1. Energy-Efficient Retrofit of the Laboratories in Juelich, Germany

1.1 Photo

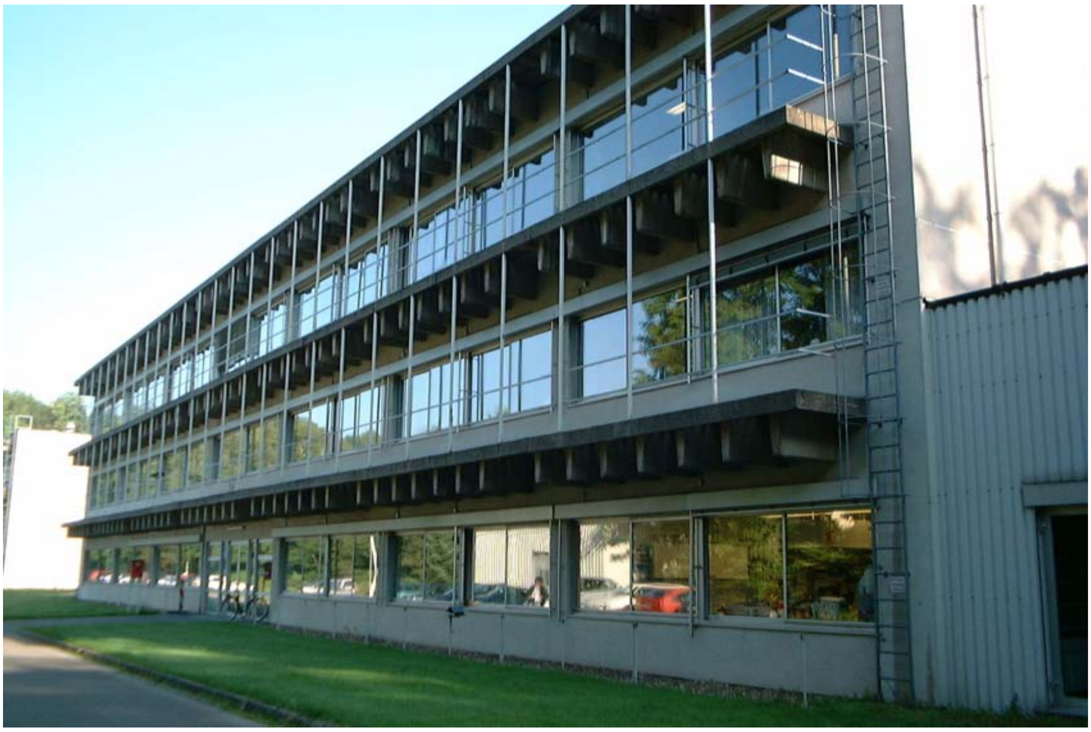

Figure 1: Northeast view of the laboratories

1.2 Project Summary

The laboratories of the research centre in Juelich show significant defects and are in need of retrofit. The defects and the old, partly broken air-conditioning system led to a high energy consumption and high energy costs. In particular, laboratories have high internal loads because of the large number of measuring instruments, a need of protection for the users from harmful substances and a lot of technical equipment including air-conditioning systems.

1.3 Site

Juelich is located in the Western part of Germany close to Cologne at an elevation of about 100 m. Its climatic conditions are best described by the Essen Test Reference Year (TRY). The coldest monsth is January with a mean of 1,9 °C and the warmest July with 17,4 °C. The mean annual temperature is 9,6 °C and the mean winter temperature 7,1 °C.

1.4 Building description /typology

1.4.1 Typology / Age

The building is occupied by a university institute and is therefore an educational building but can't be described by any of the school types.

1.4.2 General information

The laboratories are situated in a compact three-storey building erected in 1956 with a gross floor area of about 3330 m² and a surface to volume ratio of 0,3 1/m. The laboratories and offices are facing Northeast and Southwest. Two corridors separate the inner supply rooms from the labs/offices. About 35 % of the floor area is used as chemical laboratories, 10 % for physical measurements, 13 % for offices and the remainder for traffic, etc. A typical office or laboratory has a floor area of about 20 m². The retrofit will take place in 2003 and 2004.

1.4.3 Architectural drawings

Figure 2: Ground floor plan of the laboratories.

1.5 Existing heating, ventilation, cooling and lighting systems

Heating:

The heating is supplied by the central district heating system. The rooms get their heat by panel radiators with thermostats and a supply air ventilation system.

Ventilation:

The offices are ventilated by the windows only. Laboratories and inner rooms are supplied with air by air-conditioning systems. Altogether 12 supply air ventilation systems are located in the building with a total amount of supplied air of 92.000 m³/h and an air-change rate of 20 air changes per hour for the mechanical ventilated areas. The exhaust air is managed by 55 roof fans. There is no heat exchanger. The centrally generated cooling water is fed with temperatures of 6/12 °C directly into the building. Some laboratories and measurement rooms are connected to a decentralised circulating cooling system, fed by cold water. The control system was partly renewed so that all sensors work electronically. All equipment is used 24 hours. The heating and ventilation system is over-sized and has to be retrofitted.

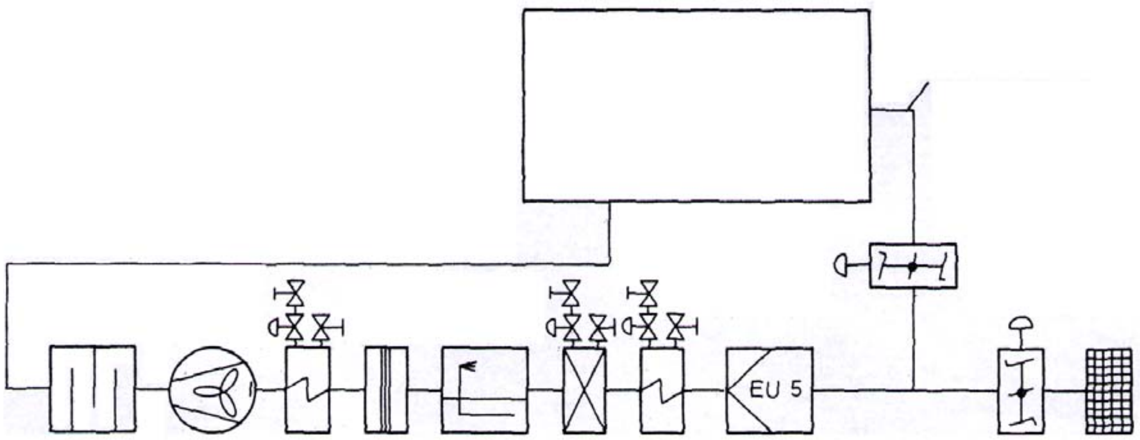

Figure 3: Scheme of the existing ventilation systems

Figure 4: Laboratory exhaust system

Lighting:
In the mainly used areas the old lighting elements have already been replaced by dimmable energy efficient light tubes in reflecting housings. Other areas are still illuminated by old-fashioned energy inefficient lighting systems.

1.6 Retrofitting energy saving features

1.6.1 Energy saving concept

Since most of the energy was used for the air-conditioning of the laboratories, the retrofit concept deals mostly with improving the efficiency of the heating and ventilation system and with decreasing the ventilation rate. Additional retrofit measures were planned for the building envelope and the lighting equipment. Special care has to be taken on the thermal bridges of the escape balconies.

Figure 5: Thermal bridges caused by brackets under the escape balconies.

1.6.2 Building

Status quo of the building fabric before the retrofit:
The steel-concrete building represents a building style often used in the 1960-ies in Germany. The facade is made of concrete elements and a window strap of 1,7 m height. During an earlier retrofit of the facade the external walls were insulated with polystyrene. The insulation material is wet and therefore because of the significant thermal bridges the original U-value of 0,38 W/m²K had increased to about 0,60 W/m²K. The sash windows have external shading facilities. The ceiling corbel outwards on two sides providing the possibility to be used as escape route, solar shading and for cleaning the windows. The building has a flat roof and no cellar. All rooms have uncoupled ceilings. The insulation of the roof also needs to be retrofitted.

Retrofit Concept:
The existing insulation of the external walls will be removed and replaced so that the average U-value will be 0,30 W/m²K. The windows will be replaced by windows with low-E-coated glazings with an U-value of less than 1,5 W/m²K. Solutions for reducing the thermal bridges have to be found.

Surface	U-Value [W/m²K]	
	Before retrofit	After retrofit
External wall	(0,38) 0,60*	0,30
Windows	3,4	< 1,5
Flat roof	0,60	0,60

* including the wet insulation material and the thermal bridges

Table 1: U-values of the building surface before and after the retrofit.

1.6.3 Heating and Ventilation

The heating and ventilation systems have to be resized according to the up-to-date demands. The air-streams shall be user-dependent and reduced to a minimum during non-use periods. The physical measurement rooms will additionally be cooled with water. The exhaust-air will be centralised and a heat exchanger will be installed. The efficiency of the fans will be improved. The ventilation rate of the chemical laboratories will be reduced to 10 air changes per hour.

1.6.4 Lighting

For the lighting a daylight-dependent artificial lighting control and different control strategies for the inner and outer rooms are planned. Additionally the implementation of daylight redirection glazings will be investigated. The daylight ratio of the corridors will be improved and up-to-date luminaires will be installed.

1.7 Resulting energy savings

The current primary energy consumption of the building amounts to 1558 kWh/m²a. Out of that 1372 kWh/m²a are needed for the air-conditioning and ventilation of the rooms, 126 kWh/m²a for additional heating, 58 kWh/m²a for lighting and 1,6 kWh/m²a for domestic hot water.
The retrofit will decrease the primary energy demand to less than a third (502 kWh/m²a) by focusing mainly on the demand for air-conditioning and ventilation (412 kWh/m²a).

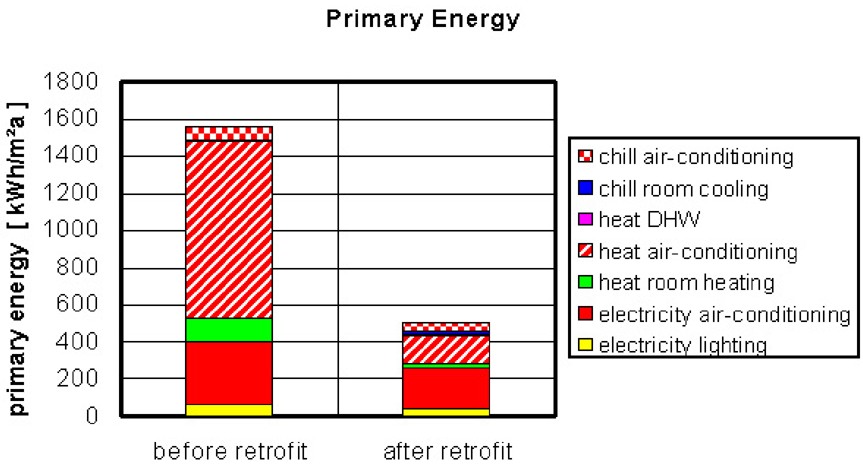

Figure 6: Monitored energy consumption before and calculated demand after the retrofit.

1.8 User evaluation

not yet available

1.9 Renovation costs

The costs of the retrofit of the laboratories were estimated to be about 5 Million Euros. In table 2 the cost are divided into different cost areas.

Position	Cost-estimation
	Euro
Building	957.000
Heating system	133.000
Air-conditioning system	3.550.000
Lighting system	61.000
Design	207.000
Project management	102.000
Research and monitoring	?
Total	5.010.000

Table 2: Cost-estimation of the retrofit.

1.10 Experiences/lessons learned

not yet available.

1.11 General data

1.11.1 Address of project

Laborgebaeude 06.20 Juelich, Forschungszentrum Juelich, 52425 Juelich, Germany

1.11.2 Project dates

Project initiation: 2002
Design completed: 2003
Renovation construction completed: 2004
Monitoring and evaluation completed: 2006

1.11.3 Date of report / revision no.

January 2004, no. 1

1.12 Acknowledgements

Project Coordination — Forschungszentrum Juelich

Research Team — Schiller Engineering

National Support program — German Ministry of Economy and Technology
Projektträger Jülich (PTJ)

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1.13 References

[1] project homepage: www.ensan.de