*Date of revision 08.03.2013*

## 1. INTRODUCTION

PROJECT SUMMARY
*Construction year: around 1975*
*Energy renovation: 2011*
*No previous energy renovations*

SPECIAL FEATURES
*Insulation of thermal envelope: added 160 mm insulation to roof, 240 mm insulation to facade and 160 mm to the base (400 mm below ground)*
*New windows with 2 layers of glass.*
*A ventilation system with heat recovery integrated in insulation panels.*
*Prefabricated window frame elements.*
*Prefabricated air duct panels*

MAIN CONSULTANT
*Architekturbüro Toni Weber, Freiburg*
ENERGY CONSULTANT
*Architect, Fraunhofer ISE*
PARTNERS
*Beck&Heun*
*Zehnder Group*
OWNER
*Fraunhofer Society*

Brochure authors: Doreen Kalz and Arnulf Dinkel
Contact: doreen.kalz@ise.fraunhofer.de

# Office and workshop building, Fraunhofer ISE Campus, Freiburg, Germany

**IEA SHC Task 47**
Renovation of Non-Residential Buildings towards Sustainable Standards

SHC SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY

## 2. CONTEXT AND BACKGROUND

### BACKGROUND

*The building is one of numerous buildings on the campus site of the Fraunhofer Institute of Solar Energy Systems in Freiburg, Germany. Built in the 70s,* this building had minimal insulation, and is one of several buildings on the ISE campus to be renovated. *It is one of several buildings on the ISE campus that will undergo an energy renovation. The layout of the ventilation system with ducts within the insulation layer will be evaluated through additional research projects.*

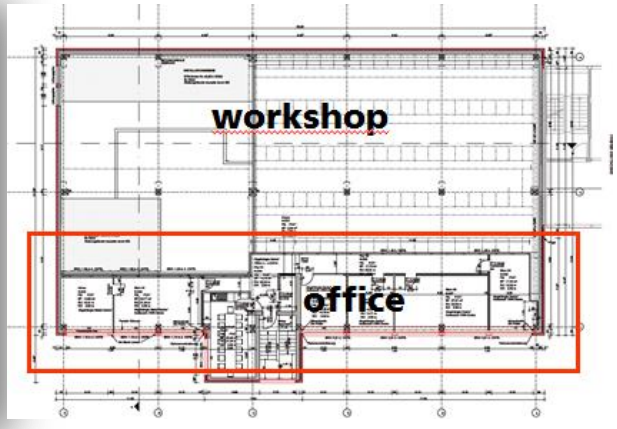
### OBJECTIVES OF THE RENOVATION

- *The main objective was to achieve an overall renovation of the building envelope, because the roof was leaking, windows were worn out, users were unsatisfied with the thermal comfort situation in summer and winter as well as the air quality in the office rooms.*
- *The renovation had to be performed during full operation of the building. The windows had to be replaced within one day.*
- *Demonstration of a ventilation system integrated in the insulation layer of the facade.*
- *Prefabricated window-frame elements with air inlets and outlets.*
- *Prefabricated insulation panels for easy mounting of air-ducts.*

### SUMMARY OF THE RENOVATION

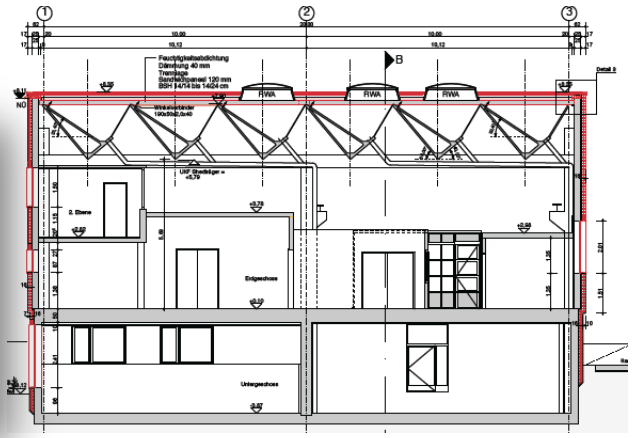
- *Roof: A complete new roofing was added on top of the existent sheds, large skylights were replaced by smaller double-glazed skylights. Insulation 140 mm Sandwich panels.*
- *Wall: The existing construction had 30 mm insulation in a concrete prefabricated sandwich panel. 220 mm´s of insulation with a cladding was added*
- *Base/foundation: The original base had no insulation and therefore 160 mm's of insulation was added on the outside to a depth of 400 mm.*
- *Windows: Existing traditional double-glazed windows were replaced by new double-glazed windows (see photos).*
- *Ventilation system: A new ventilation system with heat recovery for the office floor was added.*

*Façade detail - Before retrofit.*




*Floor plan. Office area: 145m², volume: 400m³.*

*Façade facing street - After retrofit.*



*Vertical section.*

## 3. DECISION MAKING PROCESSES

WHY RENOVATION

*The main incentives for the renovation were to reduce energy consumption and improve indoor climate. The building was built in the 70s and* therefore was very poorly insulated. *An annexed new laboratory building was created with a new combined heating and cooling system. For the function of the new- and the old building, a retrofitting of the old building was mandatory.*

PUBLIC FUNDING

*The building is owned by the Fraunhofer* society and therefore is financed *and retrofitted mostly by the government.*
*The retrofitting was additionally financed by a public market supporting program and a government financed research project was linked with the retrofitting of the building. New retrofit ideas - e.g. prefabricated façade parts with integrated ventilation - had to be demonstrated at the construction site.*

REDUCED OPERATIONAL COSTS USED FOR PAYBACK

*The reduction in operational costs will not been used for payback. The building owner has not yet established a structured and building related scheme regarding operational costs and payback times.*


*Above: Prefab window frame from market*
*Below: Adapted prefab window frames with air inlets-/outlets on top*

*Easy mounting of the prefab frames and window*



*in comparison - business as usual window mounting with lot of deteails to be solved*

## 4. THERMAL ENVELOPE

### Walls

*The wall insulation was mounted as a classic external wall insulation system with adhesive and mechanical fixation. In areas with ventilation system 2 layers of insulation have been mounted: first layer with air ducts - then second layer covering the ducts.*

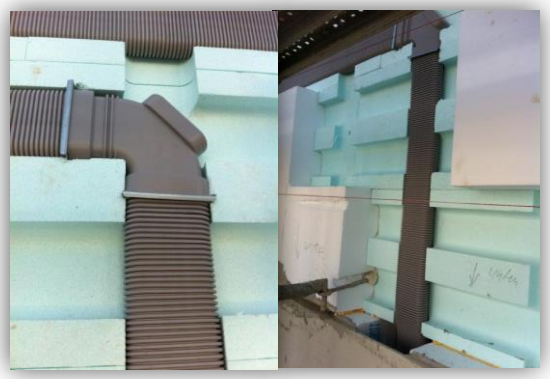
### Roof

*The roof was built with a complete new layer on top of the old layers with an insulated 40mm steel sandwich board plus 120mm rockwool insulaton.*

### Windows

*All new windows with insulated aluminium frames and double-pane glass, U value 1.1W/m$^2$K*

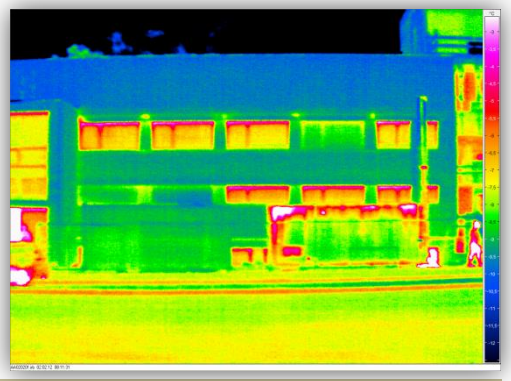
*First 100 mm layer insulation with air ducts*



*Second 140mm layer insulation covering airducts*

*Complete facade during insulation works*

*Thermography after renovation. No remarkable losses - ducts within insulation are ininvisible*



## 5. BUILDING INTERIOR SYSTEM

OVERALL DESIGN STRATEGY

**HEATING SYSTEM**
*Before: Decentralized heating*
*After: Heating from annexed new building with district heating backup*

**COOLING SYSTEM**
*No separate cooling system installed. The ventilation system will be used to cool the office rooms during summer nights.*

**VENTILATION**
*The new ventilation system was installed on the exterior wall. Air handling unit was installed in a container as a test unit to change, adapt and test several air handling units.*

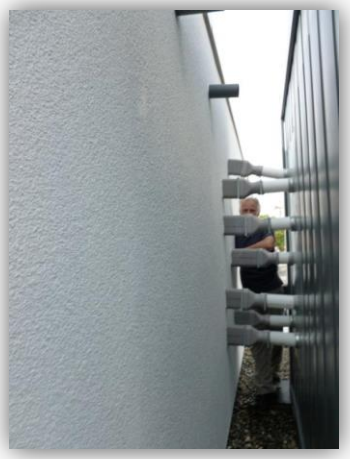
**HOT WATER PRODUCTION**
*Before: No hot water available*
*After: No change*

**RENEWABLE ENERGY SYSTEMS**
*Heat recovery system and humidity recovery through the air handling unit.*
*South east façade prepared for façade integrated PV system demonstrator.*
*Passive summer night cooling with ventilation system*

*Above: Ventilation ducts refab window frame with air inlets/outlets on top*

*Above: container with air handling unit*

*Below: duct connection to the air handling unit in container*



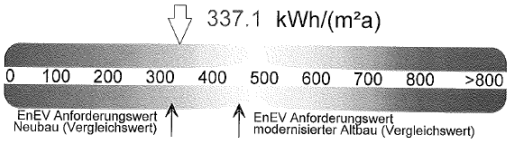
## 6. ENERGY PERFORMANCES

*A good performance was achieved while minimizing the energy consumption by adding insulation to the façade, replacing existing windows, improving air tight-ness of the building envelope and installing the ventilation system for the office rooms.*

*A summary of U-values is given in the top right. The ground floor was not insulated. Energy renovation of the floor slab would have been quite expensive and would have required a complete standstill of work and production.*

*The basement walls were insulated with 200 mm polystyrene to a depth of 400 mm underground, which reduced the heat loss through the basement walls considerably.*

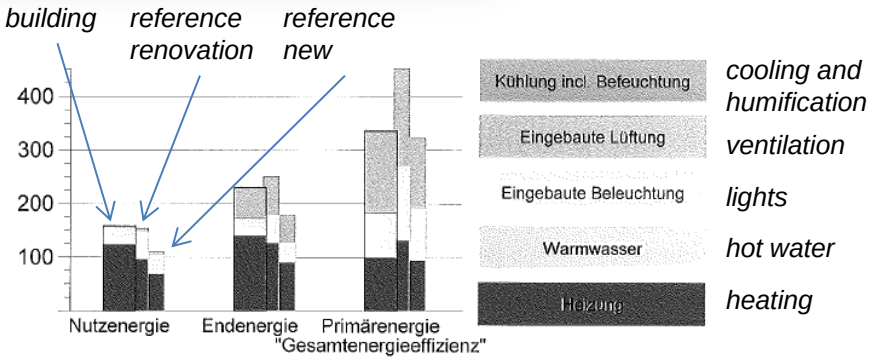
*The calculations of the primary energy use is 337 kWh/(m²a) for the building which slightly higher than a reference new building 323 kWh/(m²a) but lower than the reference retrofitting building 452 kwh/(m²a)*




*Result: "Wärmeschutznachweis ENEV 2009"*

*U-values [W/m²K]*

| | Before | After |
|---|---|---|
| Opaque envelope | 1.8 | 0.41 |
| Transparent envelope | 2.4 | 1.58 |
| Windows in roof | 2.4 | 1.20 |
| | | |




***CLARIFICATION:*** the energy calculations and given energy numbers will be according to the national standards which might vary between countries., i.e. numbers are not always comparable

## 7. ENVIRONMENTAL PERFORMANCE

INDOOR CLIMATE

*The indoor climate has improved considarably as a consequence of the facade insulation, new windows with a shading system and a new ventilation system for the office rooms.*

INCREASING QUALITY OF LIFE

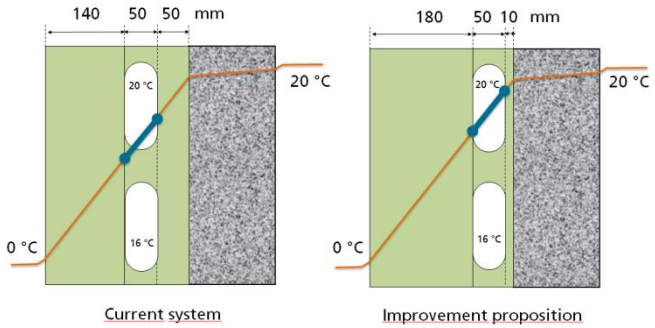
*The visual quality of the office workspace has improved as well as air quality and a better balanced temperature level.*

INDOOR AIR QUALITY

*The comfort criteria are fulfilled and the performance of the façade integrated ventilation system - a demonstrator - is better as expected and will be monitored during operation.*
*Improved indoor air quality was realized with the installation of an AHU with filters and heat exchangers with humidity recuperation. The AHU can be individually controlled by the users.*

LIGHTING QUALITY

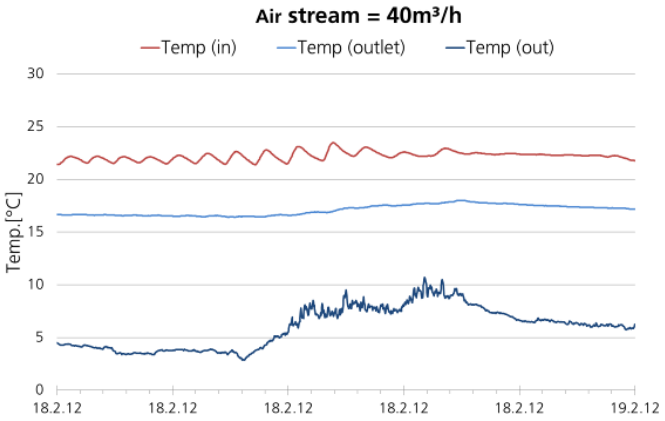
*The visual quality of the office workspace has improved due to blinds with individual control functions.*




*Above: Position of air ducts within insulation- not optimized*

*Above: Air Inlet/Outlet*

*Below: Performance of the façade integrated ventilation system*



## 8. FURTHER INFORMATION

RENOVATION COSTS
The renovation design was led by maximum efficiency measures within the given financial envelope.

The cost of insulation work: 150.000 € ex VAT
The cost of window work: 270.000 € ex VAT
The cost of ventilation work: 12.000€ ex VAT

FINANCING MODEL
*The retrofitting was financed by a public market supporting program and in addition a government financed research project was linked with the retrofitting of the building. Remaining cost have been covered by the building owner*

OTHER INTERESTING ASPECTS
*The renovated building together with the annexed new building are part of a joint energy- heating and cooling system. A research project will evaluate the energy flow within the system and between the buildings. In the new building there is a cold water storage installed to buffer energy in related temperature levels. Both buildings will be the first step of an overall integrated energy grid of all Fraunhofer campus buildings.*