Office Building, Roskilde, Denmark

Parkvænget 25, 4000 Roskilde

1. INTRODUCTION

PROJECT SUMMARY

Construction year: 1968
Energy renovation: 2010
Previous energy renovation in 1991

SPECIAL FEATURES

- *Insulation of thermal envelope*
- *New windows with 2 layers of glass, low emission coating and argon gas filling*
- *New ventilation system with higher efficiency and heat recovery*
- *Photovoltaics, 130 m^2 on southern facade*
- *LED lighting*
- *Night cooling*

MAIN CONTRACTOR

B. Nygaard Sørensen A/S

ARCHITECTURAL ADVISOR

Jakobsen Szøts ApS

ENERGY CONSULTANT

DOMINIA A/S

OWNER

Boligselskabet Sjælland

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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

Built in 1968 the office building was a typical precast concrete building with a very limited level of insulation. In 1991 the building envelope was renovated and insulation was added to the wall (175 mm) and windows were replaced with traditional double-glazed windows.

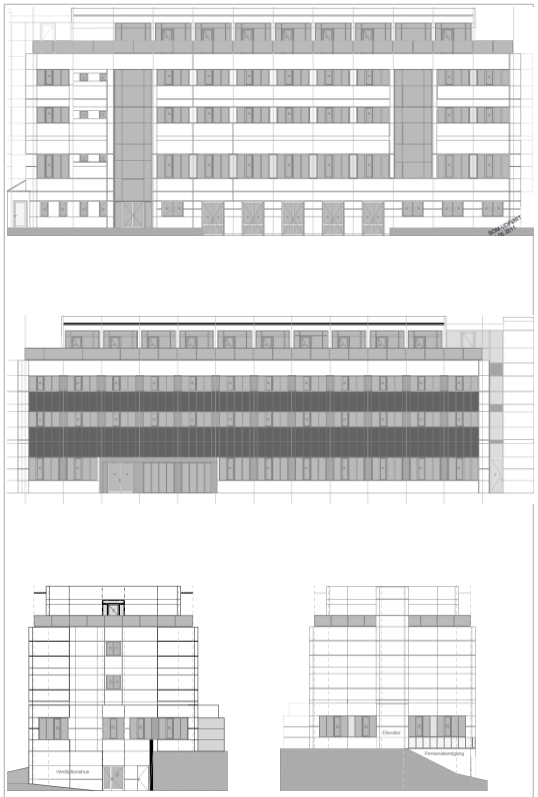
OBJECTIVES OF THE RENOVATION

- *The main objective of the renovation was to reduce the overall energy consumption of the building while also improving the indoor climate.*
- *This was achieved by adding insulation to the facade, replacing existing windows, improving air tightness of the building envelope, replacing the ventilation system and adding photovoltaic cells to the facade.*

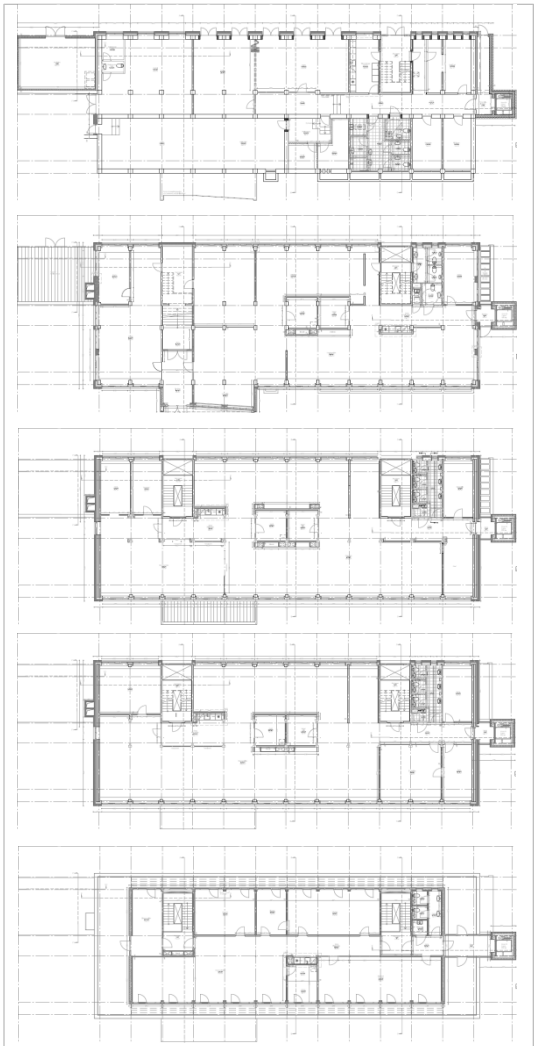
SUMMARY OF THE RENOVATION

- *A penthouse was added to the top of the building*
- *Roof: The new roof has 300-450 mm insulation. The existing roof (terrace) had 190 mm insulation.*
- *Wall: 150 mm insulation was added to the existing 250 mm, and fibre-cement cladding was added.*
- *Base/foundation: The base had no insulation and therefore the 150 mm's added to the wall was extended to cover the base of the building.*
- *Windows: Traditional double-glazed windows were replaced by triple-glazed windows.*
- *Ventilation system: The original ventilation system was replaced by a more energy efficient system.*

•Total cost of renovation: 35.9 million DKK (4.8 M€) or 14,487 DKK/m² (1,932 €/m²)



<u>Above</u>: Facades of the renovated building. From the top: north, south, west and east facade. The dark areas on the south facade represent the new PV-system, totalling 130 m² with an output of 5.1 kW_p.



<u>Floor plans from above</u>: Parterre, 1., 2., 3. floor and penthouse for renovated building. Total heated area is 2478 m².

3. DECISION MAKING PROCESSES

WHY RENOVATION

The main incentives for the renovation was to reduce energy consumption and improve indoor climate while also renewing the expression of the building to better suit the company's profile ("green" profile).

Before the renovation the building housed both shops (1. floor) and offices (2. and 3. floor). After the renovation the entire building is used as offices.

Boligselskabet Sjælland is a merger of two social housing companies (Roskilde Boligselskab and Andelsboligforeningen af 1899). Roskilde Boligselskab used the offices before the merger, but after the merger the combined administration needed more space, and therefore the renovation/extension of the building was initiated. The extension of the building was also a main incentive for the renovation.

The office building was built in 1968 and an energy renovation was carried out in 1991. Still, the building had a relatively poor insulation level and the windows from 1991 were reaching a state where they had to be replaced.

PUBLIC FUNDING

Boligselskabet Sjælland funded the energy renovation themselves. However, they received energy subsidies for insulation of the facade and installation of solar panels (agreement with energy companies).

Left: There are no photographs of the original office building, but this picture shows the back of a similar housing complex that was built at the same time and renovated in the same style as the office building (in 1991). The facade of the building had deteriorated and needed an upgrade. Windows were worn down and energy inefficient.

Right: The back of the new office building has a more regular and contemporary facade. The housing company (Boligselskabet Sjælland) wanted the facade to express a much more modern look, something that could reflect the company's profile as a modern and professional business.

4. THERMAL ENVELOPE

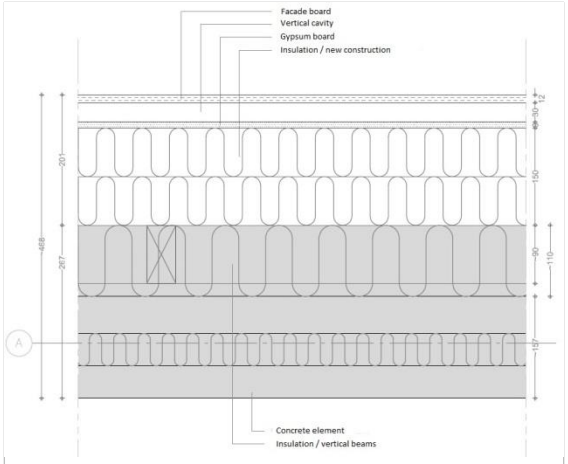
SUMMARY OF U-VALUES [W/m^{2}K] BEFORE AND AFTER RENOVATION.

	Before	After
Roof	0.20	0.10
Facade	0.30	0.14
Basement wall (above ground)	2.00	0.28
Windows	2.60	1.00

Basement wall below ground and the basement floor have not been insulated. Energy renovation of these parts of the envelope would have been quite expensive and also extend the overall renovation process significantly.

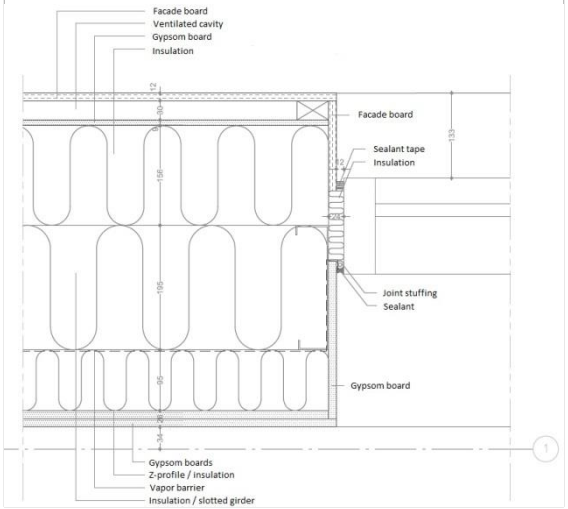
THERMAL BRIDGES

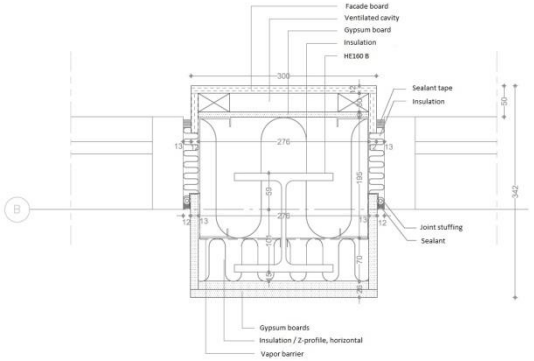
From the cross sections shown to the right, it is clear that the thermal bridges have been reduced significantly in the energy renovation process. Also, thermal bridges have been avoided in the new constructions.



Above: Horizontal section of the heavy wall. The grey area is the original construction. 150 mm insulation was added resulting in a total insulation thickness of 310 mm.

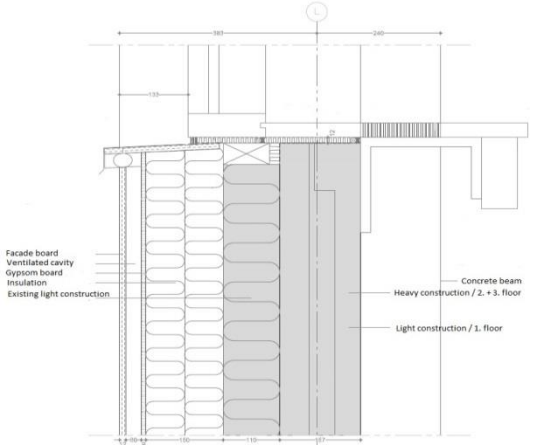
Below: Horizontal section of the light wall. It has a total insulation thickness of 436 mm.





Above: Horizontal section of a HE160 B steel section (between windows in the penthouse). The thermal bridge is significantly reduced by wrapping insulation around the steel.

Below: Vertical section of the joint between the heavy wall and a window. The window is placed so that the thermal bridge effects in the joint are minimized, i.e. so that the glass is close to flush with the middle of the insulation in the wall.



5. BUILDING INTERIOR SYSTEM

OVERALL DESIGN STRATEGY

The overall goal was to reach a level corresponding to low energy class 2015, that is better than the minimum requirements for new buildings.

HEATING SYSTEM

Heating of the building is based on district heating (both before and after the renovation). The renovation included changing both the distribution system and the radiators.

COOLING SYSTEM

The building had no cooling system before the renovation. An 80 kW cooling unit was added to the ventilation system. It can be used to cool the building before working hours. A separate free cooling system for the server room and individual printer rooms was also added.

VENTILATION

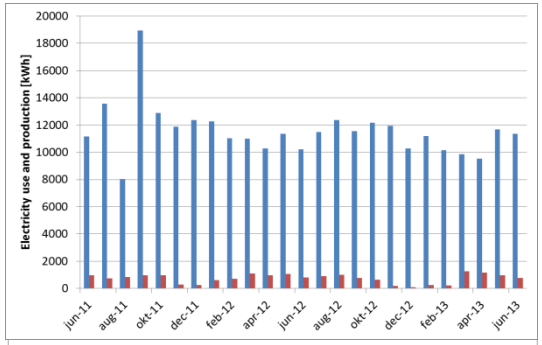
The entire ventilation system was replaced during the energy renovation. The new system has a heat recovery rate of 82%.

HOT WATER PRODUCTION

Domestic hot water production in the building is based on district heating. The entire system was replaced during the renovation.

RENEWABLE ENERGY SYSTEMS

130 m^2 PV panels were added to the south façade of the building. The graph to the right shows the electricity use and production.



Above: Electricity use and production in the office building. The mean coverage for the PV system is 6.6% and the maximum coverage is 12.3%. Total annual electricity use is 135,919 kWh and total annual energy production is 8,954 kWh (2012).

Below: The ventilation system is placed in a separate building and includes the possibility of delivering 80 kW cooling in the building before working hours to avoid overheating on hot and sunny summer days.

Above: The 130 m^2 PV panels on the southern facade produce only a relatively small amount of electricity compared to the overall electricity use in the building (see graph on the left). However, the PV panels also serve as part of the aesthetic appearance of the building and gives the impression of a modern building that also signals the green profile of the company.

6. ENERGY PERFORMANCES

CALCULATIONS

Before the renovation the expected energy use was calculated. The goal was to reduce the energy use to less than 50.6 kWh/m² per year, and the calculation showed an expected energy use of 50.3 kWh/m² per year. This corresponds to a total energy use for the building of approximately 125 MWh/year.

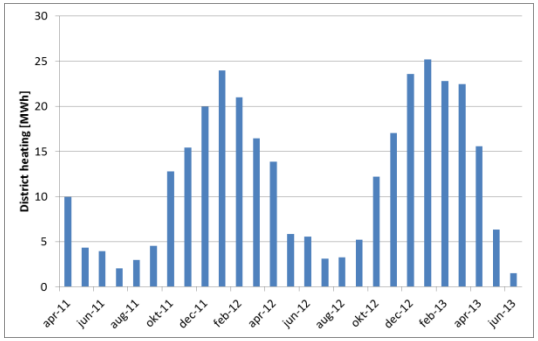
MEASUREMENTS

Unfortunately, measurements of the energy use for heating, domestic hot water and electricity use was only carried out after the renovation. Furthermore, the use of the building changed after renovation, which would have made comparisons difficult.

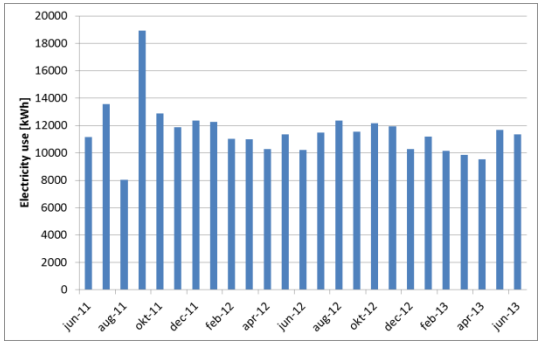
Table: Measured energy use for heating plus domestic hot water consumption and electricity use and production (in MWh and kWh/m²).

2012	Heat/ DHW	Electricity use	Electricity production
MWh	151.1	135.9	9.0
kWh/m²	61.0	55.0	3.6

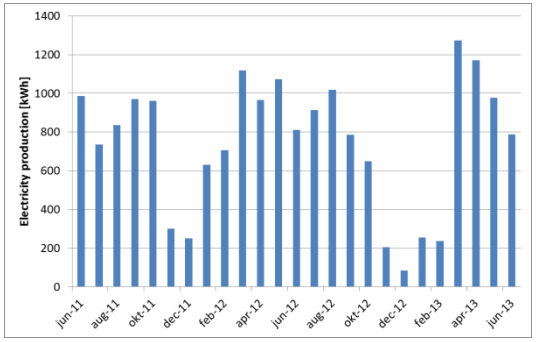
The total energy use of 278 MWh/year includes auxiliary energy (35 MWh), refrigeration compressor in the ventilation system (70 MWh), refrigeration compressor for copy/printer rooms (36 MWh), which are normally not included in the calculated results. The measured energy use can therefore be reduced to 137 MWh/year (for comparison with calculated results).



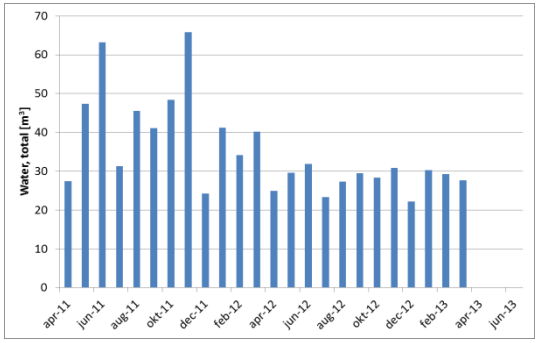
Measured heating/domestic hot water energy use after energy renovation.



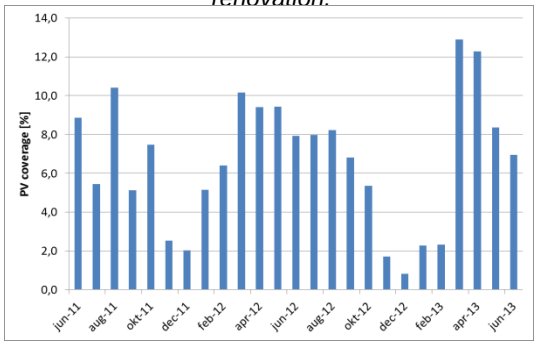
Measured electricity use after energy renovation.



Measured electricity production after energy renovation.



Measured water use after energy renovation.



Calculated PV coverage after energy renovation.

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 significantly.

The renovation included installation of special partition walls that reduce resonation, special rubber coated floors that reduce impact sound and acoustic ceilings. These features have all improved the acoustic indoor climate in the building significantly.

The general insulation/improvement of the building envelope and ventilation system have reduced the transmission and ventilation heat loss significantly. This has influenced the heat balance of the building to a level where the new radiators are actually redundant, which in turn has led to some problems with draught close to the windows (the radiators could counter the draught, but would then raise the indoor temperature too much).

INCREASING QUALITY OF LIFE

The quality of life has also improved. Especially in the new canteen, the penthouse and the accompanying terrace, which have given the staff better working conditions.

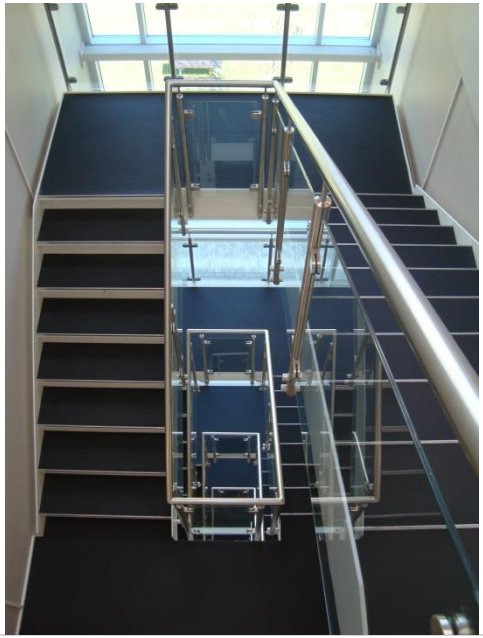
8. FURTHER INFORMATION

RENOVATION COSTS

The office building has a total heated area of 2,478 m^2 and houses approximately 84 employees.

The total cost of the renovation was approximately 35.9 million DKK (4.8 M€) or 14,487 DKK/m^2 (1,932 €/m^2)

Above: This picture shows the new facade (right) as well as the old one (left).
Below: The stairwells are much brighter after the concrete facades have been replaced with glass facades. All windows are made with sunscreen to limit overheating.



Above: The penthouse has both vertical and horizontal solar shading to avoid high indoor temperatures during summer.
Below: There is a walkway around the entire top floor, to allow the staff a place to relax and draw fresh air during work hours.