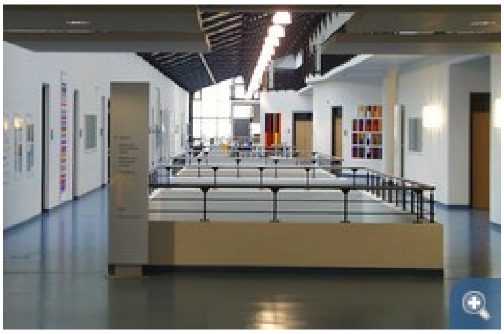
Bonn-Rhein-Sieg University of Applied Sciences

EnBau



This corridor, nicknamed ‘University street’, is an important access route in the building complex.
© FH Bonn-Rhein-Sieg

The building of the Bonn-Rhein-Sieg University of Applied Sciences in Sankt Augustin shows that energy-saving measures can also be applied to an existing design. Only after the architecture competition was the decision made to spend a further 4 % of the construction costs for ecological purposes. The basic concept could no longer be changed, but implementation methods and additional measures were still open for discussion. The students, who are the decision-makers of tomorrow, will be able to learn about ecological building methods from the broad, tangible and easily understandable range of energy and ecological measures. The measures implemented included improved thermal insulation, effective use of natural light, adiabatic/passive cooling and two photovoltaic units. In this way, the energy requirements were reduced significantly. This third-level educational facility was built as a turnkey project, and has been in operation since 1999.

Building summary

Project status	Optimized
Location	Grantham-Allee 20, 53757 Sankt Augustin, Nordrhein-Westfalen
Completion	1999
Inauguration	1999
Building owner	Land NRW, Staatliches Bauamt Bonn I
Occupant	FH Bonn-Rhein-Sieg
Gross floor area	30,100 m^2
Heated net floor area	27,381 m^2
Gross volume	124,000 m^3
Work places	1,500
A/V ratio	0.32 m^2/m^3
Key aspects	Heat insulation, Ventilation + heat recovery, Regenerative + passive cooling, Combined heat and power generation, combined heating and cooling, Photovoltaics, Ecology of building materials

Project description

The new building in Sankt Augustin houses the headquarters of the newly founded Bonn-Rhein-Sieg University of Applied Sciences and is one of the university’s two locations. The architecture competition for this new building was held in 1995, and construction was started in November 1997. Teaching begun at the start of the winter semester in 1999 in the new building, which is used by around 1,500 students from five different departments. The successful design was chosen as part of a competition organised by the federal state of North Rhine-Westphalia, and was then revised to include an ecological concept based on energy and environmental considerations. The university is situated in the west of Sankt Augustin’s city centre in an urban development zone, and is close to the neighbouring district of Siegburg-Mülldorf. The surroundings are characterised by open areas to the west and north, and by mixed development with no recognisable planned structure to the east and south.

Comprehensive evaluation of the building operation was supported by the German Federal Ministry of Economics and Technology within the context of the EnBau programme. The goal of this programme is to scientifically investigate energy optimisation in large, complex building structures which are in use. The evaluation concentrated on seminar rooms and the main lecture theatres.

Building concept

The new building is used by academic departments from the areas of technology, commerce, IT and journalism. The range of rooms on offer is just as diverse: lecture theatres, seminar rooms, canteen, library, offices, machine shop and labs are spread over three building complexes that are connected to each other. There is a net floor area of 27,000 m^2 between the three building complexes: the main building, with the round lecture theatre structure, houses the rooms that are common to the various departments. The ring-shaped structure with rooms on both sides of the corridors that goes from the west to the north is home to the engineering departments. A U-shaped block with its open end facing east is home to the commerce and IT departments. Main access to the campus is from the eastern side. The buildings have two or three storeys, and have no basements.

The following aspects were improved as part of energy and ecological optimisation:

Environmentally friendly construction materials such as wood, mineral insulation materials
Improved thermal insulation
Effective use of natural daylight
Transparent insulation systems
Passive overnight cooling in summer
Largely natural air-conditioning
Programmable heating regulation adapted for usage
Photovoltaic unit
Use of waste heat from cooling systems
Planted roofs and facades
Use and percolation of rainwater

The exterior walls of the reinforced-concrete skeleton structure consist of prefabricated concrete elements with 16-cm-thick mineral fibre panels and aluminium facing on the outside ($U=0.2\ W/m^2K$). The windows and glass facades have wood-aluminium frames and thermally insulating glazing ($U_g= 1.0\ W/m^2K$). To increase the building's thermal inertia, the inner walls are made of sand-lime brick, wherever possible. Vertical noise-absorbing elements are installed instead of suspended ceilings. The increased thickness of the raw concrete floors means that floating screed floors are not needed. One facade of the machine shop which faces due south, with an area of 100 m^2, is designed as a solar wall with transparent insulation, and its lower section is a solid concrete wall which functions as an absorber ($U\text{-wall}=1.4\ W/m^2K$). Photovoltaic elements have been included in the glass roof of the main corridor and on one of the south-facing facades in the entrance lobby. The planting of the roofs and facades and the percolation of rainwater on the grounds are intended to improve the microclimate, reduce the cooling requirement of the building, and also ease the load on the sewerage system.

Energy concept

Ventilation, cooling and heating

The seminar rooms are not air-conditioned. The cool night air removes the stored heat from the solid construction components in summer, thus keeping the indoor temperatures low. For this reason, facing rooms are connected by generous ducts in the corridors. When the skylights are opened, the pressure differences between the facing facades leads to cross-ventilation. The skylight flaps are centrally controlled. The connection ducts are quite complex, as they have to fulfil fire safety regulations (as escape routes).

According to a simulation, passive overnight cooling at its maximum performance can do the job of 100 to 150 kW of conventional cooling; the availability of overnight cooling is limited, however. For this reason, reliable, intelligent control of the sun-protection equipment is essential. As the building structure itself also 'stores' hot and cold temperatures, solid primary structures with as little cladding or coating as possible were used. Ceiling panels were employed to improve the acoustics. Only those rooms which house heavy electricity consumers (e.g. server rooms) were fitted with small, decentralised air-conditioners. Radiators heat the seminar rooms.

In many rooms, window contacts turn down the heating when a window is open. The heating can also be programmed on a room-by-room basis according to the room usage schedules. The supply air for the lecture theatre area is fed through a ground-coupled heat exchanger, where this air is preheated in the winter. In addition, a rotary heat exchanger transfers heat from the exhaust air to the supply air (heat recovery). When it gets colder outside, an additional heat exchanger is employed. The relative humidity in the lecture theatre area is very low in the winter. This effect was compounded by an excessive air-change rate, which has since been reduced. Heat recovery can be bypassed in summer, meaning that the air comes directly from the cool earth tubes. Adiabatic cooling is also provided to meet peak demands.

In this way, the supply air temperature rarely exceeds 22 °C, which makes for a pleasant indoor environment. On average, the adiabatic cooling delivers very good cooling performance. A control strategy that takes the condition of the air into account can improve efficiency even more. The ground-coupled heat exchanger detracts from the energy balance of the adiabatic cooling system, but the target supply air temperature could not be fully achieved if the two components were not used together in combination.

Daylight and lighting

Skylights with transparent insulation that are flush with the ceiling allow the daylight to penetrate far into the eight-metre-deep seminar rooms. When there is direct sunlight, the lighting level in the middle and rear parts of the rooms is improved. The skylights and windows have separate, automatically controlled louvre blinds; therefore it is possible to close only the lower part of these to avoid glare. The individual lighting strips are switched on and off manually, and controlled by sensors to match the daylight situation. Openings allow daylight from other rooms that receive direct daylight to reach the traffic areas. However, this effect is limited because of the considerable depth (8 m) of these rooms. The artificial light in the corridors is now switched on and off either manually or else using motion detectors. The rated light intensity in the corridors was increased to 180 lux to avoid the impression of dark corridors, and this impacts negatively on the electricity consumption.

Other aspects

Solar power systems connected to the grid supply a portion of the electrical energy requirements: some of the solar cells are in the roof glazing of the access hall and offer sun protection, while others are located on the south-facing facades. The building control equipment was extended to provide optimised heating operation. In addition, the choice of materials was modified taking into account the aesthetic specifications of the design: mineral insulation materials replace plastics, and wood takes the place of aluminium in the facades and window construction. The ecological concept is rounded off by the harvesting of rainwater.

Performance

The building can be considered representative of other very large construction projects. Organisational issues are of prime importance in such projects. Because of late approval for considerable sums of support funding, the winning design chosen in 1995 was only revised in 1998 to include an ecological concept. Despite this, many of the suggested measures and approaches were indeed realised in practice.

Using the combination of earth tubes and adiabatic cooling, it was possible to provide a comfortable indoor environment on hot summer days in the rooms in question. The low indoor humidity values sometimes present in winter were increased by optimising the air-change rate. Certain energy-saving strategies led to conflicts with user behaviour. One example is the window contacts which automatically switch off the radiators.

Room temperatures are generally perceived to be too low in winter. Operation was adapted to fulfil users' wishes in some areas. The main change here: the delicate automatic control of the sun-protection system, which caused considerable noise, now reacts much more slowly. Other switching and control arrangements were also modified. This does lead to increased energy consumption, but user friendliness and acceptance were the priorities here. Other compromises – for example, in the case of switching off the heating when a window is open – would be counterproductive. The heat energy consumption in 2000 was significantly less than that specified by the Heat Conservation Ordinance (WSVO) '95. In 2001, the value fell by a further 17% after the control and operation of the building services (reduction at night and at the weekend, hydraulic compensation, optimisation of heating characteristic curves) had been optimised and certain building faults had been rectified. The consumption of 11.73 kWh/m³ (climatically adjusted) was in the expected range, and over 40 % lower than the specifications of WSVO '95.

Optimisation measures and possibilities

Overall benefits were achieved by using energy monitoring of the building to identify non-optimal operating situations and other opportunities for improvement. For example, the air-change rate, which was initially too high, was reduced. Because of the size of this building project, even small changes resulted in large energy effects.

Construction costs and economic viability

The project costs amounted to 86 million German marks, or around 44 million euros.

Key energy data

Energy indices according to German regulation EnEV (in kWh/m²a)	
Heating energy demand	34.00
Overall primary energy requirement	110.20
Measured energy consumption data (in kWh/m²a)	
Site energy for heating and domestic hot water (dhw)	58.40
Source energy for heating and domestic hot water (dhw)	40.88
Total source energy	146.20
Ventilation	9.00
Light	16.00

Implementation costs

Costs of implementation in €/m^2	
Construction (KG 300)	1,620
Technical system (KG 400)	446

These figures represent established costs

Net construction costs (according to German DIN 276) relating to gross floor area (BGF, according to German DIN 277)

Website Bonn-Rhein-Sieg University of Applied Sciences

This project is funded within the framework »Energy Optimized Building« (EnOB) by the German Federal Ministry of Economics and Technology, on the basis of a decision by the German Bundestag. Get further information at www.enob.info.