DESIGN GUIDE

Energy Efficient Indoor Swimming Pools

EECA
Energy Efficiency and Conservation Authority

ENERGY EFFICIENCY AND CONSERVATION AUTHORITY 2001

FOREWORD

This brief has been developed to help close the gap between the best and worst performing pools. It is intended for use by persons specifying the construction of new pools, those specifying upgrades of existing pools, and those involved in designing pool complexes and the energy systems in pools.

While we have tried to make this a "performance brief" we have often reverted to a "prescriptive specification" format for clarity. We have also included explanatory comments (in Italics) where we feel that an understanding of background will assist decision-makers. Our intention is to encourage innovative design solutions rather than constrain practice.

This brief is likely to be periodically updated as new developments in pools occur. We encourage you to contact us for the latest version.

The authors value feedback from those that use the brief. Please contact the authors with any comments or suggestions.

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DISCLAIMER

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1 INTRODUCTION

1.1 Overview

This performance brief outlines minimum energy performance requirements for the building shell, energy systems and equipment for indoor swimming pools.

The brief complements current building codes, standards and codes of practice by specifying the best practice procedures additional to legal minimum code requirements. In all cases designers should refer to relevant code requirements.

Where energy controlling or using equipment options are being compared decisions should be based on life cycle costs, not first or equipment costs.

1.2 Financial assistance for energy efficiency

Loans to enable investment in energy efficient technologies and projects are available for Territorial Local Authorities, public and integrated schools and other publicly funded organisations through the Crown Energy Efficiency Loan Scheme. Contact EECA for further information.

1.3 Swimming pool heat and moisture transfer - a brief introduction

Water and air heating energy use is largely dictated by the evaporation of pool water into the hall. The rate of evaporation is proportional to the difference between the absolute humidity at saturation (in equilibrium with water at the pool temperature) and the actual humidity. This driving force is minimised by high humidity, so for minimum energy use relative humidity set-points will be set as high as possible consistent with comfort. It is also minimised by high air temperatures. Although building losses offset this to some extent, in practice the highest temperatures consistent with comfort almost invariably result in the lowest energy use.

Pool halls are ventilated mainly to control humidity. This is essentially a dilution process, with fresh air at lower moisture content used to replace moist air. The volume of air required depends on the ratio of the ambient absolute humidity to the absolute humidity required in the space. Since ambient absolute humidity is much higher in summer than in winter, the ventilation system must be sized for summer conditions. A turndown capability is required to reduce ventilation rates in winter. Without control of the ventilation rate, unnecessarily large volumes of air are heated from winter temperatures, resulting in excessive heating costs. It is preferable to use fan speed control, so that fan energy use is also optimised.

The pool hall ventilation system rejects air with a high latent heat load. Run-around coils, plate heat exchangers, heat pipes and other heat transfer devices are often used to recover heat from the air leaving the hall and use it to preheat incoming ambient air. This achieves sensible heat recovery and a small proportion of the latent heat of evaporation may also be recovered under some conditions.

The latent heat of evaporation can only be recovered if it is upgraded in temperature *using a heat pump. As this is the main source of rejected heat, waste heat recovery, using a heat pump, should form the basis of the pool heating system.*

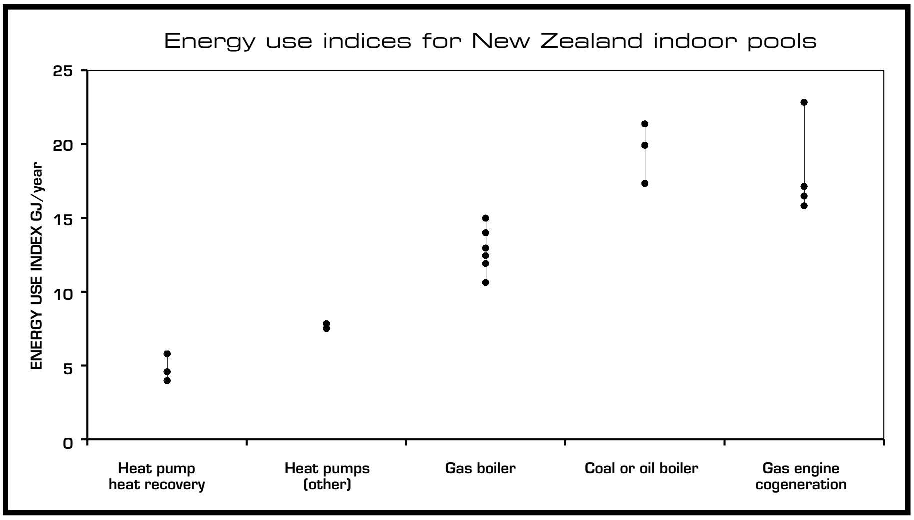
1.4 Condensation and building durability

Because of these operating conditions the pool building structure and components will face significant challenges from moisture. It is imperative that the building shell is fully insulated and a complete and durable vapour barrier is installed. The vapour barrier must be at the inside surface so that water vapour cannot diffuse, even part-way, through the insulation. This prevents moisture condensing within the wall structure and the resulting degradation of the structure and insulation. Any thermal bridging creates some risk of condensation damage and, while it is impracticable to eliminate bridging completely, every effort should be made to minimise it.

1.5 Energy use of pools in New Zealand

As the figure below indicates, indoor pools in New Zealand vary considerably with the most energy-intensive using about five times as much energy per m² of pool surface as the most efficient. While some of this variation is to be expected due to different energy supply technologies there remains substantial scope for improved efficiency at the most energy-intensive pools.

The figure below compares the energy use index (purchased energy per year per m² of pool surface area) for a number of New Zealand indoor pools. The data is from energy audits and other studies performed over the last eight years.



Common reasons for inefficiency include; over-ventilation, lack of adequate ventilation and heating control, and absence of heat recovery.

2 ENERGY USE PERFORMANCE BENCHMARKS

2.1 Delivered heat for heating loads

To benchmark the performance of the pool ventilation and heating system, it is necessary to estimate the delivered heat requirements for air and water heating. Delivered heat cannot always be measured directly but its estimation should be a basic part of the design process.

The design of the pool facility (building envelope and ventilation and heating system) shall be assessed by simulation modelling or comparison with similar installations and should aim to ensure that delivered heat usage does not exceed the benchmarks shown in Table 1. The benchmark figures are for heat required per year, per m^2 of pool water surface.

TABLE 1 — POOL ENERGY PERFORMANCE BENCHMARKS

Pool Energy System	**Benchmark GJ/m²**
Pool & space heating	6.0
Domestic hot water	0.5 - 1.0
Total **delivered** heat energy	7.0

Domestic hot water usage depends critically on expected patronage and should be assessed on this basis within the range shown.

The expected purchased energy costs can be estimated from the delivered heat using the relationship for the energy supply system (boilers or heat pumps and distribution system used):

$$\text{Purchased energy} = \frac{\text{Delivered heat}}{\text{System efficiency}}$$

2.2 Electrical energy - non-heating loads

TABLE 2 — ELECTRICAL ENERGY PERFORMANCE BENCHMARKS

Pool Energy System	**Target GJ/m²**
Filtration & pumping	1.3
Ventilation fans	0.5
Lighting	0.4
Total non-heating energy	2.2

Special loads such as saunas, hydro-slides and spa pools would be additional to these energy use indices. The energy use benchmarks, when costed for the local fuel prices, can be used to calculate expected costs for the pool energy systems.

3 BUILDING ENVELOPE

3.1 Insulation and vapour barriers

The building envelope shall meet the overall annual fabric heat-loss target described in clause 4.3.2 of NZS 4220:1982, *Code of practice for Energy Conservation in Non–Residential Buildings*. Alternatively it shall be insulated in accordance with NZS 4243:1996, *Energy Efficiency - Large Buildings* or NZS 4218:1996*, Energy Efficiency - Housing and Small Building Envelope* as appropriate.

The building shell interior surface shall provide a permanent barrier to vapour passage into or through the shell. The vapour barrier shall have a vapour flow resistance of no less than 50 MN s/g and may be part of the internal surface or its finish. Thin flexible film vapour barriers, such as polythene film, should be used with caution, as fasteners and fixings will easily puncture them.

3.2 Architectural

Special consideration shall be given to the corrosion performance of surface finishes, materials, and plant construction in the pool buildings in the high-humidity, chlorine-laden environment. In particular, avoid joining any dissimilar metals together.

3.3 Acoustics

To avoid condensation forming within the acoustic insulation, it shall be mounted so that it does not contribute to thermal resistance on the inside of the thermal insulation and vapour barrier.

Ensure walls and doors between the plant room and occupied spaces have adequate sound transmission control to prevent noise breakout from the plant.

3.4 Solar gain

The design shall incorporate architectural details or suitable glazing to minimise personal discomfort caused by solar gain. External shading shall be designed to take account of the different aspects of the building faces and shall effectively screen occupants near windows. If glazing alone is used, a solar control glass shading coefficient of no more than 0.6 shall be employed. Provision for solar gain shall not be required on walls that face south between south-east and south-west.

Where relevant the roof colour shall be as light as practical.

3.5 Glazing

All exterior glazing shall be double-glazed or better. The glazing ratio shall be less than 30% of total wall area, measured floor to ceiling and not floor to floor.

If aluminium glazing frames are to be used they shall be constructed with a thermal break between indoor and exterior surfaces.

3.6 Infiltration and draught prevention

A well-constructed and sealed building envelope will help lower energy consumption and improve comfort levels. Air and pool water heat energy use can be substantially increased by excessive infiltration and in some cases it may be impossible to achieve design temperatures on cold or windy days.

The pool hall(s) shall be physically isolated from other areas by self-closing doors with edge seals.

Entrances to buildings should be designed to isolate foyers and corridors from adverse weather conditions. Where necessary vestibules or double door sets with edge seals should be provided.

4 VENTILATION AND AIR CONDITIONING

4.1 Design conditions

The energy use in practice for ventilation and heating depends on ventilation rates and the humidity and temperature maintained in the pool hall. In order to limit energy use it is important to maintain air temperature at or near pool temperature (equal to or up to 1°C above pool temperature is recommended) and humidity as high as is consistent with comfort. Many pool operators prefer to maintain lower air temperatures (typically 25-26°C and sometimes lower) for perceived comfort reasons. This results in a significant penalty in terms of energy use.

The ventilation and air heating plant shall be designed to:

- Maintain the indoor temperature of pool hall to within ±1°C of the pool water temperature.

- Maintain humidity in both pool and general areas within the range 40% to 80% for 97.5% of the time the spaces are occupied.

- In other spaces without pools, maintain the indoor temperature between 20°C and 25°C for 97.5% of the time that the spaces are occupied.

4.2 Ventilation

The minimum level of ventilation shall be either that determined by the New Zealand Building Code 1992 or that required to avoid condensation on the coldest element of the building fabric (whichever is greater).

The use of exhaust air re-circulation is not recommended.

The air supply system shall be designed so that there is no flow of pool hall air into other parts of the building. A portion of the design air-flow may be supplied through the ancillary spaces to pressurise them relative to the hall.

4.3 Heat recovery heat pump

The primary source of heat for pool water-heating shall be a heat pump utilising sensible and latent heat in the pool exhaust air as a heat source and rejecting heat to the pool water and (optionally) to other heat loads, particularly ventilation air heating for the pool hall.

Any cost-effective heat source (co-generation plant, gas or coal boilers, ambient-source heat pumps, or other) may be used for other heat loads. Equipment and running costs shall be compared on the basis of lifecycle cost.

Where gas or fuel oil burners are used (for loads other than pool heating), the burner shall be a modulating type. The heater shall be capable of being isolated during summer.

4.4 HVAC plant

All electrical devices shall be installed with power factor corrected at the device to 0.95.

Fans shall be of a backward curved centrifugal type with direct drive motors or cogged-belt drives. Aerofoil axial fans shall not be used.

Fan speed shall be controlled by variable speed drives.

Supply and exhaust air shall be filtered to a minimum EU3 standard.

Filters and filter components in the exhaust air stream shall be constructed of corrosion resistant materials. All filters must be fitted with pressure switches, set to the maximum recommended filter pressure at full air volume, which will trigger an external dirty filter indicator. Filter face velocities shall be less than 2.5 m/s.

Evaporator and cooling coil face velocities of not more than 3.0 m/s are recommended. Evaporator coils in the exhaust air stream shall be thin epoxy-coated to prevent corrosion of finned surfaces. Evaporator coils, return fitting, expansion valves and uninsulated refrigeration pipework shall be fitted with drain trays.

Condenser and heating coil face velocities should be less than 3.0 m/s.

4.5 Air distribution

Appropriate air distribution can only be achieved by good design and placement of distribution and extract points. It is not appropriate to rely on the throw characteristics of the discharge devices used to compensate for poor placement.

Recommended design air velocity at the pool surface and occupied zone is between 0.05 m/s and 0.15 m/s *(maximum to prevent excessive evaporation and discomfort).* In order to achieve this, care must be exercised with the pool air distribution components and layout.

Air supply terminal devices need to be able to perform under variable volume conditions.

4.6 Noise levels

Noise levels generated by the ventilation system shall not exceed NC50 in the pool hall and NC45 in general spaces and reception areas.

4.7 Control and hours of use

HVAC plant shall be separately zoned for areas with substantially different heating or ventilation characteristics; e.g. gymnasiums and meeting rooms

All plants shall be controlled by an individual or central time switch or equivalent system for automatically controlling the hours of operation of the HVAC system for 365 days of the year.

Provision shall be made to operate the system after normal hours when required.

Running time outside normal hours should be controlled by adjustable timers or override switches, which automatically reset to "auto" during the next scheduled run period.

All HVAC control thermostats are to be electronic type with differential of less than 0.5°C. Mechanical thermostats are not permitted.

All components in the control system shall be selected to operate in the aggressive environment found in swimming pools. They should be recalibrated on a regular basis.

4.8 Commissioning and maintenance manuals

The designer of the pool energy systems shall specify a commissioning process conforming to relevant Commissioning Codes that ensures that the plant operates as designed. A documented record of the commissioning process shall be handed to the pool owner on completion of commissioning.

The designer of the pool energy systems shall specify a maintenance plan conforming to a standard such as CIBSE Technical Memorandum; *Maintenance Management for Building Services TM 17:1994*. The plan shall be included in the maintenance manual.

Provide a maintenance manual that contains details of the HVAC plant design, as built installation, installed plant and systems, and operating procedures. Two copies of the completed manual must be handed to the pool owner before completion of the contract.

PUMPING

Pumps shall be of a centrifugal type. Direct drive motors or cogged belt drives are recommended due to the additional drive losses and maintenance requirements of V-belt drives.

Throttling valves shall not control pump volume. Variable speed drive control is to be used if filtration and circulation rates are controllable; any turndown of filtration rates must be done with care to maintain compliance with NZS 4441:1985.

6 SOLAR WATER HEATING

In general, solar heating is not currently viable for use in indoor municipal pools in New Zealand. It is possible that the use of solar panels to contribute to pool water heating may be economic in some pool complexes.

7 POOL COVERS

The use of pool covers reduces the requirement for energy in a swimming pool complex by reducing the evaporation rate from the surface of the pool. This affects the energy use in two basic ways:

- *The reduced evaporation rate lowers the energy required to keep the pool water temperature at its operating point. The main energy loss from the pool-water is through evaporation so the reduction in energy use is significant.*
- *With very low evaporation, the need for high ventilation rates and air heating in the pool hall is eliminated allowing the air circulation system to be shut off, or turned down to a very low rate, when the covers are on.*

Insulated pool covers are an excellent cost-effective energy saving device. Typical simple payback periods are around 2.5 years. There are a number of factors that must be considered in the selection of the product:

- *storage and ease of use*
- *resistance to chemicals*
- *strong and long wearing construction*
- *good insulation properties*
- *safety requirements*

Reel frames to retract and store covers can be either manual or motorized. Manual reel frames require significantly less capital investment, but require sufficient staff availability when covers are being retrieved.

When designing the pool hall, sufficient pool-side space should be allocated to reel frames for the covers.

Pool covers provide an additional long-term benefit in building maintenance.
The reduction in pool hall humidity and condensation will prolong the life of the structure and reduce building maintenance.

8 LIGHTING

8.1 General

Lighting shall be designed and installed in accordance with AS 2560.2.5:1994 for pool areas, and to AS 1680 and its parts and the luminaire manufacturer's specifications (AS 1680 is in the process of being adopted as a replacement to NZS 6703. Some of its parts are already joint standards).

The following design assumptions shall be stated: luminaire and room depreciation (LRD) factor; light source outputs assumed; cleaning frequency assumed; maintenance illuminance achieved; and lighting energy density in W/m² for the building.

Access shall be provided to luminaires and light sources in the pool hall so that maintenance and replacement can be safely carried out while the pool is in use.

The Fédération Internationale de Natation (FINA) specifies rules and regulations for facilities to provide the best possible environment for competitive use and training. These are considerably higher than those required under AS 2560.2.5. These facility rules and regulations are on the FINA website: http://www.fina.org/facilityrules.html. The FINA rules are not intended to relate to the general public. However, if the pool is to be used for competitions under the FINA rules, consideration should be given to switching to allow FINA regulation lighting levels for the competitions.

In situations not covered by AS 2560.2.5:1994, maintenance illuminances shall be as per the relevant section of AS 1680.

8.2 Luminaires

Performance data from an accredited test laboratory shall be available for all luminaires offered.

Luminaires for use in the pool hall shall be sealed from the pool atmosphere or designed for wet corrosive environments.

Luminaires must have low loss ballasts class B1 or better, and should ideally have class A ballasts.

Power factor of luminaires shall be corrected to 0.95.

8.3 Light sources

Light sources for general areas and accent lighting shall be linear tube NG triphosphor T8 fluorescent, T5 fluorescent or high efficiency high intensity gas discharge type. The preferred fluorescent tube sizes are 36W 1200mm and 58W 1500mm or any T5 series tube. These tubes provide 20% more light than 18W 600mm and PL tubes for the same power input.

Incandescent light sources, including halogen dichroic lamps, are only permissible for a limited amount of display lighting or sensor controlled security lighting intended for short time operation.

Overnight security or outdoor lighting should be by fluorescent or High Pressure Sodium lamps. Metal halide lamps should be used in the pool area and other areas where High Pressure Sodium lamps are unacceptable.

8.4 Lighting energy

Lighting energy density shall not exceed the guidelines in NZS 4243:1996. The standard specifies a minimum "legal standard" and does not represent best practice design. Best practice targets are typically half the legal minimum, for pool halls the lighting power density should be less than 10 W/m^2. *(Possibly excluding competition use.)*

Note: When applying NZS 4243:1996, maintenance illuminances from AS 1680 shall be used in place of service illuminances from NZS 6703.

8.5 Control

Luminaires in open plan areas shall be in groups controlled by occupancy detectors. Where practical, luminaires adjacent to windows shall be switched separately.

Conveniently located switches or detectors in or adjacent to the space shall control luminaires in small offices and other cellular spaces.

Schemes involving the use of automatic switching or dimming of luminaires adjacent to the windows will be considered. Cost and performance figures for such alternatives will be required to allow for economic analysis.

Outdoor lighting required to be on during the hours of darkness shall, in all cases, be controlled by a solar radiation detection cell that ensures the luminaires do not operate during daylight hours. Should a time switch also be incorporated, the circuit shall be designed such that the solar cell overrides the time switch when ambient light levels are high enough to allow lighting to be switched off. Override switches shall have a timer fitted such that they automatically return to normal operation after two hours.

9 METERING AND TARIFFS

Provision shall be made for time of use metering of electrical energy.

Tariffs should be investigated and the most appropriate one selected. Load modification or alternative energy sources shall be considered where it may lead to lower energy or supply costs.

10 DOMESTIC WATER SERVICES

10.1 Domestic hot water

Hot water systems shall be installed in accordance with NZS 4305:1996 *Energy efficiency-domestic type hot water systems.*

Storage water heater thermostats shall be capillary bulb consumer adjustable type, set at 60˚C and tempering valves shall be used to deliver hot water to hand basins at 45˚C and showers at a maximum of 55˚C. Instantaneous heaters shall deliver hot water to hand basins at 45˚C and showers at a maximum of 55˚C.

10.2 Showers

Shower heads shall comply with AS/NZS 3662:1996 Water Supply - Water efficient mains pressure shower spray heads and should preferably have a water flow in the range 6 to 9 L/minute at normal operating pressure. Shower valves that operate correctly with a 55˚C hot water supply shall be provided.

Shower shall be provided with user activated, time limited flow valves, with automatic close off.

Consideration should be given to heat recovery from shower wastewater.

10.3 Toilets and urinals

Urinal flushing systems shall utilise occupancy control to limit unnecessary water use.

Toilet cisterns shall be dual flush type.

11 FOOD AND DRINK PREPARATION AND DISPLAY

11.1 Refrigeration

Install all refrigeration plants, condensing sets, chillers and refrigerators in accordance with the manufacturer's instructions. Do not enclose refrigeration condensers. Ensure that adequate free air is available for heat rejection, and that heat-exchanging finned surfaces are accessible for regular cleaning.

12 REFERENCES

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This brief is updated regularly to include any changes suggested by practice. If you have any comments on this brief please contact Ted Jamieson, EECA, PO Box 388, WELLINGTON, phone (NZ) 04 470 2200.