LowEx Retrofit of a Printing Workshop

Monitoring and Evaluation

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Refurbishment
Before Refurbishment

- **typical commercial property from the 1970’s**
- **common weak points**
  High energy demand (electricity and fuels), poor insulation, insufficient day lighting, unsatisfying air quality, inadequate room acoustics and thermal discomfort both in winter and in summer.
Refurbishment Concept
Building Physics

existing building

light-weight construction

natural ventilation

solar shading

No public funding.
Refurbishment Concept
Heating – Cooling – Ventilation
based on low-exergy systems

Ventilation
- Free night ventilation
- Mechanical ventilation with heat recovery

Heating
- Low-temperature radiator
- Floor heating
- Waste heat from printing plant

Cooling
- Bore-hole heat exchanger
- PCM- radiant ceiling
- Capillary tubes
At the Construction Site
Ventilation + Heating

- ventilation opening
- solar shading
- heat recovery from printing machine
- floor heating system
- pressure test of the hydronic system
At the Construction Site
Cooling System

- drilling machine
- bore-hole heat exchanger
- capillary-tube cooling system
- radiant-cooling system with phase change material

Long-term monitoring of building and plant performance as well as thermal comfort since May 2007 (high-time resolution)
At the Construction Site
Cooling System

![Image of a radiant cooling system with phase change material and temperature readings of 23 °C and 29 °C]
Monitoring: Useful heating energy before and after retrofit

- reduction of heating energy by 50%
- high potential of use of waste heat
- HR with 65%
- building envelop in high quality but not passive house standard
- quality assurance

Building was refurbished by a general contractor

![Graph showing heating energy reduction before and after retrofit.](image)
Monitoring of end energy: heating-cooling-ventilation
before and after retrofit

Reduction of final energy by 32 %

→ building operation
→ hydraulics
→ quality assurance

final energy \( [\text{kWh}_{\text{therm}}/(\text{m}^2_{\text{net}}\text{a})] \)

BEFORE retrofit

BEFORE retrofit

OPTIMIZING

Kühlen
Lüften
Beleuchten
Heizen

Nutzenergie für
Kühlen: Messwerte
Lüften: 2010 = 2008
Beleuchten: 2010–2010
Heizen gradtagbereinigt

-27%
-32%

2004 2008 2010 Planung

BEFORE retrofit

BEFORE retrofit

OPTIMIZING

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2004 2008 2010 Planung
Monitoring of primary energy: heating-cooling-ventilation before and after retrofit

**primary energy** [kWh\text{therm}/(m²\text{net} \cdot a)]

<table>
<thead>
<tr>
<th>Year</th>
<th>BEFORE retrofit</th>
<th>AFTER retrofit</th>
<th>OPTIMIERUNG</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>350</td>
<td>250</td>
<td>-37%</td>
</tr>
<tr>
<td>Neubau</td>
<td>300</td>
<td>150</td>
<td>-56%</td>
</tr>
<tr>
<td>Sanierung (+40%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erdgas</td>
<td>200</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Strom</td>
<td>150</td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>

- Anforderungswerte gemäß EnEV 2007 für Neubau (Referenzgebäude) und Sanierung (+40%)

Passivhaus Symposium, Brüssel 7th September 2012
Thermal Comfort
European Guideline EN 15251:2007-08

building allocated to comfort class II
Building and Plant Performance

Cooling System

- thermal comfort class II [%]
- SPF
- primary energy [kWh\textsubscript{prim}/(m\textsuperscript{2}\textsubscript{net}a)]
- cooling energy [kWh\textsubscript{therm}/(m\textsuperscript{2}\textsubscript{net}a)]

Graph showing performance metrics for cooling systems.
Building and Plant Performance

Cooling System

consequent reduction of auxilliary energy

replacement of primary pump

implementation of revised control and operation strategies
Conclusions

Low-energy concept successfully realized in refurbishment project

- useful heating energy and total primary energy use reduced by 56%
- good indoor environment (visual and thermal).
- building envelope in high quality.
- Phase Change Material in light-weight construction.
- hybrid ventilation system with free night ventilation.
- TABS with (direct) ground cooling
- use of waste heat
- operation and control algorithms improved
- upgrade of heat-pump system including reversible mode in summer