4 TECHNICAL FACTSHEET
Hot Water System (HWS)

Hockerton Housing Project
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Summary

The HWS initially involved an air to water heat pump connected indirectly to a 1500lt super insulated hot water storage tank. Now four out of the five HHP houses use immersion heaters to heat the water and three houses have new 500lt "Hotsi" hot water tanks.

Heat Pump System with 1500lt thermal store

In 1997 the houses were installed with a HWS which in now present in only one house. In this system hot water is provided indirectly from a large store of heated water, the temperature of this store is increased via a heat pump that transfers energy from the conservatory to the water. The 700-watt Baxi heat pumps use an evaporation condensation cycle to transfer the energy.

This heat pump uses electrical energy to extract heat energy. The ratio of delivered heat energy to electrical energy input is called the **coefficient of performance (COP)**. The manufactures predicted the COP to be about 3 - i.e. for each kWh of electrical energy in, 3 kWh of hot water energy is generated. In practice a lower figure was obtained.

The conservatories act as huge passive solar collectors heating the air inside them, thus allowing the heat pumps to operate with a relatively high input temperature. The hotter the air the more efficient the system becomes.

There is a high capacity for storing such gains during hot periods, due to the very large hot water tanks, with up to 1,500 litres capacity. These tanks are super-insulated (with at least 300mm expanded polystyrene on the sides and base) to minimize waste heat losses. Pumps are used to circulate water from the heat pump to the storage tanks.

Overall the combined system of heat pump and super-insulated thermal water store reduces the energy requirements for hot water by about 75%.

Developments

More recently HHP members have been researching how effective smaller size super-insulated stores can be used in energy-efficient systems. The HHP 'Hotsi' tank has been installed in a number of homes including three at HHP. They have been installed with conventional 1kW immersion units. There is also a trial tank connected to a solar thermal system in the HHP office.

Key Facts (Initial System)

- Water heated via air to water heat pumps
- Back up electric immersion heater
- Super capacity thermal store (1,500 litres)
- Super-insulated thermal store (min. 300mm)

Current System

- "Hotsi" Smaller scale thermal store with emersion heater

Heat pump on porch platform, insulated ducting going through wall to conservatory

The source of hot air for heat pumps

Initial Hot Water Generation

(See graphic opposite)

Summary

Heatpumps draw air from the conservatories transferring heat to water. This water is circulated between the heatpump and a large thermal store. Water for use is heated as it passes through extensive copper piping immersed in the thermal store. Thermostat controls affect end of use temperature and efficacy of the system.

Conservatories

The large conservatories are both an excellent amenity and a solar receiver. They provide the pool of heat energy from which the whole system depends

Conservatory with heat pump inlet on top left and outlet on lower right – Washing benefits from airflow!

Heat pump

Each home had a 700 Watt (including fan and pump) air-to-water heatpump. They operate essentially as reverse refrigerators taking heat from air drawn from the conservatory and transferring it to water flowing between the heatpump and the thermal store. The warmer the air is in the conservatory, the more effective the heat transfer process. The air intake is therefore located through the porch/ conservatory wall near its apex to make use of the warmer at the top of the sunspace. The COP ratio (*see text box opposite*) varies from 1 to 3 with it being lowest in the winter as conservatory temperatures drop below 10^{o}C. During this time to produce the required amount of hot water the heat pump has to run for about 6 hours, when the COP is typically only about 1. The COP ratio increases on Sunny days achieving a maximum COP of about 3 and a run time of about 2.5 hours. The COP is also affected by the water temperature running into the heat pump – the lower it is the higher the potential temperature 'lift' required.

The **coefficient of Performance (COP)** is a measure of how effective the energy output is in relation to energy input into the system. A COP of 3 means that for every kWh of electrical energy put in to run the system, it delivers the equivalent of 3kWh of hot water. A COP of 1 is where the energy inputs match the outputs and would compare with a simple direct heating mechanism such as an electric immersion.

Heat pump with lid off for inspection and repair

Whilst the heat pump is running, water is continually circulated between the unit and the thermal store by use of a 'Grundfos' pump. All piping between the heatpump and store is well-insulated with tight polythene foam insulation.

Pump with control unit above on wall *(note insulated pipes – the pump insulation has been removed for image)*

Controls

The heat pump has a set of controls that allow occupants to set 'on' and 'off' times, as well as a manual override. In most cases they are set to operate from mid-morning to late afternoon to maximise higher conservatory temperatures and increase the COP. Occasionally occupants override these settings for a number of reasons including:

- Opportunistic – Extend the running time if water is not as hot as the occupants would ideally like and the conservatory temperatures remain relatively high
- Extend the running time to meet extra demand (e.g. visitors)
- To run at night on low tariff to reduce running costs – In summer the conservatory temperatures can remain high enough to provide a favourable COP This could also be deemed to be appropriate when there is an excess of renewable energy production in autumn/ winter via the wind turbines.

Thermal Storage and supply of hot water

Initially each house had their own thermal store that consisted of a 1500 litre recycled plastic tank (ex-fruit juice container) surrounded by 300mm polystyrene block insulation on all sides including the base and cover. For the corners vermiculite insulation was poured in to fill any cavities. This high level of insulation is key to the highly energy-efficient performance of the system, as well as reducing the workload on the heatpumps and circulation pumps.

The water in this container is not used directly. When a hot tap is turned on in the home, fresh water from the non-potable system (*see Technical Factsheet 10 – Water Supply*) is pumped through an extended series of coiled copper piping immersed in the hot water store (effectively acting as a water to water heat exchanger). As the water goes through the pipes, the high conductivity of copper allows for rapid heat transfer. Microbore pipes then deliver hot water directly to taps in showers, sinks and baths (where fitted). The microbore pipes are well insulated to reduce heat losses in transit.

The large capacity heat store has been adopted to:

- Minimise relative heat loss due to small surface area to volume ratio
- Maximise heat exchange by allowing for a larger area for copper piping to be fitted
- Provide opportunity for downloading excess renewable energy generation in the form of hot water, and using it as a hot water battery.
- Reduced energy density allows lower tank temperature and thus reduced losses

Copper coils before inserting into 1500lt hot tank

Controls

A thermostat controls the temperature of the water in the tank, typically between 43 & 47 ^{o}C by initiating the heat pump system within its time settings. Occupants can adjust these setting for their own personal preferences. On most occasions hot water is provided that meets occupants needs. If the water is considered not hot enough (e.g. in winter when the heatpump is less effective) they can do either of the following:

- Run the heat pump for longer
- Use a back up immersion heater (this heats primarily the top third of the tank and can respond much faster than the heatpump)

Legionella

One of the advantages of keeping separate the water 'for use', and only heating it when required, is that the thermal store does not have to be kept at a high temperature to combat Legionella growth. A normal system would be required to be set at a much higher minimum of about 60^{o}C, which subsequently increases the level of heat losses and energy demand on the system.

Microbore and the 'dead leg'

It was originally thought that the head of water from the reservoir would create sufficient water pressure to the houses. Later it was realised that heat energy lost through hot water in the dead leg of a pipe when the taps were turned off exceeded the energy used to pump water. Smaller bore pipes ('microbore') have therefore been used with a pump thus reducing heat losses in the dead leg of the pipes. In the event of pump failure water can be fed under gravity to the houses.

Performance of Initial System

For the HHP homes the energy demand required to provide hot water for the occupants includes:

- Electricity to drive the heat pump
- Direct electrical heating (for immersion back up only)

The losses from the system that add to the demand include:

- Heat losses from heat pump
- Losses from thermal store and Pipework
- Heat pump evaporator icing up

The conservatory air is colder in the winter than in summer so the Heat Pump runs for longer (6 hours instead of 2.5 hours) to deliver the required quantity of hot water.

Energy Use

The energy use of the HWS was calculated and measured. Calculation estimate: A typical HHP home runs the heatpump (maximum rating of 700W) for:

- 6 hours/day in the autumn/winter = 6 X 0.7kW = 4.2kWh/day
- 4 hours in the spring/ summer = 4 X 0.7kW = 2.8kWh/day

Note: In the summer the heatpump will frequently come on every other day and then run for longer the next day, rather than running for short periods each day. This is due to the tolerance of the thermostat associated with the thermal store.

Therefore the approximate average daily energy use per annum = (4.2+2.8)/2= 3.5kWh

However the heatpump does not always work at its maximum rating of 700W. Therefore it is likely that the actual energy use per day is between 3 and 3.5 kWhr/day per house.

During a sunny week in February 2008 the energy use of the heat pump was measured. It supplied a family of 5 with hot water. The average daily consumption was 3.1kWh. The neighboring property's hot water energy consumption was measured. (The home also has a family of 5 but has the new Hotsi tank and immersion heater). The average daily energy consumption was 4.3kWh. This implies a COP for the heat pump of 1.4. In the spring/summer, when the conservatory can provide warmer air for longer, the COP will increase, but unlikely as high as 3, initially expected.

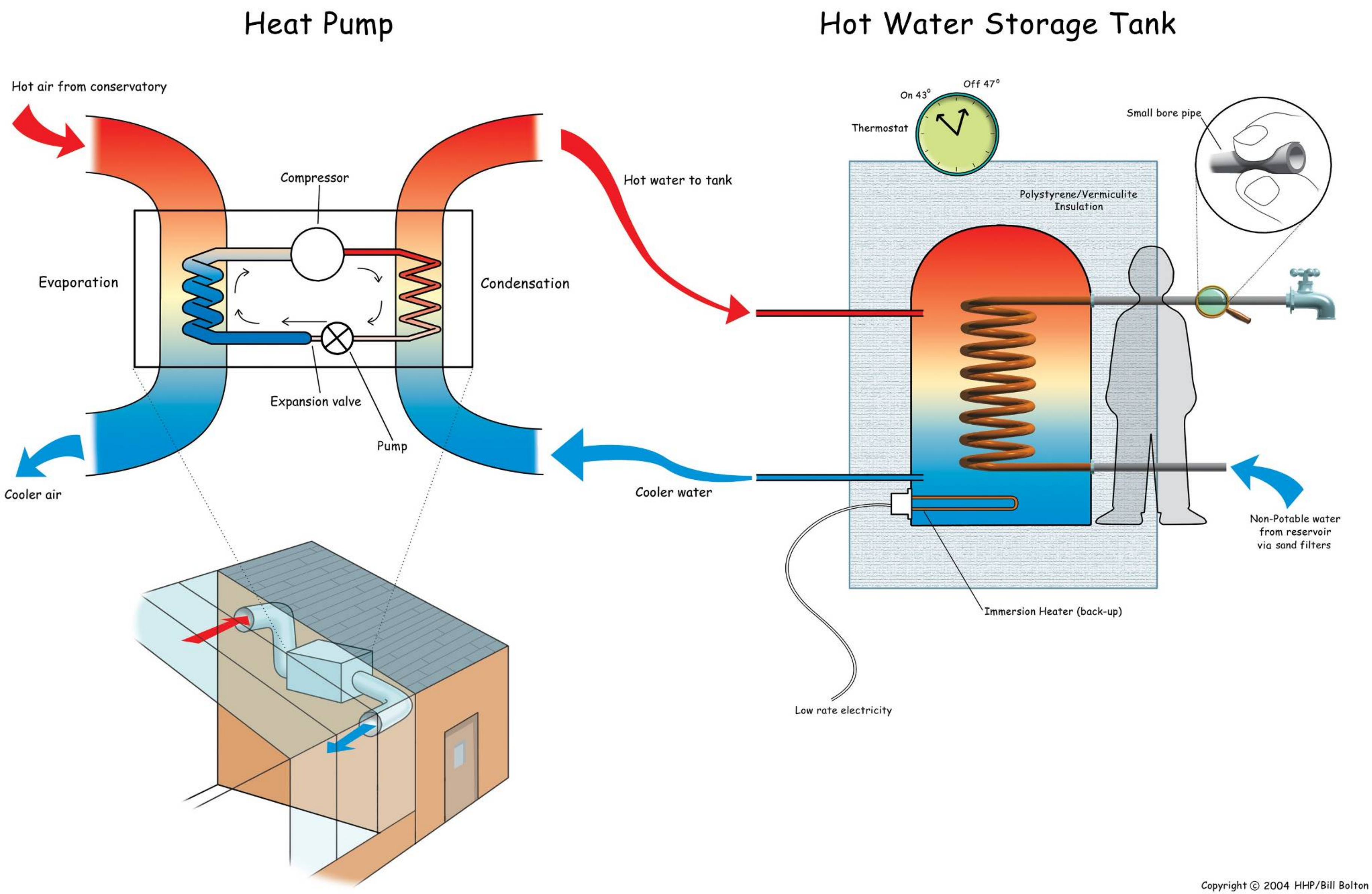
The HHP homes use only 10-12 kWhr per day for <u>all</u> energy uses in the home, so hot water is responsible for about a third of the occupants energy needs.

The yearly hot water demand for a typical comparable household is 4548kWh (Ref: GIR 53), or approx 13kWh per day, more than the HHP homes use for <u>all</u> their energy needs.

Incidental benefits of HHP hot water system

(1) Rapid clothes drying due to air flow from heat pump in conservatory
(2) Air conditioning in conservatory. It has been estimated (Ref: Databuild Construction report) that the operation of the heatpump reduces the air temperature in the conservatory by 1^oC within two minutes. In practice this does seem to be the case. After a while the drop stabilizes and maintains a conservatory temperature 3^oC below average. The temperature drop is higher in the winter and without sunshine.
(3) Storage for renewables –there is the potential for storing excess renewable energy generation in the thermal store by allowing the water temperature to go higher – this can then be saved for periods of low renewable energy production.
(4) System never runs out of <u>warm</u> water – Since the system does not run off hot water directly from a storage vessel, but transfers heat from the large store to the water in the coil – of course the water may not be as warm as everyone likes in such a situation.

HOT WATER SYSTEM



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Hot Water System Developments – The ‘Hotsi’ tank

HHP received funding support during 2002-2004 from the Pilkington Energy Efficiency Trust (PEET) to develop its thermal store system with a reduced capacity (500lt) to make it more commercially feasible for wider use. The following are the project reports that describe the work and conclusions.

Energy Efficient Electric Hot Water Tank System
Hockerton Housing Project

Interim Report - October 2003
Authors: Nick Martin, Louise Lipman and Simon Tilley

Summary

The energy efficient hot water tank system has been analysed and reported on. This report presents actual readings made from the installed tanks - mainly Tank B (see below). These reading are compared with the theoretical calculations. It can be seen that the tank supplies hot water very efficiently with minimal losses and can meet likely household demands. The estimated cost of supplying 110 litres of hot water per day is only £38 per year.

Three tanks have been installed:

- No. 5 Mystery Hill, HHP (Tank A)
- Workshop, Gables Drive (Tank B)
- Eco-barn conversion, Eakring (Tank C)

Contents

- Specifications of the tanks
- Actual and theoretical Standing losses
- Thermal capacity of the tank
- Input energy required at installation
- Heat energy requirements
- Test to demonstrate the amount of Usable Hot Water
- Future considerations and
- Operating recommendations.

Appendix A and B contain Tables and Graphs respectively.

Specification of the tanks

Tank A = First installation, Immersion heater 3KW, Multiple coil.
Tank B +Tank C = Modified second installations. Immersion Heater 1KW, Single ribbed coil.

Material	Copper
Size	1800 x 600 mm
Volume	500 Litre
Surface Area copper tank	3.96 m^2
Surface area outer box	9.18 m^2
Water Temp (Heated to)	50-55˚C
Air Temp	18-22˚C
Water Temp in	13-17˚C
U Value	0.17 free standing
Insulation	Average 200mm thick polystyrene, 150mm minimum

Standing losses

The actual loss of heat energy from the tank is shown in Table 1 and Chart 'Standing heat losses from Tank B'. These show the tank to lose approximately 2.3˚C per 24-hour period with a start temperature of 52.8˚C (see chart in appendix B).

Note also that:

- After 4 days the store was still able to heat water to a usable temperature.
- After 5 days cooling the 24 hour loss in temperature was 2˚C.

Energy loss in Watt hours =ΔT x Cp x mass
= 2.3 x 1.16 x 500
= 1334 Watt hours in 24 hours
= 1.33 kWh per day

Theoretical Standing Losses

U Value is calculated in the following way:

⇒ Thickness of insulation in metres L, 200mm is 0.2m
⇒ Conductivity, i.e. thermal resistance per metre is K.
⇒ For polystyrene K = 0.034
⇒ Resistance is R and
⇒ R = L/K
⇒ R= 0.2÷0.034 = 5.88
⇒ U = 1/R
⇒ So U=1/588 = 0.17W/m. ^{0}C

Theoretical examples to show the likely loss of energy from the water tank over a 24-hour period with water temperatures of 55˚C and 50˚C with different outside air temperatures. Note the tank is assumed not to be installed in an enclosed space. (See table eight)

Example 1 - Water temperature 55˚C, Air temperature 18˚C

Loss in Watts hours per day
= Surface area outer box x U x (T1 - T2) x 24
= 9.18 x 0.17 x (55-18) x 24
= 1386 Watt hours per day

Example 2 - Water temperature 50˚C,, Air temperature 22˚C

Loss in Watts hours per day
= Surface area outer box x U x (T1 - T2) x 24
= 9.18 x 0.17 x (50-22) x 24
= 1048.7 Watt hours per day

The actual standing losses will be reduced when the tank is installed with three walls around it and ceiling above as these will add to the insulation effect i.e. the U value will be improved.

Thermal capacity of Tank

The thermal capacity of the tank can now be found. Theoretical examples to show that, as the tank temperature is increased, the amount of energy stored is increased, are given below.
Point of use temperature is assumed to be 40˚C
Thermal capacity in Watt hours = (tank temperature - point of use temperature) x Cp x volume

Example 1 Tank temperature 50˚C

Energy stored in tank = (50-40) x 1.16 x 500
5800 Watt hours

Example 2 Tank temperature 55˚C

Energy stored in tank = (55-40) x 1.16 x 500
8700 Watt hours

Input energy required at installation

To heat a tank of water from installation cold water at 16 ˚C to a working temperature of 52˚C
Heat energy required
= Δ Temperature x Cp x volume
= (52-16) x 1.16 x 500
= 20880 Watt hours

Table Two and Graph Two 'Heating up time for Tank B' show the actual time taken to heat Tank B from 12.7˚C (bottom of tank temperature) to 47.6˚C.
Heat energy required
= Δ Temperature x Cp x volume
= (47.6-12.7) x 1.16 x 500
= 20242 Watt hours

Heat Energy Requirements

Theoretical examples to show the likely demand of energy required for use of 50 and 100 litres per day with two different input temperatures

Example 1

50 litres at 40˚C Input temperature 13˚C
Temperature Difference 27˚C
Cp = Specific Heat Capacity of water
= 1.16 watt hours per ˚C per Kg
Heat Energy Required in Watt hours
= 50 x 1.16 x 27 = 1566 Watt hours

Example 2

100 litres at 40˚C Input temperature 13˚C
Temperature Difference 27˚C
Heat Energy Required in Watt hours
= 100 x 1.16 x 27 = 3132 Watt hours

Example 3

50 litres at 40˚C Input temperature 17˚C
Temperature Difference 23˚C
Heat Energy Required in Watt hours
= 50 x 1.16 x 23 = 1334 Watt hours

Example 4

100 litres at 40˚C Input temperature 17˚C
Temperature Difference 23˚C
Heat Energy Required in Watt hours
= 100 x 1.16 x 23 = 2668 Watt hours

Test to demonstrate the amount of Usable Hot Water

Tank B was used for these tests. A Thermostatic mixer valve was used to simulate a mixer tap on a shower control. The Thermostatic mixer valve was set to the usable temperature of 41˚C to allow external cold water to mix with the hot water from the tank at temperatures greater than 41˚C. There may also have been some leakage of cold water at temperatures below 41˚C.

The tests were performed using 3 different flow rates of 5, 7 and 10 litres per minute. Water was drained from the tank in 20 litre quantities and the temperatures at the top and bottom of the tank were noted. This was repeated until the temperature recorded was less than 40˚C (ie usable temperature).

Following the test at 5 litres per minute, the tank was then reheated to the starting temperature and the time taken for this recorded so that the energy required for this use of water could be calculated.

Tables Three, Four and Five show this test for the flow rates 5, 7 and 10 litres per minute respectively and Table Six shows the re-heating time to return to the original temperature. As shown this took 3 hours 25 minutes using a 1Kw Immersion heater.

In summary, at a start temperature of 52˚C, the water tank will provide 220 litres of water at and above 40˚C at a flow rate of 10 litres per minute. The useful heat extracted was 6kWh. Readings were taken adjacent to the tank and input temperature of 17˚C. This volume could also be extended with a reduced flow rate.

Estimate of Running Costs
Assuming:

- ⇒ 110lt of hot water requires per day
- ⇒ A standing loss of 1183Wh per day (At 52˚C)
- ⇒ Air temperature of 22˚C
- ⇒ Night rate electricity at 2.45 pence per kWh

Consumption per day is	3.0kWh
Loss per day is	1.3kWh
Total	4.3kWh

Cost per day is 4.3 x 2.45 = 10.5 pence
Cost per year is 365 x 0.105 = £38

Reason for Modification on Tanks B + C
The Parts suppliers (ie Newark Copper Cylinders) no longer supplied the coils used in Tank A due an identified problem of the multiple coils rubbing together thus causing splits. (This had actually occurred in the case of an HHP 1500 litre tank.) The supplier suggested use of a single coil with a bigger bore tube which was ribbed on the outside. The ribbing would provide the increase in surface area required to compensate for the lack of multiple coils.

Future Considerations
Proposed Modification for a fourth tank (Tank D):
Due to temperature drop at the bottom of the tank, raise the coil in the tank so water being heated is spending more time in the hotter part of the tank so to increase pick-up temperature.

Operating recommendations

1. Tank Temperature

Tank minimum temperature set at:

⇒ 50˚C for a 200 litres per day volume requirement
⇒ 45˚C for a 100 litres per day Volume requirement

2. Shower flow rate examples

Shower flow rate restricted to approximately 5 litres per minute. This flow rate gives a good shower and a good pick-up temperature.

Acceptable shower flow rate found in a survey at HHP were as follows:

House No1 4 litres per minute
House No2 7 litres per minute
House No3 6 litres per minute
House No4 5 litres per minute
House No5 6 litres per minute

APPENDIX A

TABLE 1 : Standing heat losses from Tank B

Elapsed Time Hours	Top of Tank Temp ^{0}C	Average Temp ^{0}C	Bottom of Tank Temp ^{0}C	Surrounding Air Temp ^{0}C
0	52.8	52.8	52.8	15.3
3	52.7	52.3	51.9	20.5
6	52.5	51.9	51.3	19.9
9.5	52.1	51.4	50.7	18.6
15	51.7	50.7	49.7	16.7
23	50.9	49.7	48.5	15.4
26.5	50.7	49.4	48.1	20.9
28	50.6	49.3	48	22.8
31	50.3	48.95	47.6	22.2
35.5	49.9	48.5	47.1	18.2
38	49.6	48.15	46.7	16.5
47	48.6	47.1	45.6	13.9
49.45	48.5	46.95	45.4	19.2
53	48.3	46.75	45.2	23.6
74	46.4	44.7	43	19
102	44.1	42.4	40.7	20.7
125	42.4	40.75	39.1	24.4

TABLE 2 : Heating Up Time for Tank B

Elapsed Time	Top of Tank Temp	Bottom of Tank Temp	Surrounding Air Temp
0	13.7	12.7	14.8
5.42	24.5	25.4	16
8.17	29.8	30.5	15
15.17	44.1	44.9	13
16.67	47.1	47.6	14

TABLE 3 : Temperature of Water during Flow Demand 5 Litres per minute

Cold Water Temp	16.3
Water Flow Rate	5 litres per minute
Date	01/08/03
Outlet temp	41˚C
Useful Temp range	Above 40˚C
Formula	Volume passed x 1.16 (Specific Heat Capacity of Water) xΔTemp

Volume	Top of Tank Temp	Bottom of Tank Temp	Outlet Temp	Formula	Power Required
Lt	^{0}C	^{0}C	^{0}C		Wh
0	44.4	45.4			
20	44.4	43.2	40.3		556.8
40	44.4	39.9	40.7		566
60	44.4	37.8	40.5		561.4
80	44.4	35.8	40.2		554.5
100	44.4	34.3	39.9		547.5
120	44.4	33.1	39.3		533.6
140	44.4	31.5	38.7		519.7
			Total Heat Extracted		3839.5Wh
			Useful Heat extracted		2786Wh

Thus tank minimum temperature set at 45˚C for a 100 litres per day Volume requirement

TABLE 4 : Temperature of Water during Flow Demand 7 Litres per minute

Cold Water Temp	Start 17.2 End 17.4
Water Flow Rate	7 litres per minute
Date	21/07/03
Outlet temp	11/02/04
Useful Temp range	Above 40˚C
Formula	Volume passed x 1.16 (Specific Heat Capacity of Water) xΔTemp

Volume	Top of Tank Temp	Bottom of Tank Temp	Outlet Temp	Formula	Power Required
Lt	^{0}C	^{0}C	^{0}C		Wh
0	52.7	52.7			
20	52.7	51.5	41.9		573
40	52.7	49.1	41.6		566
60	52.7	46.7	41.6		566
80	52.7	44.9	41.5		563
100	52.7	42.6	41.5		563
			Total Heat Extracted		2831 Wh

TABLE FIVE : Temperature of Water during Flow Demand 10 Litres per minute

Cold Water Temp	17.4
Water Flow Rate	10 litres per minute
Date	17/07/03
Outlet temp	11/02/04
Useful Temp range	Above 40˚C
Formula	Volume passed x 1.16 (Specific Heat Capacity of Water) xΔTemp

Volume Lt	Top of Tank Temp ^{0}C	Bottom of Tank Temp ^{0}C	Outlet Temp ^{0}C	Formula	Power Required Wh
0	51.9	50.8			
20	51.9	50.2	41.7		563.8
40	51.9	47.8	41.5		559.1
60	51.9	45.6	41.3		554.5
80	51.9	44	41.5		559.1
100	51.9	42.2	41.4		556.8
120	51.9	40.7	41.3		554.5
140	51.9	39.2	41.2		552.2
160	51.9	37.8	41		547.5
180	51.9	36.6	40.7		540.56
200	51.9	35.3	40.55		535.92
220	51.8	34.3	40.2		529
240	51.8	33.4	39.3		503.7
	Total Heat Extracted				6556.6
	Useful Heat extracted i.e. to 40 Deg C				6052.9

Thus tank minimum temperature set at 50˚C for a 200 litres per day volume requirement

TABLE SIX : Recovery of Heat Energy from 5 litre per minute flow test

Elapsed Time hours	Top of Tank Temp ^{0}C	Bottom of Tank Temp ^{0}C
0	44.4	31.5
3.4167	43.8	44.9

Thus heat input is 3hours 25 min x 1000W = 3420Wh

TABLE 7 : Dimensions of Tank and insulation

Pie	3.1	
Copper cylinder		
Volume specified	500	lt
Diameter	0.6	m
Height	1.8	m
Area top	0.279	m2
Area bot	0.279	m2
Area Sides	3.348	m2
Total surface	3.906	m2
Calculated volume	0.5022	m3
Insulated envelope		
Width	0.9	m
Depth	0.9	m
Height	2.1	m
Area front	1.89	m2
Area bot	0.81	m2
Area top	0.81	m2
Total surface	9.18	m2

TABLE 8 : Theoretical Standing Losses

Example 1

Take U value of insulation as 0.17 W/m2K

Water temperature 55˚C, Air temperature 18˚C

Loss in Watts hours per day = Surface area outer box x U x (T1 - T2) x 24

= 9.18 x 0.17 x (55 - 18) x 24

= 1385.81 Watt hours per day

Example 2

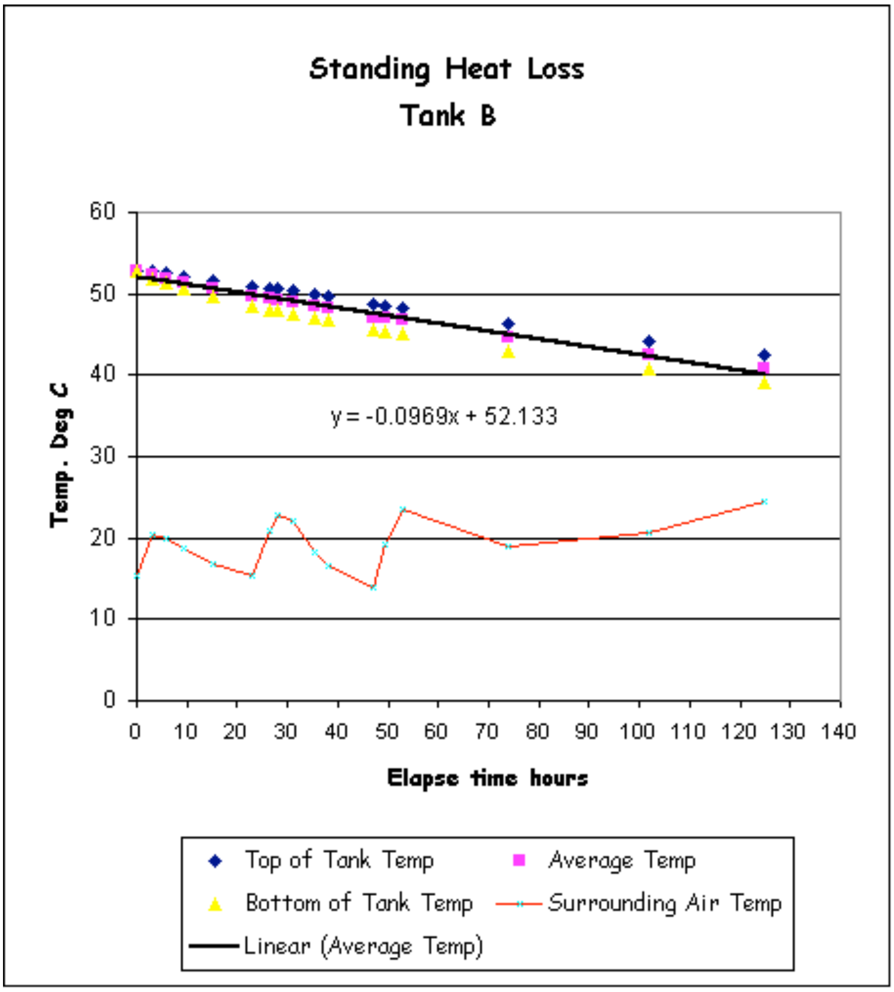
Water temperature 50˚C,, Air temperature 22˚C

Loss in Watts hours per day = Surface area outer box x U x (T1 - T2) x 24

= 9.18 x 0.17 x (50-22) x 24

= 1048.72 Watt hours per day

Chart of standing loss in tank B



Data in for chart in Table 1

Notes

Gradient of trendline is -0.097		
This means that in 24hours the temperature will drop 0.097 x 24 =	2.328	Deg C
Energy loss in Watt hours =ΔT x Cp x mass		
= 2.3 x 1.16 x 500 =	1334	Wh

Final Report – April 2004
Authors: Nick Martin, Louise Lipman and Simon Tilley

The interim report (October 2003) detailed the technical analysis of the energy efficient hot water tank system we have developed, the "Hotsi Tank". It showed that the tanks worked in practice and matched closely to their theoretically predicted performance. An ongoing monitoring phase since then has shown that the tanks have continued to operate successfully.

The PEET funded phase of the project is now complete however further work will continue. These split into two main areas: technical modifications and educational activities.

Technical Modifications

Future tanks will have the heat exchanger coil placed in the top third of the tank.

Factory fitted insulation to the "super insulation" level required will be sourced and assessed.

Modifications will be introduced to facilitate a solar thermal heating source. We are having ongoing discussions with Solar Twin (A solar thermal manufacturer) to set up a combined solar thermal/Hotsi tank demonstration model in our new Sustainable Resource Centre (since installed in 2005).

Summary of Current HWS at Hockerton

There are now (2008) three houses with the 500lt super insulated "Hotsi" tank and 1kW immersion heater, one house with a 1500lt tank heated by a 3kW immersion heater and one house with a 1500lt tank heated with a Baxi Heat pump. Hot water energy consumption of the house with a heat pump in winter is 3.1kWh per day, for the house with the smaller tank and immersion its 4.3kWh per day. The difference is small. A much larger difference is seen between average UK household hot water use, 13kWh per day and the HHP hot water energy use. This can be put down to the super insulation of the hot water tanks and pipes as well as a more careful use of hot water by the residence.

Other Issues

Heat pumps use refrigerant gasses to operate. If these gases escape at the end of their working life or during maintenance a large global warming effect could be created as they are much more potent green house gas than Carbon dioxide. Maintenance costs of heat pumps are higher than immersion heaters, as are their installation costs. The HHP heat pumps make a significant noise when running; large amounts of air is forced through the system with high speed fans causing this noise. Vibrations are also created so significant isolation mounts are used to limit the transmission of these. A system of heating water with immersion heaters supplied with electricity derived from renewables is a much simple method than either solar thermal or heat pumps systems.

Sources of materials used

Company	Materials supplied
Hepworth	Hep2O plumbing
Baxi Air Management	Mechanical ventilation and heat recovery systems, & Heat pumps
Grundfos Pumps Ltd	Water circulators

References

Hockerton Housing Project Construction Report, Sept 1998 (Databuild Ltd)

Building a Sustainable Future – homes for an autonomous community (GIR53)

The Pilkington Energy Efficiency Trust (PEET) - If you would like more information about funding provided by PEET please contact the secretary, Rick Wilberforce on 01744 692914 or by email - rick.wilberforce@pilkington.com

General Advice

(Extract from HHP publication, 'Teach Yourself Saving Energy in the Home')

No cost actions

- Check that your water thermostat is not set at too high a temperature. Ideally, it should be set to 60°C (140°F) and not lower than 55°C to reduce risk of legionnaire's disease.
- Only heat your water when you need it. A full tank of hot water, however well insulated, will always lose heat and need topping up by the boiler. Set your programmer to heat up your tank 30-45 minutes before you most commonly need a supply of hot water during the day.
- Ensure taps are turned off fully and fix any that leak - a dripping hot water tap wastes energy and over time can quickly add up (to prove this, put a plug in the bath or sink and see how quickly it fills up!).
- Take a shower rather than a bath – A five-minute shower consumes approximately half the amount of water, and energy, that a full bath takes. If you add a fine spray attachment to your shower you will use even less water. Beware of power showers as they may use as much as a bath, if not more. If you do have a bath, you could save energy by encouraging more than one member of the household to use the water!
- You could go one step further to reducing water and energy for personal hygiene – have a stand-up wash instead of a bath or a shower. This is particularly suitable in warm weather or in a well-heated bathroom.

Low cost actions

- Insulate under the bath to keep your bath water warm for longer avoiding the need for hot water top-ups.
- Insulate the hot water or immersion tank - you can buy a jacket for your hot water cylinder from your local DIY store. **This is one of the simplest and cheapest things you can do to cut your fuel bills and save energy**. Otherwise you could be losing up to 75% of the energy you are buying to heat your hot water.
- Standing heat losses from the hot water dead leg (amount of water required to be run through pipes before reaching desired temperature by user) can be considerable. This can be reduced by insulating the hot water pipes. Fitting insulation to pipes is easy if the pipes are accessible but you may need professional help for harder to reach pipework .
- Install a low-flow showerhead to reduce the amount of hot water used per shower.
- Fitting a jacket to a hot water cylinder is a relatively straight forward DIY job. Make sure the jacket is at least 80mm thick .
- You can, however, go much further than 80mm insulation if you are willing to practice those DIY skills and you have the space. You may have to use a mix of rigid and other forms of insulation in combination with a frame.

- Most new cylinders now come pre-insulated with foam sprayed on them. However, don't let this stop you adding further insulation!
- It is also worth insulating the pipes that enter and leave the cylinder - you can buy foam tubes for doing just this. Do it as far back from the cylinder as you can reach.

Investment actions - Upgrade your water heater

If your water heater is more than 10 years old it is likely to be running at less than 50% efficiency. Upgrading to a new, more efficient model will not only reduce your costs, but your environmental impact. (See 'Keeping warm' section earlier in this Chapter, for more info about upgrading boilers).

Tankless Water Heaters

Heating a large tank of water to a set temperature is the most common and best suited system for larger households that use a lot of hot water. Although such systems have become more efficient over the years, energy is still wasted when the hot water is not being used (standby energy loss).
An alternative is a system that uses 'tankless' water heaters, also known as 'on-demand' or 'instantaneous' heaters. These devices use energy only when hot water is needed, resulting in less standby energy loss. Although they tend to have a higher up-front cost, they are less expensive to operate in the long term due to their higher efficiency. When choosing a tankless water heater, you will have to calculate your required flow rate, or the total hot water consumption of the appliances you need to run simultaneously.

Further Resources

Websites

- **Action Energy** (www.actionenergy.org.uk) - the main energy efficiency programme of the UK government aiming to help businesses and public sector organisations reduce energy costs. Services offered include: a free information and advice helpline; free site visits to assess overall energy use and help identify ways of saving energy; consultancy support; funding for energy saving plans. For specific information about housing issues, see related website, **Housing Energy Efficiency Best Practice Programme** (HEEBPP), www.housingenergy.org.uk
- **Sustainability Works** (www.sustainabilityworks.org.uk) - includes section on energy.
- (www.boilers.org.uk) - Boiler database showing efficiency of gas and oil boilers sold in the UK.

Further Reading

- ***Controls for domestic central heating and hot water** (GPG 302)
- ***Domestic Condensing Boilers – 'The Benefits and the Myths'** (GIL 74)
- ***Domestic heating and hot water** – choice of fuel and system type (GPG 301)

* (Free copies available from BRESCU enquiry line 01923 664258 or see www.housingenergy.org.uk).

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