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SIMULATION OF HEATING AND VENTILATION SYSTEM OF INDOOR SWIMMING POOLS

SIMULACIJA SISTEMA ZA GREJANJE I VENTILACIJU ZATVORENIH PLIVAČKIH BAZENA

Marko MANČIĆ,
Dragoljub ŽIVKOVIĆ,
Milena TODOROVIĆ

University of Niš, Faculty of Mechanical Engineering

INTRODUCTION

- **Indoor swimming pool buildings are significant energy consumers**
- **The greatest energy consumer is the swimming pool hall where free water surface evaporation takes place, increasing air humidity in the hall and causing a demand of fresh water supply for the pool**
- **Energy balance of the swimming pool**
- **MODELING AND SIMULATION OF THE SWIMMING POOL HALL - TRNSYS**

Introduction

- Typical energy consumption of indoor swimming pools consists of:
  - 45% for pool hall heating and ventilation,
  - 33% for heating pool water,
  - 10% heating and ventilation of the rest of the building accounts ,
  - 12% lighting and other equipment
- SPORT CENTERS - 600-6000 kWh/m^2

Sport and Recreation Center (SRC) "Dubočica“ (Leskovac)

- Three swimming pools with
  - total water surface areas of 1050 m^2, 330 m^2 and 100 m^2, and
  - depths of 2 m, 1,45 m and 0,5 m respectively.
- Total water surface of the pool area is 1480 m^2
- Installed heat exchangers rated at around 3,35 MW in total
- 55000 visitors annually

Installed capacity of the heat exchangers

Radiator heating (90/70 °C)	276,153 kW	8,24 %
Convective heating for demisting of the hall's glass surfaces (90/70 °C)	261,625 kW	7,81 %
Floor heating of the pool hall (35/45 °C)	87,457 kW	2,61 %
Sanitary hot water heating (60 °C)	145,100 kW	4,33 %
Pool water heating (24 do 26 °C)	1510,000 kW	45,08 %
Air heating and ventilation	1069,510 kW	31,93 %
- Ventilation chamber for demisting of the pool hall glass surfaces	518,180 kW	15,47%
- Ventilation chamber for the pool hall stands	403,100 kW	12,03%
- Ventilation chamber for ventilation of lobbies	96,800 kW	2,89%
- Ventilation chamber for ventilation of cloakrooms	51,430 kW	1,54%

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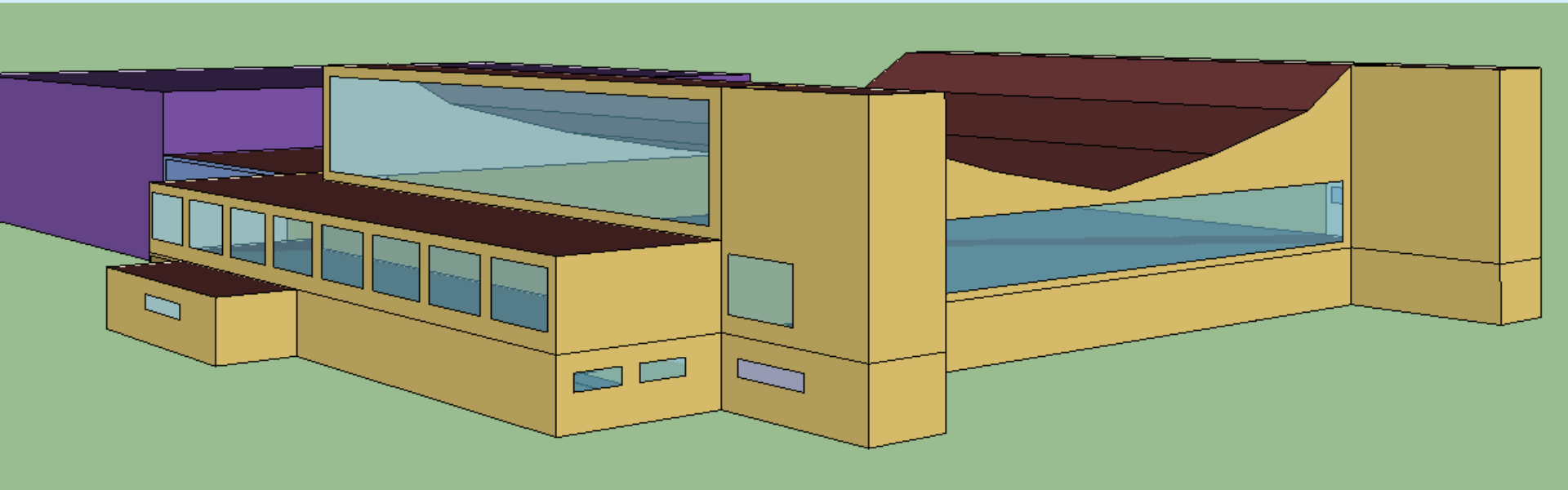
TRNSYS TYPE 56 MODEL



Energy balance of indoor swimming pools

- Energy losses of indoor swimming pools:

- Conduction through the pool walls ,
- Convection from the pool surface ,
- Radiation from the pool surface ,
- Evaporation from the pool surface ,
- Heat loss due to fresh water flow for water loss compensation,
- Heat flow rate from heating .

Energy balance of indoor swimming pools

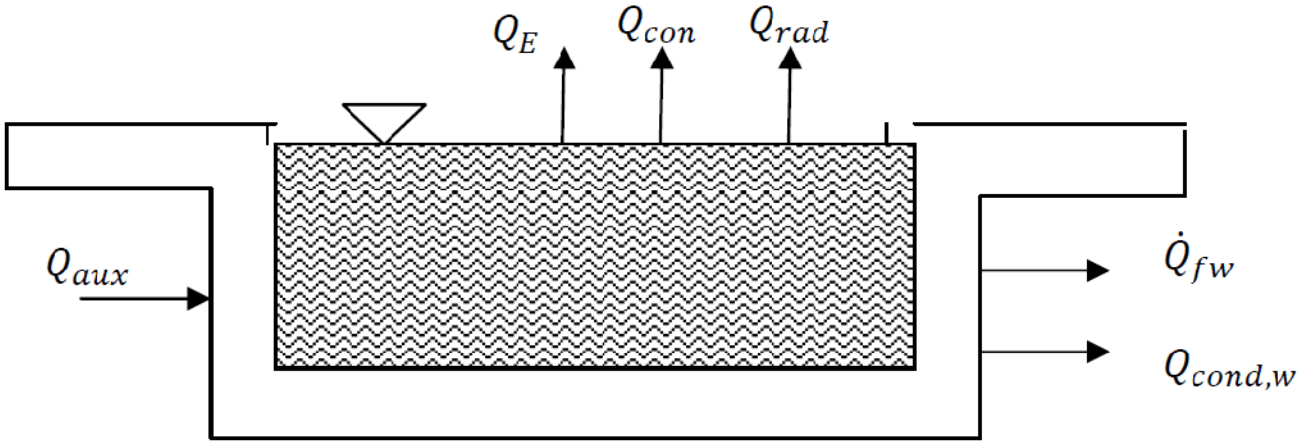


Fig. 1. Scheme of the swimming pool energy balance model

$$\rho_w c_{pw} V_{pool} \frac{dT}{d\tau} = \dot{Q}_{aux} - \left(\dot{m}_{fw} c_{pw} \left(t_w - t_{fw} \right) + A_p \dot{E}r + Q_{conv} + \alpha \left(t_w - t_a \right) + Q_{rad} \right)$$

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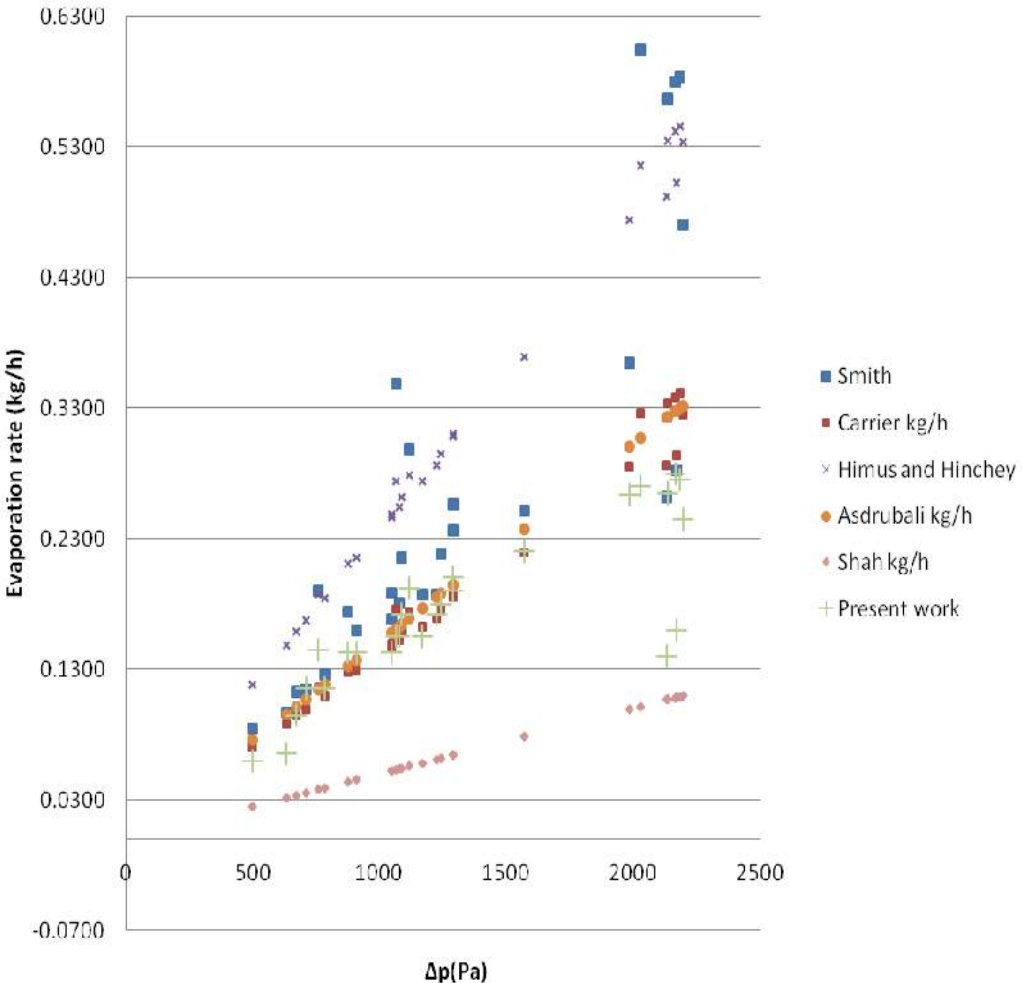
Mathematical models for predicting evaporation from free water surfaces

- empirical or semi-empirical
- heavily rely on measurement results
- real objects or
- scaled laboratory installations with controllec parameters
- Most of the correlations are based on the Daltons theor
- Corelation used in the simuations – Carrier formul (ASHRAE)



Occupied swimming pools

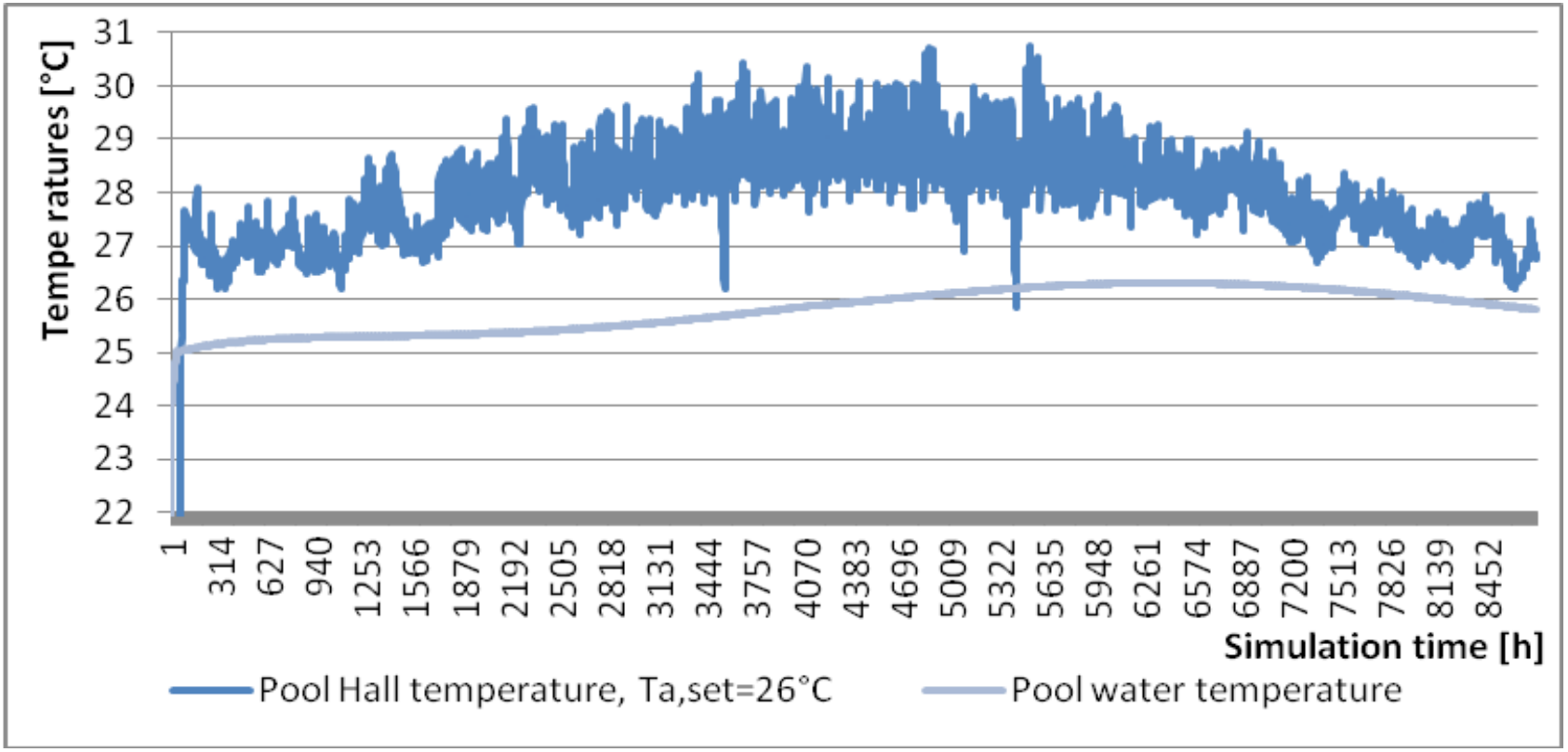
- Occupancy factor $$F = \frac{A_{max}}{A_p / N}$$

- Shah formula for occupied swimming pools

$$E_o = \begin{cases} E(3.3F + 1), F < 0.1 \\ E(1.3F + 1.2), 0.1 \leq F \leq 1 \end{cases};$$

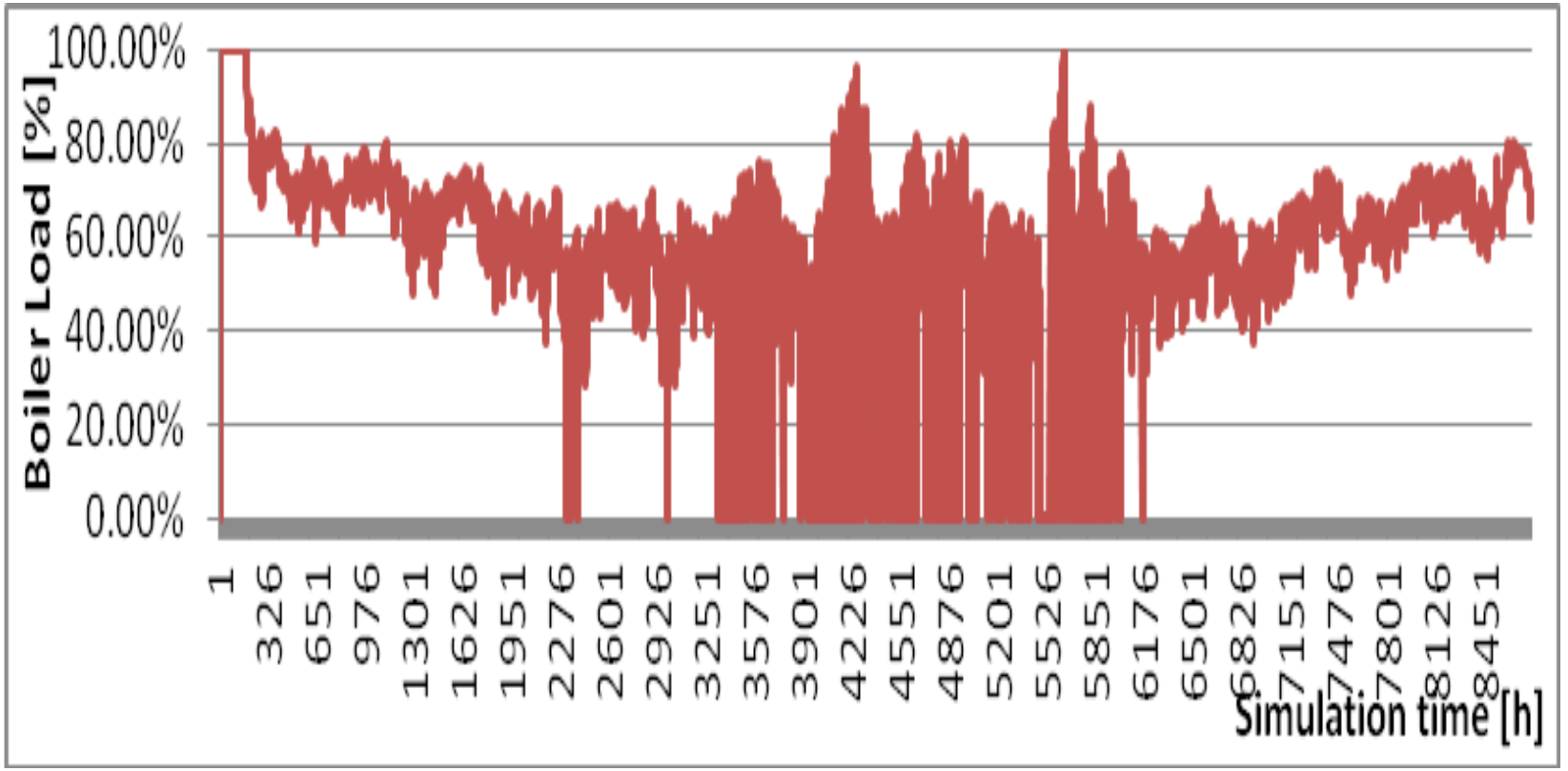
RESULTS

- Annual change of pool hall air temperature and pool water temperature



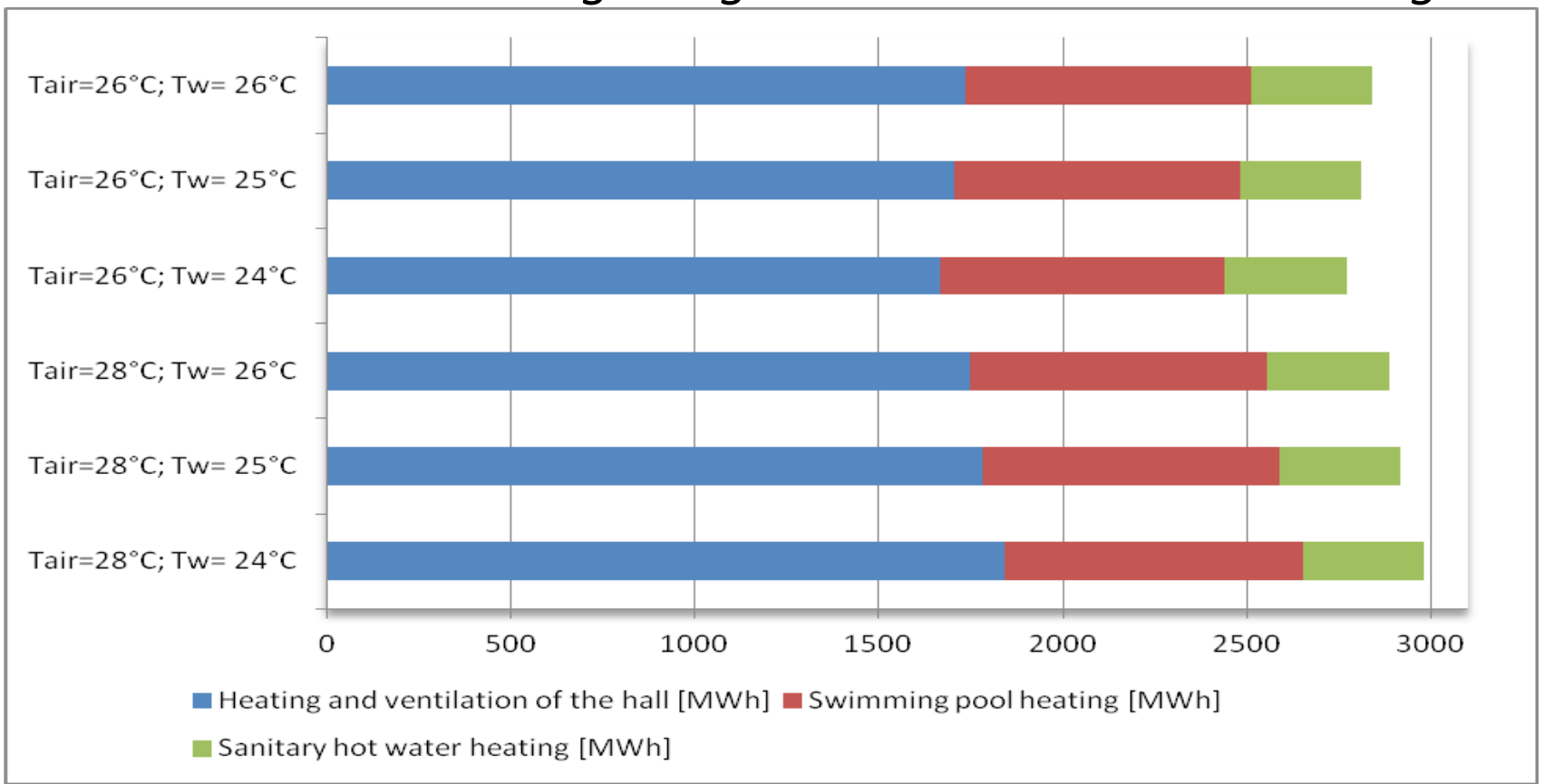
RESULTS

- *Part load ratio of the boiler used for heating*



Results

- *Simulated energy consumption for heating and ventilation of the swimming pool hall, swimming pool heating and sanitary hot water heating using considered controller strategies*



RESULTS

- Energy consumption per unit of swimming pool surface obtained by simulation by variation of controller parameters, given per square meter of pool area

Controler parameters	*Tair=28° C; Tw= 24°C*	*Tair=28° C; Tw= 25°C*	*Tair=28° C; Tw= 26°C*	*Tair=26° C; Tw= 24°C*	*Tair=26° C; Tw= 25°C*	*Tair=26° C; Tw= 26°C*
Heating and Ventilation (kWh/m^2)	1245.18	1203.10	1182.06	1125.20	1151.53	1172.08
Swimming pool heating (kWh/m^2)	546.03	544.65	544.65	522.93	524.40	523.42
Sanitary hot water (kWh/m^2)	316.07	316.07	316.07	316.06	316.07	316.06
Total (kWh/m^2)	2015.02	1971.56	1950.52	1871.95	1899.74	1919.30

CONCLUSION

- **Minimum energy for heating and ventilation of the swimming pool hall is obtained in the simulation where desired controller air temperature was set to *Tair*=26°C** (9.6% lower than the simulated energy consumption with desired air temperature set in the controller to Tair=28°C).
- **The lowest energy consumption for swimming pool heating with the controller set to *Tw*= 24°C**

  (4.2% lower than the maximm simulated energy consumption).
- Total energy consumption for heating the swimming pool can be lowered by up to 7%, by adopting an adequate control strategy (***air*=26°C, *Tw*= 24°C)**

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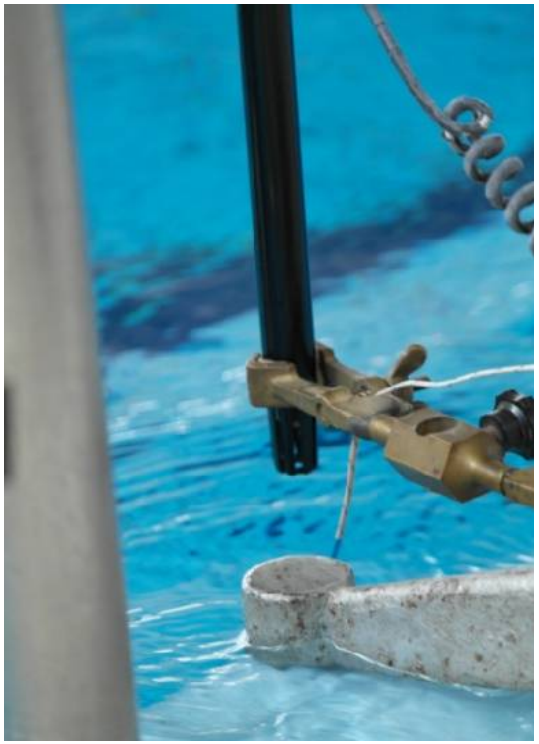

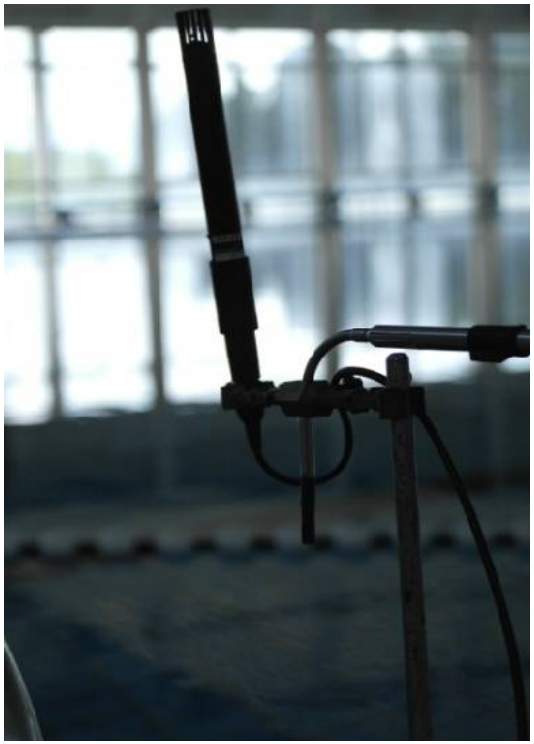

- Thank you for your attention !