

Energy performance of open air swimming pools in Greece

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Introduction – Background (1/2)

Points of interest :

- ✓ In EU-27 services and buildings others than households are responsible for 15% of annual final energy consumption and 15% of CO₂ emissions
- ✓ Economic growth increases the need for education, health and sport activities, making this sector the fastest growing energy demand sector
- ✓ There are few sources available offering information on growth rates for this sector. Indicative sector's build growth rates are 2% in the UK and 6.1% in Spain, indicating an increasing growth rate.

Introduction - Background (2/2)

- ✓ The building type and use indicates their energy needs
- ✓ Swimming pools are in the top of the most intensive energy consumers
- ✓ This results to prohibitive running cost
- ✓ Consequently they are considered major pollutants
- ✓ Pool water heating is their main energy consuming source responsible for over 85% of their total energy consumption
- ✓ This indicates that there is a broad field to apply energy conservation measures

Gap in knowledge

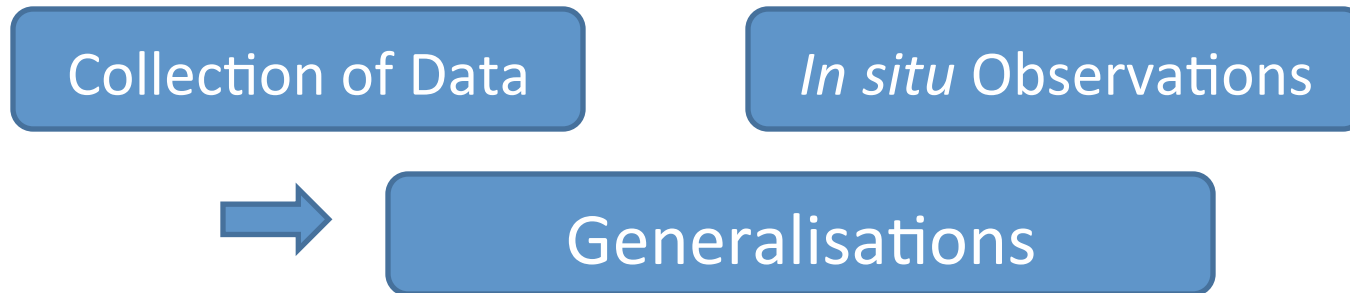
- Most research on energy issues has focused on residential buildings.
- Information on typical energy consumption of swimming pools is rather limited and mainly analyses the performance of indoor pools
- There is a lack of knowledge concerning outdoor swimming pools
- The growth of the sector stresses the need for specific studies for outdoor swimming pools

Aim of this research

- Register outdoor swimming pools operating in Greece
- Assess their energy performance
- Investigate potential energy conservation measures

Methodology (1/2)

1. The approach adopted is an *inductive, bottom - up empirical approach* implemented through *cross sectional surveys* and *cross sectional case studies*



2. It is also implemented through *discovery surveys* as current technologies and the market situation were investigated and assessed

Methodology (2/2)

The research procedure adopted consists of:

- ✓ *Analysis of existing outdoor swimming pool stock*
- ✓ *Preliminary Energy Audits – Questionnaires consisting a national survey*
- ✓ *Energy Surveys and Audits applied on 3 cases*

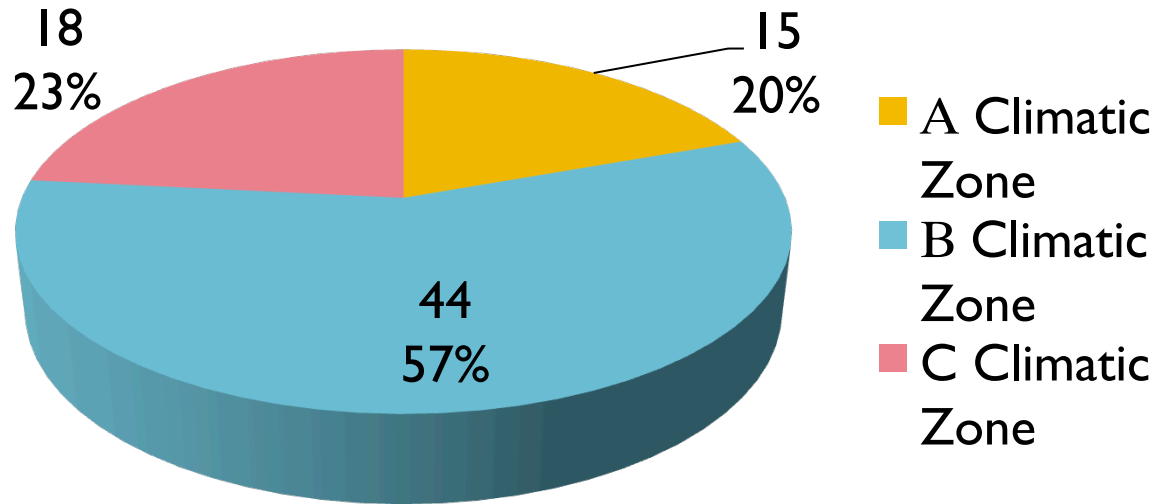
Present state situation (1/2)

Existing outdoor swimming pool stock

- No official archives exist in Greece providing data concerning the existing swimming pool stock
- No similar work has been done before
- This research was oriented towards athletic swimming pools that mainly operate all the year
- Data was retrieved after search in databases of Greek General Secretary of Sports, Hellenic Swimming Federation and other internet databases
- The total number of outdoor swimming pools in Greece belonging to athletic centres resulted to be 77

Present state situation (2/2)

Existing outdoor swimming pool stock

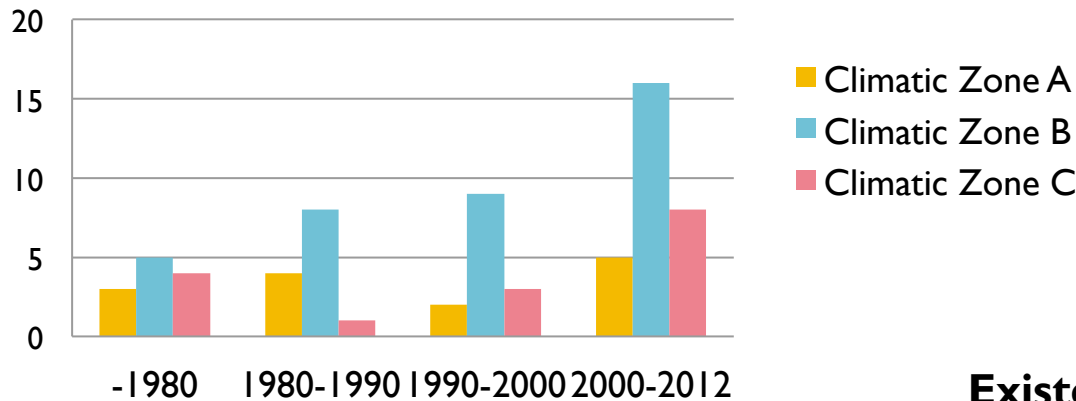


- A questionnaire was addressed to all 77 pool operators, regarding the installations characteristics and energy performance
- 68 out of 77 filled questionnaires were gathered (88%)

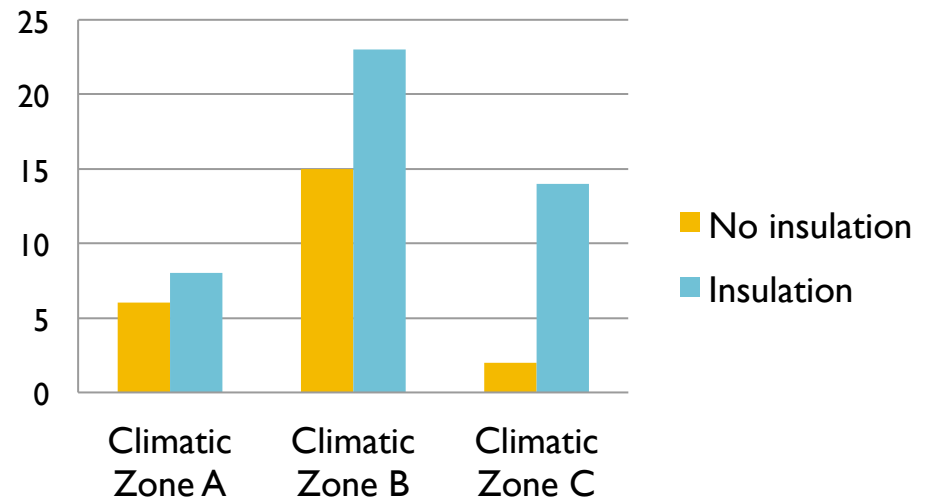
Findings of national survey (1/3)

Installations' characteristics

Age of installations



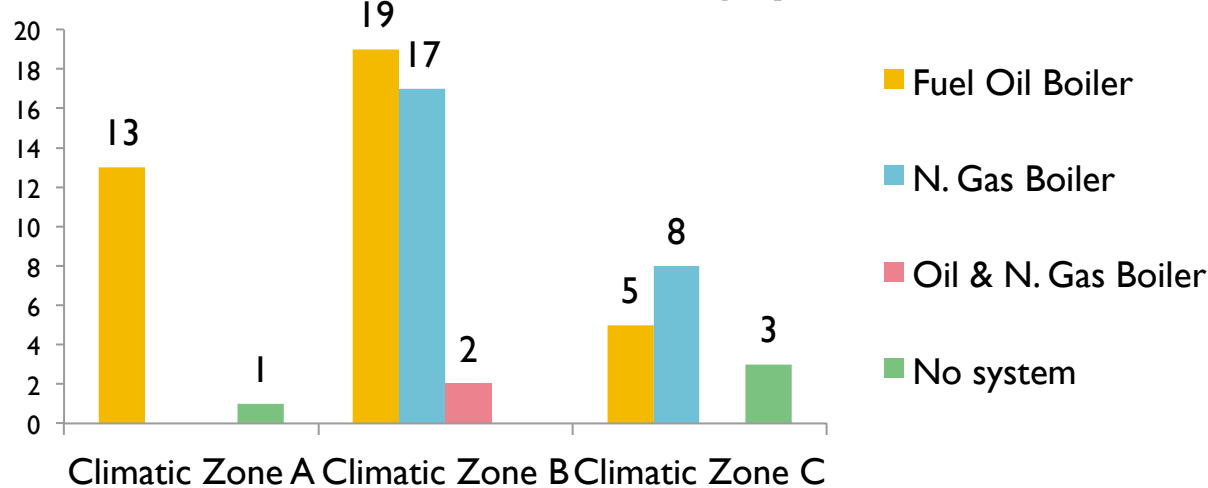
Existence of insulation



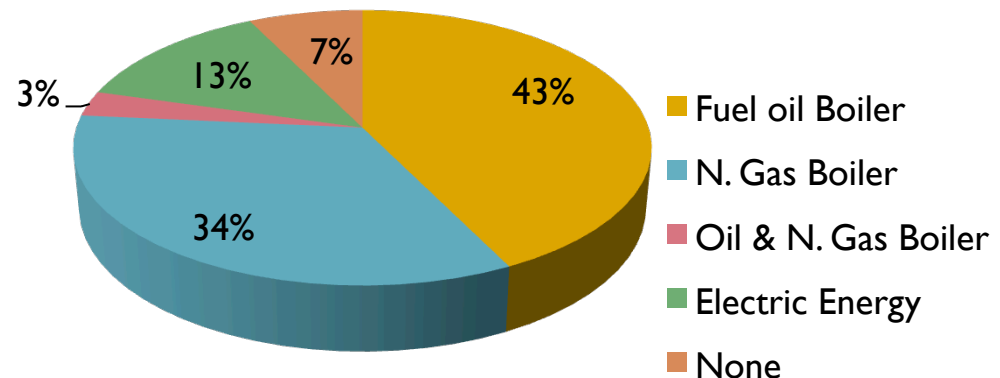
Findings of national survey (2/3)

Installations' characteristics

Pool water heating system



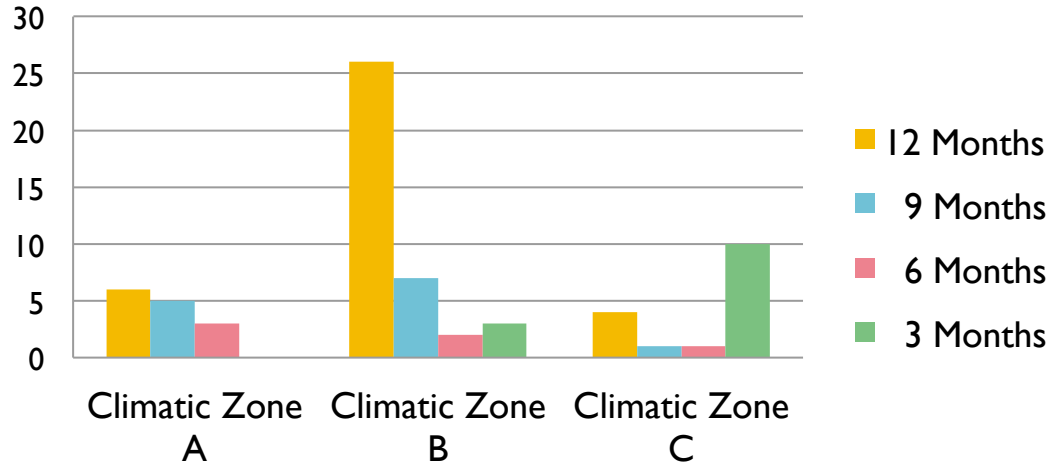
Buildings heating system



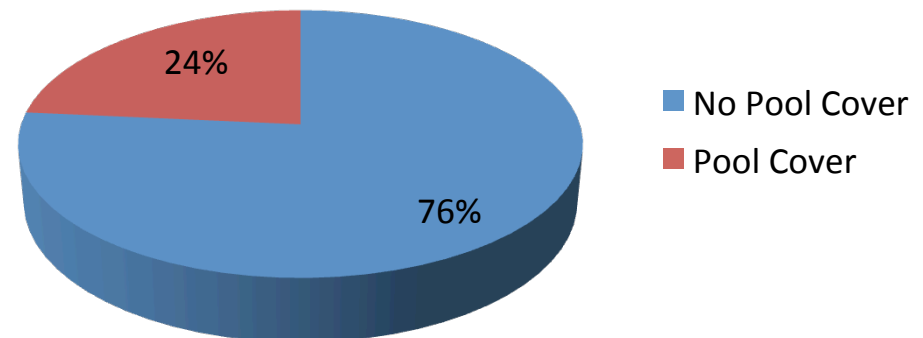
Findings of national survey (3/3)

Installations' characteristics

Annual Operating period



Existence of a pool cover



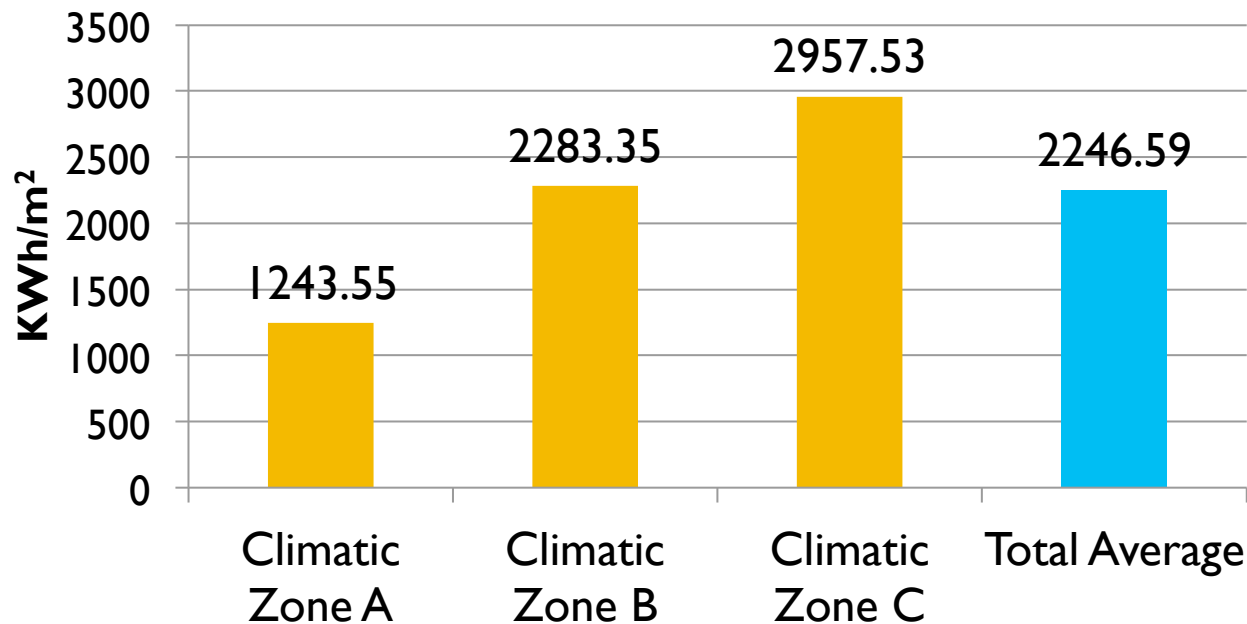
Major assumptions

- Heating demands of the buildings were assumed insignificant compared to that of the pools, consequently
- Specific energy consumption of swimming pools was estimated from their total thermal energy consumption per pool surface.
- Electric energy consumption was assessed only through the selected case studies, as it was impossible to collect the needed data from pool operators through the questionnaires, as bills are paid by the municipalities for all municipal buildings in total

Findings of national survey (1/3)

Energy performance assessment

Specific annual thermal energy consumption per climatic zone

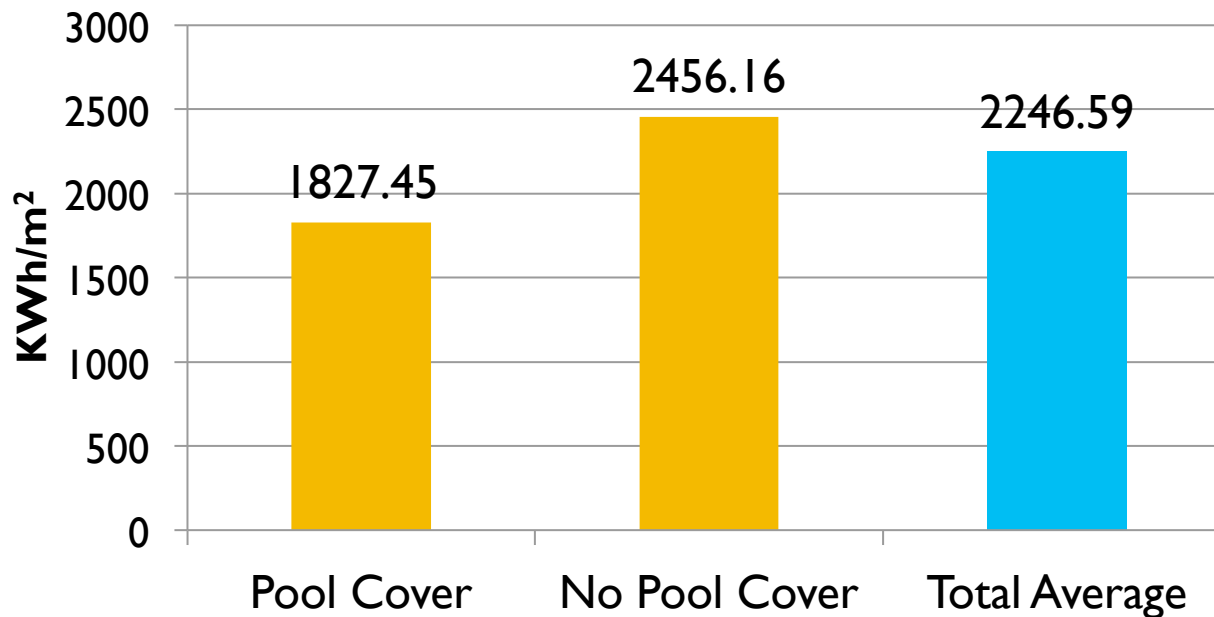


Findings of national survey (2/3)

Energy performance assessment

Specific thermal energy consumption related to the existence of a pool cover

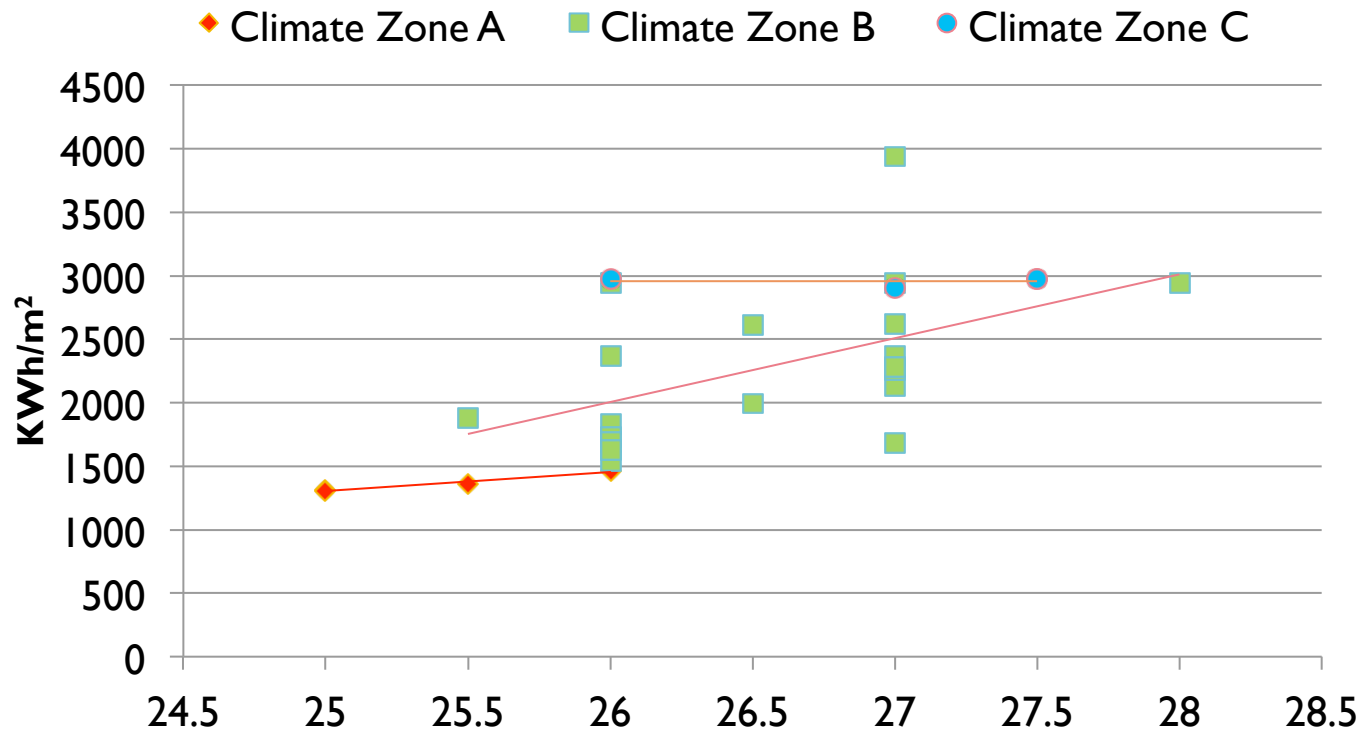
- 25,60% energy consumption reduction



Findings of national survey (3/3)

Energy performance assessment

Reducing the operating pool water temperature 1°C, results to the reduction of thermal energy consumption of 500 kWh/m²



Findings of energy audits

Energy performance assessment

Swimming Pool	Thermal Energy (kWh _{th} /m ²)	Electric Energy (kWh _{el} /m ²)	Cost (€/m ²)	Thermal CO ₂ Emissions (ton./m ²)	Total CO ₂ Emissions (ton./m ²)
Case no 1	3,941.03	358.97	346.50	0.77	1.15
Case no 2	2,944.73	198.29	305.85	0.71	1.00
Case no 3	1,687.62	304.76	199.43	0.46	0.78
National Average	2,246.59	287.34	252.78	0.50	0.80

Electric energy consumption ranges from 6.31 to 15.00% of thermal energy consumed, receiving an average value of 11%

Findings of national survey and energy audits

Other results

- The specific energy consumption in pools using natural gas is higher than those using fuel oil
- However this increase is not proportional to the increase in CO₂ emissions and operating cost
- No solid conclusions were drawn regarding energy consumption and age of installations
- Rational pool management results to significant energy savings

Internal discussion

- The main deficiency met was the exact estimation of the annual operating period, as a number of swimming pools faced closure due to high operational costs.
- The three representative cases were examined thoroughly in terms of energy performance and no subjective judgment was used in these cases
- The results derived from the national survey are the average of several different operating and meteorological conditions, while those derived from the energy audits concern specific conditions.

External discussion (1/2)

- No relevant survey has been conducted in Greece, or any published data and information in the literature were found so no cross- comparisons can be made at this point.
- A similar procedure, was attempted by the SOLPOOL Project (2009), that finally identified 44 operating outdoor swimming pools, but the research focused only on the type of pool water heating systems used.
- Studies have been conducted concerning indoor swimming pools energy consumption and some conclusions can be drawn (ICEU (1994); Balaras (1996) ; Trianti et al (1998)).

External discussion (2/2)

- Regarding total energy consumption (2534 kWh/m^2) satisfactory consistency exists with that stated by Balaras (1996) and ICEU (1994), that for an indoor swimming pool, its energy consumption, about 4300 kWh/m^2 for Mediterranean climates and 5200 kWh/m^2 for continental European zone, is about 2 times higher than an outdoor one.
- Regarding the energy savings achieved with the use of a pool cover (25.60% of the average thermal energy consumption when no cover is used), the findings are similar to that stated by Balaras (1996) and Psarras (2008), 10-30% and 34% respectively, while no consistency exists to that stated by Ladopoulos (2007), 58%, and pool cover suppliers, 40-60%.
- Reducing pool temperature 1°C , resulted to 500 kWh/m^2 thermal energy savings, similar to the value stated by Balaras (1996)

Conclusions

- Outdoor swimming pools is a high energy consuming sector with **specific annual thermal energy consumption 2,246.59 kWh/m²** and **total 2,534 kWh/m²** presenting a broad field for energy saving measures
- **Pool cover** results to energy savings ranging from 25-30%. Must be considered as an essential first investment for any energy efficiency programme.
- **Rational management** is of high importance. Reducing the operating pool water temperature 1°C, results to reduction of thermal energy consumption of about 500 kWh/m².

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