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# Installation of Decentralized Ventilation System for Ventilation of an Indoor Swimming Pool

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## Abstract

*In swimming pool facilities ventilation systems are, in addition to water preparation systems, the most vital elements without which the pool cannot operate. Nowadays central ventilation systems, in which one unit prepares the air of equal parameters for the entire pool hall, are used. This article proposes to move away from this approach in favor of a decentralized system. The main principles of the decentralized ventilation system that show its advantages over a centralized system will be presented. Among the biggest advantages that should be mentioned are improving air quality in the occupied zone and ensuring proper parameters for each location in a pool hall.*

*The article presents the results of a simulation in which the primary energy consumption of heating ventilation air in a typical design of a swimming pool facility has been compared with a decentralized system with a traditional air handling unit and a central system. The results show that decentralized ventilation with properly sized air handling unit provides substantial energy savings, up to 50%, in heating supply air in a pool hall.*

**Key words- decentralized ventilation; swimming pool; air handling unit**

## 1.Introduction

Swimming pool halls should be properly maintained with strict conditions to provide thermal comfort for users of these facilities, as well as proper air quality. Air parameters in a pool hall should be appropriately selected so as to:

- provide thermal comfort for users who are undressed – temperature in the occupied zone should be higher than water temperature
- provide thermal comfort for the audience - if it is designed
- not to intensify the evaporation from the water surface - air temperature should not be higher than 2°C more than water temperature
- prevent moisture condensation on building envelope - relative humidity of air should be in the range between 50 to 60%

An important issue here is the correct choice of parameters for the air supplied into the pool hall to ensure removal of moisture gains, harmful compounds related to the occurrence of water disinfection by-products and heat losses.

Traditionally designed ventilation systems are based on a pool ventilation unit, which prepares the air for the entire pool hall, providing the same parameters in the whole volume of the pool hall. This leads to significant power consumption by the unit. The central system is also not able to provide the appropriate parameters for each zone of the pool hall.

It is recommended to use decentralized ventilation system instead. Here, pool ventilation unit prepares the air only for pool basin area. This saves energy as the air handling unit maintains the required air parameters only for the occupied zone. Thus, swimmers can enjoy thermal comfort. However, it is important to provide protection of building envelope from moisture condensation and implement systems that cover transmission heat losses of a pool hall. [1]

## **2.Analyzed Swimming Pool Facilities**

Swimming pool hall can be divided into several zones with different functions [2]:

- pool basin zone (occupied zone) – thermal comfort should be ensured, air and water parameters need to be adjusted to the purpose of the pool, thermal balance of this zone does not depend on external air temperature
- building envelope zone – thermal balance depends on temperature of external air, air parameters need to prevent water condensation on cold surfaces
- audience zone - appropriate air parameters providing thermal comfort of dressed audience should be ensured, absence of such a zone causes discomfort in the audience zone due to high temperature and relative humidity; the design should offer the possibility to turn on and off the heating system if there is some competition planned

Dividing pool hall into zones ensures proper air parameters in each of the zones. Consequently, energy is saved because the systems are activated only when it is necessary. The division into zones is an indicator for the supply air parameter selection.

It should be noted that the separation of pool basin zone and installation of a separate ventilation system, applicable to its use, improves air quality. Outdoor air is supplied directly to the occupied zone. Additionally, air is removed at the bottom of the pool hall, which allows to eliminate disinfection by-products in the place of their origin. The by-products include chloramines and trihalomethanes. Due to the fact that they are heavier than air and are accumulated above the water surface, they are inhaled by swimmers and have harmful effect on them. [2,3,4]

A decentralized system, shown on the drawing below (Fig.1), consists of three or four separate ventilation units.

- Air handling unit 1 – operates in pool basin area and is the most important unit in the entire system, it must operate all year round regardless of the weather and the outside air temperature
- Air handling unit 2 – operates in roof area - dries the air and reduces roof heat losses , operates periodically
- Air handling unit 3 – operates in windows area, operates periodically

- Air handling unit 4 – for the audience, operates when needed

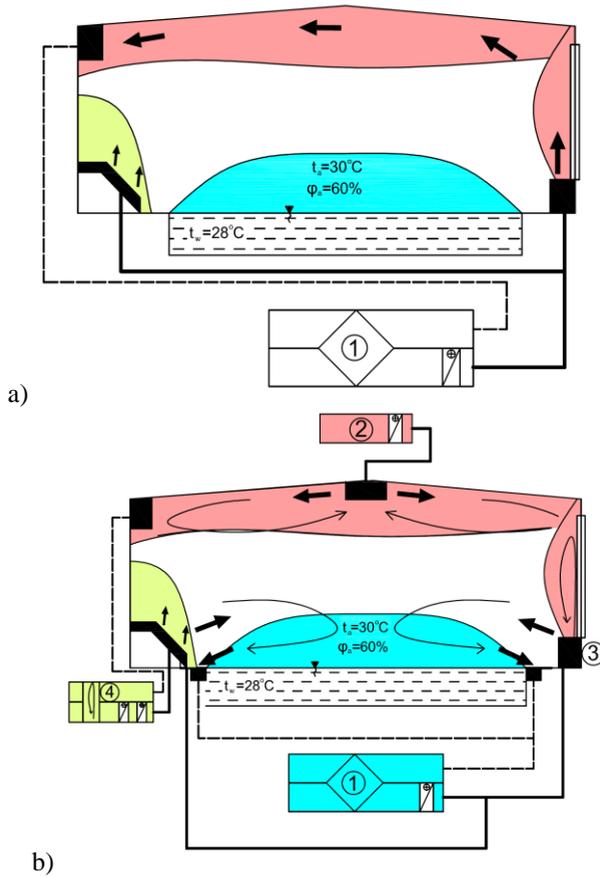


Fig.1. Air distribution system in a swimming pool hall a) central b) decentralized [2]

Two types of swimming pool facilities have been analyzed. Pool hall A is a traditional swimming pool, 25 m long, while pool hall B is a small hotel pool located on the middle floor of a high building. The characteristic parameters of these facilities are summarized in Table 1.

Table 1. Parameters of analyzed swimming pool facilities

Parameter	Structure A	Structure B
Water surface [m <sup>2</sup> ]	325	109
External walls surface [m <sup>2</sup> ]	1005	284
Windows surface [m <sup>2</sup> ]	657	84
Average heat transfer coefficient [W/(m <sup>2</sup> K)]	0,89	0,60
Volume of the pool hall [m <sup>3</sup> ]	3900	680

Two types of ventilation systems for the pool hall have been chosen - central and decentralized. The analyzed variants are presented in Table 2.

Table 2. Variants for the calculations

Variant	Pool hall	Ventilation system
1	A	Central
2	B	Central
3	A	Decentralized
4	B	Decentralized

### 3.Method

The calculations of the amount of energy required to heat up ventilation air have been performed for two selected pool halls (A and B). The pool hall air is prepared by the air handling unit equipped with a cross heat exchanger and internal recirculation, shown in Fig.2.

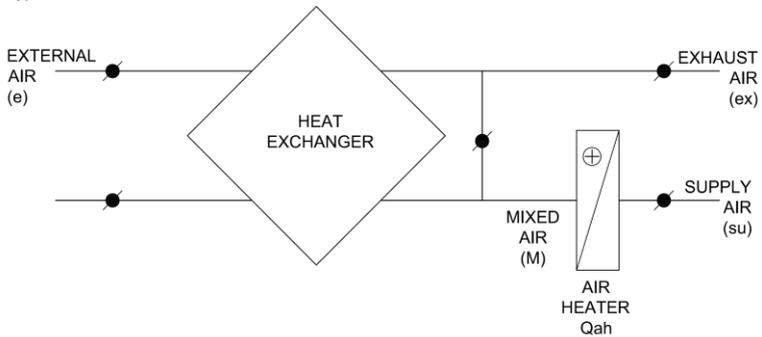


Fig.2. Air handling unit with heat exchanger and internal recirculation

The calculation results are determined by the climate data, namely the location of the building as well as parameters of indoor air. The calculation assumptions are presented in Table 3.

Table 3. Input data for the calculation

Supply air stream at daytime	$m_{su}$	40 kg/(h.m <sup>2</sup> )
Supply air stream at nighttime	$m_{su,N}$	32kg/(h.m <sup>2</sup> )
Heat recovery efficiency	$\eta$	60%
Air parameters in swimming pool hall	$t_a$	30°C
	$\phi_a$	60%
	$x_a$	16g/kg
Climate parameters	shown in Fig. 3 and 4 [5]	
Supply air temperature	shown in Fig. 3 and 4 [6]	

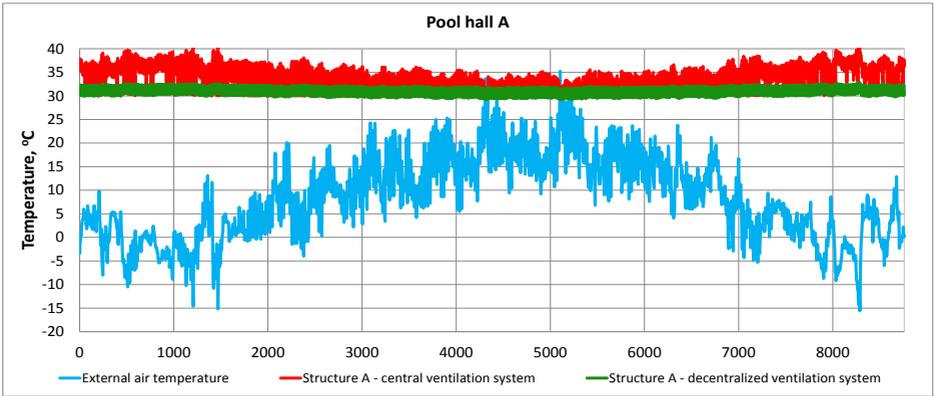


Fig.3.External and supply air temperature over a year period for pool hall A

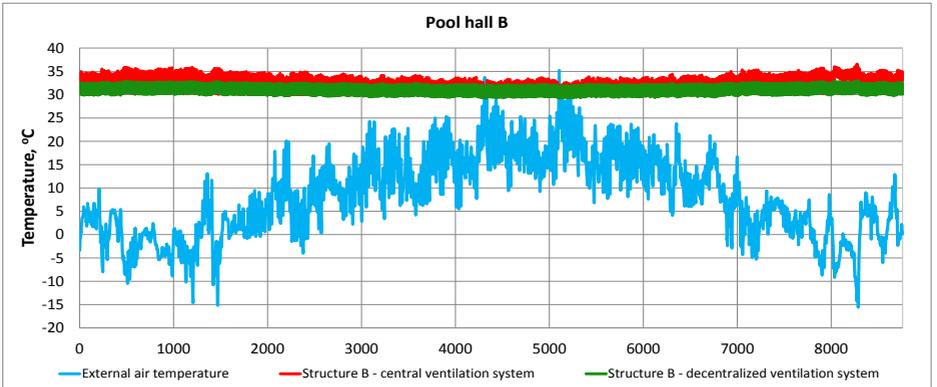


Fig.4. External and supply air temperature over a year period for pool hall B

For the calculation of heating power of the air heater in the air handling unit the following equations (1)-(4) have been used. They are related to equipment and circumstances/processes that take/have place in the unit.

$$Q_{ha} = m_{su} \cdot c_{ps} \cdot (t_{su} - t_M) / 3600 \text{ [kW]} \quad (1)$$

Supply air temperature ( $t_{su}$ ) calculations included thermal balance and moisture balance of pool hall and pool basin area. The graphs above (Fig. 3 and Fig.4) present the results of these calculations. The red color is used to demonstrate the case of central ventilation system and the green is used for decentralized system.

The parameters of air before air heater ( $t_M, x_M$ ) are the result of the participation of fresh air which must be delivered to the pool hall in order to ensure proper moisture content, to pick up moisture gains arising as a result of evaporation of water (2).

$$\epsilon_e = (x_M - x_a) / (x_E - x_a) \quad (2)$$

In order to determine the temperature before the air heater (4), temperature after the heat exchanger should be defined (3).

$$t_{ex} = t_e + \eta \cdot (t_a - t_e) \text{ [}^\circ\text{C]} \quad (3)$$

$$t_M = \epsilon_e \cdot t_{ex} + (1 - \epsilon_e) \cdot t_a \text{ [}^\circ\text{C]} \quad (4)$$

#### 4. Results

The graphs below (Fig.5 and Fig.6) show the results of the calculations of the air heater power for selected types of swimming pool facilities (pool hall A and B), located in Poznan, with central and decentralized ventilation systems. The air heater power is 1056 and 569 kWh/(m<sup>2</sup>·year) respectively.

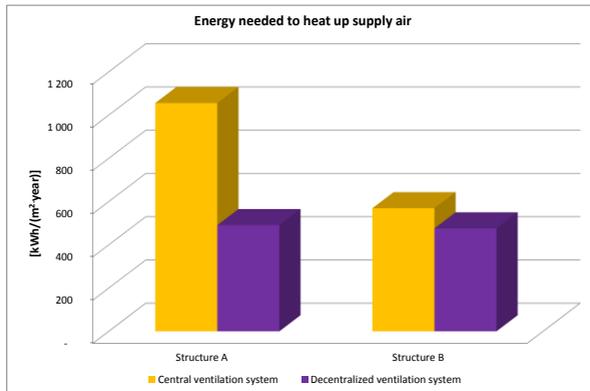


Fig.5. Energy needed to heat up supply air for different structures and ventilation systems

Energy saved owing to the use of decentralized ventilation system in pool hall A, as shown on the bar graph below (Fig.6), is significant - 53%. As for pool hall B, it is only 16%. Due to the fact that pool hall B has a small pool hall volume, heat losses in this case are small. It is a similar situation to the calculation of pool basin area for decentralized ventilation.

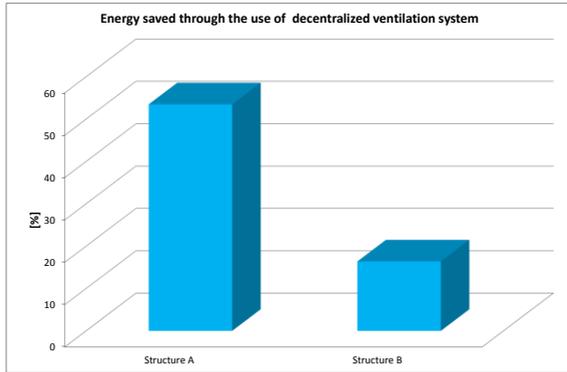


Fig.6. Energy saved through the use of decentralized ventilation system

## 5. Conclusions

Parameters of supply air should be adjusted depending on the ventilation system. The use of decentralized ventilation system means that each zone of the pool hall has appropriate parameters required for operational reasons.

In addition, the use of decentralized ventilation system reduces primary energy consumption because some of the systems can only operate at low outdoor temperatures and not all year round, as it is the case with central ventilation system in which air handling unit ensures equal performance across the pool hall.

Designing appropriate air separation system, as it is in the case of decentralized ventilation system, will further improve air quality by removing disinfection by-products at their source.

Analyses indicate that by using the decentralized ventilation system, energy savings of up to 50% can be achieved, depending on the type of facility, its architecture and construction and geographic location. The larger the indoor pool hall volume, the greater the energy savings. However, in the case of decentralized ventilation system, additional expenses of energy for heating and other potential securing of glazed building envelope have to be incurred.

Additionally, installation of a heat pump in the air handling unit may even lead to greater energy savings for heating ventilation air..

This article focuses on showing differences in primary energy consumption by the air handling unit for an indoor swimming pool. Attention has been paid to other problems

occurring in the halls of indoor swimming pools as: removing moisture gains, eliminate any harmful contamination or the need for use of additional equipment for decentralized ventilation system. Problems occurring swimming pools are so wide that it was decided to examine only some of them. The future work will describe in more detail the other issues that are as important as energy consumption of air handling unit.

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