

Energy and Resource Efficiency in Indoor Pools: The Role of Installation Design

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INTRODUCTION & AIM

Indoor swimming pool facilities are among the most energy-intensive building types due to continuous operation and the need to maintain stable thermal and sanitary conditions. Energy demand is primarily driven by water heating, evaporation, ventilation, and water treatment processes, which together form an interdependent energy–water system. In many existing facilities, suboptimal system design contributes to increased energy consumption and reduced overall resource efficiency.

The aim of this study is to evaluate how installation design influences energy and water efficiency in indoor swimming pool facilities, with emphasis on integrated modernization approaches.

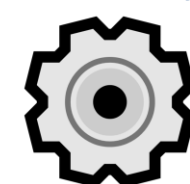
METHOD

A case study approach was applied to three indoor swimming pool facilities in Poland (Ełk, Limanowa, and Skoczów), representing diverse climatic conditions, system configurations, and operational characteristics.



BASELINE ASSESSMENT

Energy and water consumption were quantified based on BMS data, utility records, and on-site measurements.



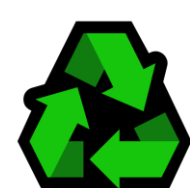
SYSTEM EVALUATION

Heating, HVAC, and water treatment systems were evaluated to identify system inefficiencies.



SCENARIO DEVELOPMENT

Multiple retrofit options, including heat pumps, combined heat and power (CHP), photovoltaic (PV) systems, and hybrid systems, were developed.



INTEGRATED ANALYSIS

Energy use, costs, CO₂ emissions, and water recovery potential were evaluated to assess optimization strategies.

RESULTS & DISCUSSION



High Energy demand:

1.25–1.64 GWh – Heat demand

0.82–0.89 GWh – Electricity demand



Hybrid energy systems ↓ 20–50% heat

↓ 15–25% electricity



Integrated solutions



40–70%
Energy coverage



Up to 50% Cost reduction



Up to ~70% Oversizing issue

Energy performance depends on installation design and system integration. Hybrid systems (CHP, heat pumps, PV) offer clear efficiency advantages, while system oversizing reduces efficiency and increases energy losses. Integrated control (BMS) and energy–water recovery solutions significantly improve performance and load management.

CONCLUSION

- Installation design drives energy performance.
- Integrated energy–water systems deliver significant resource savings.
- Hybrid solutions (renewable energy sources + recovery systems) reduce Energy and water consumption.
- Supports low-emission, circular infrastructure.