Energy and Buildings 90 (2015) 166–172

Contents lists available at ScienceDirect

Energy and Buildings

journal homepage: www.elsevier.com/locate/enbuild

Energy performance of open air swimming pools in Greece

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ARTICLE INFO

Article history:
Received 10 December 2014
Received in revised form 2 January 2015
Accepted 3 January 2015
Available online 10 January 2015

Keywords:
Swimming pools
Operational energy
Benchmarking

ABSTRACT

Sport centers and more specifically swimming pools are regarded as high energy consuming installations and also major air pollutants, contributing to Green House Gas (GHG) emissions as their demand in energy is extremely large. Taking into consideration EU mandating directives and policies in accordance with this high energy consumption, it is obvious that establishing guidelines for swimming pools in order to improve their energy performance by implementing energy conservation actions and increasing their energy efficiency will consequently result to significant energy savings. The aim of this paper is to assess energy performance of outdoor swimming pools operating in Greece. The approach followed is a bottom-up approach as it first analyses the characteristics of all operating swimming pools based on data retrieved from General Secretary of Sports, questionnaires and specific energy audits and surveys, with the aim of quantifying their energy performance. Examining the performance of swimming pools, which mainly use conventional oil or gas fired boilers to cover their thermal needs, it is made clear that there is a broad field to apply energy conservation measures and achieve financial and environmental benefits.

1. Introduction

Swimming pools are considered as high energy consuming installations as their demand in energy is large. Their energy consumption differs significantly depending on the size, the type (indoor or outdoor), the location, the use (races, recreation, etc.), the operating period and the heating system, varying between 600 and 6000 kW/m^2 [1]. For indoor pools in the Mediterranean climate average energy consumption per water surface is about 4300 kWh/m^2, as for continental Europe and Northern countries it can be as high as 5200 kWh/m^2 [2]. No relevant information about energy consumption of outdoor pools in Europe is available nor any pieces of data presenting the number and size of existing pools [3]. This consumption was acceptable when fuel prices were low, but after the fuel crisis in the late 70s and the rising import prices for oil and gas the European Union (EU) has experienced the last few years, which have reached in December 2008 and January 2011 unprecedented levels in nominal terms, it has become unaffordable driving many swimming pools to stop operating during heavy winter periods. Furthermore, sport centers are also major pollutants, contributing to Green House Gas (GHG) emissions. As stated by Gaglia et al. [4] in the EU-15 in 2002, non residential (NR) buildings were responsible for 23% of total annual CO_2 emissions while, in the period 1980–1990, CO_2 emissions from buildings grew by 1.7% per annum. However energy policies have focused on the domestic sector despite the fact that the services sector presents a higher growing rate [5] indicating that it is critical and essential to develop studies by building type presenting their energy performance to allow furthermore analysis and efficient energy policies in the future.

The overall energy consumption of a swimming pool sport center is made up of electrical energy for cooling, ventilation, lighting, catering, information technology (IT) equipment, etc., and thermal energy for pool water heating, sanitary water heating and space heating. Outdoor swimming pools have a relatively higher requirement than indoor swimming pools in energy consumption for pool water heating, but at the same time have a lower demand for space heating and ventilation loads, with pool heating remaining the main energy consumption source in both cases [6,7]. The main heat losses in open–air swimming pools are due to evaporation, radiation and convection, with evaporation being the most significant, over 70% [8]. Other less important losses are conduction to ground and the fresh water addition, if its temperature differs significantly from that of the pool. These losses are not considered significant and are compensated by solar radiation gains [9].

The main aim of this research was to investigate energy consumption of outdoor swimming pools in sport centers in Greece, evaluate their energy performance and examine potential energy

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http://dx.doi.org/10.1016/j.enbuild.2015.01.004
0378-7788/

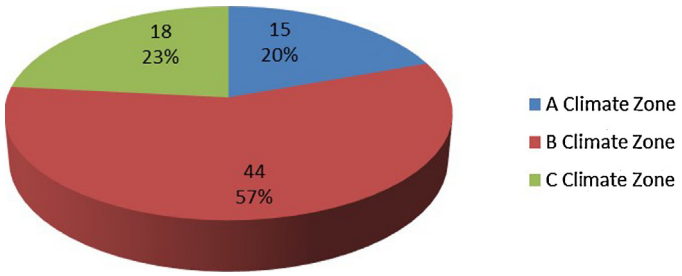

Fig. 1. Number of outdoor swimming pools in relation to the climatic zones in Greece as set by KENAK.

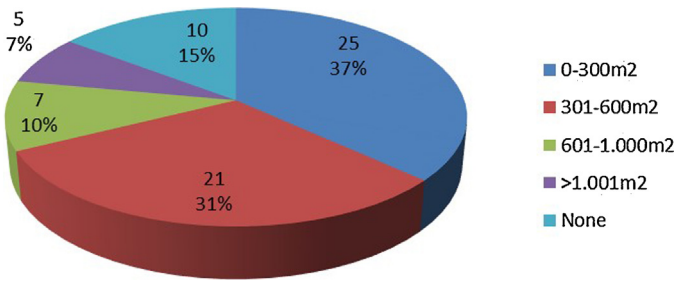

Fig. 2. Area of building facilities.

conservation measures in accordance with the payback period and the corresponding environmental impacts. This was achieved through a questionnaire distributed to all operating outdoor sport swimming pools in Greece assessing their energy performance and secondly through an intensive survey monitoring the energy performance of a number of outdoor swimming pools operating in the metropolitan area of Athens, and more specifically in the southeastern side of the area. Potential measures to reduce energy consumption of outdoor swimming pools and alternative solutions to reduce energy needs and to cover swimming pools energy demand were evaluated, in accordance with the corresponding advantages covering energy, environmental and economic benefits in each case.

2. Outdoor swimming pool stock characteristics

In Greece there is no official administrative body to provide data concerning the volume of swimming pools, both private and public, moreover information concerning the existence of a pool heating system and their energy consumption. Regarding private pools, even though the existence of outdoor swimming pools in private dwellings, hotels and resorts is very common in Greece, there is no registration system, so their number has never been elaborated and there is no reliable way to assess it. Moreover, as the main purpose of this study is the evaluation of energy performance of outdoor swimming pools and the fact that it is rather uncommon for Greece to use a heating system for these pools, as they are mostly used during summer periods, this lack of information was evaluated insignificant and private swimming pools were not included in this analysis.

This study covers those pools operating at athletic and sport centers, mostly belonging to the public sector, municipalities or clubs, characterized by high density of visitors independent of weather conditions, making it necessary to install a heating system. As there are no official archives concerning these pools, information regarding the existence of sport pools was retrieved after search of databases from the Greek General Secretary of Sports, the Hellenic Swimming Federation and other databases. The data was merged together into a sufficient list and some phone interviews took place to verify the search results. The final total number of outdoor swimming pools operating as athletic centers resulted to be 77. The dispersion of outdoor swimming pools operated by public authorities and clubs, in relation to the four climatic zones in Greece, as they are set by the Greek Regulation for Energy Performance of Buildings (FEK, 2010 – 407B/9.4.2010) is illustrated in Fig. 1.

These results seem sufficient since the distribution is analog to the population density in Greece and the climatic conditions, whereas zone B presents the highest population, over 60% of total (as it includes the metropolitan area of Athens) and zone A the mildest climatic conditions (the majority of Greek islands) even though is sparsely populated. Finally there is no outdoor swimming pool operating in zone D (the coldest zone) possibly due to the rough climatic conditions considering Greece average.

2.1. Building characteristics

With the purpose to analyze the existing stock, classifying the installations according to their age, size, type and other useful construction characteristics, and recording their 3-year energy consumption, data were obtained through a short structured questionnaire addressed to all the operating swimming pools. In general, the response to the questionnaire was sufficient as 45% completed questionnaires were returned without second notice. In order to gather more information the pool operators who had not responded were contacted by telephone and were reminded to return the questionnaire, resulting to a final amount of 88% filled questionnaires. Table 1 illustrates the dispersion of filled questionnaires returned, in relation to the three climatic zones in Greece (that have open-air swimming pools), and other interesting indicators relevant to the swimming pools operation, as total area, the number of athletes per zone and the available swimming area per athlete. A first observation is that outdoor pools are more popular in climatic zone B, which mainly includes central Greece and Athens (1.51 m^2 /athlete), while they become less attractive in zone C (3.532 m^2/athlete) where lower temperatures are met, especially during winter months.

Almost all swimming pool centers (85%) besides the main pools have additional building facilities. The type and total area of these additional facilities depend on the size and use of the installation. In general they include dressing rooms with shower facilities, lavatories, a medical room, managerial offices while some have a training room, increasing the area of the building over 600 m^2 (Fig. 2).

Regarding the construction age of the examined sample, the first conclusion is that the majority of outdoor swimming pools are less than 20 years old. This seems reasonable as in Greece the construction of public sport installations and more specifically swimming pools was developed widely during the last two decades. A small percentage, about 17.6%, was built prior to 1980, while another 19.1% was built between 1980 and 1985. As the Greek Building Thermal Insulation Regulation that sets mandatory requirements for the thermal insulation of the building envelope was introduced in 1979, the building installations in the swimming pools built prior to 1980 are not thermally insulated, while those built prior to 1985 are expected to have inadequate thermal insulation, matching the findings of the filled questionnaires, resulting in both cases to considerable heat losses. However, as the majority of the swimming pools is considered new (more than 41%), built after 2000, when the implementation of building regulations was more strict, a general evaluation of the stock considers them satisfactory. Details on the existence of insulation are illustrated in Fig. 3. It is worth noticing that in climatic zone C the majority of the buildings has insulation, while in zones A and B, where meteorological conditions are milder this number decreases. Regarding the pool size the