

Solar Energy Usage in Ipswich Hospital

a report by

Harry Barron

Technical Services Coordinator, West Moreton Health Service District,
Ipswich Hospital, Queensland, Australia

The word 'sustainability' has become the catch-cry of the early 21st century. As mankind ruthlessly exploits the fossil fuels inherited from ages past, ever-increasing demand is driving prices to record highs. However, concern is mounting amongst thinking people that the sudden (relative to the aeons of history) release of huge quantities of carbon dioxide (CO₂) may be producing adverse effects on our planets climate.

Enlightened individuals, corporations and governments are seeking to limit the discharge of greenhouse gases (GHGs) by implementing various initiatives to reduce the usage of fossil fuels. The added advantage is of course that energy costs also reduce with decreasing usage. Even relatively conservative entities such as the Building Code of Australia are introducing sustainability provisions with new energy efficiency provisions for Class 9a buildings scheduled for introduction in May 2006. The mood of the time can probably be summed up by the following statement:

"While this [the doubling of the price of oil] may sound gloomy, the planet may well benefit from an oil crisis, enabling more environmentally sympathetic alternatives, such as solar, to be developed and embraced."

Terence Jeyaretnam, *Engineers Australia*, April 2005.

Of course hospital engineers and managers have always promoted efficient energy use and lowest possible energy costs in their facilities, which are acknowledged as large users of energy. They have succeeded when given the opportunity, the finance and the political/corporate will to do so.

This paper represents the efforts of the Building, Engineering and Maintenance Service at the West Moreton Health Service District based at Ipswich in Queensland, to produce a positive effect on the bottom-line of energy costs in that district. Of course any reduction in purchased energy will be desirable, but some initiatives are better than others.

The purpose of this paper is to share our experience

with solar energy with other hospital energy managers, for mutual gain.

Solar Heated Domestic Hot Water

Description of Original Hot Water Service

This part of the paper is concerned with the production of domestic hot water for the main in-patient accommodation at Ipswich Hospital, colloquially known as The Ward Block.

The domestic hot water is produced by a bank of six electric cylinders and a bank of six natural gas fired cylinders installed in a parallel arrangement as shown in *Figure 1*. This unusual configuration was chosen to allow for flexibility according to the changing relative price of different energy sources and to allow repairs on one bank to be completed without affecting the production through the other bank. The downside of this arrangement is that control to produce a constant discharge temperature is difficult to achieve.

The total storage capacity is 3,540 litres with a maximum power input of 129.6kW of electricity and 258kW of natural gas. The estimated daily usage of hot water from this source is 16 kilolitres and the daily energy consumption has been measured at 3,200 megajoules. The energy cost is around AU\$2,000 per month and town water costs around AU\$620 per month.

Description of New Solar Water Heating Installation

In mid 2003 approval was given for the purchase of 12 flat panel (1,900 x 990) solar water heaters. These were installed on the roof of the Ward Block, immediately above the existing hot water service plant room. This plant room was on the eighth (top) level of the Ward Block.

The pitch of the roof and the solar heater installation was 6.5° to the horizontal. This is well below the

Harry Barron is the Technical Services Coordinator at the West Moreton Health Service District, based at Ipswich Hospital, Queensland, Australia. West Moreton Health Service District consists of four hospitals (Ipswich, Boonah, Esk and Laidley hospitals); a tertiary mental health facility – The Park – Centre for Mental Health, and a large Community Health Service. Mr Barron has worked for 14 years in Queensland Health in a variety of roles. He has a degree in mechanical engineering and has recently completed a post-graduate qualification in health service management. He is a Chartered Member of the Institution of Engineers Australia and an Associate Member of the Institute of Hospital Engineering Australia.

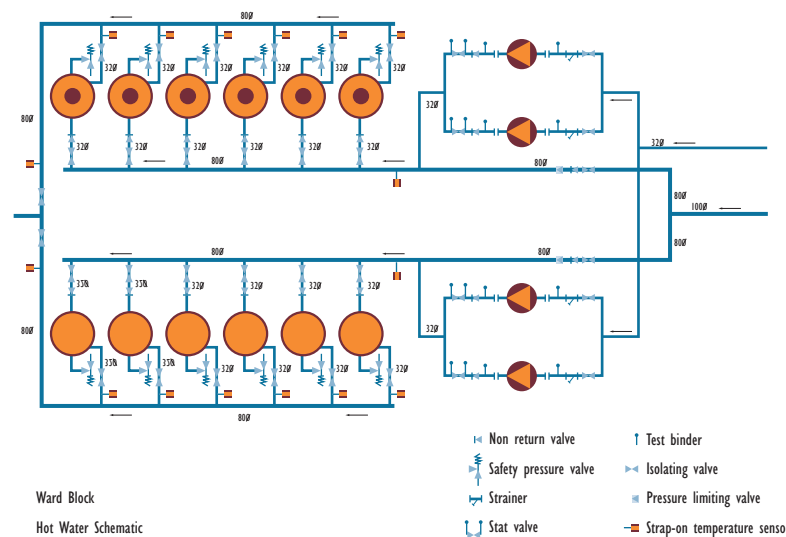
Table 1: Effect of Insulation on Water Temperature

Insulation	Litres	Average Flow Temperature	Average Return Temperature	Temperature Difference
None	5,180	53.2	62.6	9.4
25mm Fibreglass	5,010	53.3	67.3	14

Table 2: Solar Hot Water Heater Performance Pre-modification

June 2004	Daytime Operation	Night-time Operation	Net Gain/Loss
Average Time of Operation (Hours)	5.1	18.8	
Average Boost/Loss (°C)	7.2	-22.4	
Average Flow (litres)	1,991	1,034	
Average Energy Gain (MJ)	62.4 (Day)	-97.0 (Night)	-34.6 (loss)

Figure 1



25° recommended in AS 4234 for the hospital's latitude. This was not considered a major concern as the solar heat energy was always going to be fully used. In reality this orientation meant that the solar input in winter would be less than its possible potential for that time of the year. However, the summer solar heat input would be increased. As the electricity and gas tariffs as well as the usage of hot water are reasonably constant throughout the year, the added expense of the manufacture and installation of suitable supporting frames was not considered to benefit overall annual performance to any substantial amount.

The solar panels were installed as a pre-heater to the electric cylinders, adding heat to the make-up water to these heaters. The solar-heated water flowed back into the electric cylinders via a pipe work connection at the top row of elements, which were removed. All six cylinders were connected. A schematic drawing of the new arrangement is shown in Figure 2.

The initial installation and commissioning was completed under the instruction of the original equipment manufacturer.

Insulation

Initially, the installation used pre-lagged hot water pipes insulated by a 3mm thick PVC coating. This piping is commonly used on internal domestic and commercial hot water applications. This lagging could be expected to handle temperatures of up to 80°C. During installation this lagging was found melted and dripping from the return pipe work. Unfortunately this occurred in unusual circumstances. The newly installed solar collectors had been left pressurised by town water but the return valve had been left closed. The water temperature reached an estimated 120°C in mid-autumn. At the time this gave an overly optimistic expectation of the heater's performance.

The original insulation was replaced with foiled-covered pre-formed fibreglass insulation that has a much higher melting point. The effect of insulation can be seen from Table 1.

Commissioning

Eventually the system was put into service, still under the direction of the manufacturer's representative.

The original installation did not include monitoring equipment. Thus, the actual performance of the system could not be determined. After a short time of operation, monitoring equipment was approved and installed to measure the flow and return temperatures and the exact flow quantity. These were connected to the site building management system (BMS) for ease of recording and reporting results.

This monitoring showed that the original control system was indeed switching the circulating pump on and off at suitable times and daytime performance was acceptable. However, the monitoring also showed that at night a thermosiphon was occurring, taking the hot water from the make-up line in the low usage night-time and cooling it through the solar water 'heaters'. In fact, the night flow losses were exceeding the day flow gains (as shown in Table 2). The new solar hot water heater arrangement was costing more than the original system.

A solenoid valve fitted with a variable flow bypass was installed in the pipe work as shown in Figure 2. This valve is opened by the same control signal that starts the pump. This solenoid valve reduced the night flow to practically zero, considerably increasing the overall efficiency of the solar heating.

The only other problem encountered was that the standard connector clips between the twelve panels cracked after becoming brittle after nine months service. These were replaced by the manufacturer under warranty.

Flow Rate Through Solar Heaters

In an experiment, the flow rate was doubled by increasing the speed of the solar heater’s circulating pump. The result was half the temperature rise through the solar heaters. This indicated that the heating effect was at the maximum achievable with this installation.

Heater Performance

Several different performance measures were monitored over a period of twelve months to determine the worth of the new solar energy source. Of these three are presented here:

Table 3

Average daily heat gain (MJ)					
Aug 04	Sept 04	Oct 04	Nov 04	Dec 04	Jan 05
120	207	155	183	208	247

Average hours of operation per day					
Aug 04	Sept 04	Oct 04	Nov 04	Dec 04	Jan 05
6.4	7.8	6.8	7.5	8.6	9.3

Average solar heater temperature boost (°C)					
Aug 04	Sept 04	Oct 04	Nov 04	Dec 04	Jan 05
10.4	13.2	10	11.7	12.5	12.9

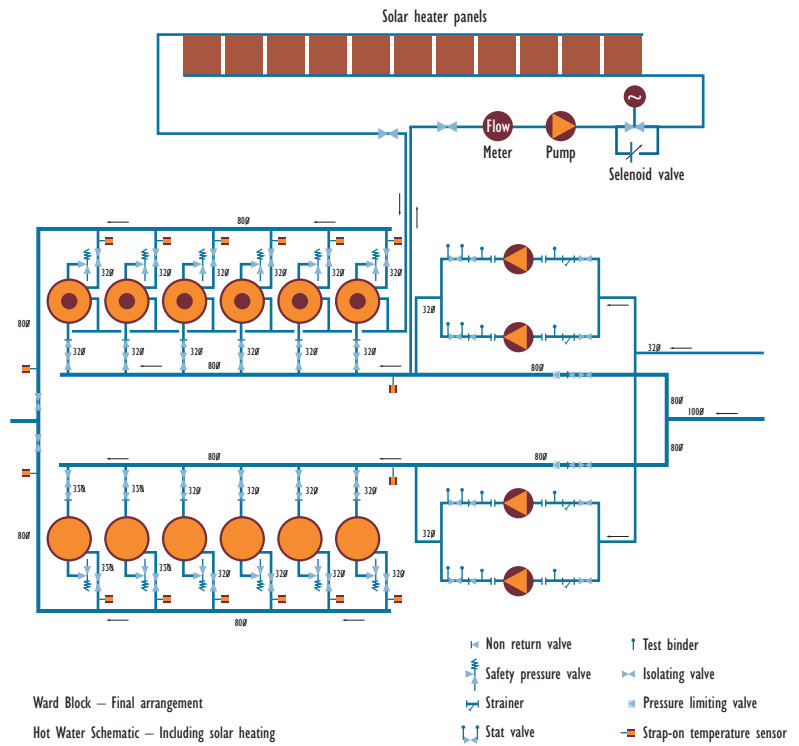
On 7 July 2005, the quantity of solar-heated water passed 1.5 million litres.

Summary of Heater Performance

After the first 12 months of monitoring several aspects of the performance of the solar heaters became apparent:

- Effectiveness was dependent on the weather and the season. While obvious, the extent and random effect of the weather can be seen in the collected results. The actual temperature rise across the heaters varied between 10°C and 13.2°C. However, the highest was in September and the lowest in October.
- The pay back period achieved by this installation was 14.4 years at 2004 energy prices. However, electricity prices have recently risen considerably (up to 40% for peak times of usage) and the Queensland government has introduced a ‘green’

Figure 2



levy on electricity produced from coal for large users. These increases are seen as a portent of the future, but have impacted positively the pay back period for the project.

- Performance monitoring is desirable when installing new equipment, especially when the depth of knowledge evident in the supervising personnel is limited.
- Increasing the number of collectors would result in increased savings. For no electric input to be required during the operating hours of the solar heater, a total of 218 solar heating panels would be required at Ipswich Hospital. Additional panels will have a pay-back period of 9.6 years at 2004 pricing, because the supporting infrastructure is already in place.

Conclusions

Installation of the latest generation of flat solar heaters does not become an economic source of commercial hot water until energy charges exceed AU\$0.113 cents per kilowatt-hour. However, in those facilities where this unit price is charged, this form of heating does become an economical proposition. The West Moreton Health Service District is using the results of the Ipswich Hospital installation to determine in which locations solar hot water is appropriate. It appears that small rural hospitals and off-site residences offer good opportunities. ■