OFFICE OF ENVIRONMENT & HERITAGE

Energy efficient water heating technology guide for aquatic centres

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Photography, front cover: Bega Memorial Pool (Bega Valley Shire Council)
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Gas boiler (OEH)
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Contents

Acronyms and abbreviations

AHU	air handling unit
BMS	building management system
COP	Coefficient of performance
EEV	electronic expansion valve
ESC	energy savings certificate
ESS	energy savings scheme
GJ	gigajoules (1 GJ ~= 277.8kWh)
HVAC	heating, ventilation and air conditioning
kWe	kilowatt electrical
kWh	kilowatt hours
kWth	kilowatt thermal
M&V	measurement and verification
OEH	Office of Environment and Heritage
SCADA	supervisory control and data acquisition
TXV	thermostatic expansion valve
VSD	variable speed drive

About this guide

The Energy efficient water heating technology guide for aquatics is for all those involved in managing water heating systems at aquatic centres and other facilities with heated pools, such as gymnasiums and recreation centres. It provides high-level guidance on commercially-proven, energy efficient and cost-effective practices and available technologies to help centre owners and operators reduce energy use and operating costs related to pool water heating.

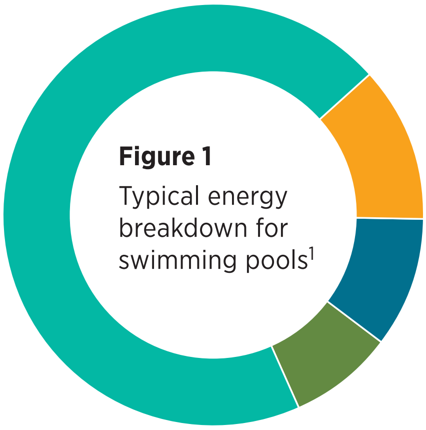

Figure 1 Typical energy breakdown for swimming pools[1]

The high cost of energy

Water and space heating can account for up to 80% of an aquatic centre's total energy costs and is the single most expensive operating cost after labour. **Figure 1** indicates a typical energy breakdown in an aquatic centre with heated indoor or outdoor pools (for indoor pools, "pool heating" also includes heating of the air in pool halls).

What's covered in this guide?

This guide has four main parts:

Part 1
Reducing water heating demand

Part 2
Improving the efficiency of existing water heating systems

Part 3
Upgrading to new, more efficient water heating systems

Part 4
Case studies

1 Based on audits conducted by Northmore Gordon on four NSW aquatic centres.

Part 1 – Reducing water heating demand

Understanding heat loss

Reducing heat loss is one of the easiest and cost effective ways to reduce pool heating and energy costs. It can also allow downsizing of water heating equipment. **Figure 2** shows that most of the heat loss is from evaporation, therefore this should be a key focus when aiming to reduce heating demand.

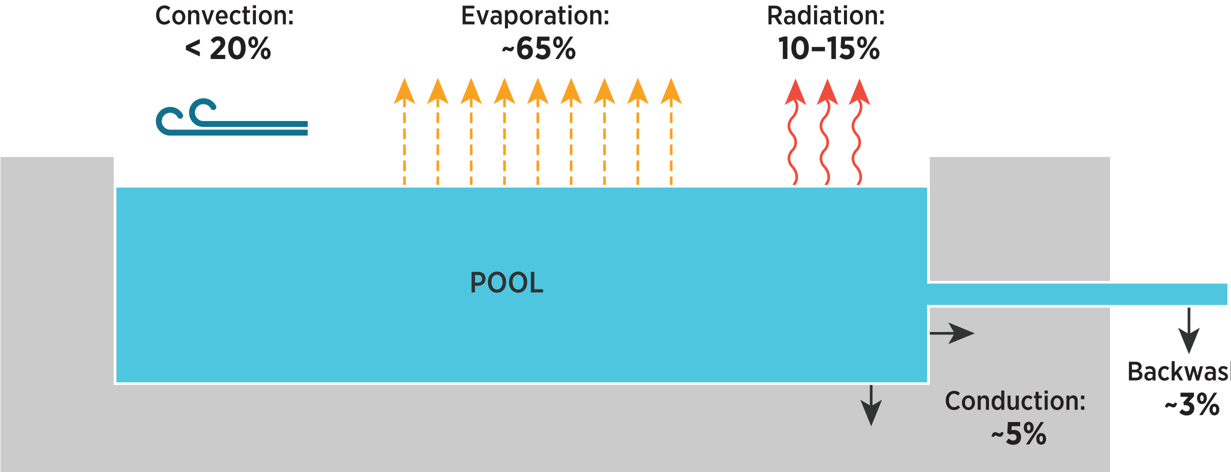

Figure 2 Typical distribution of heat losses in heated swimming pools

Reducing the demand for heating

Before considering costly heating equipment modifications or upgrades, pool operators should first look for opportunities to reduce the demand for water heating.

1. Reduce pool water temperature set point

Lower pool water temperature reduces energy costs as well as reducing heat losses from evaporation. This opportunity requires adjustment of the pool water temperature set point. There are several possible scenarios:

- permanent change (for instance, 26°C instead of 27°C all year round)
- seasonal change (for instance, 26°C instead of 27°C in summer only)
- daily adjustments based on the attendance of the pool. If the pool has regular attendance patterns, the pool temperature can be automatically adjusted, according to a programmed schedule, to be warmer when young children occupy the pool and colder otherwise
- a combination of the above.

Opportunity cost:
• $0 (if completed by pool operator) • or up to $1000 (if completed by BMS contractor)
Payback
< 1 year

2. Increase relative humidity set point (indoor pools only)

Higher relative humidity reduces heat losses from evaporation. It is recommended to maintain the relative humidity inside the pool hall between 50% and 60%. Higher humidity can increase the risk of structural damage to the building from condensation and corrosion[2].

If the relative humidity set point is 50%, consider increasing the set point to 55% and then 60%. Customer feedback must be closely monitored as a high relative humidity might create a feeling of damp atmosphere and result in a reduction of attendance.

Opportunity cost:

- $0 (if completed by pool operator)
- or up to $1000 (if completed by BMS contractor)

Payback

< 1 year

3. Optimise filter backwashing

Backwashing the filters is necessary to maintain good water quality and commonly happens on a fixed time schedule. This can result in unnecessary backwashing. A more energy efficient strategy is to only backwash when required. As the amount of contaminant in the filter increases, the pressure drop across the filter increases, and this change in pressure drop can be used to identify when backwashing is needed. The filter manufacturers provide guidelines about the optimum pressure drop for backwashing a filter.

This opportunity requires:

- installing pressure gauges on each filter (if not yet installed)
- identifying the optimum pressure drop for backwash
- training pool operators about the new backwashing procedure.

Opportunity cost:

- $0 for changes in backwashing procedure (assuming all done by pool operators)
- $200 to $300/filter for the installation of manual reading pressure gauges by plumber

Payback

< 1 year

Very low energy savings but significant water savings

4. Insulate pipework

This opportunity is relevant for outdoor pipework. While insulating outdoor pipework saves energy in all heated pools, significant savings are likely where the yearly average outdoor temperature is 10°C lower than the heated water in the pipe. When this is the case, insulated outdoor pipework will reduce heat loss to ambient air.

Opportunity cost:

- $60 to $100/m of pipework to insulate (assuming easy access to the pipework)

Payback

From 2 to 9 years

2 2011 ASHRAE Handbook—HVAC Applications, Chapter 5, Natatorium, Humidity Control.

5. Increase pool hall air temperature (indoor pool only)

Higher air temperature while maintaining the relative humidity in pool halls, reduces water evaporation from the pool. However, it's important to ensure that the additional energy required to heat the air is lower than the expected savings from reducing evaporation losses. This can be assessed by a qualified consultant.

Opportunity cost:

- $0 (if completed by pool operator)
- or up to $1000 (if completed by BMS contractor)

Payback

May require assessment of the additional energy cost required to increase pool hall air temperature

Payback varies depending on complexity of assessment

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6. Use pool covers overnight

Pool covers are an easy, cost effective opportunity that will significantly reduce energy in most heated pools, however they require storage and maintenance.

Opportunity cost:

- $2400 + $70/(m^2 of pool to cover) for the purchase of a thermally insulated pool cover

Payback

- 0 to 3 years for outdoor pools
- 2 to 7 years for indoor pools

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7. Reduce air movement above pool water surface (outdoor pool)

Lower air movement above the pool surface reduces heat losses from convection and evaporation. Installing glass walls around a heated pool will reduce wind levels.

8. Insulate pool walls

Roughly 5% of heat from the pool water is lost through the ground. Installing or upgrading pool wall insulation can save energy but is recommended only during major refurbishment or redevelopment of pools.

9. Insulate the pool hall (indoor pool only)

Improved insulation of pool halls reduces heat loss, saves on energy costs, and helps to regulate the indoor climate making it more comfortable for patrons.

Lithgow Aquatic Centre

Reducing energy demand through passive design

Re-opened in 2015 following a $6.2 million overhaul, Lithgow City's JM Robinson Aquatic Centre operates efficiently year-round despite Lithgow's frosty winters thanks to its passive design that has dramatically reduced energy demand.

Passive features include: high insulation walls, ceiling and floor; a lopsided roof shape enabling louvres at the high and low end to create a highly effective natural ventilation system (there's no mechanical ventilation in the entire centre); thermally broken double-glazed windows. The hall also has under-floor hydronic heating and the pool water temperature, and the hall's ambient temperature, are maintained by a solar heater on the roof.

Part 2 – Improving the efficiency of existing water heating systems

Determining system efficiency

It is important to know the efficiency of existing water heating systems. It can help to:

- define a baseline before implementing an energy efficiency project
- compare the performance of a system with the manufacturer specifications
- confirm the validity of an energy efficiency or upgrade project business case.

Calculating efficiency

System efficiency can be readily determined using the generic equation:

$$\textbf{System efficiency} = \frac{\textbf{Energy output*}}{\textbf{Energy input**}}$$

* Energy output – thermal output can be calculated based on the incoming and outgoing water temperature. Heat and electrical energy output can be obtained directly from cogeneration plant.

** Energy input use electricity or gas consumption of water heater.

Alternatively, specialists can conduct an efficiency test, ranging in price from $500 to $5000 depending on the type and quality of the test.

If the efficiency is well below specifications or typical benchmarks, then there are likely to be several low-cost improvements that can be made. If it is close to its expected efficiency, then the only way to improve is to reduce demand or upgrade/replace with more efficient technology.

Energy efficiency opportunities

Improving the operation of heating system

1. Maintenance

Thorough and regular maintenance is one the most important actions pool operators can take to reduce energy costs. For all major energy-consuming assets, verify the following:

- they are clear from obstructions – nothing restricts the air flow around boilers or air-to-water heat pumps
- they are clean – dirty condensers have a lower heat transfer, and will therefore increase the energy consumption of a heat pump. Dirty thermal solar panels will reduce their effectiveness
- staff operate the system as specified by the operator handbooks
- routine maintenance programs are managed by an experienced company
- records of the previous maintenance works are available (date and tasks completed).

Proper housekeeping and routine checks of the heating systems can be enough to generate an energy saving of at least 5% while reducing cost of repair and risk of downtime.

Opportunity cost:
• $0 (if completed by pool operator) • $0 (correct maintenance and routine check should be part of a contractual agreement)
Payback
< 1 year

2. Regulating multiple heating devices

When multiple types of heating systems are used verify the following:

- they are not all starting at the same time: a gradual increase in heating capacity is more energy efficient
- the starting order is correct: based on your priorities, the cheapest, or the most energy efficient heating system should be used first. For example, if you have a gas boiler and a solar thermal system, make sure that the heat of the solar system is used before topping-up with the gas boiler especially on sunny days.

Opportunity cost:
• $0 (by pool operators) to $1000 (BMS contractor) if there is no need for additional metering or integration of additional equipment to the BMS
Payback
< 1 year

3. Monitoring heating systems

Ongoing monitoring and regular reviews of the performances of water heating technologies can result in significant energy cost savings and maintenance cost savings. Please refer to OEH's Energy and water metering and monitoring guide for aquatic centres (co-located with this guide). For information about where to meter, types of meters and how to monitor, see OEH's Electricity Metering and Monitoring Guide**.**

Optimising specific heating technologies

Gas boilers

1. Maximise heat recovery from gas boilers

As mentioned in the Maintenance section, verify that staff operate the system as specified by the operator handbooks. Sometimes, when a standard gas boiler has been upgraded to a condensing boiler, the downstream pieces of equipment, such as heat exchangers and controls are not updated.

Typically, a standard gas boiler (80-85% efficiency) operates within a water closed-loop and requires 60°C in and 80°C out. To achieve the highest efficiency, a condensing boiler (90-95% efficiency), needs to operate with an incoming water temperature of 30°C for an outgoing temperature of 50°C.

If the heat exchanger is not designed for these lower temperatures, it needs to be upgraded.

Opportunity cost:

- $0 to $1000 for BMS control updates
- $10,000 for purchase and installation of new heat exchanger

Payback

1 to 4 years

2. Install an oxygen probe with a burner optimiser

Even within months of commissioning, the efficiency of a gas boiler can drift by a few percentage points. When the energy cost of a gas boiler is $100,000/year, 2% of efficiency loss represents an additional cost of $2000/year.

The combustion efficiency can be calculated from an oxygen probe. A controller connected to the burner can then adjust the mix of gas and air to improve the combustion and reduce the heat losses.

Opportunity cost:

- $5000 to $10,000 burner optimiser

Payback

2 to 5 years

3. Retrofit boiler flue stack with an economiser

The flue gas from a standard gas boiler has a high temperature and can be a source of heat recovery. An economiser is a heat exchanger installed at the exhaust of a gas boiler where cold water can be circulated to recover heat. The waste heat can be used to pre-heat the boiler feedwater or to heat water for domestic uses (showers and hot water tap). Not all gas boilers can be retrofitted with an economiser. Contact the boiler manufacturer to ask for advice.

Assess the practicality and economic viability of this opportunity. You might need to outsource this task.

Opportunity cost:

- Varies depending on size of boiler – site dependant

Payback

Varies depending on size of boiler – site dependant. Economisers typically improve the efficiency of a boiler by ~5%.

4. Upgrade existing burner with higher efficiency burner

Before considering the installation of a new boiler, it might be more cost-effective to only upgrade the burner.

Opportunity cost:
• Varies depending on size of boiler – site dependant
Payback
Varies depending on size of boiler – site dependant.

Electric heat pumps

1. Resolve icing problems

Air source heat pumps can be subject to icing. Icing can occur if:

- there is poor ventilation (restricted air flow around the coil)
- the refrigerant pressure is not controlled properly
- the defrosting system is malfunctioning.

Apart from in extreme weather conditions, heat pumps should not ice. If, despite proper maintenance, icing keeps occurring, consider replacing the heat pump with a more reliable model.

Opportunity cost:
• $0 to $5000 for maintenance check and repair to resolve icing problems
Payback
<1 year

2. Retrofit of electronic expansion valves

Older heat pump systems are likely to be fitted with thermostatic expansion valves (TXVs) which is very inefficient in the case of swimming pools where the load varies greatly. TXVs can be replaced with electronic expansion valves (EEVs). Because this opportunity applies to old systems, it is important to assess the expected lifespan of the heat pump when considering this optimisation for implementation. The EEV retrofitting can lead to 10 to 15% energy savings.

Opportunity cost:
• $1000 to $7000 for expansion valve upgrade
Payback
1 to 2 years

3. Remove unnecessary heat loops

It is common to see heat pumps providing heat to the pool through an intermediate closed-loop, as illustrated in **Figure 3a**. This configuration protects the heat pump from the corrosive environment of pool water to reduce maintenance cost. However, it increases the operating temperature of the heat pump and, therefore, reduces its Coefficient of Performance (COP). Newer heat pumps can be designed to directly heat pool water without damage, which is more energy-efficient, as illustrated in **Figure 3b.** The following steps should be undertaken before implementing this opportunity:

- verify if the heat pump compressors can run with pool water
- assess the devices (pumps, heat exchangers, pipes) which might need to be modified
- conduct a cost benefit analysis of this opportunity (capital cost, energy savings, and possible increase in maintenance cost).

Opportunity cost:
• Unknown – site dependant
Payback
Unknown

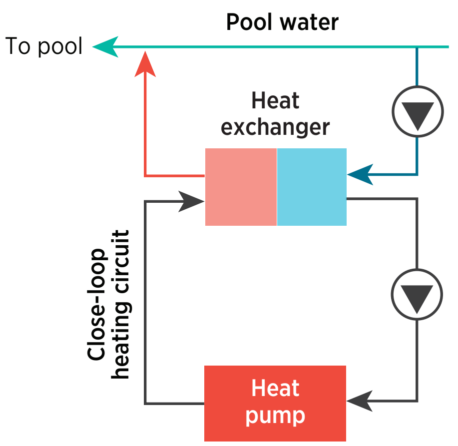

Figure 3a Common configuration

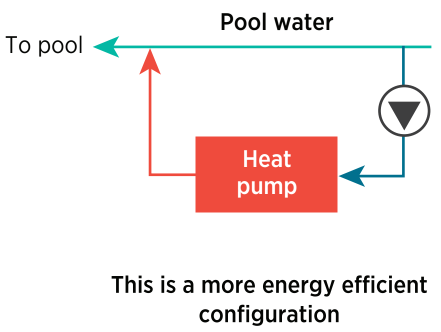

Figure 3b Direct heating – more efficient

4. Recover heat from the HVAC exhaust (indoor pool only)

In indoor pools, the air temperature of the pool hall is maintained all year round. To maintain air quality, air from the pool hall is rejected to the outside via the Air Handling Unit (AHU) on a continuous basis. As a standard feature, sensible heat from the exhaust is recovered to pre-heat the incoming air. However, the exhaust air still contains a high amount of energy through the latent heat of the moist air.

Recovering the latent heat from the AHU exhaust can be a significant energy saving opportunity, especially in winter. A heat pump can use the AHU exhaust as a heat source (instead of the outside air); the small temperature differential between air and pool water, and the continuous air flow going through the AHU can dramatically improve the COP of an air-to-water heat pump.

This opportunity requires the installation of a coil in the AHU, a bespoke engineering design and good controls between pool water heating systems and air heating systems.

Depending on the configuration of the pool, it is possible to install a pre-packaged AHU unit which can recover heat from the exhaust to heat the incoming pool hall air, as well as heating the pool water.

Opportunity cost:

- Unknown – site dependent

Payback

Unknown

To improve the efficiency of water heating and improve the pool hall area environment, **Junee Aquatic Centre** installed a heat exchange ventilator unit (pictured). This unit controls the temperature and humidity of the air in the pool hall while providing heat to the pool water.

You can read the full case study on page 20.

Photo: ESBS Pty Ltd

Solar thermal system

1. Maximise heat use by control adjustment

As mentioned previously, make sure that the heat generated by the solar system is used before any other systems.

Consider slightly overheating the pool with the solar system during the day to reduce the use of other heating systems later in the evening.

Opportunity cost:
• $0 to $1000 for remote control adjustment by Cogen contractor
Payback
<1 year

2. Replace with photovoltaic (PV) solar system

Depending on your location and energy prices, consider replacing solar thermal system with a photovoltaic (PV) system to generate power on site. This requires a careful cost/benefit analysis.

Opportunity cost:
• $1.8/(W of PV panel) for the purchase and installation of the PV system
Payback
>5 years

Gas fired cogeneration system

1. Maximise heat use by control adjustment

As mentioned previously make sure that the priority order of heat generation is correct. When a cogeneration unit generates heat, concurrently to a heat pump or a gas boiler, the heat generated by the cogeneration system should be used first.

Opportunity cost:

- $0 to $1000 for remote control adjustment by Cogen contractor

Payback

<1 year

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2. Maximise heat recovery by adding heat users

Cogeneration systems generate electricity for the site and heat for the pool water. Additional heating loads can be added to the cogeneration system such as Domestic Hot Water and pool hall space heating to increase the overall heat recovery from the cogeneration system and improve its overall efficiency level.

This opportunity requires a complete feasibility study to verify its economic viability and practicality.

Opportunity cost:

- Unknown – site dependant

Payback

Unknown

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3. Utilise or export excess electricity

Cogeneration systems are more efficient at full load. Consider using excess generated power on site or export excess to the grid (requires a renegotiation of agreement with energy provider) This requires a careful cost/benefit analysis.

Opportunity cost:

- $0 to $1000 for remote control adjustment by Cogen contractor

Payback

<1 year

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4. Verify the economics of the system on a regular basis

Cogeneration systems are economically profitable when gas is cheap, and electricity is expensive. If the economics aren't favourable, stop the cogeneration system and restart it only when it is economically viable to use it again.

Opportunity cost:

- $0 for analysis of economics of the cogeneration system by pool operators

Payback

0 years

Part 3 – Upgrading to new, more efficient water heating systems

Replacing the heating system should be considered if the existing one is reaching the end of its expected service life or cannot be optimised or upgraded to deliver cost-effective energy efficiencies. This section provides an overview of the costs, advantages and disadvantages, and common pitfalls associated with different heating technologies.

Also see **Appendix 1 Common aquatic centre water heating technologies**.

Heating technology costs

1. Purchase and installation cost

Heating technology	Price guideline for installation cost*
Gas boiler	$100/kWth
Electric Heat Pump	$5000 + $400/kWth
Biomass boiler	$250,000 + $300/kWth
Gas fired cogeneration system	$400,000 + $700/kWe

* **Note:** these are estimates only and can vary widely depending on site

2. Energy efficiency, energy cost, carbon emissions, and maintenance costs

Table 2 below shows that electric heat pumps are typically the most energy efficient heating system, solar thermal systems are the cheapest to operate, and gas-fired cogeneration (at 100% heat recovery) is the least carbon intensive.

All values were relevant at the time of publication of the guide and should be updated to reflect your current situation.

Assumptions used in this table are:

- electricity price: $145.00/MWh[7]
- gas price: $17.50/GJ[7]
- biomass price: $8.00/GJ delivered[7]
- electricity GHG emission (Scope 2): 0.83 kg CO_2/kWh[8]
- gas GHG emission (Scope 2): 51.5 kg CO_2/GJ[8]

Table 1 Energy input, energy cost and GHG emission to generate 1 GJ of heat

Heating technology	Rated efficiency[3]	Energy Source	To generate 1 GJ of heat			Maintenance costs
			Energy input (GJ gas or GJ electricity/ GJ heat)	Energy cost[4] ($/ GJ heat)	GHG emission[5] (kg CO2/GJ heat)	
Gas Boiler	85%	Gas	1.18	$20.59	61	$
Electric heat pump	COP: 4	Electricity + Air/Water/ Ground…	0.25	$10.07	58	$$
Biomass boiler	80%	Biomass	1.25	$10.00	0	$$$
Solar thermal	50%	Sun	0.00	free	0	$
Gas fired co-generation (at 100% heat recovery)	45% thermal 30% electricity 75% overall	Gas	2.22	$12.04	-396	$$$

3 Efficiency can vary depending upon the specific technology and site conditions.
4 Energy cost does not include maintenance costs
5 GHG emissions are related to energy only and do not include lifecycle GHG emissions of manufacturing and transporting the device
6 The energy cost and GHG emissions of the cogeneration include the savings related to the production of electricity
7 Based on aquatic centre audits conducted by Northmore Gordon
8 GHG National Account Emission Factors July 2017

Pros and cons of different technologies

The following table provides a brief overview of pros and cons of the most commonly used pool water heating technologies.

Table 2 Pros and cons of water heating technologies

Heating technology	Space required	Pros and Cons
Gas boiler	**Small**	✔ Widely used technology ✔ Wide operating range ✔ Suitable as the sole source of heat of the pool
Electric Heat Pump	**Small**	✔ Widely used technology ✔ Wide operating range ✔ Suitable as the sole source of heat of the pool ✘ Require a supplementary heat source
Biomass boiler	**Medium (fuel storage)**	✔ Might be suitable as the primary source of heat of the pool: depends on the fuel availability ✘ Not widely used ✘ Require long-term contractual agreement for biomass fuel supply
Solar thermal	**High**	✔ Extremely efficient and reduces costs when coupled with another technology ✔ Uses free, renewable energy ✔ No greenhouse gas emission ✘ Cannot be used as the sole source of heat ✘ Weather and season dependent
Gas fired cogeneration system	**Small**	✘ Cannot be used as the sole source of heat ✘ Not compatible with solar PV (unless export is possible)

Feasibility studies and common pitfalls

Because of the large capital cost involved, it may be prudent to conduct a feasibility study before selecting a system. Equipment suppliers or engineering consultants can carry out feasibility studies to confirm the practicality and economics of different systems to determine the best option for your centre. They can also review the regulatory requirements related to the different technologies.

The feasibility study should review the following:

- the impact of energy prices on the financial viability of the project. For example, a cogeneration system is cost effective when electricity is expensive and gas is cheap; while an electric heat pump is cost effective if there is a low electricity tariff and/or the site has lots of solar PV (or plans for PV in the future). When comparing energy costs, it's important to consider several energy pricing scenarios
- the installation requirements: each technology will have different requirements for the location, accessibility, and regulatory requirements – as full assessment is advised
- the on-going operations and maintenance procedures, such as:
  - what are the maintenance requirements, and can they be carried out in-house?
  - how often is a maintenance routine required?
  - what are the impacts of the maintenance on pool operations?
  - what will be the associated cost?

The table below outlines some of the risks and challenges involved in upgrading water heating technologies.

Table 3 Common pitfalls

Heating technology	Common pitfalls
Air-to-water electricity heat pump	In winter, due to cold air temperature and low air movements, ice can form on the coil resulting in a poor efficiency of the heat pump. Therefore, when specifying this type of heat pump, ensure it includes a defrosting feature. Some models handle cold ambient temperatures better than others. Ask your suppliers to provide examples of installations in areas with a similar climate.
Biomass boiler	Long-term contractual agreements are necessary to secure the supply of biomass for several years. When comparing biomass prices, you should compare $/GJ delivered.
Gas fired cogeneration system	When requesting a feasibility study for a cogeneration system, request the analysis to be based on gas High Heating Value (HHV). It is common practice that the efficiencies of cogeneration systems are calculated based on the Low Heating Value (LHV) of natural gas (~34 MJ/m_3), whereas gas is charged based on the HHV (~38 MJ/m3). This tends to artificially increase the efficiency of the system and make the system appear more profitable than it is. The main challenge faced by pool operators using a cogeneration system is the ability to fully recover heat. During the feasibility study, request scenarios where heat is not entirely recovered, to assess the financial risk of the project.

Thinking outside the box

Have you considered other sources of heat or energy that might be available in the vicinity of the pool?

Swimming pools have a low-temperature heat requirement. Therefore, they can benefit from the recovery of waste heat from diverse sources. Waste heat sources can include:

- HVAC systems from nearby commercial facilities with constant cooling need such as data centres or refrigerated buildings
- large wastewater line.

Alternative energy sources can include:

- biogas generated by a local digester which could be used in a dual-fired gas boiler
- biomass generated by local gardeners or farmers which could be used in a biomass boiler.

Although these ideas can result in substantial energy savings, they require careful design and analysis, but when the high costs of energy are considered, it is important to consider all available options.

Part 4 – Case studies

Case study: North Sydney Olympic Pool

Optimising different heating systems, especially the cogeneration system, the heat pumps, and the solar thermal

'Since the audit, and associated project management and advice, running the pool equipment at optimal levels has become much easier. Maximising the available renewable heat over imported gas and electricity has become easier too, leading to energy, GHG emissions and cost savings.'

Ian Garradd
Sustainability Officer,
North Sydney Council

Photo: North Sydney Council

The North Sydney Olympic Pool is an iconic swimming and exercise complex located adjacent to Sydney Harbour at Milsons Point between the Sydney Harbour Bridge and Luna Park. The complex includes two outdoor and three indoor pools, a gym, and a sauna, as well as a café and a restaurant.

The different heating systems were not well integrated and as such were not maximising energy efficiency outcomes. With the support of the NSW Office of Environment and Heritage (OEH), North Sydney Council engaged a specialist energy consultant to investigate options for saving energy and reducing costs.

Energy use

North Sydney Olympic Pool has a combination of four different heating technologies to heat the different pools and to provide domestic hot water. These heating technologies include:

- 3 x Electric water-to-water heat pump, with heat extraction from the Sydney Harbour
- 7 x Gas boilers (4 units for domestic hot water, 2 for HVAC and pool water heating backup, 1 for pool water heating)
- 1 x Gas-fired reciprocating engine cogeneration unit
- 1 x Solar thermal system

The following table provides data on overall energy consumption for the complex for 2015.

Energy type	MWh per year	GJ per year	%	Annual energy cost $	Unit cost	GHG tCO2-e per year
Electricity	943	3395	21	$145,871	$182/MWh (with GreenPower)[1]	290 (with GreenPower)
Gas	3452	12,428	79	$241,740	$19.41/GJ	799
Total	**4395**	**15,823**	**100**	**$397,611**		**1704**

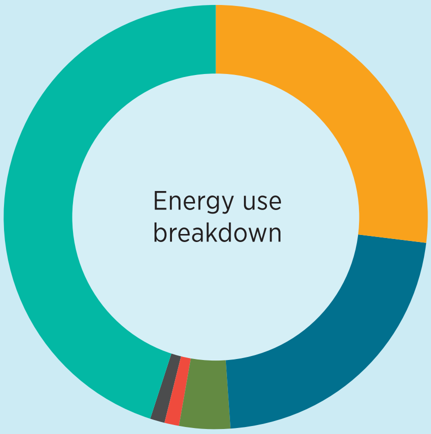
Actions taken

With the support of the NSW Office of Environment and Heritage, an extensive sub-metering plan was implemented in 2017 to identify and quantify the energy flows throughout the site. Following this work, several energy efficiency opportunities were implemented under the supervison of the specialist consultant. The main opportunities involved control optimisation of the different heating systems: especially the cogeneration system, the heat pumps, and the solar system. The work included:

- installation of 18 temperature sensors
- integration of nine variable speed drives (VSDs) to the building management system (BMS) to record the status and speed of each pump
- integration of three boiler relays to the BMS to record the status of the boiler
- development of new BMS interfaces
- enabling new alarms
- programming all energy transfer calculations
- implementing new temperature control settings for the different heating systems.

The entire project took two years to complete and cost $80,900. The table below shows the breakdown of the costs:

BMS contractor	$50,200
Consultant	$42,000
Plumber	$2500
Cogeneration contractor	$1200
Grant from government funding	-$15,000
Total	**$80,900**



45%
Gas boiler and restaurant

27%
Cogeneration unit

22%
Pool filtration

4%
Distribution board

1%
Gymnasium

1%
Motor control

1 During Calendar 2015 North Sydney Council had committed to purchase 62% of its electricity from renewable energy sources, Greenpower. The additional cost is $44.14/MWh of Greenpower.

Other benefits?

All energy consuming assets of the pool have been integrated into the BMS giving better understanding of the pool operation to the operators.

With the new BMS dashboard (below), staff can see at a glance where heat is being used, the real-time power consumption of the site, any faults of heating equipment, and the temperature of the pools and indoor areas.

Savings achieved

Measured energy savings for the period May 2017 to April 2018 (compared to the 2014 and 2015 baseline): 1144 GJ (mix of electricity and gas savings)

Measured energy cost savings: $19,900[2]

Additional expected savings: $11,200

Payback period: 2.6 years.

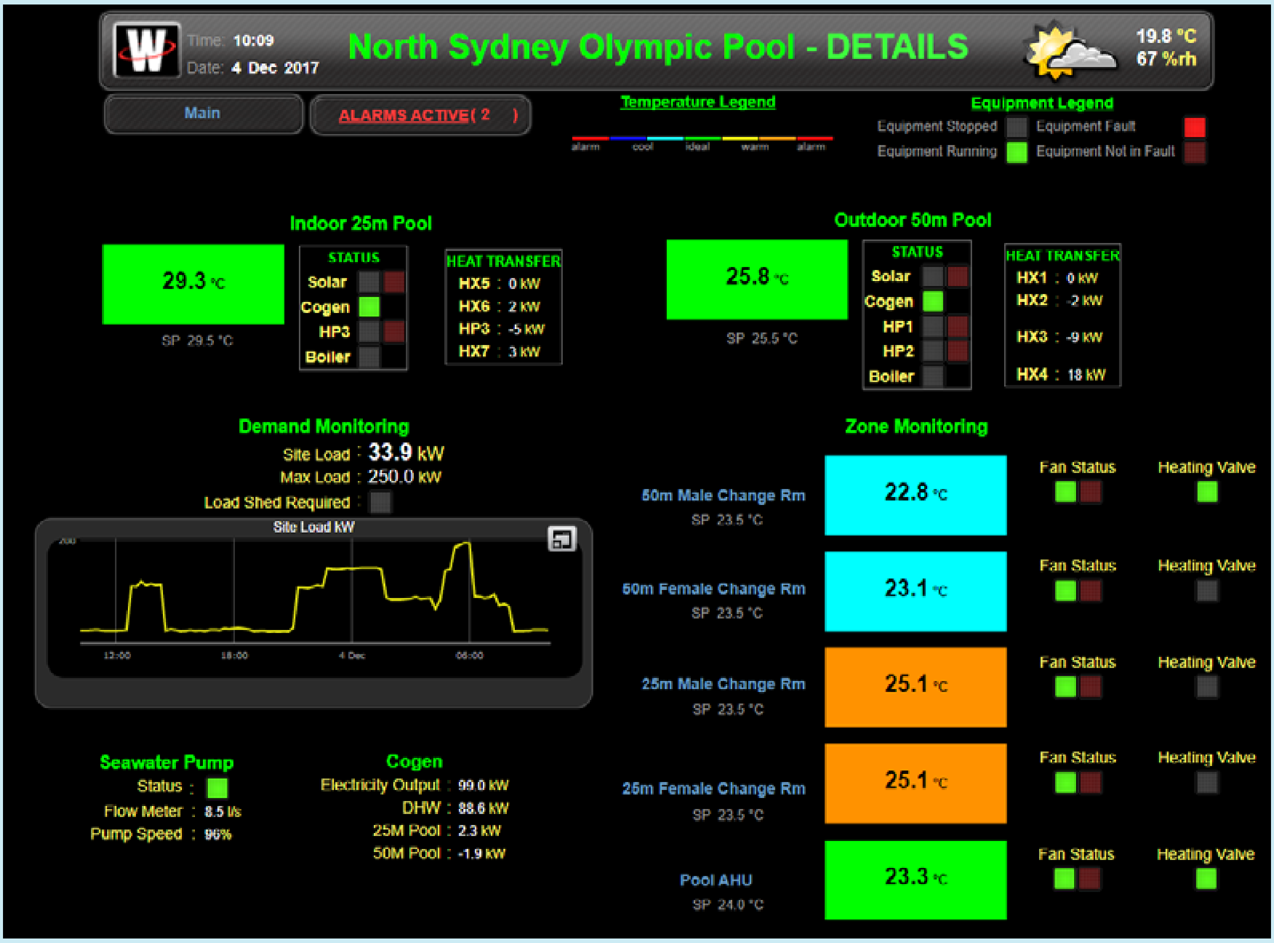


Image: North Sydney Council

2 Based on $17.37/GJ assuming that most of the energy savings are from gas. This is average electricity price for the period FY2016-2017. It is a conservative approach, gas is cheaper than electricity.

Case study: Junee Recreation & Aquatic Centre

Reducing energy demand by installing new equipment and improving the pool hall environment

'The equipment upgrades are already saving us about $25,000 and when our new boilers are operating at full capacity we expect even more energy savings.'

James Davis
General Manager
Junee Shire Council

Photo: Junee Shire Council

The Junee Recreation & Aquatic Centre in Riverina NSW, is owned and operated by Junee Shire Council. The Centre, enclosed in a large concrete and plasterboard building, comprises 50m and 25m heated pools, indoor stadium, gym, and change rooms, plus a creche, manager's office, plant rooms and storage. The pool hall is enclosed by a galvanised steel structure that supports a lightweight double skinned polycarbonate skin and foldable transparent PVC curtains. In winter, the 50m pool is partitioned to be 25m and the pool hall has a PVC curtain applied over the partition.

Junee Shire Council sought assistance from the Office of Environment and Heritage to conduct an energy audit of the facility to determine overall energy consumption and to identify potential energy and cost saving opportunities.

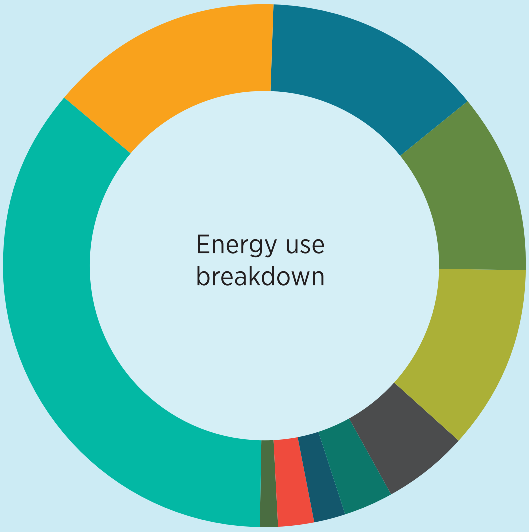
Note: The pool hall enclosure and partition across the 50m pool and the hall have poor thermal insulation and are leaky, which reduces the overall heating efficiency.

Energy use

The following table provides data on overall energy consumption in the centre in the year prior to the energy assessment.

Energy type	MWh per year	GJ per year	Annual cost $	Greenhouse gas emissions tonnes per year
Electricity	370	1,332	$109,744	392
Gas	1,224	4,407	$83,418	222
Total	**1,594**	**5,739**	**$193,162**	**614**

The following pie graph shows the energy consumption breakdown for the Centre (including energy losses)



35%
Pool heating

14%
Hydronic heating

13%
Boiler energy loss

11%
Pumps

11%
Heating supply air

5%
HVAC

3%
Pool water leak

2%
HVAC

2%
Appliances

1%
Uninsulated piping

Actions taken

The energy audit identified a number of issues with aging equipment and the pool hall fabric, and recommended an upgrade to improve energy efficiency as well as improve compliance with standards. Following the audit, Junee Shire Council embarked on an extensive upgrade of the pool hall heating and ventilation system.

A number of energy efficiency recommendations were implemented to reduce pool heating demand and energy demand across the entire centre. Actions included:

1. Replacing existing conventional boilers with high efficiency, condensing-type boilers to achieve higher thermal efficiency by maintaining condensing conditions.
2. Replacing the heat pump with exchange ventilator unit to heat and ventilate the pool hall and provide heating to pool water.
3. Installing variable speed drives (VSDs) to all new ventilation equipment.
4. Installing a heat exchanger unit to change area to maintain positive pressure and reduce entry of moist air from pool hall.
5. Installing sub-meters and a building management system (BMS) across the centre.

Figure 2 New high efficient condensing boilers (ESBS Pty Ltd)

Figure 3 Exchange ventilator unit with LPHW (ESBS Pty Ltd)

Savings achieved

Over a five-month reporting period (December to April) actual electricity consumption was reduced by 16,800 Kilowatt hours (kWh) or about 13%, equating to cost saving of around $25,000 per year.

Delays that occurred in the post-commissioning of the condensing-type gas boilers has meant that at the time of writing, the predicted energy efficiencies have not yet been met.

Case study: Bega Memorial Pool

Large solar array and variable speed drives boost site energy efficiency

Photo: Bega Valley Shire Council

'Through a detailed energy audit supported by the OEH, we were able to identify key efficiency projects and attract other funding to reduce costs and avoid emissions.'

Daniel Murphy
Manager Economic Development, Bega Valley Shire Council

The Bega Memorial centre is one of six centres owned and operated by the Bega Valley Shire Council on the NSW far-South Coast. The pool is an outdoor pool with change facilities and kiosk and is open for the six-month summer swimming season. Data on pool size and heating is provided in table below.

Energy use

The following table provides data on overall energy consumption in the centre in the year prior to the energy assessment.

Patrons per year	Pool length (m)	Pool volume (kL) and area (m^2)	Pool water heating method	Domestic water heating method	Pump
40,000	33 (plus separate learners and small children's pool)	856 / 500	Heat Pump/ Solar	Electric Element/ Heat Pump	18.5kW

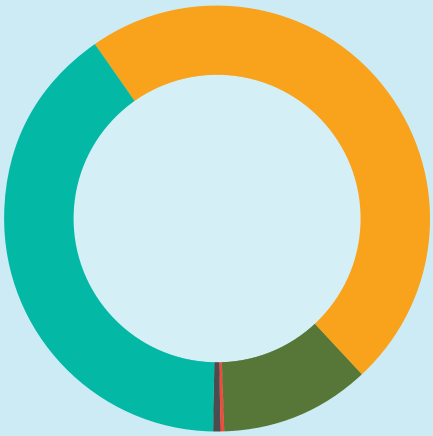
The substantial energy operating costs encouraged Bega Shire Council to seek assistance from the Office of Environment and Heritage (OEH) to conduct targeted energy audits at all six pools.

Energy use

For the year prior to the energy assessment the combined energy usage for all pools was 1040.5 megawatt hours (MWh) per year or $224,666 per year, with greenhouse gas emissions of 916 tonnes per year. Bega pool's share was 134MWh costing $20,000 per year.

The energy breakdown for the Bega pool is shown in the table and graph below.

Energy end use	% of total energy use	MWh	Cost
Heat pumps	40.2%	54.08	$10,903
Pumps	47.8%	64.25	$5978
Showers	11.3%	15.25	$3075
Kiosk	0.4%	0.50	$47
Lights	0.3%	0.36	$34



40.2% Heat pumps

11.3% Showers

0.3% Lights

47.8% Pumps

0.4% Kiosk

Actions taken and savings achieved

The heat pump system for warming pool water and heating showers is responsible for 40% of energy use. A 176 square metre solar array was installed to replace the existing smaller aging array at a cost of $34,640. The new system resulted in savings of approximately $6600 per year. The recommended maintenance in the showers/changerooms is approximately $5000 per year.

The installation of a variable speed drive (VSD) on the filtration pump, resulted in further savings of approximately $4,4150 per year.

The combined energy efficiency initiatives reduced greenhouse gas emissions by nearly 53 tonnes per year.

Appendices

Appendix 1 Common aquatic centre water heating technologies

There are a wide range of heating technologies suitable for swimming pools which come with their own advantages and disadvantages in terms of running costs, practicality, complexity, and availability. Below we list the most common and usually best suited water heating technologies for heating swimming pools in New South Wales.

Other water heating technologies include electric boilers, geothermal water heating systems, combined heat and power (CHP) technologies, and other fuel-based systems using diesel and ethanol. However, these have low or no prominence in New South Wales at the time of publication, and as such have not been included in this guide.

Gas boilers are the most common water heating technology and generate heat from the combustion of natural gas.

Electric heat pumps extract heat from an external heat source to heat water. Possible heat sources include air, water (lake, river, seawater), ground, and other waste heat sources such as cooling towers and wastewater treatment.

Solar thermal systems collect heat from sunlight via a calorific fluid which is then used to heat pool water. This system provides ‘free heat’. However, the output is dependent upon seasonal and weather conditions. Solar thermal systems can also be used to pre-heat water before it is passed through other heater technologies, such as gas boilers.

Gas-fired cogeneration systems generate electricity and heat from a gas engine. Engine heat can be recovered to heat pool water or domestic hot water, while the electricity powers other onsite facilities or is fed back into the grid.

Biomass boilers generate heat from the combustion of biomass such as municipal waste, forestry residues, etc. A biomass boiler must be selected based on the fuel type. Long term contractual agreements are necessary to secure biomass supply.

Gas-fired heat pumps, similarly to gas fired cogeneration systems, generate electricity via a gas engine. This electricity is used to power the compressor of an air-to-water heat pump which extracts heat from the air to heat the pool water. The heat generated by the combustion engine can also be recovered to heat the pool water.