

# Printing Workshop and Office Buildings

## 1. INTRODUCTION

### PROJECT SUMMARY

*Construction year: around 1978*

*Renovation: phase one 2005 and phase two 2011*

### SPECIAL FEATURES

- *Ventilation system with heat recovery*
- *Direct cooling using the ground as environmental heat sink*
- *Night-time ventilation*
- *Use of waste heat from printing plant*
- *Radiant cooling panels with integrated phase-change materials (PCM)*

### Partners

*Karlsruher Institut für Technologie (fbta)*

### OWNER

*E&B engalhardt & bauer  
Karlsruhe, Germany*



## IEA SHC Task 47

Renovation of Non-Residential Buildings towards Sustainable Standards

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## 2. CONTEXT AND BACKGROUND

### BACKGROUND

- typical commercial property
- low-rise building, gross area of 480 m<sup>2</sup>
- intensively equipped with office devices of high technical standard, i.e., measured internal heat gains are about 400 Wh<sub>therm</sub>/(m<sup>2</sup>d)

### OBJECTIVES OF THE RENOVATION

- weak points: high energy demand (electricity and fossil fuels), poor insulation, insufficient day lighting, unsatisfying air quality, inadequate room acoustics, and thermal discomfort both in winter and in summer
- heat energy demand: 150 kWh<sub>therm</sub>/(m<sup>2</sup>a)

### SUMMARY OF THE RENOVATION

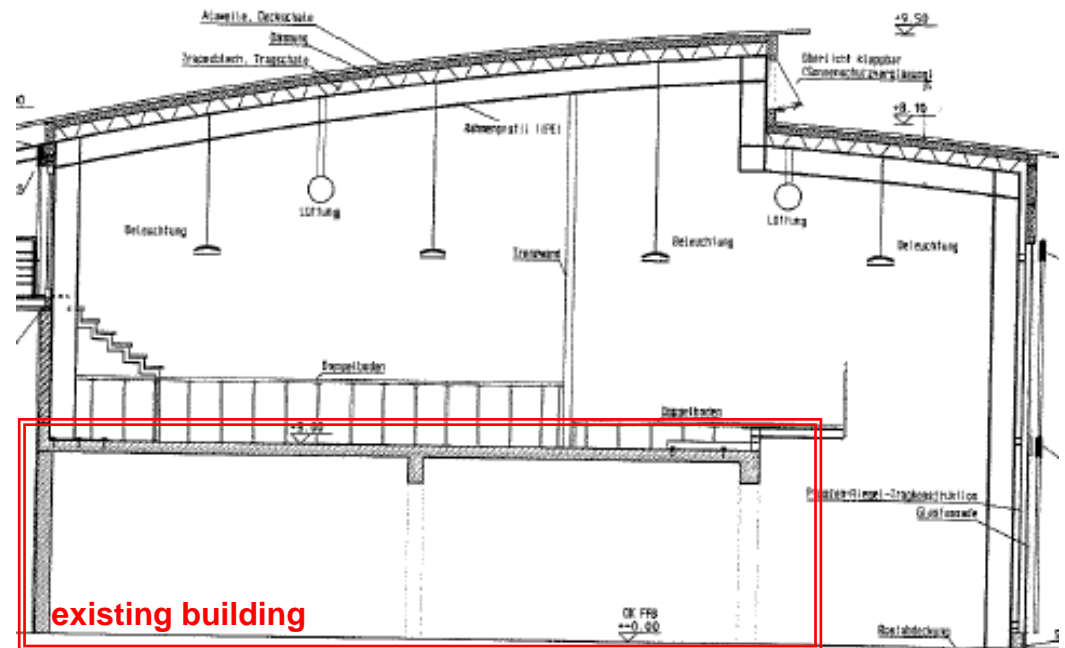
- building enlarged by a 2nd floor: 1,110 m<sup>2</sup>
- new building envelope is a light-weight steel construction
- intermediate concrete ceiling is exposed
- ceiling panels with phase change materials (PCM) enforce the thermal storage effect
- improved insulation standard
- removal of the suspended ceiling altered the previous room into a higher and brighter workplace
- automatic solar shading system reduces the solar heat gains
- room acoustics in the landscape office is enhanced by the new room geometry, textile partitions and cooling panels



Before retrofitting



After retrofitting: building enlarged by a second floor: 1,110 m<sup>2</sup>, new building envelope is a light-weight steel construction

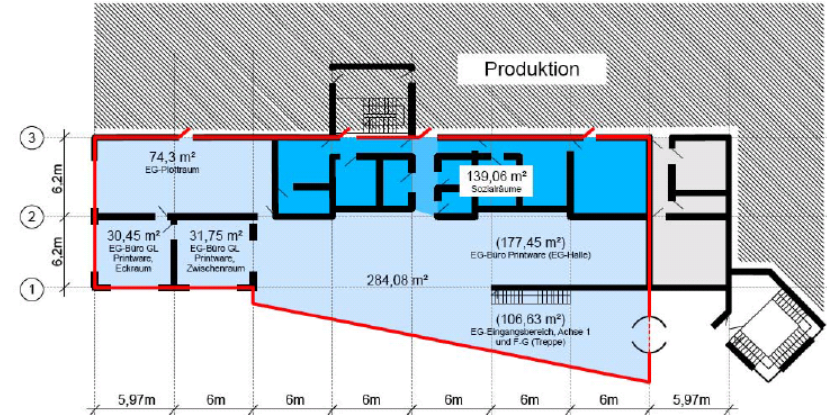


## 4. BUILDING ENVELOPE

**Roof construction** : *U-value: 0.19 W/m<sup>2</sup>.K*  
*trapezoidal sheet metal* 135 mm  
*Mineral fiber* 180 mm  
*Total* 315 mm

**Wall construction** : *U-value: 0.3 W/m<sup>2</sup>.K*  
*Plaster* 10 mm  
*precision blocks* 175 mm  
*EIFS* 120 mm  
*Total* 305 mm

**Windows** : *U-value: 1.4 W/m<sup>2</sup>.K*



Floor plan.

### Summary of U-values [W/m<sup>2</sup>K]

	Before	After
Roof/attic	0.5	0.19
Floor/slab	-	-
Walls	2.6	0.3
Ceilings	-	-
Windows	2.7	14.



Façade with ventilation slats and solar shading system.



Upper floor with suspended cooling panels w/ integrated PCM.

## 5. BUILDING SERVICES SYSTEM

### LIGHTING SYSTEM

A large glass-façade opens the building to the west and provides a good view the landscape office. The automatic solar shading system guarantees a glare-free daylight condition by a cut-off control algorithm.

### HEATING SYSTEM

Before: gas boiler

After: Use of waste heat from the printing workshop, heat pump system, gas boiler as back-up. Radiators as heat delivery systems.

### COOLING SYSTEM

Before: no cooling

After: night-time ventilation system and direct cooling via geothermal system. During period of high cooling demand, active cooling via reversible heat pump system. Cooling ceiling and cooling panels as delivery system.

### VENTILATION

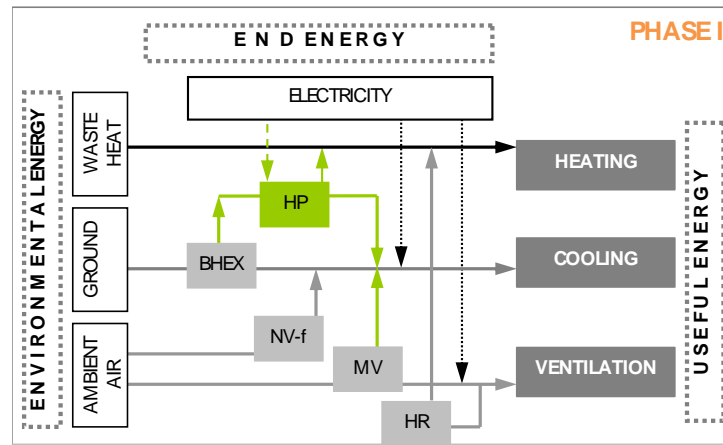
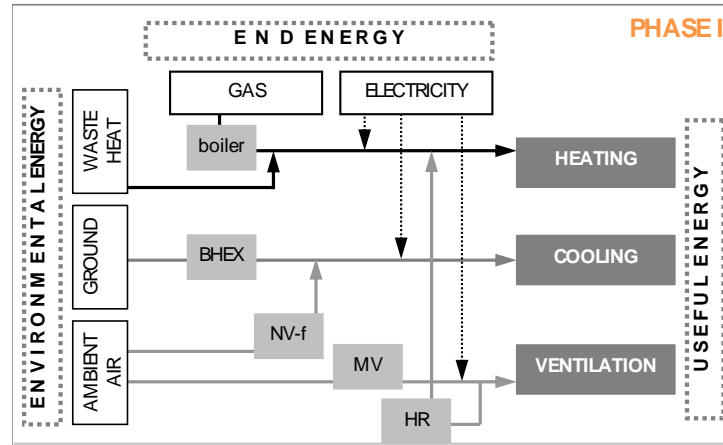
Before: no ventilation

After: mechanical ventilation system with heat recovery, 65%

### RENEWABLE ENERGY SYSTEMS

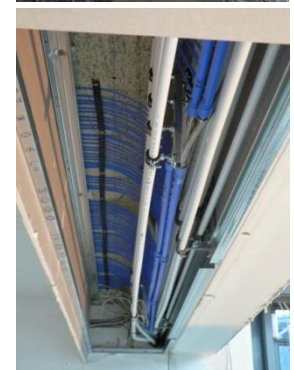
Use of waste heat.

Ground-coupled heat pump system with 12 bore-hole heat exchangers (60 m deep)



Energy schematic for heating, cooling and ventilation.

Retrofitting was carried out in two phases. Note: heat pump (HP), borehole heat exchanger (BHEX), mechanical ventilation (MV), free night-time ventilation by opening ventilation slats in facade (NV), heat recovery (HR).



Drilling machine for bore hole heat exchangers (1), bore hole heat exchanger (2), cooling ceiling in first floor: water driven capillary tubes (3).



## 6. ENERGY PERFORMANCES

The monitoring and the evaluation of the building and plant performance confirm that both the energy efficiency and the interior comfort could be improved considerably.

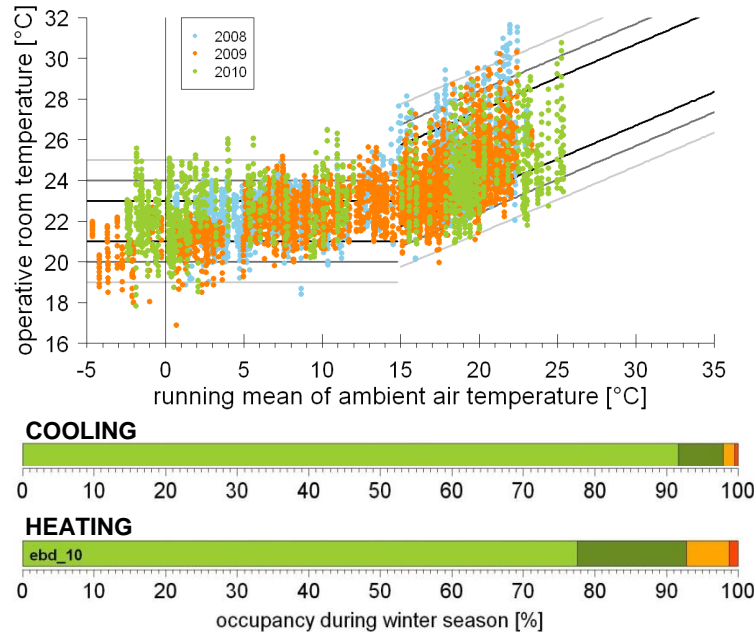
After the retrofit, the heating energy use could be reduced by 52% to  $64 \text{ kWh}_{\text{therm}}/(\text{m}^2\text{a})$ . The total primary energy consumption for heating, cooling, ventilation and lighting was reduced by 37%. After some optimization measures, the consumption is even 58% lower than before the retrofit ( $134.5 \text{ kWh}_{\text{PE}}/(\text{m}^2\text{a})$ ).

Occupant thermal comfort assessments of the building in summer and winter are evaluated according to the European guideline EN 15251:2007-08 by means of number of hours during occupancy when the operative room temperatures exceed defined comfort classes.

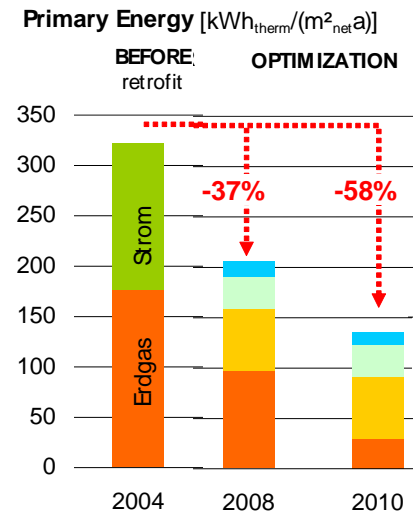
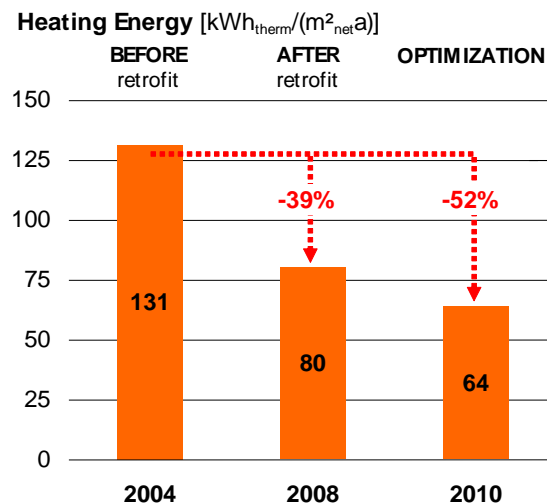
### RENOVATION COSTS

Construction costs: 860 Euro/m<sup>2</sup>

HVAC: 370 Euro/m<sup>2</sup>



**Thermal comfort evaluation:** mean operative room temperature of the building [°C] during the time of occupancy plotted against the running mean ambient air temperature [°C] according to the comfort guideline DIN EN 15251:2007-08. The building's thermal comfort footprint indicates the time during occupancy in summer season [%], when thermal comfort complies with class I to IV; here for the adaptive comfort approach of DIN EN 15251. Note: class I (light green), class II (dark green), class III (orange), and outside the defined comfort classes (red). Result: In summer, comfort class II is achieved 98% during occupancy, in winter 93%.



**End und primary energy performance:** before and after retrofit.

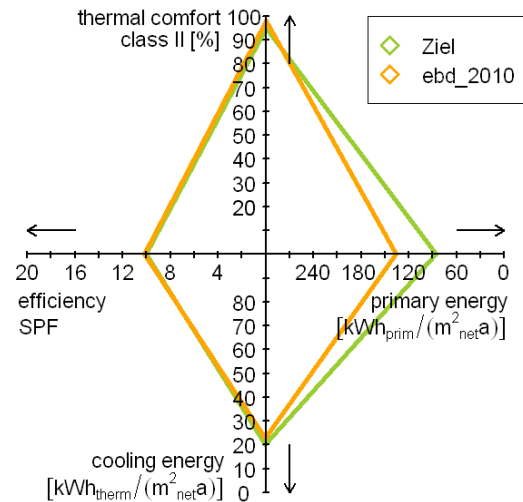
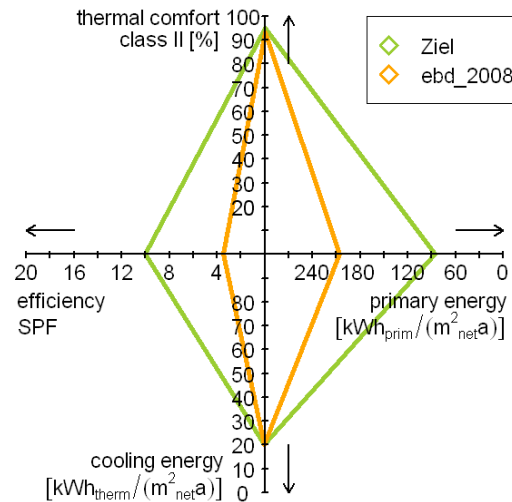
## 8. MORE INFORMATIONS

### POST OCCUPANCY EVALUATION

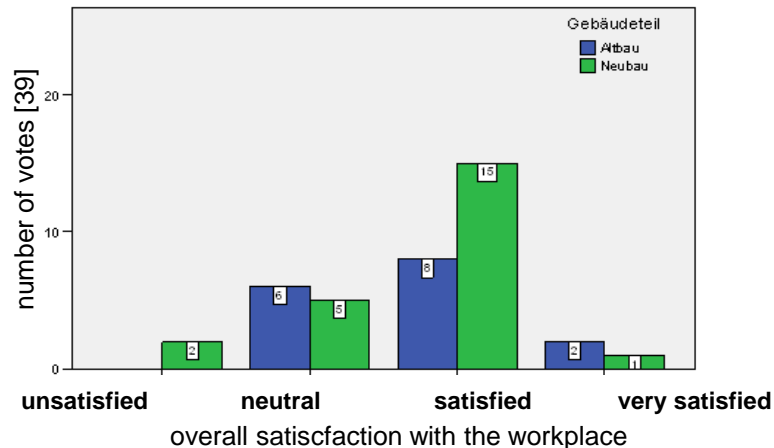
A post-occupancy evaluation in 2008 shows high satisfaction with the overall building concept but need for optimization regarding thermal comfort. The occupants were satisfied with the indoor air quality, the light conditions at the workplace and the relative humidity. However, they perceived the room temperature in winter cool and in summer warm. Due to the landscape office, the occupants criticized insufficient individual possibilities to change the indoor environment.

Occupants feel more comfortable in the retrofitted building ("Neubau") than in the old part of the building ("Altbau").

### EVALUATION OF COOLING CONCEPT



**Building performance:** correlating useful cooling energy use [kWh<sub>therm</sub>/m<sup>2</sup><sub>net.a</sub>], energy efficiency related to the primary energy use of the entire system [kWh<sub>therm</sub>/kWh<sub>prim</sub>] and thermal comfort classification according to EN 15251:2007-08. The green square represents the target objective for these four parameters and the arrows indicate the direction of the optimum.



**Post occupancy evaluation:** evaluation of user satisfaction with the workplace.