1. INTRODUCTION

PROJECT SUMMARY
- building period 1960s
- numerous expansions

SPECIAL FEATURES
- Renovation meeting Passive House Standard
- decentralized ventilation system
- expansion from 4,140 m² to 6,214 m² useable area
- pellet heating (110 kW)
- 6.7 kW_p photovoltaic system (68 m²)

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IEA – SHC Task 47
Renovation of Non-Residential Buildings towards Sustainable Standards
2. CONTEXT AND BACKGROUND

BACKGROUND
- secondary school with musical focus
- polytechnic school

OBJECTIVES OF THE RENOVATION
- increase of building compactness
- integration of planned expansion
- achieving passive house quality
- enhanced use of daylight
- building envelope of high ecological value
- innovative insulation from soil

SUMMARY OF THE RENOVATION
- use of prefabricated façade elements
- no significant impacts on school activity during renovation
- heating demand = 14.1 kWh/m².a
- primary energy demand = 71 kWh/m².a
  (calculated values, PHPP)
- total costs for renovation and expansion = 7,700,000 €, including …
  - ~ 700,000 € for passive house technology (9.1 % additional costs)
  - ~ 185,000 € for other energy related equipment (2.4 % additional costs)
3. DECISION MAKING PROCESSES

- Call for demonstration projects in sustainable refurbishment of the Austrian research programme ‘Haus der Zukunft’ / ‘Building of Tomorrow’
- A conventional renovation project for the School of Schwanenstadt was due, plans were ready
- A study for refurbishment meeting Passive House Standard for the School was submitted and accepted for funding.
- After finishing the study, the demonstration project was submitted
- Excursion to schools with ventilation systems with decision makers from municipality
- Prejudices against mechanical ventilation: one year of testing in one prototype class-room

Timeline for the decision making process

- Submission as research project
  - June 2002
- Clearance with school building authority
  - July 2003
- Submission as demonstration project
  - September 2003
- Assignment of general planning
  - June 2005
- Start of renovation
  - May 2006
- Renovation completed
  - October 2007
- First measuring period
  - June 2007 – May 2008
- Second measuring period
  - June 2008 – May 2009
4. BUILDING ENVELOPE

**Roof construction**: \( U \)-value: 0.101 \( \text{W}/\text{m}^2\cdot\text{K} \)

Materials (Interior to exterior):
- gypsum filler: 3 mm
- reinforced concrete: 300 mm
- vapour barrier: ---
- insulation: 400 mm
- oriented strand board: 22 mm
- EPDM: ---

Total: \( \sim 725 \text{ mm} \)

**Wall construction**: \( U \)-value: 0.130 \( \text{W}/\text{m}^2\cdot\text{K} \)

Materials (Interior to exterior):
- concrete: 150 mm
- reinforced concrete supports and solid wood construction with cellulose insulation: 450 mm
- cellulose insulation: 150 mm
- breathable wood panel: 15 mm
- battening: 30 mm
- wooden facade: 20 mm

Total: \( \sim 815 \text{ mm} \)

**Slab construction**: \( U \)-value: 0.154 \( \text{W}/\text{m}^2\cdot\text{K} \)

Materials (Interior to exterior):
- flooring: 5 mm
- bonded screed: 45 mm
- wooden planks: 200 mm
- foam glass gravel: 600 mm

Total: \( \sim 850 \text{ mm} \)

### summary of U-values \( \text{[W/m}^2\text{K]} \)

<table>
<thead>
<tr>
<th></th>
<th>before</th>
<th>after</th>
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</thead>
<tbody>
<tr>
<td>roof/attic</td>
<td>( \sim 3.3 )</td>
<td>0.101</td>
</tr>
<tr>
<td>floor/slab</td>
<td>( \sim 0.6 )</td>
<td>0.154</td>
</tr>
<tr>
<td>walls</td>
<td>( \sim 2.3 )</td>
<td>0.130</td>
</tr>
<tr>
<td>ceilings</td>
<td>( \sim 3.3 )</td>
<td>0.130</td>
</tr>
<tr>
<td>windows</td>
<td>( \sim 1.3 )</td>
<td>0.8</td>
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</tbody>
</table>

*Detailed view – insulation from soil*
5. BUILDING SERVICES SYSTEM

OVERALL DESIGN STRATEGY
- expansion from 4,140 m² to 6,214 m² useable area
- achieving passive house quality
- increase of building compactness
- innovative insulation from soil
- building envelope of high ecological value

LIGHTING SYSTEM
- enhanced use of daylight

HEATING SYSTEM
- before: gas heating
- after: pellet heating

COOLING SYSTEM
- passive only (night-time ventilation and external shading)

VENTILATION
- decentralized ventilation system

HOT WATER PRODUCTION
- before: gas heating
- after: pellet heating and electric water heater for some tapping points

RENEWABLE ENERGY SYSTEMS
- pellet heating (110 kW)
- 6.7 kW_p photovoltaic system (68m²)
6. ENERGY PERFORMANCES

CALCULATED VALUES
- Heating demand = 14.1 kWh/m².a
- Primary energy demand = 71 kWh/m².a
- PHPP, energy reference area = 5,899 m²

MONITORING PERIOD 2 YEARS

Summary of Energy Consumption [kWh/m².a]

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Heating demand, measured</td>
<td>18.59</td>
<td>21.89</td>
</tr>
<tr>
<td>Heating demand, temperature corrected</td>
<td>19.29</td>
<td>18.40</td>
</tr>
<tr>
<td>Electricity consumption</td>
<td>20.02</td>
<td>19.58</td>
</tr>
<tr>
<td>Final energy consumption</td>
<td>48.44</td>
<td>52.91</td>
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<tr>
<td>Primary energy consumption</td>
<td>59.69</td>
<td>59.64</td>
</tr>
</tbody>
</table>

OVERHEATING IN SUMMER
- 2007 / 2008 = 11.3%
- 2008 / 2009 = 4.6%
- Ratio of hours above 26°C during school

PEF (electricity) = 2.7 | PEF (heating) = 0.7
7 ENVIRONMENTAL PERFORMANCE

CERTIFICATION / LABELS
- Total Quality Building Certificate (TQB)

ECOLOGICAL MATERIALS
- Cellulose insulation

INCREASING QUALITY OF LIFE
- 7 out of 8 are satisfied

RENEWABLE ENERGY SOURCES
- Pellet heating system
- Photovoltaic facade

FAST RENOVATION
- Prefabricated components

LIGHTING QUALITY
- Enhanced use of daylight

TQB assessment

- resource conservation
- harmful impacts on humans and the environment
- user comfort
- durability
- safety & security
- planning quality
- infrastructure and equipment
- overall assessment

satisfied

highly satisfied

not too satisfied
LIGHTING QUALITY
- *Enhanced use of daylight*
8. MORE INFORMATION

RENOVATION COSTS
- expansion (from 4,140 to 6,214 m²)
- achieving passive house quality
- 7 700 000 € including …
  • ~ 700 000 € for passive house technology (9.1 % additional costs)
  • ~ 185 000 € for other energy related equipment (2.4 % additional costs)

ADDITIONAL BUILDING COSTS
in detail …
- 142,442 € for sun protection
- 45,63 € for PV system
- 421,245 € for ventilation
- 85,349 € for windows
- 114,048 € for slab construction
- 36,516 € for roof construction
- 95,019 € for wall construction

minus savings of …
- 53,730 € for heating system

Additional costs for meeting Passive House Standard per square meter usable area

- sun protection
- photovoltaic
- heating system
- ventilation
- windows
- slab construction
- roof construction
- wall construction
8. MORE INFORMATIONS

ADDITIONAL TOPICS
- Costs for ventilation systems in schools should not be added to costs for meeting Passive House Standard as ventilation should be standard in class rooms for comfort reasons.

Additional costs for meeting Passive House Standard

<table>
<thead>
<tr>
<th></th>
<th>usual renovation</th>
<th>done renovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ 421 000 €</td>
<td></td>
<td></td>
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<tr>
<td>for ventilation</td>
<td></td>
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<tr>
<td>+ 279 000 €</td>
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<td></td>
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<tr>
<td>for other PH equipment</td>
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</tbody>
</table>

Total yearly energy costs

4140m²: 40 000 €
6214m²: 60 000 €

Annual total energy costs in €:

- before: 40 000 €
- done renovation: 60 000 €
- usual renovation: 60 000 €
Thank you for your attention!

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