DC Hotel

Swimming Pool Energy Audit

An energy audit on the swimming pool and associated plant located at the DC Hotel. This audit will give an overview of energy being consumed unnecessarily through maintenance issues. Recommendations are made of the course of action that should be taken in order to minimise energy costs.

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1. INTRODUCTION

The Trend BMS management controls the pool heat exchanger and also the controls for the swimming pool area air handling unit. These are controlled off an IQ250 controller. It was found that from complaint through the leisure center staff there were control issues associated with the swimming pool water temperature. After some basic investigating it was found that the swimming pool air handling unit switches off at night and no pool cover is put over the pool. This is the first point of concern. Checks had to be carried out to determine the cause of the lack of control over the pool temperature and also an investigation into the possible savings that could be made by changing the control strategy and/or introducing energy saving measures.

2. THE POOL'S HEATING CONTROL

The following is a graphical representation of the pool heat exchanger used to control the pool temperature:

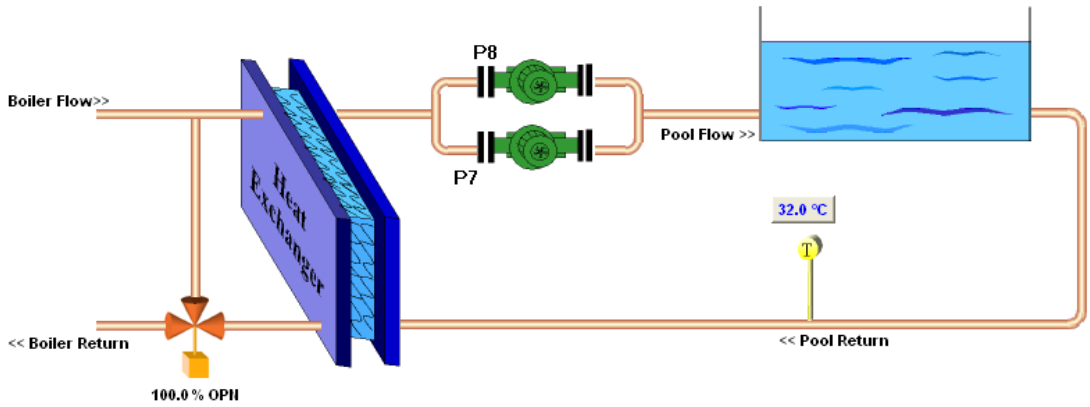

Figure 1: Pool Heat Exchanger

As you can see there are two pumps, one temperature sensor and one control valve on the BMS controls for the pool. As the pumps would not have a direct effect on over heating the pool these have not been investigated. The only other two control elements are the temperature sensor and the control valve.

The temperature sensor was check three times over a fifteen minute period. During this time the BMS temperature fluctuated by over 2^{o}C while the hand held temperature probes remained at a steady 31.7^{o}C. It was decided to replace the temperature sensor in order to help stabilise the readings.

The sensor was replaced and the system was allowed to settle for a couple of hours before being re-checked. It was found that there were still temperature control issues.

The control actuator on the heating valve was stroked fully from 0% to 100% with no sign of sticking or jamming. The logical conclusion was to remove the actuator and try to manually close off the control valve. This solution was let lie for a couple of hours before a recheck on the pool temperature was carried out. Although the pool temperature had dropped, there was a slight amount of hot water still passing through the control valve flow pipe.

As such it was concluded that the control valve was passing although the actuator was fully functional. For the moment the hand valve located just behind the control valve on the pipe-work has been throttled back in order to reduce the flow through the control valve when it is both open and closed.

3. COST ASSOCIATED WITH INABILITY TO CONTROL

In order to calculate the cost of the valve passing measurements must be first made of the pool. Below is an overview diagram of the pool dimensions.

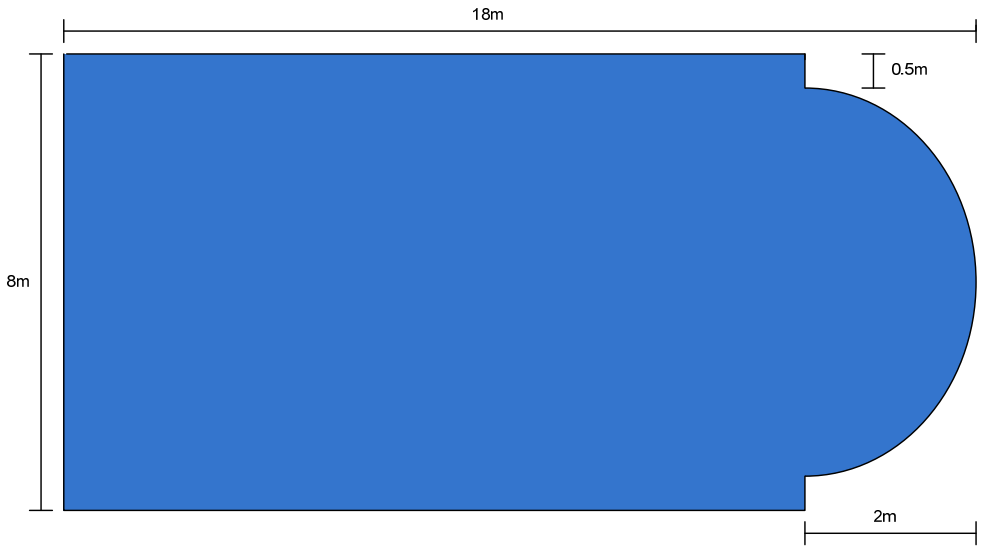

Figure 2: Pool Layout

As you can see this is only a two dimensional drawing and so no indication of depth has been given. In fact the pool depth was measured at a constant 1.5 meters.

3.1 POOL VOLUME CALCULATIONS

In order to calculate the volume of the pool, we must first find the surface area of the pool. Then multiply this by the depth.

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$$Volume\ of\ Pool = 206.15m^3$$

We know that there are 1000 liters of water in $1m^3$. There the volume of water in the pool is approximately 206150 liters of water.

4. ENERGY CALCULATIONS

The current running costs associated with the pool are as follows:

1. The first cost to look at is the cost of having the pool 2°C above set-point. The cost associated with this is the once of cost of heating the pool from 30°C to 32°C.
2. The second cost on the pool is the cost of heating it up each day after leaving it sitting idle over night.
3. The third cost to consider is the cooling of the pool due to the set point being 6°C low than the pool temperature. Currently the pool set-point is 30°Cbut controlling to 32°C therefore, normally, the supply air set-point should be 1°C above the set-point at 31°C. The current pool area set-point is 26°C.
4. The fourth and final cost to consider is that of the staff manually opening and closing the heating valve every day to the control the pool temperature. Under automatic control the pool temperature can get to within 0.1°C of the pool set-point. Under manually control it can be seen that the pool temperature on average fluctuates by 2°C.

4.1 POOL DEAD TIME

The first step in the process is to find the dead time of the pool. This is done by applying a set input into the control system and measuring the response time. In practice this is a simple set point change. After carrying out this procedure it was

found that the dead time for the pool was 1 hour for every 0.1^{o}C temperature change, when the pool requires heating.

4.2 CURRENT POOL TEMPERATURES

The pool temperature was plotted and recorded over a seven day period in order to get an average temperature during occupancy and non-occupancy. These averages were found to be 32.0^{o}C and 31.7^{o}C respectively. This represents a 0.3^{o}C difference in the temperature.

4.3 COST OF POOL HEATING

The following are the costs of heating the pool

4.3.1 INITIAL COST

It can be seen that the pool temperature has risen by 2^{o}C when the valve started to pass. From the dead time the following calculation on how long it would have taken for this to happen is as follows:

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So it has taken the pool approximately 72,000 seconds to increase 2^0C.

In kW cost on gas consumption this equates to the following:

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$$Gas\ Consumption\ in\ kW = 23.99kW$$

The above figure shows us that it has cost 23.99kW of energy (gas) to heat the pool up by the extra 2^oC.

4.3.2 DAILY HEATING COST

The daily cost of heating the pool water up by 0.3^0C is as follows:

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$$Gas\ Consumption\ in\ kW = 23.92kW$$

4.3.3 COST OF KEEPING POOL AT TEMPERATURE

As the pool air handing unit has a set-point of 26°C, which is 6°C lower than the pool temperature, there is an associated cost of energy loss from the pool water temperature to the air. The amount of evaporated water from the pool can be calculated as follows:

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$$Gas\ Consumption\ in\ kW = 43.81\ kw$$

4.3.4 COST OF MANUALLY CONTROLLING THE POOL TEMPERATURE

At present the time the pool temperature is being controlled by the leisure center staff by simply opening and closing an isolating valve just before the LPHW flow to the heat exchanger. It was found that the staffs on average open and close the valve with a swing of 2°C. After checking the control graph it was found that the staffs opens the valve and closes the valve once per day.

This has the following cost implication:

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$$Gas\ Consumption\ in\ kW = 23.99kW$$

4.3.5 TOTAL COST OF HEATING THE POOL

The cost of heating the water up beyond the set-point of 30^{o}C to 32^{o}C was found to be: 23.99kW. This was a once of cost as the valve passed. In monetary terms this works at €0.72

The cost of heating the pool up after being left idle over night was found to be: 23.92kW. This is a daily cost and works out as follows:

Time Scale	Day	Week	Month	Year
Energy	23.92	167.44	669.76	8037.12
Cost (@3c/kW)	€0.72	€5.03	€20.10	€241.21

The cost of evaporation from the pool to the pool area was calculated to be 60.16kw. This cost works out as follows:

Time Scale	Day	Week	Month	Year
Energy	60.16	421.12	1684.48	20213.76
Cost (@3c/kW)	1.8048	12.63	50.53	606.41

The cost of manually controlling the pool heating was found to be: 23.92kW. This is a daily cost and works out as follows:

Time Scale	Day	Week	Month	Year
Energy	23.92	167.44	669.76	8037.12
Cost (@3c/kW)	€0.72	€5.03	€20.10	€241.21

Total cost heating the water is as follows:

Time Scale	Day	Week	Month	Year
Energy	108	756	3024	36288
Cost (@3c/kW)	€3.24	€22.68	€90.72	€1088.64

5. RECOMMENDATIONS

The following recommendations will help reduce the cost of heating the pool:

1. Replace the valve on the pool heat exchanger.
2. Increase the pool area set-point to be 1^{o}C higher than the water temperature.

5.1 REPLACING THE HEAT EXCHANGER VALVE

By replacing the valve on the pool heat exchanger the following savings could be made immediately:

Time Scale	Day	Week	Month	Year
Energy	23.92	167.44	669.76	8037.12
Cost (@3c/kW)	€0.72	€5.03	€20.10	€241.21

As the pool heating is being manually controlled these figures are only estimated only. In reality these values could be worse as it depends on human intervention.

5.2 INCREASE POOL AREA SET-POINT

It was noted that the pool air handling unit return fan was tripping out. This should be investigated further but could be the reason for such a low pool area set-point. The pool set-point is at 30°C therefore the pool area temperature should be 31°C.

At this stage it is assumed that the pool heat exchanger actuator has been replaced.

Assuming that the airflow above the water is almost 0m/s then following calculation can be made:

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Most of the heat required for the evaporation is taken from the water itself. To maintain the water temperature heat must be supplied. The heat supplied can be calculated as:

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$$Heat\ Supplied = 27.69\ kw$$

5.3 TOTAL COST OF POOL HEATING AFTER RECOMMENDATIONS

The total cost of heating the pool after the recommendations have been carried out is as follows:

1. The first cost on the pool is the cost of heating it up each day after leaving it sitting idle over night.
2. The second cost to consider is the cooling of the pool due surround air temperature.

The cost of heating the pool up after being left idle over night was found to be: 23.92kW. This is a daily cost and works out as follows:

Time Scale	Day	Week	Month	Year
Energy	23.92	167.44	669.76	8037.12
Cost (@3c/kW)	€0.72	€5.03	€20.10	€241.21

The new cost of evaporation of the water to the air is now 27.69kW

Time Scale	Day	Week	Month	Year
Energy	27.69	193.83	775.32	9303.84
Cost (@3c/kW)	€0.83	€5.81	€23.29	€279.11

Now the total cost of heating the pool on a daily basis is as follows:

Time Scale	Day	Week	Month	Year
Energy	51.61	361.27	1445.08	17340.96

Cost (@3c/kW)	€1.55	€10.84	€43.35	€520.22

5.4 TOTAL SAVINGS OF POOL HEATING AFTER RECOMMENDATIONS

The following is the current cost and energy use:

Time Scale	**Day**	**Week**	**Month**	**Year**
Energy	108	756	3024	36288
Cost (@3c/kW)	€3.24	€22.68	€90.72	€1088.64

The following table now highlights the project cost and energy use based on the recommendations above:

Time Scale	**Day**	**Week**	**Month**	**Year**
Energy	51.61	361.27	1445.08	17340.96
Cost (@3c/kW)	€1.55	€10.84	€43.35	€520.22

This yields the following savings on both cost and energy

Time Scale	**Day**	**Week**	**Month**	**Year**
Energy	56.39	394.73	1578.92	18947.04
Cost (@3c/kW)	€1.69	€11.84	€47.37	€568.41

6. CONCLUSION

It can be seen from the above information that the main cost heating the pool is due to evaporation from having to low a pool area set-point and also allowing staff to manually control the pool heating. Taking into account the recommendations above the pool costs and energy usage would drop to 48% of the current running costs while yielding a savings on the pool of 52% or €568.41. It can be agreed that these are in fact significant savings.

It should be noted however that all calculations are based on controls sensors which are currently not accurately calibrated and in the case of the return humidity sensor: faulty. This means that the results do hold a degree of error.

Also as these results are base on bulk historical information and not live data there is also a degree of error inherent in the results. Ideally a monitoring and targeting package should be installed alongside the BMS in-order to make calculations on live data.

The above results are based solely on the swimming pool and the heat exchanger. Savings could also be made through the pool ventilation system.

It can be agreed that the purpose of this document was to fulfill the role of calculating current cost as well as saving for the swimming pool. This has been done as accurately and fairly as possible. If you have any questions regarding the content of this document please do not hesitate in contacting the author.