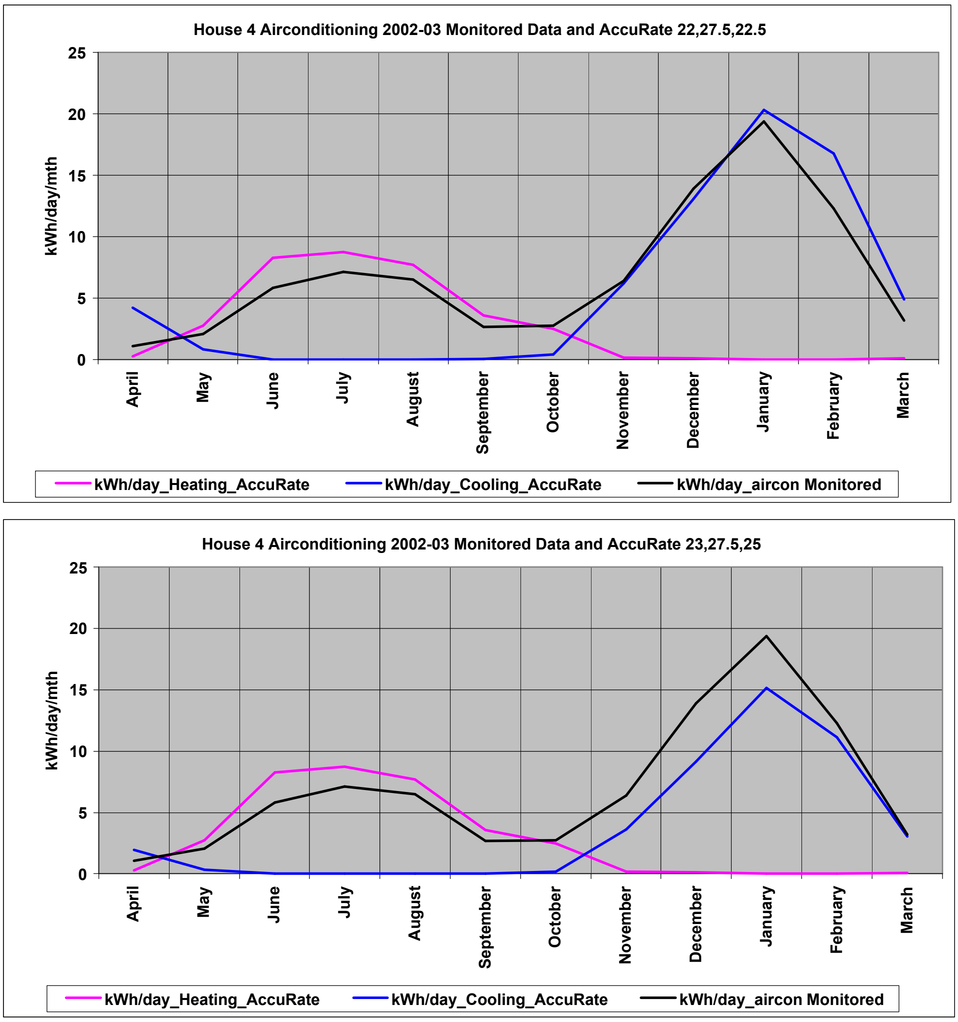
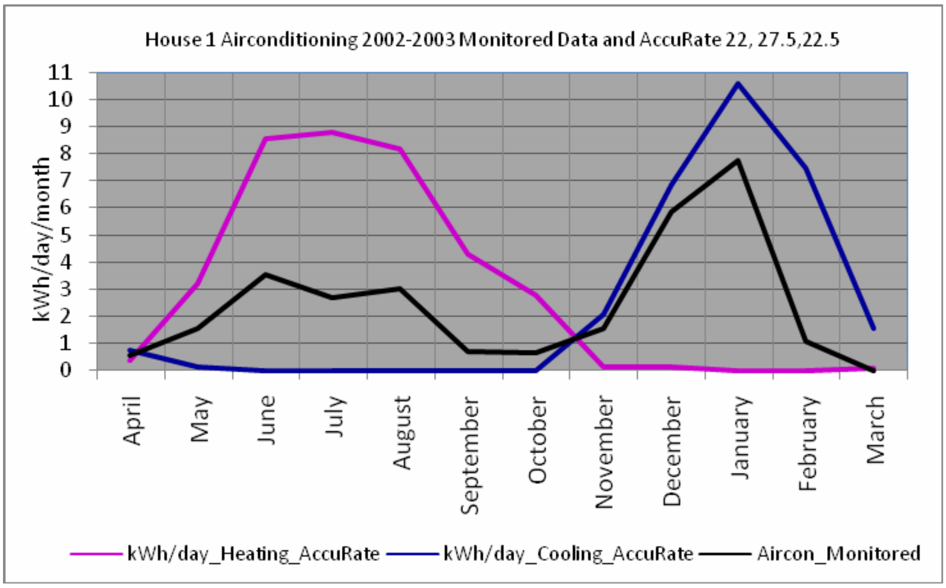


Figure 4: House 4, Monitored and AccuRate data 22,27.5,22.5 and 23,27.5,25

The only other home with a ducted air conditioner was House 1, a home where the people were very energy conscious and used about 10 % less energy than the state average for their household occupancy of 3 persons. They also used their air conditioner sparingly, mainly only turning it on when temperatures were higher than 34ºC. For this home the cooling parameter 23, 27.5, 25 was the best fit over the whole of summer, as shown in Figure 5.



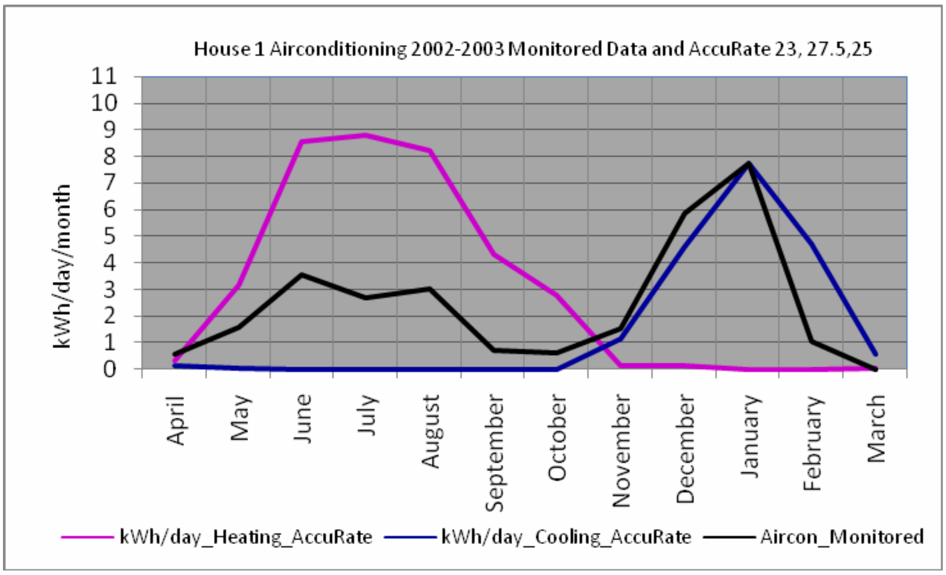
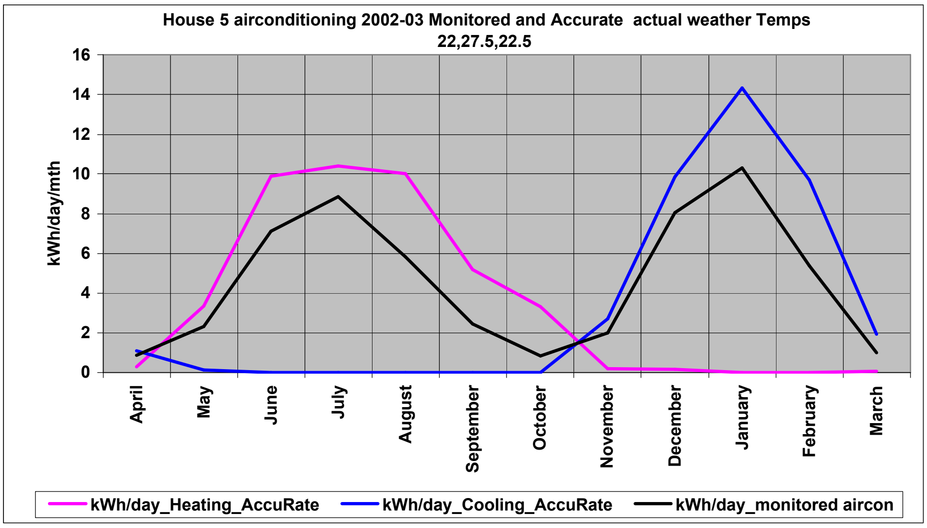


Figure 5: House 1, Monitored and AccuRate Data 22,27.5,22.5 and 23,27.5,25

The remaining two air conditioners are the evaporative system in House 2 and the split RCAC in House 5. The evaporative air conditioner is interesting as it will be shown later that it appears that the used EER value of 8 has been an overestimate. Also the monthly profiles seem to show little sensitivity to the thermostat setting.

All the ducted RCACs show quite an increase in peak daily load as the temperature increases, however, this is not as noticeable with the split RCAC in House 5 even though its EER is the lowest at 2.45, as shown in Figure 7 (Note: the star rating of House 5 is the second highest at 4.2). The best match with monitored data is with AccuRate cooling parameter 23, 27.5, 25 for the whole year, as shown in Figure 6.



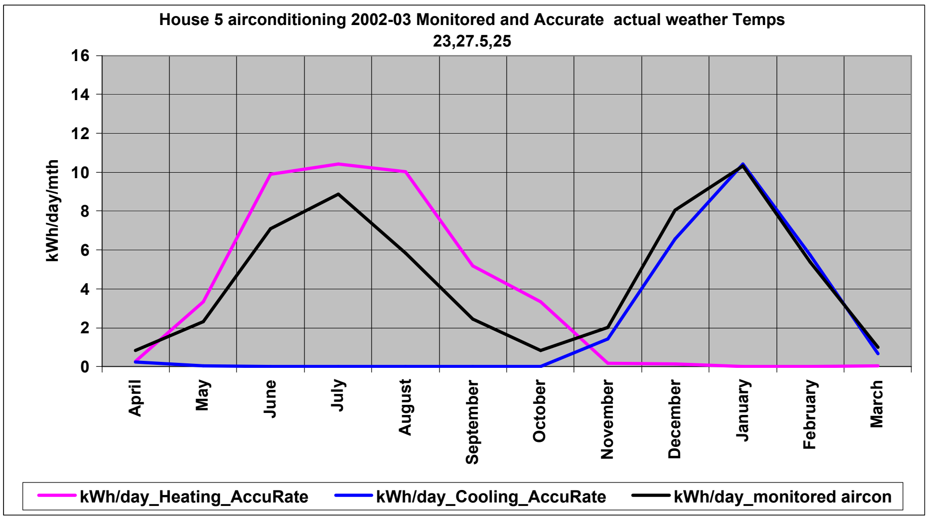


Figure 6: House 5, Monitored and AccuRate Data 22,27.5,22.5 and 23,27.5,25

2.3 IMPACT OF TEMPERATURE ON POWER DEMAND AND ENERGY CONSUMPTION

In this report the interest is mainly on total energy use rather than power demand. Never the less, it is useful to show how the maximum daily power demand of the various air conditioners varies as the maximum daily temperature increases. Figure 7 demonstrates how consistent the monitored power demand of the evaporative air conditioner is over the full temperature range. The split RCAC shows the next lowest variation, though it has some 'outlying' points which could be spurious. All the other RCAC's are ducted and show significant increases in power demand with ambient temperature. The number of points in the graph demonstrates the frequency of air conditioner use. The low use of the cooling system in House 1 is evident with the next lowest use being in House 6, with systems in the remaining houses operating frequently even during milder weather.

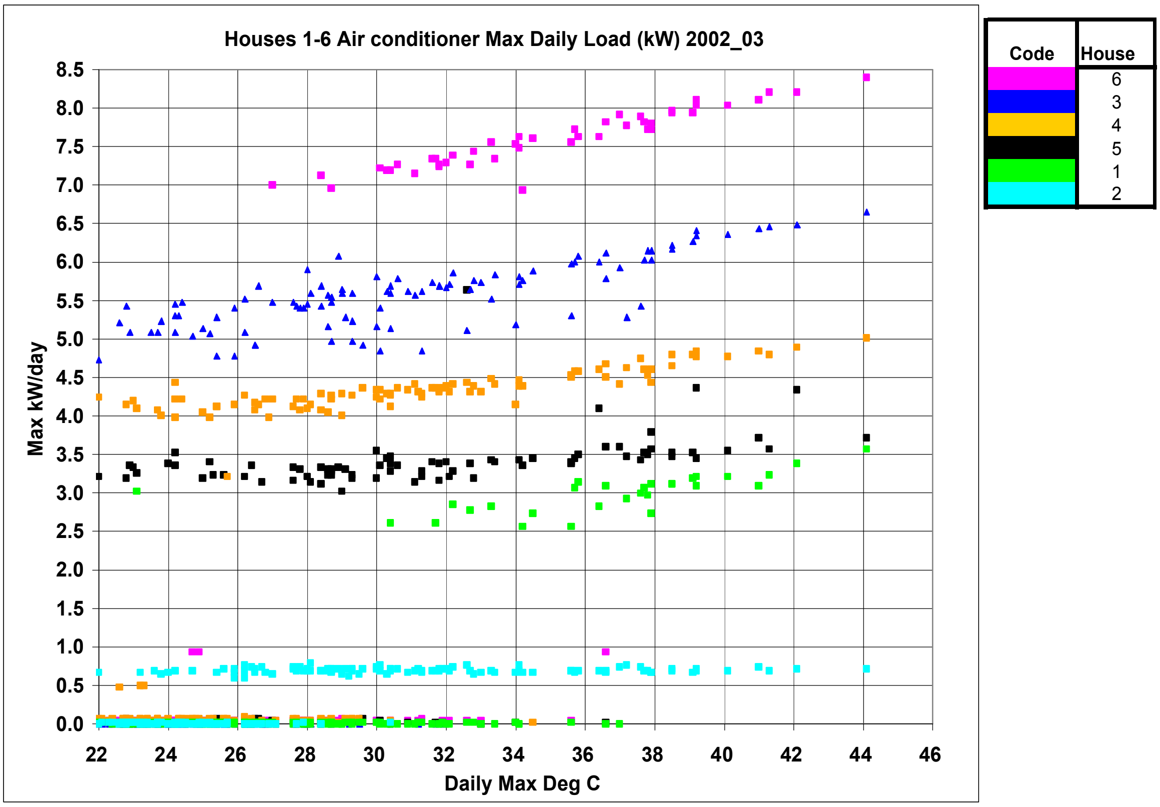


Figure 7: Maximum Daily Air conditioner Load (Cooling) vs. Maximum Daily Temperature for the Year 2002-03.

A comparison of monitored and AccuRate predicted energy as a function of temperature is given in Figure 8 for the average of all homes and for the cooling parameters 22, 27.5, 22.5 and 23, 27.5, 25. It should be noted that there is a better match for temperatures up to approximately 36ºC for cooling parameter 23, 27.5, 25, but the match becomes marginally better at higher temperatures for 22, 27.5, 22.5.

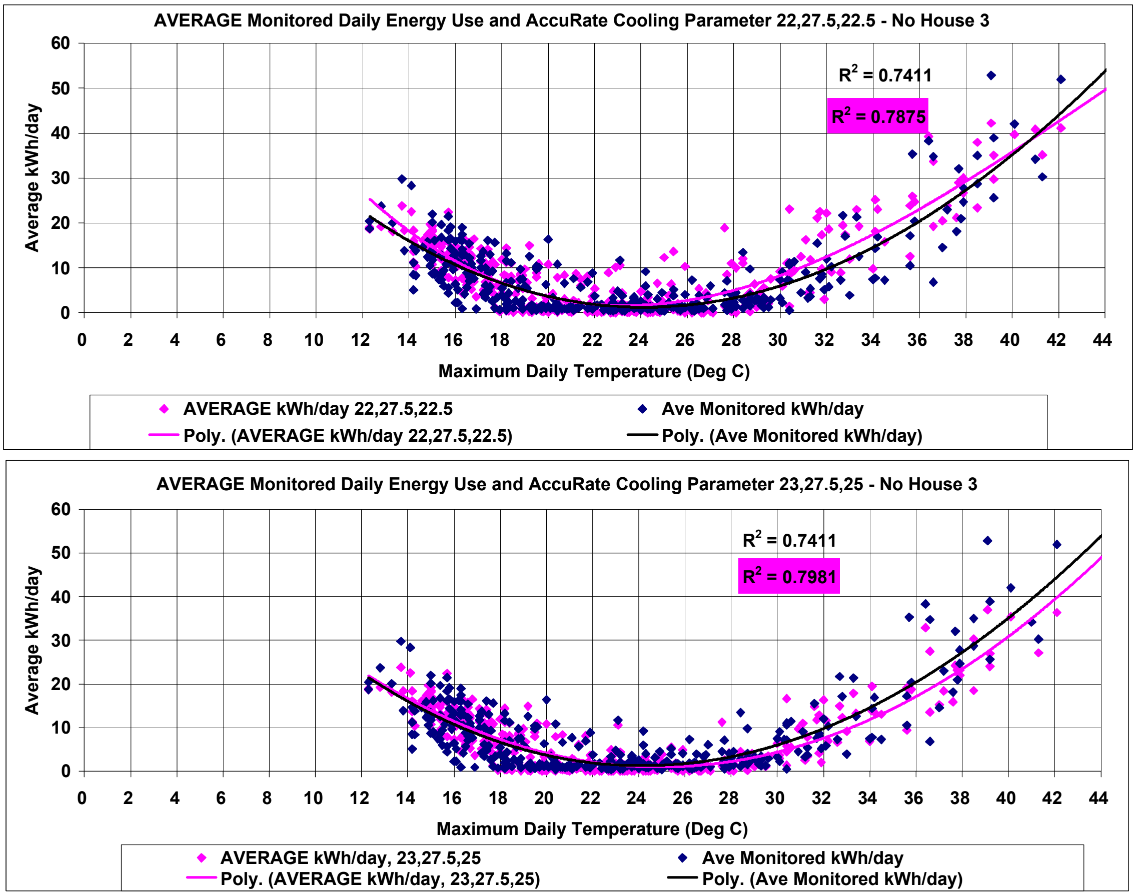


Figure 8: Average from All Homes Daily Energy vs. Max Daily Temperature 2002-03 (No House 3)

Figure 9, Figure 10 and Figure 11 display similar graphs for House 6 (ducted RCAC), House 5 (split RCAC) and House 2 (evaporative). Figure 11 shows a closer match between the monitored and AccuRate data when an EER value of 6 rather than 8 is used for the cooling parameter 22, 27.5, 22.5. This result alerts to the need to correctly account for ducting energy losses in evaporative cooling systems.

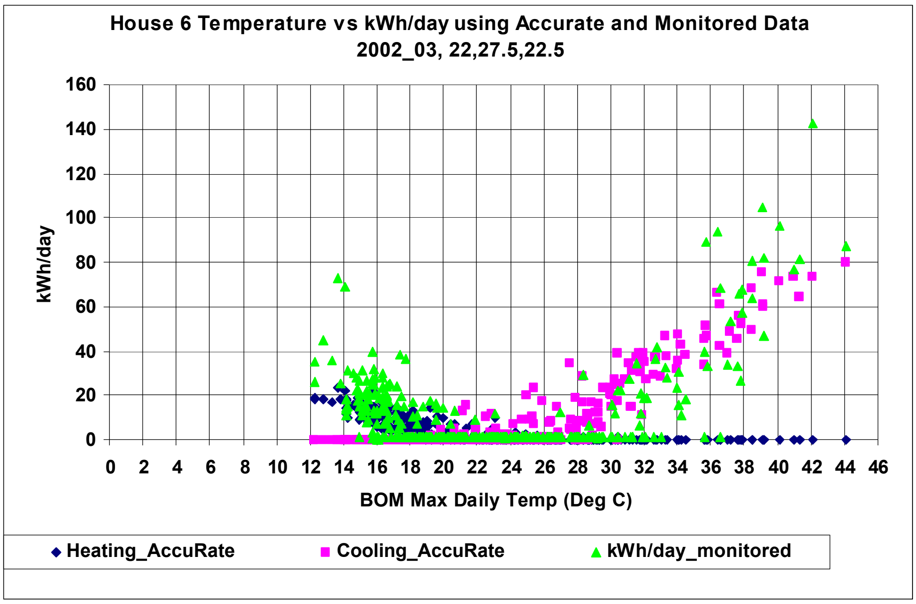


Figure 9: House 6, Daily Energy vs. Max. Daily Temperature 2002-03

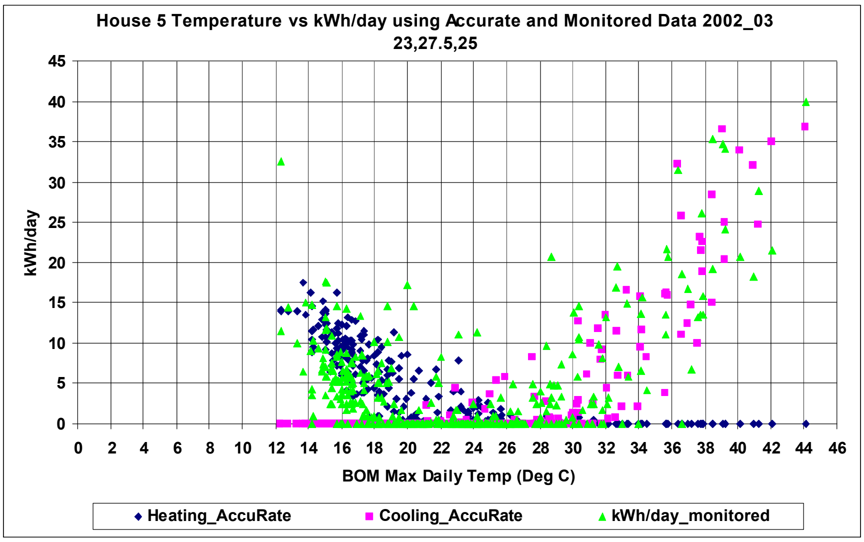


Figure 10: House 5, Daily Energy vs. Max. Daily Temperature 2002-03

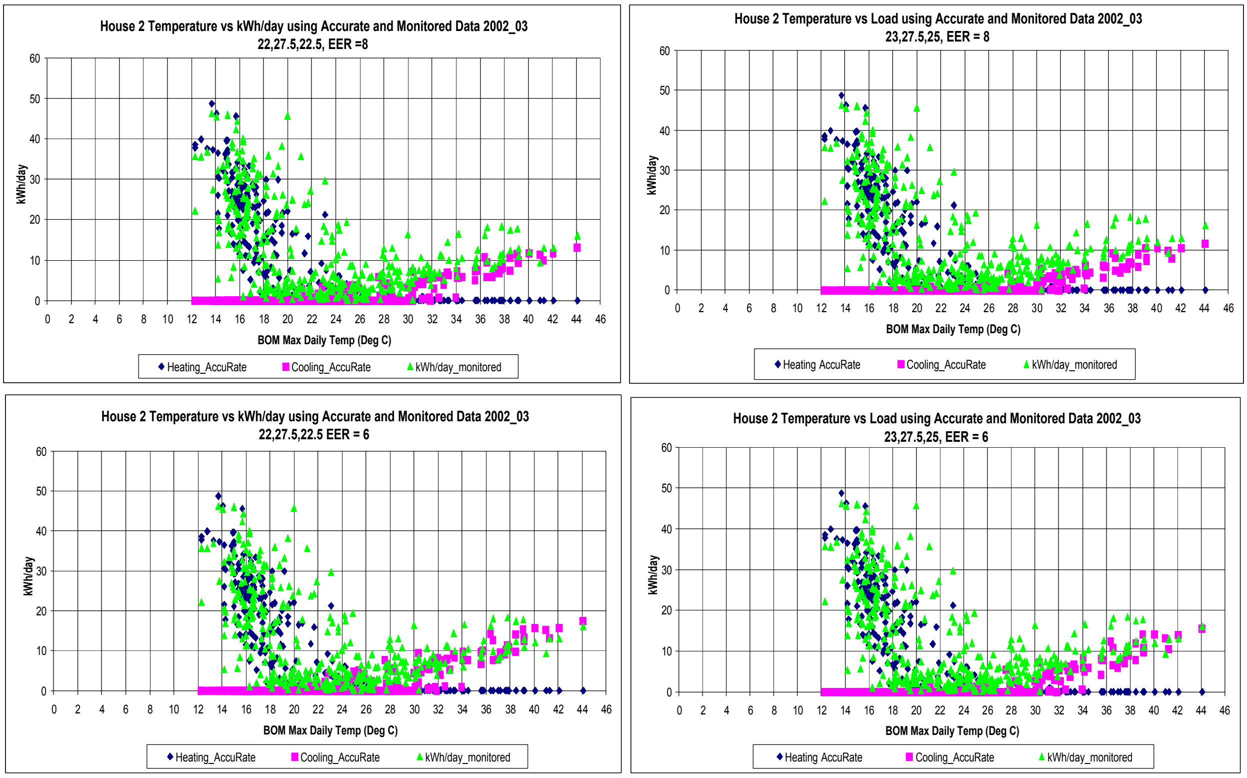


Figure 11: House 2, Daily Energy vs. Max. Daily Temperature 2002-03, EER = 8 & 6

2.4 MATCHING DAILY RATHER THAN MONTHLY DATA

It has been shown that a reasonable match can be produced between monitored and AccuRate data on a monthly basis by adjusting the "cooling parameters". Looking at the match on a daily basis, but also averaged over all homes, the match is not as good. However, as would be expected, the same conclusions arise that on average AccuRate at 23, 27.5, 25 provides the best match with monitored data, as shown in Figures 12 - 14.

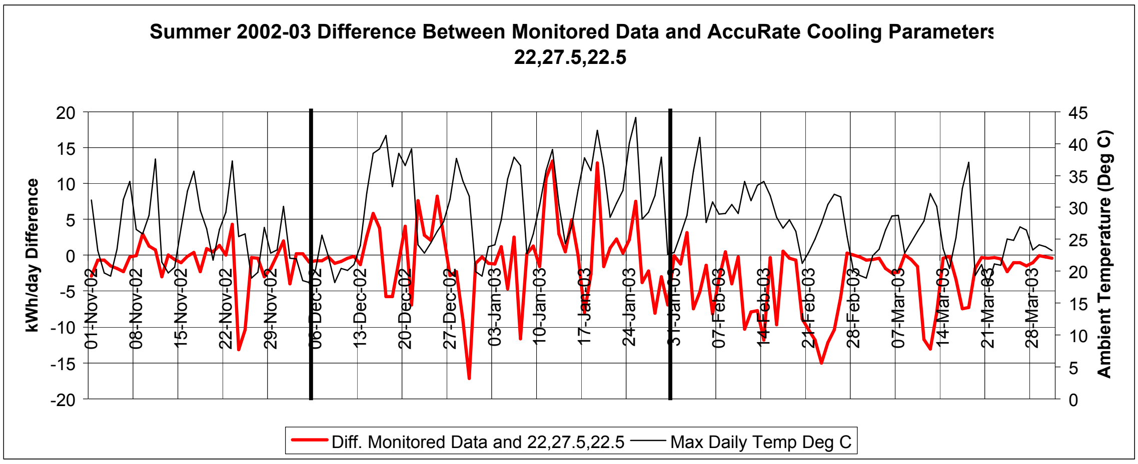


Figure 12: Average Daily Difference Between Monitored Data & AccuRate Cooling Parameters 22,27.5,22.5 for Summer 2002-03 (All Homes)

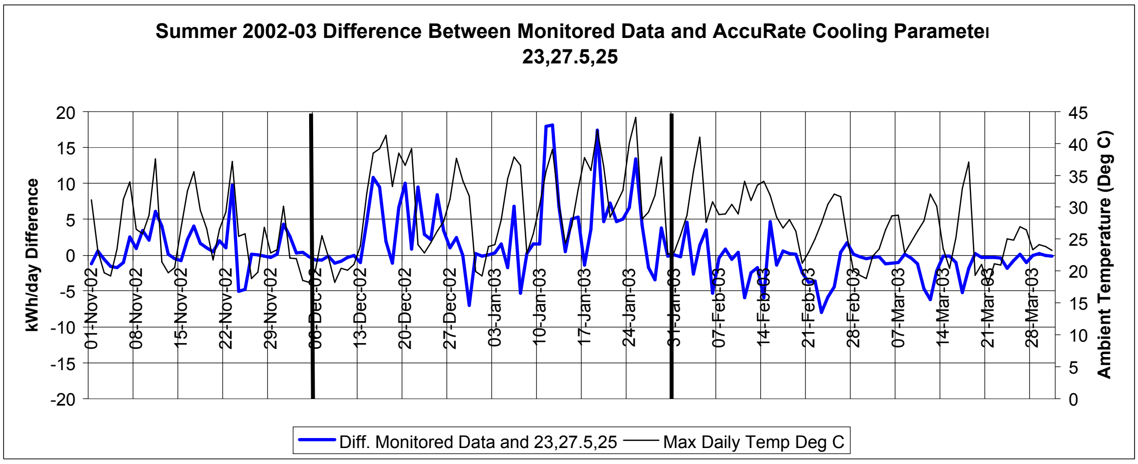


Figure 13: Average Daily Difference Between Monitored Data & AccuRate Cooling Parameters 23,27.5,25 for Summer 2002-03 (All Homes)

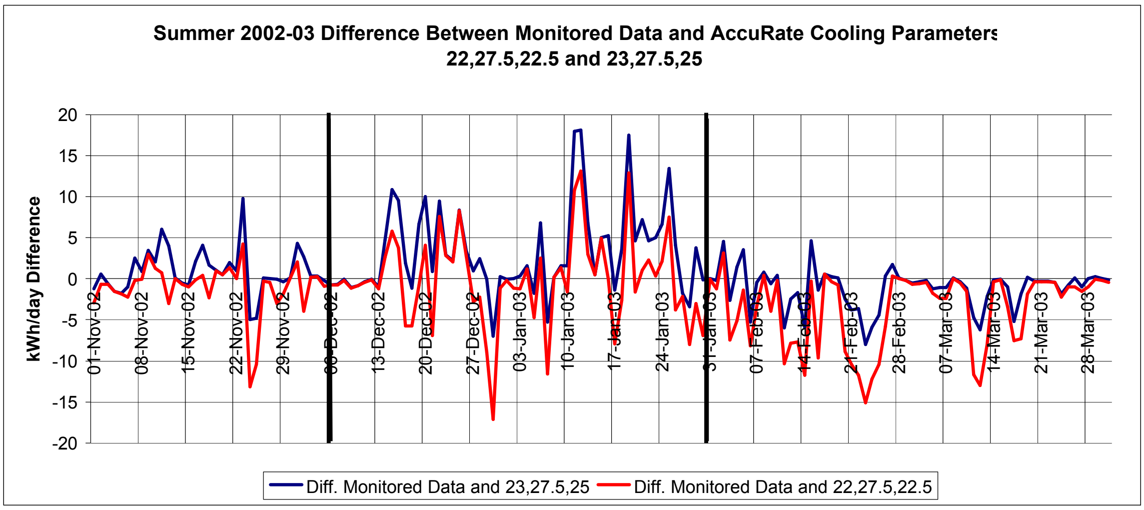


Figure 14: Avg. Daily Diff. Between Monitored Data and AccuRate Cooling Parameters 22,27.5,22.5 & 23,27.5,25 for Summer 2002-03 (All Homes)

Table 5: Average Monthly Energy Difference between Monitored Data and AccuRate Data (Derived from Figure Data)

Month	**Difference between Monitored Data and AccuRate 22,27.5,22.5 (kWh/mth)**	**Difference between Monitored Data and AccuRate 23,27.5, 25 (kWh/mth)**
November	-34	24
December	-20	69
January	7	122
February	150	-36
March	-73	-32
Total (kWh)	**-270**	**147**

From Table 5 it can be seen that 23, 27.5, 25 gives the best overall match, which is best in February and March and 22, 27.5, 22.5 provides a better correlation in December and January. In November, two large negative numbers on mild days have skewed the results for 22, 27.5, 22.5.

2.5 NEW COOLING SETTINGS: IMPLEMENTATION OF THE NatHERS WORKSHOP RECOMMENDATIONS

A NatHERS Expert workshop held in Adelaide on 14 December 2007 discussed the findings presented in an earlier version (December 2007) of this report detailed above. The participants included Associate Professor Richard de Dear (Macquarie University), Emeritus Professor Steve Szokolay (Queensland University), Associate Professor Terry Williamson (Adelaide University), Professor Wasim Saman (University of South Australia), Associate Professor Monica Oliphant (University of South Australia) and Dr Angelo Delsante (CSIRO).

To improve the theoretical basis for AccuRate cooling predictions, the workshop discussed various factors affecting thermostat setting including thermal comfort, activity and local outside temperatures.

The cooling settings for all NatHERS climate zones are linked to the unique Neutral Temperature T_n. The current version of AccuRate set the cooling thermostat set point based on the following logic:

If temp > (T_n + 2.5 + air movement benefit) then cool to T_n

Based on this logic, the reference manual built in the AccuRate software lists the cooling thermostat settings for 69 different climatic zones. The same manual lists the heating/cooling period for each type of room as shown in Table 6.

Table 6 – AccuRate heating/cooling periods

Room Type	Heating/Cooling
Bedroom	16.00 - 09.00
Living/Kitchen	07.00 - 24.00
Other (daytime usage)*	07.00 - 24.00
Other (night-time usage)*	16.00 - 09.00
Garage*	07.00 - 24.00

* If heated or cooled

The workshop determined that there was a sufficient evidence basis for the consideration of two additional aspects for the cooling methodology:

(a) Separate cooling settings for assumed sleeping hours and waking hours based on the consideration of the insulation qualities of the bed and bedding, and the inability of the sleeping occupant to respond to discomfort (this concept already exists for heating settings); and,
(b) Separate cooling settings for periods after the initial trigger of air conditioning, based on evidence that discomfort perception for a particular space will change in periods immediately after cooling has been invoked.

The workshop also determined that the suggested improvements could be quantified and incorporated into the Chenath model.

Delsante (2008) translated the Workshop consensus into a new algorithm for formulating the cooling temperature setting and the cooling trigger temperatures as follows:

Cooling thermostat setting

$T_{C\text{-waking}}$ = 24.0°C everywhere

T_C-sleeping = 22.5°C everywhere

Neutral temperature, T_n

Neutral temperature (waking), $T_{n\text{-waking}}$, is based on mean outdoor temperature for December, January and February (previously January mean only).

$T_{n\text{-sleeping}} = T_{n\text{-waking}} - 1.5$

Trigger temperature, $T_{trigger}$

$T_{trigger\text{-waking}} = T_{n\text{-waking}} + 2.5$ + ventilation benefit ← if cooling was not ON in the previous hour

$T_{trigger\text{-waking}} = T_{n\text{-waking}} + 0.5$ + ventilation benefit ← if cooling was ON in the previous hour.

$T_{trigger\text{-sleeping}} = T_{n\text{-sleeping}} + 2.5 + 0.5$ * ventilation benefit ← if cooling was not ON in the previous hour

$T_{trigger\text{-sleeping}} = T_{n\text{-sleeping}} + 0.5 + 0.5$ * ventilation benefit ← if cooling was ON in the previous hour

The above algorithm translates into the following new trigger settings of AccuRate for the Adelaide climatic zone (Delsante, 2008), shown in Table 7. These new settings were used to generate AccuRate results presented in Section 2.6.

Table 7 - AccuRate's new thermostat settings for Adelaide

Usage	Time	Thermostat Settings (°C)	Trigger temperatures (°C)	
			cooling was not ON in previous hour	cooling was ON in previous hour
Daytime	09.00–16.00	24.0	27.3	25.3
Waking	07.00-09.00 16.00-24.00	24.0	27.3	25.3
Sleeping	24.00-07.00	22.5	25.8	23.8

As the cooling settings for all NatHERS climate zones are linked to the Neutral Temperature T_n, calculated from the local weather data, therefore the above settings are only valid for Adelaide. Similar settings can be constructed for all NatHERS climatic zones.

2.6. COMPARISON BETWEEN 2 YEAR AVERAGED MONITORED DATA AND PREDICTIONS OF ACCURATE WITH 3 DIFFERENT SETTINGS

The comparison between the 2 year averaged monitored data and the predictions of AccuRate for 3 different thermostat settings is given in Table 8. The two first AccuRate settings were the settings proposed by UniSA (see section 1) which predict better than the original 'default' settings. The 'new settings' are the settings proposed by the Workshop (Table 7).

Table 8 – Comparison Between 2 Year Averaged Monitored Data and Predictions of AccuRate With 3 Different Setting

2 Yrs Ave.	Monitored Data			23,27.5,25			25,27.5,25			New Settings		
House	H	C	T	H	C	T	H	C	T	H	C	T
1	527	415	942	1204	547	1751	1203	434	1637	1203	502	1705
2	3661	558	4219	3584	275	3859	3581	222	3803	3583	260	3844
3	16461	1641	18101	5197	1618	6815	5187	1331	6518	5195	1507	6702
4	1175	1411	2587	1147	1304	2450	1145	1062	2207	1146	1232	2378
5	928	771	1699	1422	725	2148	1422	579	2001	1422	674	1999
6	2191	1862	4053	1683	2056	3739	1682	1730	3413	1683	1958	3641
Ave with H3	4157	1109	5267	2373	1087	3460	2370	893	3263	2372	1022	3394
Ave excl H3	1697	1003	2700	1808	981	2789	1807	805	2612	1808	925	2733

The percentage differences between the monitored data and AccuRate predictions from 3 different settings are presented in Table 9.

Table 9 – Percentage Difference Between Monitored Data and AccuRate With Three Different Settings Based on 2 Year Average Data.

AccuRate Settings	Heating	Cooling	Total
New Settings	6.5%	-7.8%	1.2%
23,27.5,25	6.6%	-2.2%	3.3%
25,27.5,25	6.5%	-19.7%	-3.3%

As can be seen in both Tables 8 and 9, on the 2 year average basis and excluding house 3 data, the predictions of "23, 27.5,25" settings and "New Settings' closely match the monitored data results.

Figure 15 shows the 2 years average values of monthly average energy use from monitored data and AccuRate predictions with 'new' and the original 'default' settings (excluding House 3). As seen, on a monthly basis, the results of AccuRate 'new settings' are close to the monitored data.

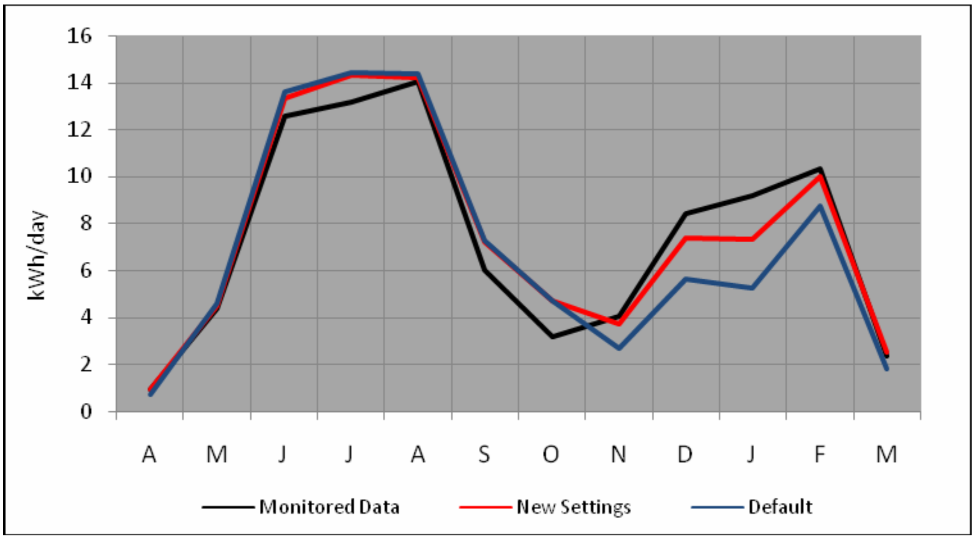


Figure 15: Monthly Average Energy Use from Monitored Data and AccuRate Predictions With New and Default Settings (2 year average – excluding House 3)

2.7 PEAK POWER DEMAND - COOLING DAYS

Since peak power demand in a home can be determined not only by weather, but also by special activities taking place in the home which require abnormal energy use, the peak load day in this report is the day of maximum SA electricity system demand, February 4th 2003. In 2002-03 this did not coincide with the hottest day, which occurred on January 25th, close to the Australia day holiday. Figures 16 and 17 plot the February 4th monitored air conditioner power demand (electricity use) and AccuRate predictions. It should be noted that monitored profiles show an appliance that is either on, off or cycling between these two positions. The difference in demand profiles predicted by AccuRate and those actually taking place is not surprising in terms of both the magnitude and timing. The AccuRate profiles are based on house heating and cooling requirements to maintain the temperature within defined temperature set points. They are based on rigid, predetermined occupancy patterns. On the other hand, the timing of energy use by the cooling appliance is determined by the space occupancy pattern and the occupants' behaviour in switching the appliance on or off. The maximum power demand is solely determined by the appliance power demand which is determined by its cooling capacity and EER.

There is therefore little likelihood that these two profiles will ever look the same for a single home and single day occupant behaviour, but it must be recognised that the profiles produced by 2nd Generation NatHERS software could mimic the average behaviour of all households in that climate zone.

This study has determined that a substantially larger sample will be needed to establish a realistic profile of household consumption for a single hour or single day. The exercise examining the total annual heating and cooling energy consumption masks much of the impact of hourly or daily behaviour by assessing a total of over 100,000 hours over the two year study. This masking is not possible when exploring a single 24 hour period of extreme temperature.

Below, the load curves for cooling parameters 22, 27.5, 22.5 and 23, 27.5, 25 are compared to highlight the problem of assessing single day behaviour from a small sample.

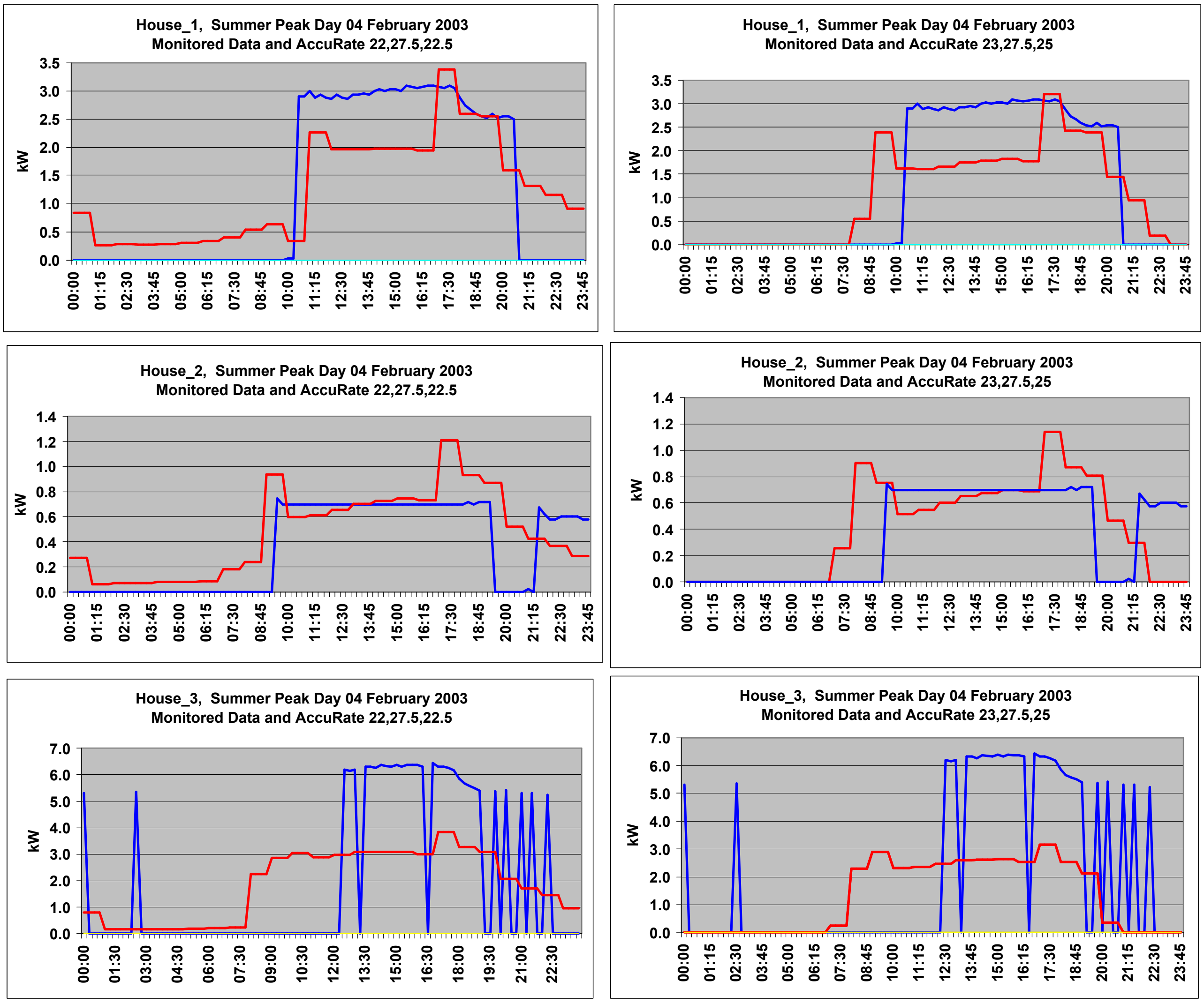


Figure 16: Peak Load Day 4/2/03, Houses 1 - 3. Comparison between Monitored air conditioner load and AccuRate Data – Cooling Parameters 22,27.5,22.5 and 23,27.5,25 [Legend: Monitored Data, AccuRate Data]

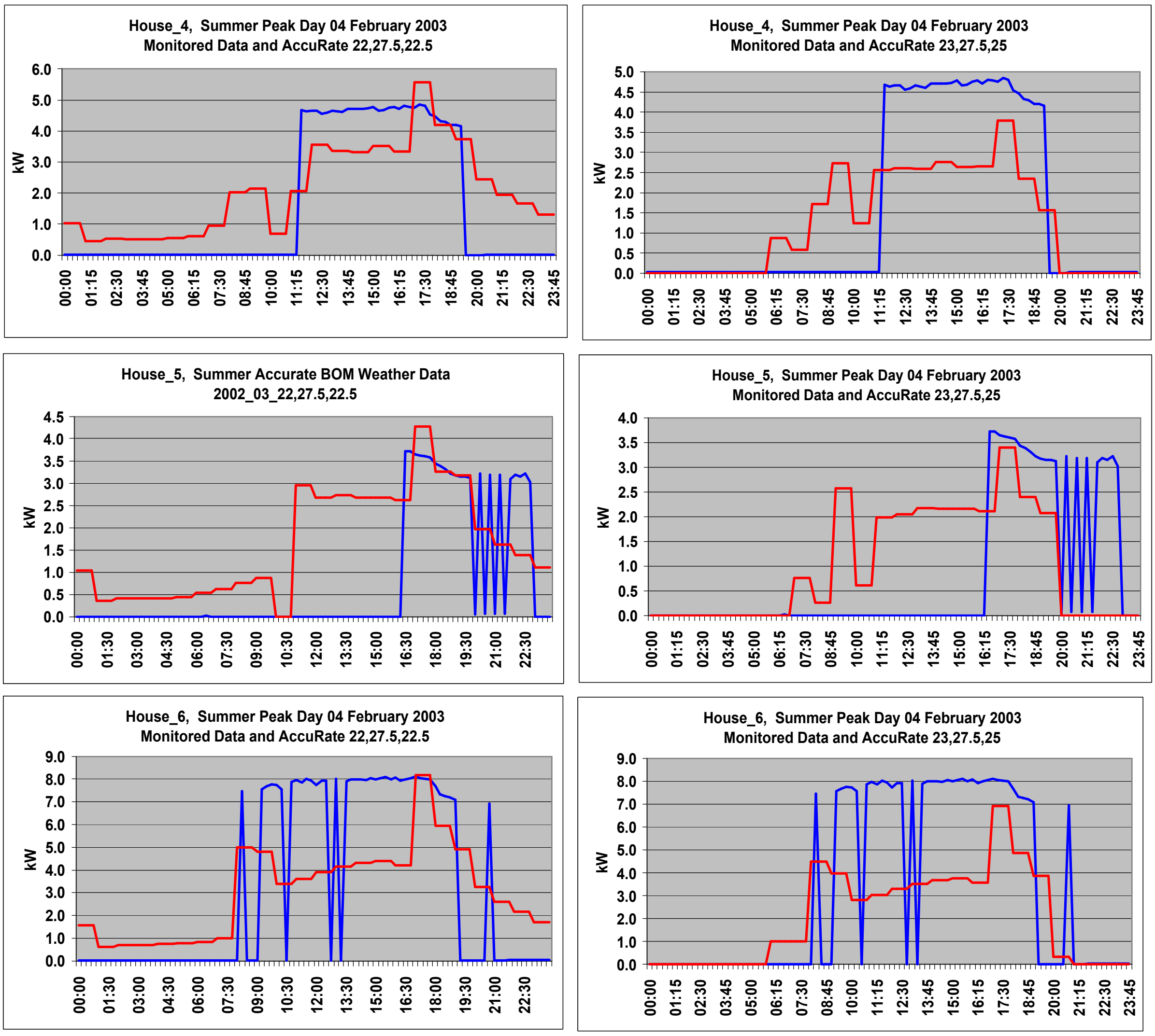


Figure 17 - Peak Load Day 4/2/03, Houses 4 - 6. Comparison between Monitored air conditioner load & AccuRate Data – Cooling Parameters 22,27.5,22.5 and 23,27.5,25

[Legend: Monitored Data, AccuRate Data]

3. CONCLUSIONS

The previous study conducted earlier (Saman et. al., 2007) supported the perception that the current cooling methodology in 2nd Generation NatHERS was consistently underestimating the amount of cooling measured in the small Adelaide sample.

The data obtained from the earlier research showed that the AccuRate "cooling settings" of 23, 27.5, 25 provide the quantum of change necessary to gain a better fit with the monitored consumption. Using the 'Default' settings from the previous report, the respective differences were -46.3 % and -33.1 %, therefore a significant improvement could be achieved. In addition, it was also found that using the cooling settings of 23, 27.5, 25 provides a better match between AccuRate and monitored data at lower temperatures but the settings of 22, 27.5, 22.5 are better at higher temperatures.

This study notes that a group of Australian thermal comfort experts who assembled to consider this issue have agreed on a new theoretical basis for changing the cooling calculation set point parameters whilst remaining consistent with the original intent of the methodology, and have quantified the changes described as "New Settings". The report has shown that the AccuRate "New Settings" recommended during the NatHERS workshop provide a good fit with monitored data, predicting cooling energy use to be just 7.8% less and total annual energy use 1.2% more on a 2 year average basis.

The monitored data shows – especially for ducted air conditioners – that as temperature increases, the monitored energy requirements also increase. Conversely, it is seen that the monitored energy use of the evaporative air conditioner is considerably lower and not influenced by temperature. In addition, since evaporative air conditioners have not generally had thermostat controls in the past, the match with monitored data is minimally impacted by AccuRate cooling parameters. Currently evaporative coolers make up less than 10 percent of the Australian market.

Using temperature versus energy graphs, as displayed in Figure 10, may provide a good indicator on whether an appropriate COP or EER has been used to convert modelled (AccuRate) results to electrical energy consumption. Although the best available data for COP and EER was obtained for use in this project, preliminary research involving testing of actual systems, carried out at UniSA (Bruno 2007), has demonstrated a drop in the thermal performance of cooling systems due to elevated ambient temperatures.

The AccuRate cooling study has demonstrated the need to adjust the cooling temperature settings in 2nd Generation NatHERS to bring the predictions closer to monitored data and to enable the use of AccuRate as a means for predicting energy consumption. However, this analysis has been based on a very small sample and needs to be repeated on a much larger and diverse group of homes, with occupants having differing socio-economic characteristics. The results therefore need to be viewed with caution.

4. RECOMMENDATIONS

Based on the outcomes of this project, the following recommendations are proposed in order to further improve the confidence and validity of 2nd Generation NatHERS rating tools:

- The cooling methodology in 2nd Generation NatHERS tools be changed to the "New Settings" determined by the expert group.
- Larger, statistically representative samples of detailed household energy consumption behaviour are needed as a matter of national research priority.
- Additional comparisons of AccuRate outputs on a larger sample of household energy data when they become available will be necessary to improve the statistical validity of this work. This sample should include different locations and households with diverse socio-economic characteristics.
- As energy use of air conditioning appliances is a significant factor in determining peak power demand and total energy consumption, the impact of age and ambient temperature during periods of extreme ambient temperatures on the thermal performance of air conditioning appliances needs further examination.
- Specific peak demand research focusing on average occupant behaviour is necessary before AccuRate estimation of peak power demand for heating and cooling can be relied on.

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