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Solar Heating for Commercial Swimming Pools – Experiences in south-eastern Australia

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Abstract

Commercial swimming pools, particularly aquatic centres are increasingly common features of large towns and cities in Australia as people are encouraged to increase their levels of physical activity. Swimming is regarded as a low impact form of exercise and use of indoor facilities allows this to continue all-year round. Aquatic centres are large users of energy for water and space heating with an energy intensity which can be up to seven times that of a commercial office building in Australia. Much of the energy is used to heat water to relatively low temperatures and therefore solar energy technology is capable of providing this energy. In the residential sector, solar thermal systems for heating water and swimming pools is well-established. This is not the case for commercial swimming pools i.e. aquatic centres. In Victoria, a program to encourage commercial pool operators to install solar systems was funded in the early 1980s. This paper describes an investigation into the current use of and attitudes to solar systems in commercial pools through a survey of municipal pool operators in Victoria, south-eastern Australia. The survey found that there has been very little increase in the use of solar energy and that barriers to the use of the technology remain the same as they were nearly 30 years ago. Lack of roof area, poor payback periods and an inability of solar to meet pool heating needs are the most common misconceptions. To improve the uptake of solar heating in commercial pools, further research, particularly looking at the feasibility of integrating traditional heat sources with solar collectors using smart control, is required. An incentive programme and the education of the new generation of consultants and aquatic centre operators, unfamiliar with the potential benefits of solar systems, would also help to increase their uptake.

1. Introduction

The recent reports from the IPCC have reinforced the need for urgent global action to embrace renewable energy technologies wherever possible to reduce greenhouse gas emissions (IPCC 2011). Solar thermal energy has been identified as a major area for increased use (IEA 2012). Swimming pool heating, particularly using unglazed solar collectors, is already competitive with alternative fuels and could reach an installed capacity of 200 GWth producing around 400 PJ annually of solar heat by 2050 (IEA 2012). Australia has long history of using solar energy for swimming pool heating and is the second largest per capita user of solar pooling heating in the world (Mauthner and Weiss 2014). The idea of using solar energy for swimming pool heating is therefore far from new in Australia and is regarded as commonplace, particularly for residential pool heating. Recent anecdotal evidence, however, suggests solar is being overlooked for various reasons for a modern commercial pools or aquatic centres.

This paper describes research, the aim of which was to determine the status of solar heating in commercial swimming pools in Victoria, Australia. Specific objectives of the research included to determine: the number of municipal pools that currently use solar heating; whether there has been any increase in uptake of the technology over the last 30 years and the current barriers to further uptake. The results of a 2014 survey of council-owned operators of commercial swimming pools to determine their use and attitudes to solar heating are presented and discussed. These results are compared to a similar survey conducted in the early 1980s. Future research directions for improving the uptake of solar technology in commercial swimming pools is briefly discussed

2 Previous Research

Commercial swimming pools, particularly aquatic centres, are increasingly common features of large towns and cities in Australia as people are encouraged to increase their levels of physical activity. Swimming is regarded as a low impact form of exercise and use of indoor facilities allows this to continue all-year round. Victoria has in excess of 500 aquatic facilities with 277 (55%) belonging to local government. The remaining 233 (45%) include private swim schools and educational institutions (ARV Industry database, 2009). In Western Australia there are 120 public aquatic centres that provide significant benefit in terms of community development, sport, recreation, health and fitness and the total annual expenditure in aquatic centres is estimated to be $57 million (Leaversuch & Gibbs, 2010). Multi-purpose facilities with indoor pools improve financial viability and participation rate, compared to facilities with outdoor pools (Howat, 2005). Pool heating, particularly in cooler climates, is energy intensive and these facilities consume large quantities of energy. A recent study in Australia found that aquatic centres are seven times more energy intensive per floor area than a commercial office building (Rajagopalan 2014). A search of the international literature, however, shows only limited research specific to these large indoor swimming pools and the use of solar energy. Given the targets of the IEA cited above, this is surprising.

Of particular interest to this study are evaluations of very large aquatic centres with multiple pools and other hot water uses which have installed or assessed solar energy systems to reduce heating energy requirements. Ruiz and Martinez (2010) investigated the use of solar energy for small open-air private swimming pools in Spain using TRNSYS and compared their results with experimental results. The main purpose of their study was to assess the impact of unglazed solar collector area on heating a 50 m^2 outdoor pool. Collector areas recommended by standard ‘rules of thumb’ were compared i.e. 50% and 100% of pool area. The larger area increased water temperatures but also increased heat losses and covering the pool was confirmed as the best strategy to minimize losses. TRNSYS was also used to assess multiple heating options, including solar collectors, for two small outdoor pools in Crete (Katsaprakakis, 2015). In a very comprehensive study, heating loads were simulated and then various passive and active solar systems were evaluated technically and financially. Payback times are approximately three years for all scenarios.

Some of the research focus is on the use of heat pumps to save energy used in pool heating. Tagliafico et al. (2012) developed a model of a solar-assisted heat pump for an Olympic size pool where water temperature was limited to 28°C. In terms of multi-pool aquatic centres, this is the lowest water temperature maintained. The study was theoretical and no experimental data was presented. Sun et al. (2011) investigated the savings achieved when a heat pump was used to recover the latent heat from dehumidification of the moist air of indoor pool facility and this heat was then used for water heating. A system with a 225 m^2 pool area in Shanghai, China was studied and found to result in a very low payback period of 1.10 years when compared to a conventional dehumidifier. Chow et al. (2012) also investigated the use of solar-assisted heat pumps for large-scale installations. TRNSYS was used to simulate a facility in Hong Kong where roof areas are limited. Energy savings of 79% were predicted with a payback of less than five years.

Some detailed audit data for swimming centres in northern and southern Europe have been published by two research teams. Kampel et al. (2013) analysed data from 41 Norwegian facilities, developed a 'final annual energy consumption' (FAEC) figure and compared this to corresponding Danish data. The latter have a lower FAEC and this indicates a potential saving of 28%. Although no detailed analysis is provided and solar energy is not used, the figures provide a useful benchmark, despite climatic differences. The research of Trianta-Stourna et al. (1998) also provides useful benchmark data but this time in Greece which has a climate more comparable to Victoria. Although various scenarios are considered including using solar collectors, no details of the simulations using DOE-2 are presented. Using a solar system produces energy savings of 25% in two of the three scenarios. More recent research in Greece (Mousia and Dimoudi, 2015) indicates that only 18% of the 76 facilities surveyed had installed solar collectors. No details of the systems are provided.

3 Past Use of Solar Heating for Commercial Pools in Victoria

One of the first indoor public pools in Victoria to have a solar heating system was at The University of Melbourne. Known as the Beaurepaire pool, the system was installed in 1978 and consisted of 160 m^2 of industrial-grade solar collectors. The system was monitored for one year between September 1979 and August 1980. The solar contribution was found to be 46 per cent, while parasitic power (for pumping) was found to be 2.4 per cent of the solar contribution (Morse 2000). Although the system was removed some years ago, it provides an indication of the possible contribution of a solar system. Other installations of that era included the then State Swimming Centre which used a large (886 m^2) integrated roof solar collector with acrylic sheet glazing to reduce costs. This centre no longer exists and has been replaced by a more modern facility at a different location. Two other large (496 m^2 and 185 m^2) swimming pool solar systems were built in the same era as demonstration projects.

In the early 1980s, the Victorian Government investigated the use of solar heating of pools in Victoria. It was found that while the use of solar heating for domestic pools had increased significantly due to the growing number of pools and the realization by the owners that the enjoyment of their investment could be increased by installing a solar heater, market penetration of solar heating in larger, commercial pools was not growing in the same way (Guthrie 1987). A feasibility study was therefore conducted to establish the potential for solar heating of public and institutional swimming pools by surveying all operators and analyzing the cost-effectiveness of solar heating for large pools. Higgs (1984, cited by Guthrie, 1987) identified 453 large pools across the State. These included public, commercial and institutional pools, and 46% of the owners/operators responded to the survey. Of the 149 municipal pool respondents, only seven (5%) had solar heating. In total, there were 26 pools found to have solar heating. Although 30% of respondents had a positive view of solar energy, the main barriers perceived to installing a solar system were initial capital costs, lack of reliable information and negative, pre-conceived ideas of the viability of solar heating.

As a result, the Victorian Government created an incentive scheme to promote solar heating in commercial pools. The scheme's objectives were to effect the installation of solar heating systems for selected commercial pools and encourage the installation of solar heating on other pools by providing technical information and advice to pool owners/operators. The government awarded grants ranging from 20-25% of the fully installed solar system costs to 34 pool operators, 28 of which were municipal pools. The balance of the system cost was met by the operators themselves to ensure their commitment. The scheme and funding only ran until the mid-1980s and currently there is no rebate or incentive schemes available for solar heating of pools.

4 Current Status of Solar Heating in Victorian Commercial Swimming Pools

In order to determine the current status of solar heating in commercial pools in Victoria, a questionnaire was emailed to the 79 municipal councils across the state. These bodies, either directly or indirectly, represent the bulk of the commercial pool owners/operators in Victoria. Analysis of the 1980s data indicates that country and metropolitan municipal pools represented 64% of the total identified. In total, the 79 councils are responsible for 259 commercial swimming pools identified. The survey contained three questions (see Appendix A). The survey was designed to be simple and therefore not time-consuming, yet elicit useful information about the current status of solar heating of commercial pools and the reasons it is used or not used. It is important to note that survey respondents were encouraged to supply additional technical information, where appropriate. This provided some richness to the data as the pool managers and pool installers were able to further explain their reasons for their survey answers.

Of the total 79 questionnaires distributed by email, 33 replies were received, indicating a 42% response rate, compared to the 52% response rate from municipal pool operators 30 years earlier. This level of response is likely to mean that the survey provides a representative view of solar heating by municipal pool owner/operators. From the survey results it was determined that 51 (57%) of responses referred to indoor pools/aquatic centres while the remaining 39 (43%) of responses referred to outdoor pools. Of the 259 municipal pools identified in Victoria in 2014, 76% of these are indoor pools/aquatic centres whilst the remaining 24% are outdoor pools indicating that the survey data slightly over-represents outdoor pools. Of the 90 pools covered by the survey respondents, 30 (33%) of them use solar energy as part of their heating system. This figure includes solar as a supplement to a gas-boosted system and solar blankets as well as stand-alone solar systems.

These figures can be compared to those available approximately 30 years ago, before and after the Victorian government introduced its incentive and grant scheme (Guthrie 1987) (Table 1). It should be noted that the number of municipal pools identified in 2014 is 10% lower than in 1984. This fall could be due to a variety of factors such as: the transfer of pool ownership from municipal to private owners; pool closures; differences in the identification process; or some other reason. The number of municipal pool respondents is also lower (42% compared to 52%). This fall could be due to a number of reasons: i) the survey was not passed on to the appropriate person; ii) the survey was forwarded to the appropriate person but they were too busy, disinterested or did not wish to divulge the information; or iii) the first survey was part of an official government programme, while the later survey was a student research project. A final difference that should be considered is that in the recent survey, pool blankets are considered to be a form of solar heating, while in the earlier survey only active systems were considered. These differences notwithstanding, the percentage of municipal respondents using solar energy to heat their pools appears to have risen.

While the 2014 survey figures in Table 1 indicate a rise in the percentage of municipal pools using solar energy, closer analysis is required to better understand the changes and trends. Two of the responding councils use solar blankets only, with no active solar heating system. One of those pools with an active solar system was used only for heating water for showers and not pool water. Another council planned to install a solar domestic system for the same purpose. Another council currently with solar heating will be installing a cogeneration unit next year because it was considered to be a better option than solar, offering year-round savings. The above qualifications to the survey results mean that effectively 26 pools (not 30) or 29% are using active solar heating systems. Cautiously, this means that some increase in solar heating of municipal pools has occurred. However, given the significant time period (27 years) since the last survey, the incentive scheme and growing environmental awareness, a greater impact of solar heating might reasonably be expected.

Table 1. Comparison of municipal swimming pools with solar heating over 30 year timeframe

Year	Solar incentives scheme timeline	No of municipal pools identified	No of municipal respondents to survey	No of municipal respondents using solar	% of municipal respondents using solar
1984	Before solar incentives	288	149	7	5
1987	Immediately after solar incentives	288	149	28 + 7 = 35	23
2014	27 years after solar incentive scheme	259	90	30	33

5 Attitudes to Solar Pool Heating

The responses to the survey questions enabled current attitudes to solar heating to be assessed. Some of the users of solar heating systems responded positively. One user cited savings of approximately $12,000 per year in gas costs. Another stated that only solar energy was feasible to heat an outdoor 50 m Olympic pool which was kept at around 23°C. Perhaps more instructive to understanding current attitudes were the negative responses. As shown in Figure 1, twelve councils (36%) believed that solar energy could not meet the energy demands. Eight councils (24%) believed that construction costs were too high and six councils (18%) believed there was not enough roof space to accommodate the solar collectors. These responses reflect the findings of the 1984 survey, indicating little change over the intervening period.

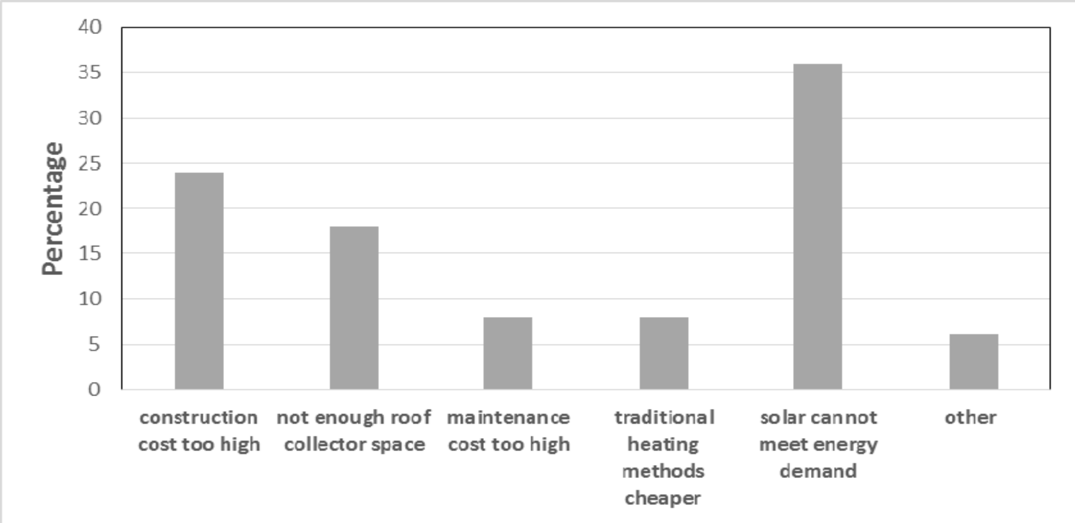

Figure 1: Attitude towards solar pool heating

The views of one of the leading suppliers of swimming pool solar systems and installers of the majority of the commercial pool solar heaters were also sought. They believed that commercial solar systems will generally have a payback period of 5-7 years, with some having a payback period of only 2-3 years, which means energy savings and profit begin shortly after installation. According to this particular installer, many councils are realizing that the shorter payback coupled with a greater environmental awareness means installing a solar heating system is practical. They quoted the examples such as 'The Horsham Aquatic Centre' in Victoria which had a payback period of 3.6 years and the 'Australian Institute of Sport aquatic centre' in Canberra that had a payback period of 1.6 years.

After being informed that many of the council staff believed 'construction cost is too high' as one of the hindering factor, the installer responded that as councils have strict budgets during the design and construction of aquatic centres, solar systems are not often in the list of priorities and can be omitted if construction costs are running tight. Sometimes solar systems are not well thought about during the feasibility stage.

The installer also agreed that operational and maintenance issues exist with these systems. Another concern is the difficulty to provide heat efficiently to multiple end-uses with tight tolerances as the availability of solar energy varies with season and time of day. Smart control could be a possible solution to solve these problems. Other comments included the fact that in conventional solar heating systems, the pool itself was the storage. Large storage systems added to the system cost.

5 Discussion

The responses to the survey on the use of solar energy for pool heating in Victoria by municipal councils has enabled an insight into current attitudes to the technology, particularly the barriers to its acceptance. The results confirm the anecdotal evidence that many remain sceptical about the viability of solar energy to reduce their energy needs and costs. One of the arguments used to dismiss solar energy is that there is insufficient roof area. Majority of the Council aquatic centres are single to double storeyed with large roof areas that can accommodate solar collectors. Solar collectors may provide sufficient energy to heat whole or part of the pool. This can be confirmed by doing a detailed calculation of the heating requirements of various pools and the area of solar collector required. Another barrier to installing solar system by pool owner/operators is that solar energy cannot meet the energy demands of the pool. Glazed and unglazed solar collectors are proven technologies for hot and warm water production, both for domestic use (~65°C) and swimming pools (~35°C). Most of the centre operators are unfamiliar with the potential benefits of solar systems and latest technologies available in the market. Generally, electricity is viewed as energy and heat is forgotten. An education program for the new generation of consultants and aquatic centre operators will be helpful. In addition incentive programmes from the Federal or State government and inclusion of these building types in the national rating systems will help to improve the uptake of solar heating.

Integrating solar heating with conventional gas heating can be difficult because of the varying end uses, hence not seen as viable because of technical complexities and cost. Combining two heat sources (boiler and solar collector array) to provide heat to multiple end-uses with tight tolerances will be challenging and innovative. Further research is required to investigate if solar heating can be incorporated technically and economically in modern aquatic centres with multiple water bodies. This may require storage system and advanced smart controls.

Another significant barrier identified was that the construction costs for solar systems are too high. Hot water production by solar energy is financially viable in Australia. Rising electricity and gas prices will improve this viability. Further work is required involving detailed financial evaluation techniques such as payback periods, net present value and internal rate of return with glazed or unglazed collectors.

The current price of gas is a major determinant of the Councils' decision making. Future gas prices are difficult to estimate but will have a significant effect on the payback of the solar systems. Gas prices are predicted to rise sharply in Australia following the linking of domestic prices to the international market. The current price of gas to domestic users is approximately 1.8 cents/MJ and this is similar to small business consuming under 1000 GJ per annum. However aquatic centres are relatively large consumers of gas. The contract price to large users of gas is hard to obtain in the current tight and uncertain gas supply market (AIG, 2013). A doubling of the gas price from its present level is not inconceivable in the foreseeable future and this would significantly reduce the payback of solar systems.

As reported in recent publications by IEA (2015), it is widely recognised internationally that the progress of renewables in the heating sector, which comprises almost half of total final energy consumption has been slower than electricity stronger uptake of renewable heat requires deeper and more widespread policy frameworks.

6 Conclusions

The review of published literature reveals that there is little research assessing the feasibility of solar energy for very large aquatic centres with multiple pool types and extensive non-swimming activity areas. If the solar thermal goals of the IEA are to be met, more needs to be done to drive the research and installation of solar thermal systems in areas such as swimming pool heating which have a long history of use in small and medium-sized pools. Australia has the highest per capita use of solar heating for residential swimming pools, so there is great familiarity with this technology. However, there has been only a marginal increase in uptake in municipal pools in Victoria, where a survey of local municipal authorities revealed that the main barriers to the installation of solar systems are similar to those of 30 years ago. The main perceived barriers are cost, lack of roof area and inability of solar to meet the energy needs of aquatic centres. Further research looking at the feasibility of integrating traditional heat sources with solar collectors using smart control is underway. Following the 'proof of concept' and a good promotion program for councils and pool operators, it is anticipated that there will be considerable interest in this work from the various industries involved.

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Appendix A – Survey Questions

Q1. Are any of your council pools using solar heating to heat the pool? (including solar blankets)

a) Yes

b) No

Q2. If so, what are the reasons for using solar?

a) Energy savings over life span of system?

b) Environmental concerns?

c) Most feasible system?

d) Other (please elaborate)

Q3. If the pools are not using solar, what are the reasons?

a) Construction costs too high?

b) Not enough roof collector space?

c) Maintenance costs too high?

d) Traditional heating (gas/electric) cheaper over all?

e) Solar cannot meet energy demands?

f) Other? (Please elaborate)