Energy efficiency in swimming pools
– for centre managers and operators
CONTENTS

1 INTRODUCTION 4
2 HEAT PRODUCTION 6
3 HEAT SUPPLY 8
4 VENTILATION AND AIR QUALITY 9
5 HEAT RECOVERY 10
6 OTHER ISSUES 12
FURTHER READING AND REFERENCES 14
INTRODUCTION

Swimming pool halls are unlike any other type of building. They house large volumes of water which must be continuously filtered, treated and heated. In this humid environment the fabric of the building needs to be protected through adequate ventilation. Consequently, swimming pools consume more energy per unit area than other building types. For example, they use five times as much energy per square metre as offices. Therefore swimming pool design and operation call for extra vigilance on the part of management.

Typically, indoor pools are in constant use – they are open almost every day of the year. They are voluminous buildings, and they:

- contain large open areas of warm water which are constantly being agitated by bathers or water features
- have constantly high internal temperatures (often up to 30°C)
- need substantial ventilation systems to maintain comfortable conditions, to help regulate evaporation from the pool surface and to protect the fabric of the building.

Energy costs represent a substantial proportion of the overall operating costs of a typical pool – usually 25%. Energy efficiency is a practical way of reducing operating costs without lowering the standard of service to users.

Where the energy is used

The energy used for different purposes in a pool hall, and the resulting costs, are shown in figure 1.

Design integration

Environmental services, including pool water treatment, form a core element of the overall building design. The following services should be carefully integrated into the design:

- heating
- ventilation
- electrical services
- pool water treatment
- domestic water supply.

In addition, the architectural and structural aspects of the building should be integrated with, and serve to enhance, the energy-efficient design features of the swimming pool.
INTRODUCTION

Option appraisal

Given a pool which is consuming more energy than desired as indicated by the ‘typical’ energy figures (table 1), it is important to consider ways in which it can be made more energy efficient. Assuming that all the plant is working correctly, and the appropriate operational procedures are adhered to, then investment in energy efficiency measures must be considered. Energy efficiency measures will also need to be considered during refurbishment – for example, when ageing plant may need to be replaced – or when specifying a new pool.

Typical measures which may be considered would be:
- combined heat and power (CHP)
- condensing boilers
- ventilation heat recovery
- variable ventilation rates
- pool water heat recovery.

Each of these offer significant improvements in energy efficiency and could produce attractive pay-back periods. However, because of the complex nature of the energy use in a swimming pool, care must be taken when calculating the benefits of energy efficiency measures. If the cost-effectiveness of each of these is taken in isolation it may give a misleading impression of the benefits achieved when they are combined. For example, the cost-effectiveness of a CHP system may be lessened as a consequence of reduced electrical and heating demand resulting from installing variable speed ventilation fans with heat recovery.

To ensure that the most cost-effective techniques are selected, it is essential that the full range of energy efficiency measures are investigated by a process of option appraisal.

It is recommended that a two stage approach is adopted to assess the benefits of a number of measures. In the first stage the individual pay-back periods of each measure are calculated and the most cost-effective measure selected as a priority. The second stage then involves the addition of the less cost-effective measures in turn, and the calculation of the overall pay-back period for the package of measures. By this means the incremental value of each measure – taken in the context of other measures – is more accurately determined, and the risk of adopting measures based on unrealistic pay-back periods is eliminated. This exercise should be carried out in consultation with a competent building services engineer.

<table>
<thead>
<tr>
<th>Typical annual energy use (kWh/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sports centre with pool:</strong></td>
</tr>
<tr>
<td>Good</td>
</tr>
<tr>
<td>&lt;510</td>
</tr>
<tr>
<td><strong>Dry sports centre:</strong></td>
</tr>
<tr>
<td>Good</td>
</tr>
<tr>
<td>&lt;290</td>
</tr>
</tbody>
</table>


**Table 1**

<table>
<thead>
<tr>
<th>Typical pool operating costs (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour</td>
</tr>
<tr>
<td>Interest on capital</td>
</tr>
<tr>
<td>Energy</td>
</tr>
<tr>
<td>Maintenance, rates and supplies</td>
</tr>
</tbody>
</table>

**Table 2**

FURTHER READING

Energy Consumption Guide 51
HEAT PRODUCTION

DESIGN ISSUES

Fuel
The most important factors to be considered in the selection of fuel and the means of heat production are:

- the availability and convenience of the fuel
- the efficiency of the means of heat production
- the price.

Other factors that should influence the choice of fuel are:

- the environmental issues
- the methods of handling the fuel
- the level of maintenance associated with the fuel
- the means of production and distribution.

Unless there is some particular local energy source that warrants consideration (such as waste, process energy, or renewable sources such as solar or wind power), the choice will normally be restricted to coal, oil, natural gas or bottled liquefied petroleum gas (LPG), or electricity. (For most pools, coal is unlikely to be appropriate because of the requirements of storage, handling and maintenance.)

The environmental effects of different fuel options should be taken into account (table 3). Note that electricity is not a primary fuel but has to be produced and distributed, thereby entailing substantial energy loss and carbon dioxide (CO₂) emissions.

The method in which the fuel is used will be the next determining factor in energy efficiency.

Heat production
The main heating requirement for a swimming pool is to heat the pool water and the pool hall air supply. The most efficient way to supply and control this heat is by means of heat exchangers using heated water of low or medium temperature.

| CO₂ emissions per unit of delivered energy (kg/kWh) |
|---------------------------------|--------|
| Gas                             | 0.19   |
| Oil                             | 0.28   |
| Coal                            | 0.32   |
| Electricity                     | 0.63   |

(Source: Energy Consumption Guide 51, p6) Table 3

<table>
<thead>
<tr>
<th>Typical seasonal efficiencies* (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHP</td>
</tr>
<tr>
<td>Gas boiler</td>
</tr>
<tr>
<td>Condensing boiler</td>
</tr>
<tr>
<td>Solid fuel</td>
</tr>
<tr>
<td>Oil boiler</td>
</tr>
<tr>
<td>Electric heaters</td>
</tr>
</tbody>
</table>

*Seasonal efficiency is defined as the average thermal efficiency over a year under all operating conditions Table 4

The usual methods of producing the required heat are:

- CHP units
- condensing boilers
- modern standard or modular boilers
- standard boilers
- heat pumps.

A list of typical seasonal efficiencies is given in table 4. CHP units produce heat and electrical power from the same unit using a single fuel source. The maximum efficiency of CHP units can exceed 90% but to achieve this they need to run at full load for as many hours as possible – provided there is sufficient demand for both heat and electrical power. Swimming pools often provide the ideal circumstances for this.
Condensing boilers can be particularly effective in pool installations and payback on the extra cost can be achieved in 2-3 years when compared with conventional non-condensing boilers.

A combination of these options can be used. For example, CHP could fulfil the baseload requirement, with condensing or modular boilers to cater for the peak loads.

Heat pumps are probably most cost-effective as part of a heat recovery/dehumidification system.

**OPERATIONAL ISSUES**

**Fuel**

Provided the type of fuel used remains the most appropriate, regular checks should be carried out to ensure that it is being bought at the most beneficial tariff. Check:
- the price being paid for fuels
- that relevant tariffs continue to be competitive
- whether there have been any changes to the pool or its method of operation.

**Heat production**

It is essential that the heat production plant is operated efficiently and is properly maintained. The efficiency of heat-generating plant can be reduced substantially if burners and control equipment are not serviced and adjusted regularly. Advice on maintenance in sports centres is given in Good Practice Guide 137. CHP units in particular require regular specialist servicing if they are to be reliable and operate at maximum efficiency.

**FURTHER READING**

- Good Practice Guides 137, 144, 187; Energy Consumption Guide 51; Good Practice Case Studies 43, 74, 280, 281; CIBSE CHP Information Pack
**HEAT SUPPLY**

**DESIGN ISSUES**

It is important that optimal use is made of the heat produced, and the following elements require careful consideration (particularly with regard to the relatively low temperatures and high flow rates in swimming pool facilities):

- heat exchangers
- pumps
- heat emitters (radiator, convectors etc)
- circulation and distribution systems.

**Pool water heating**

The optimum operating temperature for each particular pool or water area will depend on:

- the type of pool (e.g., competition, leisure, teaching, diving)
- the activity taking place
- the occupants.

It is impracticable to vary the water temperature within a single pool. However, it is recommended that separate bodies of water can be heated by means of a separate heat exchanger and/or control circuit to the recommended pool temperatures indicated in table 5.

Shell and tube heat exchangers have traditionally been used in swimming pools. However, plate heat exchangers are now more efficient, and are easier to control and maintain. It is important that they are selected carefully and are matched to the appropriate load (pool water is normally heated at a rate of 0.5°C per hour).

**Domestic hot water**

Typically there will be a considerable requirement for domestic hot water (DHW) for pre-swim and post-swim showers. It is recommended that local energy-saving shower controls (such as percussion timer controls) be incorporated.

Hot water can be provided from either storage or non-storage calorifiers served by primary hot water from the boiler or CHP plant, or by means of direct-fired hot water generators. Great care must be taken to avoid the incubation of Legionella (table 6). Careful assessment of the estimated load patterns and heat requirements should result in the selection of the most energy-efficient option.

**OPERATIONAL ISSUES**

**Pool water heating**

Although the pool water temperature is controlled automatically, there is a need for frequent checking because temperature sensors may drift. Even a 0.5°C rise will result in a substantial waste of energy, because of the high thermal capacity of water. There will also be a significant increase in the rate of evaporation, which will, in turn, lead to a need for increased ventilation in order to protect the building fabric and maintain a comfortable air temperature.

It is essential that the temperature of each separate pool or water area is:

- checked several times a day and in various locations
- adjusted to the optimum level for the activity in progress
- set to the lowest temperature compatible with the comfort and satisfaction of users.

Automatic control settings should be checked against actual temperature readings to ensure that the relevant controls remain correctly calibrated.

**Domestic hot water**

To ensure that the DHW supply services operate efficiently and without waste, operators should regularly check that:

- showers and taps operate only when required
- showers and taps are not dripping
- heat exchangers are clean (check temperatures and pressure across the heat exchanger)
- controls are properly set and calibrated.

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**REFERENCES**

Good Practice Guides 130, 144, 146; Good Practice Case Study 76; Pool Water Guide (PWTAG)

<table>
<thead>
<tr>
<th>Recommended pool temperatures (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fitness</td>
</tr>
<tr>
<td>Recreational</td>
</tr>
<tr>
<td>Leisure</td>
</tr>
<tr>
<td>Children</td>
</tr>
<tr>
<td>27</td>
</tr>
<tr>
<td>28</td>
</tr>
<tr>
<td>29</td>
</tr>
<tr>
<td>30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Domestic hot water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Store at 60°C; distribute at 55°C;</td>
</tr>
<tr>
<td>PRE-SWIM SHOWER</td>
</tr>
<tr>
<td>Supply at 2°C above pool temperature (i.e. 31/32°C)</td>
</tr>
<tr>
<td>POST-SWIM SHOWER</td>
</tr>
<tr>
<td>Supply at 40°C</td>
</tr>
</tbody>
</table>

Table 5

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**ARCHIVED DOCUMENT**
During periods when there are fewer bathers energy efficiency may be improved by:
- reducing the ventilation rate
- reducing the intake of fresh air.

Variable-volume fans or variable fresh air/recirculation air dampers generally achieve this. Where air circulation quantities are variable, care must be taken to ensure that, within the pool hall, the air distribution is not impaired and that air quality is not reduced below comfort levels.

**OPERATIONAL ISSUES**

The ventilation system must be operated at optimum levels at all times to achieve maximum energy efficiency.
- Make sure that the operation of fans, filters, heat exchangers and dampers remains within the design specification (Good Practice Guide 137 gives details).
- Adjust the temperature and humidity if necessary.
- Adjust the ventilation air supply when necessary.
- Cover the pool when it is not in use.

Where variable ventilation volume or partial recirculation systems are employed, or there are changes in the operation or occupancy of the pool, it may be necessary to check and, where required, manually override any automatic control systems for that period of operation.

Pool covers (see Good Practice Case Study 76), where available, should always be used when the pool is unoccupied in order to minimise evaporation and allow some air recirculation or reduced ventilation.

**FURTHER READING**

Sports Council Guidance Notes: Swimming Pools – building services
GPG 137, GPCS 76

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**Table 7**

<table>
<thead>
<tr>
<th>Recommended conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air temperature: typically 30°C</td>
</tr>
<tr>
<td>Relative humidity: 50-70%</td>
</tr>
<tr>
<td>Ventilation (general guideline): 10 litres per second per square metre of total pool hall area (water plus wet surrounds)</td>
</tr>
<tr>
<td>4-6 air changes per hour standard use 8-10 air changes with extensive water features</td>
</tr>
<tr>
<td>Minimum 12 litres per person per second (includes all occupants)</td>
</tr>
<tr>
<td>100% fresh air operation should be available</td>
</tr>
</tbody>
</table>
HEAT RECOVERY

Definitions

Sensible heat is the heat associated with a change in temperature
Latent heat is the heat associated with a change of state (e.g. condensation)

DESIGN ISSUES

Most of the energy load of a swimming pool is used to heat the pool water and pool air. In order to control pool hall air quality large amounts of heated moist air are expelled from the hall. Heat from pool water is also discharged during the backwashing of filters, or when water is dumped in order to dilute with fresh make-up water. Considerable scope therefore exists for the use of heat recovery systems.

The most important means of heat recovery in a pool is usually the pool hall ventilation system.

Sensible heat recovery devices

The simplest forms of heat reclamation systems for pool hall ventilation are sensible heat recovery devices. There are three main types.

- The cross-flow heat exchanger, capable of recovering up to 75% of the sensible heat, is the most efficient of the three types. It comprises a series of parallel plates between the supply and extract ducts, which allow heat exchange from the warmer extract air to the cooler inlet air. Supply and extract routes must be immediately adjacent to each other.

- Run-around coils are probably the most flexible type of heat recovery device, although typical efficiency is only about 60%. Two heat exchange coils, one in the supply duct and one in the extract duct, are linked by pipework carrying a heat transfer fluid. The fluid is pumped between the two, transferring heat from the warmer extract air stream to the cooler inlet. The supply and extract systems do not need to be close to each other, making this system particularly flexible and especially suitable for refurbishment and improvement projects.

- The thermal wheel system achieves heat transfer using a rotating disc-shaped heat-retentive honeycomb matrix, through which air can pass. The disc rotates through both supply and extract air streams at about 20 rpm. Heat is transferred via the wheel from the warmer extract duct to the cooler supply air system. This system requires the supply and extract ducts to be close to each other and occupies more space than other systems. Heat transfer efficiencies of up to 75% have been achieved but, because of its moving parts, this device generally requires more maintenance than alternative types of heat recovery device.

Pool water heat recovery

Whenever warm pool water is discharged during backwashing (or when fresh water is introduced for dilution purposes) it can be used to heat incoming fresh water. The most effective and energy efficient device for this purpose is likely to be a cross-flow plate heat exchanger.
HEAT RECOVERY

Sensible and latent heat recovery

- The warm, moist air extracted from a pool hall contains both sensible and latent heat energy. If a dehumidification system is used, much of the latent energy can be released as the vapour condenses and the temperature falls. Dehumidification devices can be used to control the humidity of pool hall air by removing water vapour without requiring excessive amounts of fresh air. This saves energy by reducing the amount of cold air to be heated, and recovering latent heat. However, care should be taken to maintain sufficient fresh air supply; it is critical to satisfy both environmental and comfort conditions.

- Where heat pumps are used to recover exhaust heat, the evaporator removes sensible and latent heat from the extract air. This heat is then imparted at the condenser to the delivery airstream, which is a mixture of cold saturated air and outside air.

- A gas-fired desiccant wheel, containing a chemically treated honeycomb matrix, works in a similar way to the thermal wheel by recovering sensible and latent heat from the pool air.

OPERATIONAL ISSUES

The technologies described in this section need to be operated and maintained effectively if they are to realise their full potential for heat recovery.

Simple cross-flow plate heat exchangers require minimal maintenance due to the absence of moving parts, but even these should be checked regularly for any blockages of the fluid pathways and contamination of the heat exchange surfaces.

FURTHER READING

Energy Consumption Guide 51; Good Practice Guides 130, 137, 144, 146
OTHER ISSUES

The issues highlighted below are not specific to pools, nevertheless they are important, and require consideration.

Lighting
Usually about 16% of the energy cost of an indoor swimming pool is attributable to the artificial lighting, which may need to be on for 16 hours or more each day. Using high-efficiency lamps with appropriate controls can make savings of up to 50%. Good housekeeping and low-cost measures, such as planned maintenance, can also reduce running costs.

Building fabric
In the pool hall environment, the fabric of the building is a crucial issue that should be considered at the design stage. The thermal quality of the building fabric is more important for pool halls than for most other types of building. Pool halls are, in general, maintained at temperatures about 10ºC higher than most conventional buildings, and may suffer up to 50% more heat loss than other facilities with similar insulation standards and external temperatures. Serious attention should therefore be paid to specifying fabric insulation levels up to 50% above those laid down in Building Regulations for both new-build and refurbishment.

Refurbishment
Refurbishment offers many opportunities for improving the energy performance of the building and its services at little extra cost. Building fabric, lighting, heating and ventilation systems all need careful consideration. A heat recovery system appropriate to the facility can be a particularly cost-effective installation in existing swimming pools. Run-around coil systems are especially attractive for recovering heat from parts of the facility that are separated from each other.

Power correction equipment
In centres that have a high electrical load – for equipment such as wave machines – it is a good idea to determine the power factor. Installation of power factor correction equipment may be worthwhile.

Heating and ventilating other areas
Although of less significance than the pool hall itself, other areas of a pool building can have a significant impact on energy consumption.

Heat recovery
Changing-rooms provide an excellent opportunity to apply heat recovery techniques. They require a substantial quantity of entirely fresh ventilation air (about 10 air changes per hour) in order to provide adequate air quality, and they are normally maintained at about 25ºC.

Toilet areas also require substantial fresh air ventilation (about 10 air changes per hour) and heat recovery should therefore be considered.
TADCASTER COMMUNITY SWIMMING POOL
This new building was opened in December 1994. The main pool is 25 m x 13 m, with a 12 m x 7 m learner pool.

Energy efficiency measures:
- CHP unit
- air/air plate heat recovery
- high-efficiency boilers
- highly insulated pool hall fabric.

Pool conditions:
- pool water temperature: 29°C
- pool air temperature: 30°C, 55% relative humidity
- operating hours: 100 per week/5200 per year.

SPENBOROUGH POOL
This pool was originally built in 1969. It has a 33 m x 12 m main pool with a small teaching pool of 12 m x 7 m. Substantial programmes of energy efficiency refurbishment work were carried out in 1988 and 1995.

Energy efficiency measures:
- thermal wheel
- CHP unit
- pool cover
- energy management system
- modular boilers
- flue-gas heat recovery
- power factor correction.

Pool conditions:
- main pool water temperature: 28-29°C
- learner pool temperature: 29-30°C
- pool air: 30-32°C, 60% relative humidity
- operating hours: 94 per week/4888 per year.
FURTHER READING

Sports Council Guidance Notes
English Sports Council, 16 Upper Woburn Place, London WC1 0QP
- SCGN 383 Sports halls – lighting
- SCGN 387 Swimming pools – building services

Chartered Institution of Building Services Engineers (CIBSE)
Chartered Institution of Building Services Engineers, Delta House, 222 Balham High Road, London SW12 9BS
- CIBSE CHP Information pack, 1995
- CIBSE Technical Memorandum 13: ‘Minimising the risk of Legionnaires’ Disease’

Pool Water Treatment Advisory Group (PWTAG)
PWTAG, Field House, Thrawdeston, Diss, Norfolk IP21 4BU
- Pool water guide – the treatment and quality of swimming pool water, 1995

Good Practice Guides
130 Good housekeeping in swimming pools – a guide for centre managers
137 Energy efficiency in sports and recreation buildings: effective plant maintenance. A guide for sports centre managers and maintenance staff
144 Energy efficiency in sports and recreation buildings: a technology overview. A guide for owners and managers
146 Energy efficiency in sports and recreation buildings: managing energy. A guide for sports centre managers
176 Small-scale combined heat and power for buildings
182 Heating system option appraisal – a manager’s guide
187 Heating system option appraisal – an engineer’s guide for existing buildings
211 Drawing a winner. Energy efficient design of sports centres

Good Practice Case Studies
43 Energy efficiency in sports and recreation buildings: condensing gas boilers
74 Energy efficiency in sports and recreation buildings: potential benefits of boiler replacement
76 Energy efficiency in sports and recreation centres: swimming pool covers. Eastern Leisure Centre, Cardiff City Council
280 Energy efficiency in sports and recreation buildings. CHP – the ‘capital purchase’ option
281 Energy efficiency in sports and recreation buildings. CHP – the ‘supplier financed’ option

DETR ENERGY EFFICIENCY BEST PRACTICE PROGRAMME DOCUMENTS

The following Best Practice publications are available from BRECSU Enquiries Bureau. Contact details are given on the back cover.

Introduction to Energy Efficiency Booklet
7 Sports and recreation centres

Energy Consumption Guide
51 Energy efficiency in sports and recreation buildings: a guide for owners and energy managers

Pool Water Guide
18 Pool water guide – the treatment and quality of swimming pool water, 1995

English Sports Council, 16 Upper Woburn Place, London WC1 0QP
The Department of the Environment, Transport and the Regions’ Energy Efficiency Best Practice programme provides impartial, authoritative information on energy efficiency techniques and technologies in industry and buildings. This information is disseminated through publications, videos and software, together with seminars, workshops and other events. Publications within the Best Practice programme are shown opposite.

For further information on:

Energy Consumption Guides: compare energy use in specific processes, operations, plant and building types.

Good Practice: promotes proven energy efficient techniques through Guides and Case Studies.

New Practice: monitors first commercial applications of new energy efficiency measures.

Future Practice: reports on joint R&D ventures into new energy efficiency measures.

General Information: describes concepts and approaches yet to be established as good practice.

Fuel Efficiency Booklets: give detailed information on specific technologies and techniques.

Introduction to Energy Efficiency: helps new energy managers understand the use and costs of heating, lighting etc.

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