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REPORT TITLE: Case Study 2: Comparison of different solar technologies for use within an indoor commercial pool

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Executive Summary

Solimpeks Australia has carried out an energy analysis on behalf of the client for an indoor swimming pool facility run by the the client in Sydney. The indoor pool has a surface area of 26.2m^2 with an average depth of 1.25m (V_{pool} = 33,000L). Currently a 62kW gas burner manufactured by Raypak (Rheem Australia) is used to heat water to the desired pool temperature of 33°C. As long term energy forecasts indicate that gas prices will only continue to rise, so too will the running costs of the facility making a solar solution more appealing.

The aim of this report is to provide the results of an energy analysis and quantify the solar contribution and consequently the reduction in gas consumption. As the performance of any solar system will constantly vary throughout its operational lifetime, a computer simulation using the software package Polysun has been performed to simulate the performance of two possible solar energy solutions:

1) System 1: Solar thermal system consisting of Solimpeks flat plate collectors.
2) System 2: Combined photovoltaic/solar thermal system using the Solimpeks hybrid flat plate collector.

System 1 is a solar thermal only solution using the high performance Solimpeks flat plate collector which consists of a selective surface aluminium absorber and copper fluid network. System 2 consists of the Solimpeks PowerVolt collector which is an integrated heat and power unit.

Based on the requirements of the pool, it was found that approximately 40,000 kWh of energy is required to maintain the pool at the set temperature. The two solar systems stated above were found to make

significant contributions to this energy load. Overall, the following two systems were found to be optimised solar contribution and solar collector efficiency for this specific application.

For system 1, it was found that a twenty flat plate collector system was optimal. This system would on average provide 75% of the pools thermal load from the sun reducing the amount of auxiliary energy from 40MWh to approximately 13MWh (including power consumed by pumps).

For system 2, it was found that 30 hybrid photovoltaic/thermal collectors was the optimal size. Although this system would only provide 40% of the thermal load, reducing the auxiliary energy consumed from 40MWh to 23MWh (including pump power), it would also provide on average 7600kWh of electricity a year.

Based on the results of this work, as the principal objective of the solar energy system is to reduce gas consumption, the engineering recommendation is to install a flat plate collector system (System 1) with a minimum array size of 20 collectors. The Solimpeks Wunder ALS 1809 is a high performance European made solar thermal collector that is well suited for this application.

1.0 Introduction

The solar thermal collector is a unique heat exchanger capable of harnessing radiant energy from the sun by converting it to thermal energy (heat) via an absorption process. The absorption process is a well-known natural phenomenon where an object is simply heated while exposed to the sun. The solar thermal collector is designed in such a way to maximise this process and heat a fluid (typically water) for use in domestic hot water, space heating, or pool heating applications.

The core components of the solar thermal collector are the absorber plate and fluid channels which are shown in Figure 1 below. The absorber plate, made from a material that is thermally conductive (aluminium, copper, steel) is coated on its top surface to improve its ability to absorb solar radiation in the short wavelength (0.3 - 3μm). When exposed to solar radiation, the absorber is consequently heated via the absorption process and its temperature rises. Fluid channels incorporated into the absorber plate, as shown in Figure 1, contains the circulating fluid (e.g. water) which transports heat away from the absorber to a storage tank or swimming pool depending on its intended application.

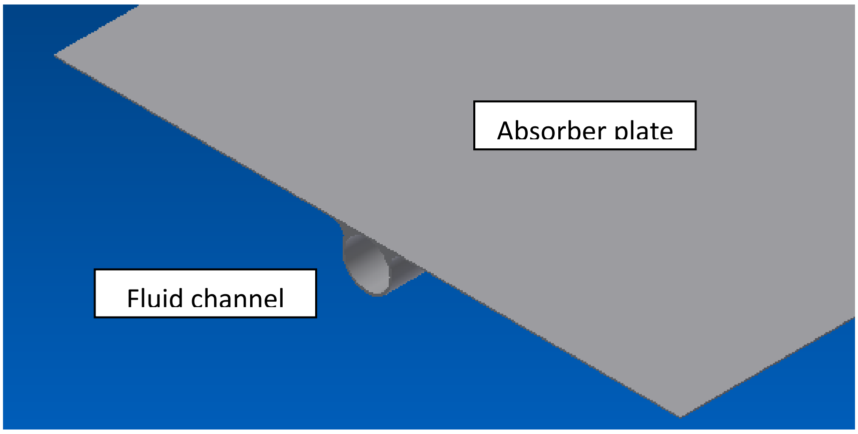

Figure 1 The core component of the solar thermal collector is the absorber and fluid channel assembly shown above.

As the absorber plate temperature rises above ambient temperature, heat losses to the environment will naturally occur. Heat losses are a parasitic loss, and attempts are made in the design of the collector to minimise this loss so that the maximum amount of heat is collected by the fluid being heated. To achieve this, the absorber plate is covered with a glass cover with an air gap in between to suppress convective heat losses and insulation is placed underneath the absorber/fluid channel assembly.

In addition to heat losses by convection and conduction, losses also occur via radiation. Identical to the process of the sun radiating heat to the earth, as the absorber plate temperature increases, thermal loss from radiation will also increase. This will naturally occur during the operation of the solar thermal collector as radiation from the sun will vary over the day and year, and also because the temperature of fluid being heated will rise. For an absorber plate that is simply black painted in order to increase its absorptivity, thermal losses from the top surface of the absorber due to radiation can be substantial. To minimise these losses, the absorber surface can be coated with a selective surface which will significantly reduce thermal radiation losses and proportionally increase the available heat transfer to the fluid. Figure 2 provides a comparison between two absorbers coated with black paint and the Tinox selective surface. Examining this figure, we can see that a black painted absorber will lose up to 45% of the heat absorbed from the sun reducing the amount of available heat to the fluid to 50%. Alternatively, the selectively surface coated absorber will suffer only 5% heat loss, increasing the amount of heat going into the fluid to 90%.

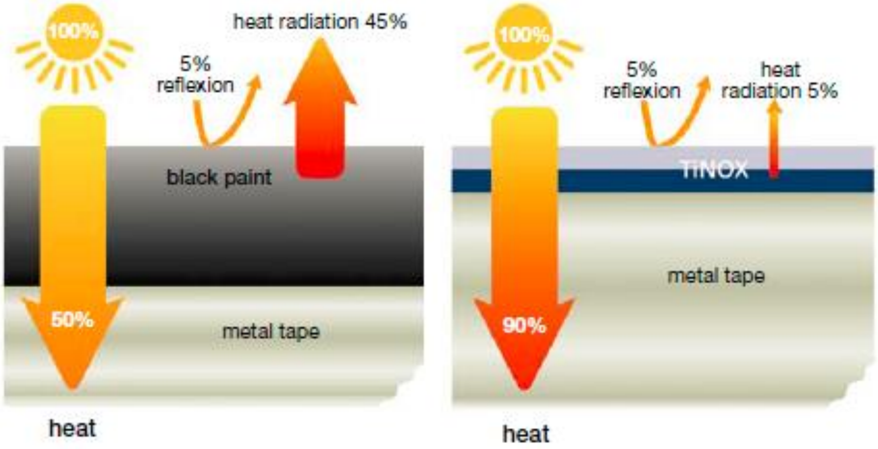

Figure 2 Energy comparison between a black painted and Tinox coated solar thermal absorber (*source: Almeco solar*).

The application of a selective surface will substantially improve the performance of a solar thermal system under most conditions and typical applications. The Solimpeks Wunder ALS 1809 flat plate collector is a high performance flat plate collector manufactured with the Tinox selective surface coating.

To highlight its performance advantage, two domestic hot water systems were simulated using Polysun commercial software:

1) System 1: Two non-selective surface coated flat plate collectors (Collector Model: Edwards Australis series 2). Gross collector area = 4.02m^2.
2) System 2: Two Solimpeks Wunder ALS 1809 selective surface flat plate collectors. Gross collector area = 3.6m^2.

Both systems were modelled under Sydney weather conditions with a 300L storage tank, 25kW in-line gas booster, and a thermal load of 250 litres a day at 50 degrees C. Identical load profiles were assumed for both systems. The schematic of the system under study is shown in Figure 3.

An annual simulation of the two systems revealed the following key results:

System 1 resulted in an average solar fraction of 59.5%, while the value for System 2 was found to be 71.9%. The solar fraction is the percentage of thermal energy taken from the system that is provided from the solar collectors.

The average collector efficiencies were found to be 38.3% and 55.1% for System 1 and 2 respectively.

Interestingly the Wunder ALS 1809 was not only able to perform the best, but also uses 10% less roofing area.

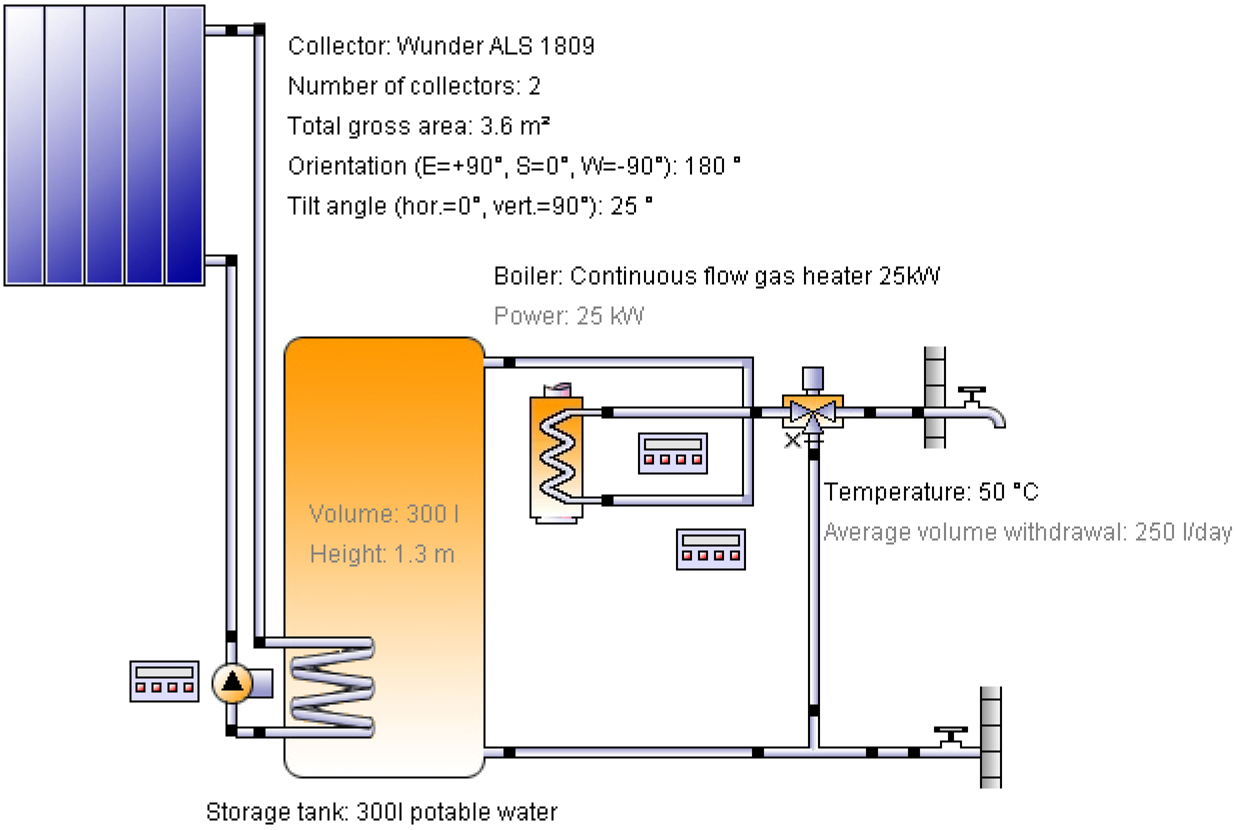

Figure 3 Polysun analysis of a flat plate collector system for domestic hot water system.

2.0 Problem statement and analysis method

The The client indoor swimming pool is located at Sydney with details provided in Table 1. A high pool temperature is required which is to be operated all year (with a shutdown period over Christmas).

Table 1 Basic characteristics of the The client indoor swimming pool.

Climate	Sydney, Sydney
Pool dimensions	6.1m x 4.3m
Average depth	1.25m
Desired pool temperature	33°C
Hours of use	9-5pm, five days a week, all year

A large roofing area is available on site with minimal shading making solar a feasible solution. A proposed system was designed in Polysun energy analysis software in order to determine the optimum collector size. With solar thermal systems, there is a balance point between optimising the solar fraction (i.e. contribution from the solar collectors) and the collector array efficiency. A parametric analysis was therefore performed where the number of collectors for System 1 and 2 were incremented and results appropriately queried. From the computer simulations, values for solar collector contribution (kWh), Auxiliary energy consumed by gas heater, collector efficiency, and displaced carbon emissions were approximated taking into account the specific weather of the installed site, the characteristics of the swimming pool, and the engineering design of the solar/gas system.

The schematic of the system investigated for the energy analysis is shown in Figure 4 below. The schematic includes the solar collector array with the necessary plate heat exchangers, swimming pool, and a generic 60kW gas burner to provide necessary auxiliary boosting.

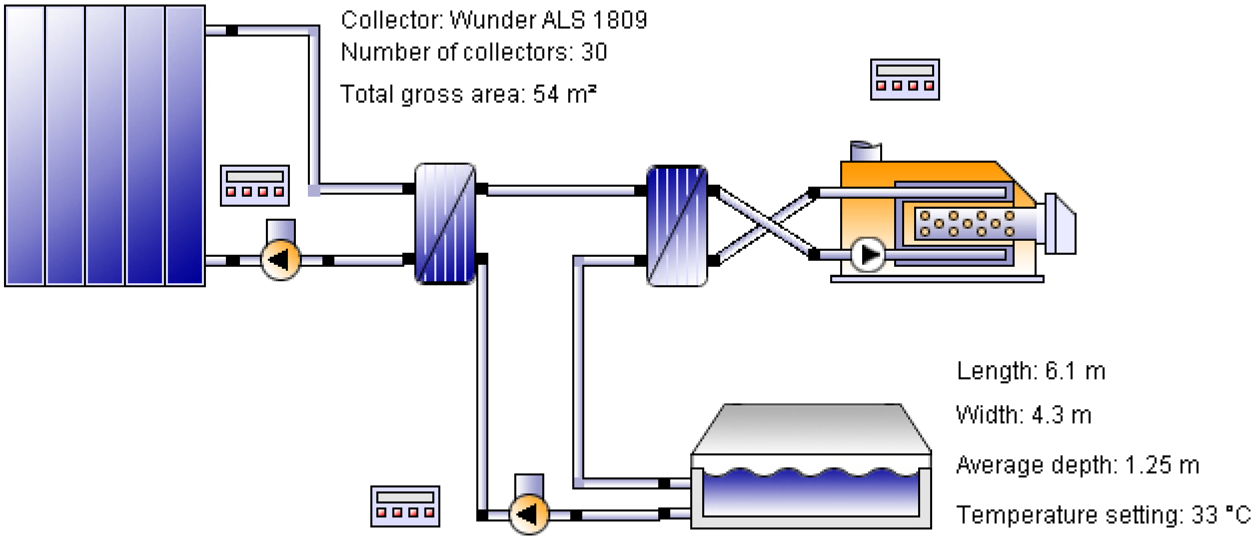

Figure 4 Schematic of the system analysed using Polysun software.

Results are presented in the proceeding section.

3.0 Results and discussion

Results of the parametric studies are presented in Tables 2 ad 3. From this data, we can plot the variation of the solar fraction and collector efficiency ($\eta_{th,col}$) against the collector array size. These plots are presented in Figures 5 and 6. Examining these graphs, we can see that as we increase the size of the collector array, the solar fraction is increased as expected due to the higher surface area of absorber. However, as the size of the array increases, collector efficiency will drop as the array reaches a point where it is oversized in sunny/hot conditions (i.e. summer) resulting in high collector operating temperature and reduced overall performance due to increased heat loss to the environment. Figures 5 and 6 simplify the selection process by choosing the point where both solar fraction and collector efficiency are maximised. This point coincides with the intersection point. For System 1, this is 20 Wunder ALS 1809 flat plate collectors while for System 2, it is 30 PowerVolt PVT collectors.

Table 2 Simulation results for System 1 (flat plate solar thermal collector system).

No. of collectors	Solar fraction (%)	$\eta_{th,col}$	E_{tot}	System Performance	CO_2 emissions reduction (kg)
6	27.3	60.5	32025	1.16	2673
8	35.5	60.3	29195	1.31	3552
10	43.6	60.2	25965	1.49	4430
12	50.5	59.9	23591	1.7	5286
14	57.7	59.4	20505	1.98	6119
16	64.5	58.9	17555	2.35	6940
18	71.2	58.7	14555	2.87	7775
20	75.2	57.3	12915	3.33	8428
22	77.5	55.1	12055	3.66	8913
24	80	53	10946	4.1	9364
26	83.2	51.2	9348	4.83	9803
28	85.3	49.4	8292	5.52	9227
30	87.3	47.8	7346	6.31	9580

Table 3 Simulation results for System 2 (hybrid PVT solar collector system).

	No. of collectors	Solar fraction (%)	$\eta_{th,col}$	E_{tot}	Sys. Performance	CO_2 emissions reduction (kg)
1	10	14	26.5%	37622	0.99	2798
2	15	21.2	26.5%	33700	1.08	4276
3	20	28	26.3%	29988	1.18	5746
4	25	34.3	26.1%	26428	1.29	7058
5	30	40.5	26.0%	22933	1.43	8223
6	35	45.9	25.6%	20240	1.57	9282
7	40	50.4	25.1%	18125	1.71	10123
8	45	55.4	24.9%	15589	1.89	10982

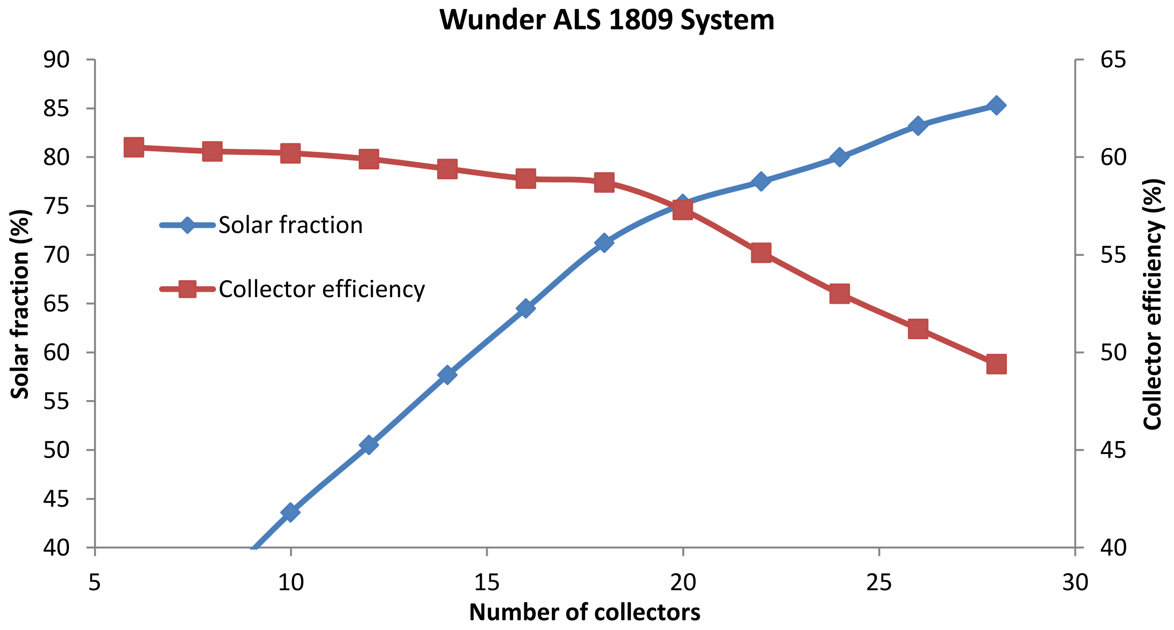

Figure 5 Results of the parametric study for System 1.

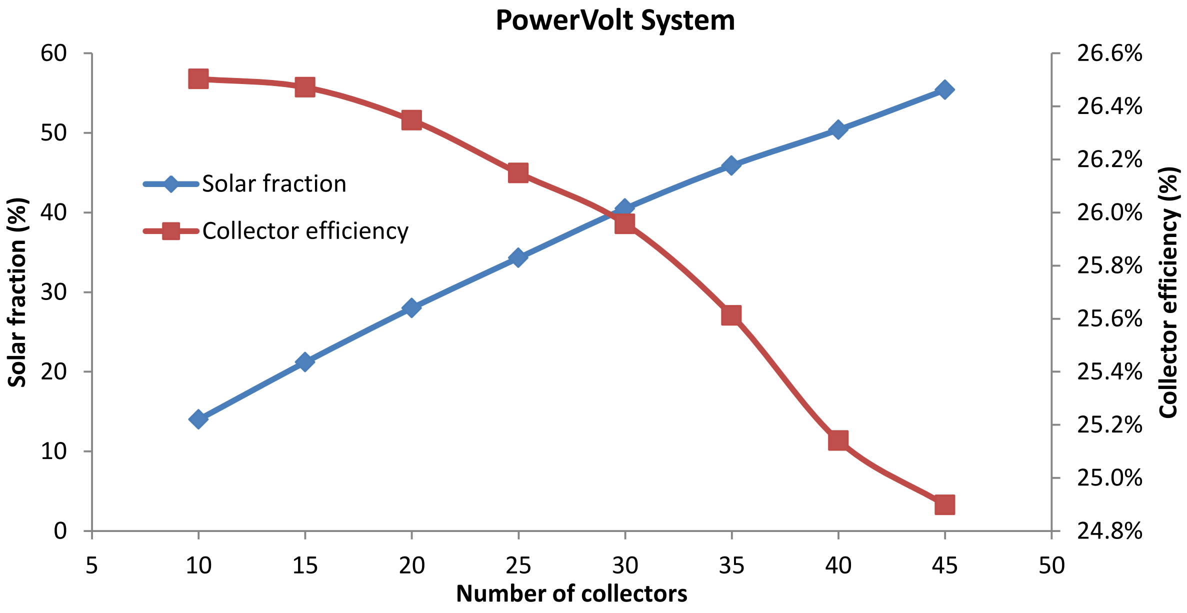

Figure 6 Results of the parametric study for System 1.

5.0 Concluding remarks

A parametric study has been completed in this work using computer simulations to identify the optimal solar solution for an indoor pool located in Sydney. It was found in this work that a pure solar thermal solution using the Solimpeks Wunder ALS 1809 flat plate collectors can make a significant contribution to the heating demand of the pool.

A combined heat and power PVT collector system is also presented as an option should the client want to sell photovoltaic energy to the grid. However this option will not provide the same thermal contribution as the flat plate collector solution.

Based on the work carried out, a solar thermal collector array consisting of the Solimpeks Wunder ALS 1809 collectors with a minimum size of 20 panels is recommended.