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Energy analysis of swimming pools for sports activities: cost effective solutions for efficiency improvement

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Abstract

Swimming pools for sports activities are very much energy-consuming since, in addition to the energy requirements that are common to all types of sports facilities (air conditioning and lighting in large spaces, high levels of water heating requirements, etc.), heating, filtration and continuous replacement of water must be considered, which involve huge consumption of natural resources in terms of primary non-renewable energy resources (according to the local fossil/renewable mix) and drinking water, whose use is mandatory. The paper calculates, through our *ad-hoc* developed algorithm (named EnerPool), potential savings in terms of non-renewable primary energy consumption, achievable through energy efficiency actions involving heating, filtration and water replacement. This work analyses in detail a number of possible solutions to reduce heat needs, therefore allowing high non-renewable primary energy savings (up to more than 50%) at low cost and with a payback time of less than two years. Thanks to the facilities' data (number and size of pools, utilization rate, etc.) supplied by CONI (the Italian National Olympic Committee) about swimming schools and facilities affiliated to FIN (the Italian Swimming Federation), and based on the results of the analysis on energy efficiency actions, this article presents nationwide estimates of the potential savings of non-renewable primary energy through cost-effective efficiency improvement solutions. Furthermore, the solutions analyzed are not alternative to other heat production solutions through high-efficiency systems (condensing boilers, water/air heat pumps, combined heat and power production plants) or by means of renewable sources (solar collectors, photovoltaic panels), therefore achieving economic and energy savings albeit with much higher initial costs.

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Nomenclature

COP	Coefficient Of Performance of heating pump
c_w	Specific heat water (J/kg K)
DHW	Domestic Hot Water
DM	Italian Ministerial Decree
η_P	Global efficiency of the pump
g	Gravitational acceleration (9.81 m/s^2)
HEC	High-Efficiency Cogeneration
H_p	Head of the pump (m)
I_{abs}	Solar radiation absorbed on the pool (W)
$\dot{m}_{ev,w}$	Evaporation flow rate of water (m^3/s)
$\dot{m}_{r,w}$	Replacement flow rate of water (m^3/s)
P_P	Electrical power absorbed by the pump (W)
q_{cond}	Heat loss by conduction (W)
q_{conv}	Heat loss by convection (W)
q_{ev}	Heat loss by evaporation (W)
q_{irr}	Heat loss by irradiation (W)
Q_p	Volumetric flow rate of the pump (m^3/s)
$q_{r,w}$	Thermal power for heating replacement water (W)
$q_{s,l}$	Heating power supplied to compensate for heat losses (W)
$q_{tot,w}$	Total heating power supplied (W)
ρ_w	Water density (1,000 kg/m^3)
T_n	Water supply network Temperature (K)
T_P	Water Pool temperature (K)
V_{tot}	Total volume of water

1. Introduction

In general, sports facilities are energy-consuming [1] as they normally have large volumes to be heated and illuminated, high need for hot water, as well as other specific energy-consuming requirements; for this reason, they have a great potential for energy-efficiency actions. For this reason, there are some improvements in terms of efficiency actions that, in general, fit into all sports facilities (or, more generally, all the most energy-consuming utilities) such as the adoption of high efficiency (condensing) boilers, led lighting, installation of solar panels, cogeneration plants, etc. As regards sports facilities in particular, specific energy requirements may vary considerably depending on the sports discipline the venue is used for (gyms, swimming pools, soccer fields, etc), architectural and dimensional characteristics and intended use (school facilities, neighbourhood facilities, plants with or without state, etc.). Among the various types of sports facilities, swimming pools have a high potential for energy efficiency actions. In fact, swimming pools, in addition to the energy needs common to all types of sports facilities (room heating, Domestic Hot Water - DHW, lighting, etc.), also have particular requirements such as heating, filtration and water replacement.

2. Mass and energy balance to heat swimming pools

As regards Fig. 1 it is possible to define a mass and energy balance of a pool; for the heating of swimming pools, mass balances have an impact on energy balances since the replacement water must be heated from the water network temperature (about 12 ° C) to the pool usage temperature (averagely 28 ° C).