CENTRE OF LOW-ENERGY BUILDINGS IN PISEK –
A CASE STUDY FOR NZEB

Summary

Energy study for the retrofit of old building – future Centre of Low Energy Buildings in Pisek – is presented. Use of dynamic building and energy system simulations has helped in the design process to decide on the concept of the building technical system. Original ideas and requirements have been corrected especially in the field of extensive PVT collectors application, large-scale long-term storage use, potential use of passive cooling or the share of auxiliary electricity on total demand. Developed energy system concept combined with recommended HVAC system allows the classification of the building in nearly zero energy level.

Keywords: NZEB, dynamic simulation, building retrofit

1 Introduction

Former military building complex “Zizkova kasarna” in Pisek undergoes the retrofit from the brownfield to a modern technology park. One of the buildings has been chosen to become the Centre of Low-Energy Buildings, the business incubator for new entrepreneurs and innovative companies active in the field of energy savings in buildings operation and realization, new construction technologies and intelligent energy systems.

The building has 4 floors and partial basement (total volume 19 000 m³, total floor area 5 446 m²). Building has quite a heavy core from full 65cm brick walls and brick vaults. A south extension of the building (congress hall) has been designed as a light timber construction. All constructions are designed to have heat loss coefficients typical for low-energy buildings.

Detailed building and system energy study has preceded the design stage to assess the building behaviour and to develop the effective combination of system components
(energy sources, energy storage and HVAC). Target has been set by developer and investor – nearly zero energy building, i.e. building with minimized primary energy consumption. The energy study has been elaborated in close cooperation with developer. The inputs for the study have been significantly changed and refined as work proceeded on, e.g. information on the building usage, preference of particular energy sources, etc. Use of innovative technologies as solar PVT collectors, large-scale long-term storage, ground source heat pumps or heat recovery combined in a complex system has been required.

A principle question on possible user structure and profile has been found as crucial. There were several scenarios of possible occupation profiles and technology equipment placed in the building, from pure administrative building to combination of administrative, laboratory and technology plant with a production line with high energy inputs and cooling loads. This led to two principle scenarios being investigated and taken into account in the evolution of the system concept: „full technology“ – scenario with technology equipment (production line for PV modules, kitchen, laboratory) and „no technology“ as administrative only case to cover possible scenarios for future building usage.

## 2 Energy analyses, system concepts and results

Energy study of the building needed the complex models both for the building and for the energy system being developed. Two simulation softwares have been used and combined: ESP-r for dynamic building performance simulation and TRNSYS for energy system simulation. Results of building simulation in ESP-r (hourly data on heating and cooling demands to meet the comfort criteria) have been transferred and used as inputs for TRNSYS system simulation (see Fig. 1).

![Information flow between simulation programs](image)

**Fig. 1** Information flow between simulation programs

### 2.1 Building simulation

Building energy model has been divided to 25 zones with different orientation, operation profiles or comfort requirements. Reference climate database similar to typical weather in Pisek has been used in simulations. Difference between two scenarios of building usage is shown in Tab. 1 in terms of energy demands.
Results have shown that 75% of cooling loads and 90% of cooling demand are represented by technology zones in the “full technology” scenario. Situation for space heating is completely different. Rooms with high ventilation rates (kitchen, restaurant, congress hall) impose the highest heating loads and laboratory and technology zones have shown a minimum heat demand due to high heat gains from technology equipment. Significant impact of ventilation on heating demand due to the high specific flowrate 50 m$^3$/h.person has led to recommendation of highly effective heat recovery 70%.

**Tab. 1** Energy demand of CLB building

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Heating [MWh/a]</th>
<th>Cooling [MWh/a]</th>
<th>Hot water [MWh/a]</th>
<th>Electricity [MWh/a]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full technology</td>
<td>73.9</td>
<td>160.9</td>
<td>46.0</td>
<td>325.6</td>
</tr>
<tr>
<td>No technology</td>
<td>93.9</td>
<td>14.6</td>
<td>20.0</td>
<td>61.6</td>
</tr>
</tbody>
</table>

Variant with passive cooling by night ventilation have been investigated for summer season. Only administration rooms in first and second floor have the potential for passive cooling if the massive ceiling would not be „disconnected” from interior by suspended ceiling. This possibility remained open for final decision of investor.

Two energy distribution system concepts have been suggested for decision: heating/cooling fan-coils and ceiling system with 40/30 °C for heating and 13/18 °C for cooling. Separate cooling systems have been recommended for zones with high specific cooling loads.

![Fig. 2 Scheme of energy system for CLB in Pisek](image)

2.2 System simulation

Energy system has been considered in two concepts – energy effective system (EE) with electricity need minimized using the long-term energy storage with volumes optimized by parametric simulations in the frame of study (heat 1200 m$^3$, cold 400 m$^3$) and cost minimized system (CM) without the long-term storage. The system consists of heat pumps (132 kW) repumping the heat from cooling system to heating with a back-up from 7 pieces of 200m ground boreholes (as heat source) and dry fan cooler (as heat sink). PVT
collectors (500 m²) covering the envelope of the congress hall has been considered as source of heat (hot water preheating), cold (precooling) and electricity for the building.

Use of large-scale field of PVT collectors is valuable especially for cooling in winter, unglazed PVT collectors work as a large air-liquid heat exchanger. Low specific heat gains for hot water preheating have shown that PVT area is oversized. Share of west and east PVT collectors has been found negligible both for heating and cooling. Moreover, PVT heating and cooling potential depends significantly on the load. Difference between PVT energy gains for „full technology” scenario and „no technology” scenario was found 90 % for cooling and 50 % for heating.

Balance of electricity demand (exported energy, used energy) of both system concepts has been determined in given operation scenarios. High share of auxiliary electricity 35 to 45 % on total demand resulted from analyses, especially for fans of air handling units. Final comparison of electricity demand has shown that cost minimized system concept achieves 7 MWh (14 %) higher values in „full technology” scenario and 1.5 MWh (4 %) higher values in „no technology” scenario while the cost difference the concepts is about 400 000 EUR.

3 Building classification

Classification of the building results from national standard rating. The building meets the criteria for mean $U$-value (< 0.35 W/m².K) and specific space heating demand (< 30 kWh/m².a) in both operation scenarios. Maximum primary energy requirement for nonresidential building is set 120 kWh/m².a in level A (incl. appliances, technology, etc.) and 90 kWh/m².a in level B (technical systems of building only). It is clear from Tab. 2 that full technology operation scenario can’t meet the primary energy criterion due to high electricity demand for the technology equipment (production line). The energy efficient concept meets the criterion for zero energy buildings in level B in both scenarios, cost minimized concept is sufficient for nearly zero energy building requirement.

<table>
<thead>
<tr>
<th>Operation scenario</th>
<th>Energy system concept</th>
<th>$U_{em}$ [W/m².K]</th>
<th>$q_H$ [kWh/m².a]</th>
<th>$PE_A$ [kWh/m².a]</th>
<th>$PE_B$ [kWh/m².a]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full technology</td>
<td>EE</td>
<td>0.28</td>
<td>23.3</td>
<td>303.0</td>
<td>-3.8</td>
</tr>
<tr>
<td></td>
<td>CM</td>
<td></td>
<td>310.5</td>
<td></td>
<td>3.5</td>
</tr>
<tr>
<td>No technology</td>
<td>EE</td>
<td></td>
<td>29.6</td>
<td>40.0</td>
<td>-16.7</td>
</tr>
<tr>
<td></td>
<td>CM</td>
<td></td>
<td>41.5</td>
<td></td>
<td>-15.2</td>
</tr>
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</table>

4 Conclusion

Design of the energy efficient buildings with nonuniform user structure (combined residential, administration and technology use) requires the detailed dynamic simulations of buildings and energy system to develop the optimum concept meeting the comfort demand on one side and energy efficiency on the other side with minimized investment costs. Energy study of building retrofit for CLB in Pisek has shown how important could be knowledge on future building use in the design stage and has clarified the questionable issues for further design process (high fraction of fan power on electricity demand, extent of PVT collectors use, storage capacity for heat and cold and its cost benefit).