Research and teaching buildings at the University of Stuttgart, Germany

D4

1 Photo

Figure 1: *Left:* Photo of IZW
Below: Photo of ETI 1

2 Project summary

University buildings normally use very sophisticated HVAC systems. Frequently, these systems have to be adapted to the actual user needs and if this is not carried out on a regular basis the energy consumption becomes quite high. The adaptation of the systems can be financed through third party contracting. An impressive example of this is the renovation of the HVAC system in two buildings on the University of Stuttgart campus.

Building 1 Electrotechnical Institue 1 (ETI 1)
The building was constructed in 1984. It includes several institutes and lecture halls seating from 50 to 500 students. The institutes extend up to the 4th floor, while the main lecture halls are located on the ground floor. The institutes include offices, shops and laboratories. The offices (heating only) are mainly on the south side of the building. Rooms which need ventilation and/or air-conditioning are located mainly on the north side. The floor area totals 14500m^2. Both utilisation and energy consumption have remained relatively stable over the years.

Building 2 Engineering Science Centre (IWZ)
It is a building composed of four individual tracts with a total floor area of more than 30000m^2. Test facilities and maintenance rooms are located in the basement. The upper floors of the 5 storey building mainly comprise of lecture rooms, study rooms and offices. The rooms in the north and west parts of the building as well as the interior zones are cooled with conditioned fresh air as long as no air-conditioning is required. Cooling and electricity demands of this building fluctuate heavily due to scientific tests performed at irregular intervals, thus power consumption rose continuously in the years prior to the retrofit.

The project described concentrates only on the technical systems.
No retrofitting of the building envelope was undertaken.

3 Site

Universitätsgelände Pfaffenwald, Stuttgart-Vaihingen, Germany
Latitude : 48.46° N
Longitude : 9.11° E
Altitude : ca 450m
Temperate Climate
Mean annual temperature : 9.7°C
Mean winter temperature : 4.9°C

4 Building description /typology

4.1 Typology / Age

Mega–stucture university building. 1975
Educational level: University, graduate studies

4.2 General information

Year of construction: 1975 (IWZ) / 1984 (ETI 1)
Year of renovation (as described here): 1997
Total floor area (m2): 30.500 (IWZ) / 14.500 (ETI 1)
Hours of operation: Operation of the systems starts around 7:30 with office type use.
Some systems have to be operated 24 hours a day

4.3 Architectural drawings

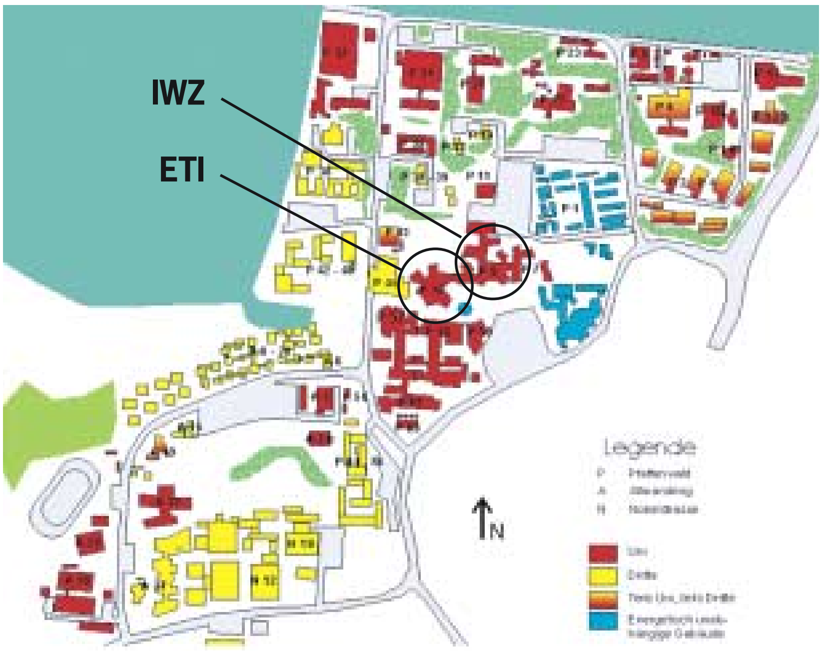


Figure 2: Site layout

5 Previous heating, ventilation, cooling and lighting systems

The buildings receive heat, cooling and electricity from the university owned combined heat and power station.
The local control systems were functioning but could not fulfil modern requirements. The central DDC system of ETI 1 even was deficient.
In both buildings most of the technical systems were oversized to meet future utilisation needs. This oversizing resulted in low efficiency and utilisation numbers. Due to the oversizing big fluctuations in energy demand could not be met efficiently by the control systems. This resulted in an additional degree of inefficiency.

6 Retrofit energy saving features

6.1 Energy saving concept

Installation of control and DDC techniques for the buildings.

6.2 Heating and Ventilation

The following list of measures should be considered as an example of typical measures which proved to be cost-effective in the University of Stuttgart Project whilst in other buildings similar measures have to be identified according to their actual state and operation. In this case, the adaptation of the HVAC systems to the user needs and the operation of the systems according to the actual user needs proved to be most effective.

MEASURES:
Retrofit of DDC Control
Installation of new DDC/GLT System
Installation of 100 temperature and humidity sensors to measure heating needs
Replacement of oversized motors for ventilation
Optimisation of ventilation strategies
Measurement of CO_2 to adapt ventilation to utilisation needs
Utilisation of internal heat gains
Optimisation of heat recovery
Optimisation of cooling and heating according to actual user requirements
Continuous energy monitoring
Continuous training of operators

7 Resulting Energy Savings

Due to the special situation at the University the savings are shown in MWh rather than in Euro.
Nevertheless the project was successfull as a third party contracting project

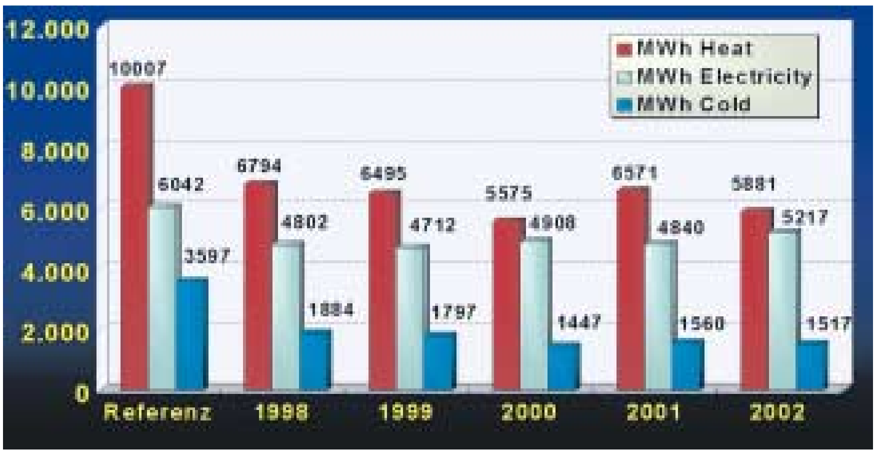
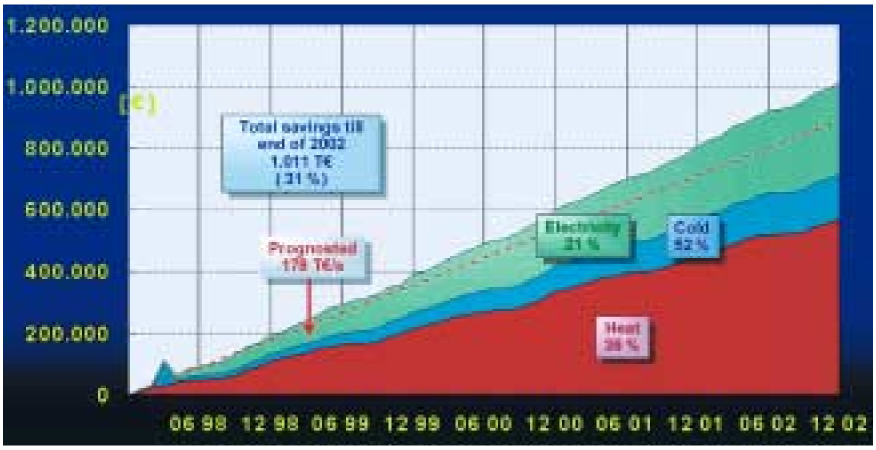


Table 1: IWZ & ETI 1 : Energy used before and after retrofit

too, which demonstrates the high potential of retrofit measures of this type. Some crude financial figures are as follows:

Energy costs before retrofit:	€650.000 inc.VAT
Energy costs after retrofit:	€450.000 inc.VAT
Energy savings after retrofit:	€200.000 inc.VAT

Table 2: IWZ & ETI 1 : Savings from Jan. 98 – Dec. 01



8 User evaluation

Owners, operators and users are satisfied with the new operation which fully meets user needs.

9 Renovation costs

Systems retrofit: €1.256.000 inc.VAT
System operation for 8 years (energy management and financing): €168.000 inc.VAT
Additional savings for the state of Baden Württemberg: €32.000 inc.VAT

10 Energy use

Efficient operation saved up to 31% of total energy costs

10.1 Practical experiences of interest for a broader audience

The experiences described under this chapter are derived from various contracting projects and apply for this case study as well.
Operation of HVAC systems in most educational buildings is far from efficient. This results in efficiency numbers which are up to 100% higher than expected.
Adaptation of system operation to user requirements is a very cost-effective measure, which can be afforded even if no other renovation measures are possible.
Adaptation of system operation to user requirements should follow any other retrofit measures. Usually only this will guarantee the planned energy savings are achieved.
Commissioning of systems after retrofit seems mandatory.
Energy management should be initiated after retrofit. Energy management will be the basis for a long term reduction of energy costs.
Training of operators is required.

10.2 Resulting design guidance

Best results can be achieved by combining retrofit and third party contracting. Contracting could include:

- Installation of energy management
- Optimisation of system according to user requirements

- Commissioning of system
- Guarantee of predicted savings with unchanged comfort conditions
- Control of energy usage and continuous adaptation
- Maintenance of optimised system
- Control of comfort conditions

Retrofit should include measures which are too expensive to be included into contracting but which are required for other reasons.

A possible workflow could be as follows:
– Perform energy audit of building
– Adapt building model to measurements
– Analyse building automation system
– Find optimal solutions by simulation
– Determine strategy
– Determine baseline
– Prepare contract
– Establish energy efficiency partnership
– Please your management through success

11 General data

11.1 Address of project
University of Stuttgart,
Pfaffenwaldring 47,
D 70550 Stuttgart

11.2 Existing or new case study
Project initiation: 1995
Design completed: Dec. 1996
Renovation construction completed: Dec. 1997
Monitoring and evaluation completed: Continuing

11.3 Date of report / revision no.
June 2002

12 Acknowledgements

Builder: University of Stuttgart
Architect: not applicable
Engineer: Axima Württemberg GmbH
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National, international support programmes: None, the project was completely financed by energy savings.
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13 References

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