Refurbishment and expansion to become energy-plus school

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Entrance area of the existing school before refurbishment
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Instead of attending three different school sites in the Rostock suburb of Reutershagen, in future school pupils shall be taught in a central and expanded school building that has been refurbished in terms of its energy efficiency. The school is designed to achieve the energy-plus standard, which means that it will produce more energy than the building requires during the course of the year. The project can be transferred to other schools because this type of building is widespread in the former East German federal states and also exists in a similar form in the West German federal states. The school previously consisted of a main building and two ancillary buildings. In future, only the main building will remain, whose building envelope will be refurbished to make it more energy efficient, whereby a ventilation system will be integrated into it. Two new buildings will be constructed that shall be separate from the main building. The area between the buildings will be covered with a transparent roof and used as an unheated intermediate climate zone. The energy supply is based on district heating combined with an ORC plant and solar and wind energy utilisation. The innovative design of the new external envelope, which incorporates the existing external construction components and uses efficient building technology, will minimise the energy requirement while simultaneously expanding the usage possibilities. The project will therefore provide an exemplary model for schools of the same type located elsewhere.

Building summary

Project status	Projected
Location	Mathias-Thesen-Straße 17, 18069 Rostock-Reutershagen, Mecklenburg-Vorpommern
Year of construction	1960/61
Refurbished	2011
Building owner	Hansestadt Rostock
Gross floor area	9,136 m^2
Heated net floor area	6,805 m^2
Gross volume	28,473 m^3
Work places	644
A/V ratio before refurbishment	0.40 m^2/m^3
A/V ratio after refurbishment	0.21 m^2/m^3
Key aspects	Heat insulation, Facade systems, Glazing + windows, Atrium, Daylight planning, Daylight systems, Optimised lighting, Ventilation + heat recovery, Thermo-active building element systems, Combined heat and power generation, combined heating and cooling, Heat / cold storage, Control technology, operational management, building automation, Solar thermal energy

Project description

The Reutershagen secondary school and the affiliated primary school are all-day schools and have recognition both as Europe schools and as special centres for fostering particularly gifted school pupils. The school concept is supplemented with diverse extracurricular activities, which range from musical, artistic and sports events to the school newspaper and the Europe club. This places considerable demands on the flexible room use. As part of the energy-based refurbishment, a new spatial concept has therefore also been developed.
The secondary school was previously housed in two identical school buildings that are respectively located in Mathias-Thesen-Strasse 17 and Bonhoefferstrasse 16, and which date back to around 1960/61. In future, all school pupils will be housed in the refurbished building in Mathias-Thesen-Strasse, along with a primary school that is also currently being constructed there.
Located directly on the new bypass, the site is situated in a convenient location with very good visibility.

Refurbishment concept

The identical schools each consist of three building sections, which are arranged around a schoolyard and are linked together with single-storey connecting buildings. The three-storey main building is constructed as a solid structure with brick masonry and composite floor slabs made of reinforced concrete. This is where the classrooms and specialist rooms are located, facing south. On the north side, the corridors in the main building are linked to a single-storey sports hall and a two-storey nursery building. This form of connection, with the rooms arranged on just one side of the corridor, creates a very large circulation area and – compared to the room volumes – a very large external surface area (A/V ratio). This leads in winter and the transitional seasons to high transmission heat losses and in summer to considerable overheating in the building. It is exacerbated by the fact that the windows, facades and roof of the building have remained unchanged from the time the building was built. An improvement in the thermal insulation properties of the overall building envelope combined with a more compact form of structure for the refurbished and extended new school building therefore form important components of the refurbishment concept.

At the Mathias-Thesen-Strasse site, a new central school building is being created, whereby the structure of the main building will be largely retained. The two old ancillary buildings will be demolished. A new sports hall will be built at a later date. In order to accommodate all school pupils and create both larger classrooms and urgently required multipurpose spaces, the main building will be supplemented with separate additional buildings to the north and west. An unheated intermediate climate zone is being created between the buildings, which will consist of a timber structure with a transparent covering of glass and ETFE film cushions. This buffer area divides the resulting larger building into climate zones and at the same time provides double-sided connections with recreational, communication and circulation areas.

With the exception of the walls in the intermediate zone, all external walls of the existing building will be completely thermally insulated with timber cladding. Double windows are being developed for the windows on the south and east side. The existing gable roof structure will be built back to form a flat roof and correspondingly sealed and insulated. The floor plate will be insulated with PS rigid foam and vacuum insulated panels. The new building sections adjacent to the buffer zone will be constructed using a plate structure made of lime-sand brickwork and reinforced concrete slabs, whereby the roof structure and the internal walls will be executed using a lightweight structure. Wood-aluminium windows will be used.

Energy concept

In the previous building, an outdated heating system connected to the district heating network supplies the users with heat and hot water. The windows must be opened to provide the necessary air exchange. This creates high ventilation-induced heat losses during the heating period. During the summer months, the large openings on the southern, longitudinal side of the building promote overheating in the main building, whereby the classrooms there have insufficient solar shading protection. All these faults create an uncomfortable indoor room environment in summer and considerably impede the school pupils' ability to concentrate. In addition there is noise nuisance caused by the nearby bypass.

A central cornerstone of the refurbishment is therefore the installation of modern building services equipment. The school is intended to achieve the energy-plus standard and thus produce more energy annually than is used during its operation for heating, hot water and lighting.

Because of the favourable primary energy factor for district heating in Rostock, this will supply the building with heating at a low temperature level using transfer systems. The existing heating system in the existing building will be resized to meet the considerably lower energy requirement after the refurbishment. Various heating alternatives are currently being examined for the new building, including a system for thermal concrete core activation.

The ventilation will be provided by an air supply system for decentrally supplying each individual classroom as well as a central air exhaust system in the intermediate climate zone. The heat from the exhaust air will be recycled via a rotation heat exchanger and used for pre-heating the supply air. The transparent covering of the intermediate zone also helps to control its temperature by providing passive solar energy. This increases the air supply temperature for the decentral ventilation units and thus also reduces the transmission- and ventilation-induced heat losses in the building.

The windows in the classrooms on the south side are equipped with solar shading and light-diverting systems to ensure an optimised provision of daylight. Additional skylights above the intermediate climate zone are also planned in order to enable double-sided natural lighting. The atrium will be equipped with movable light scoops and holographic optical elements.

The heat from the district heating network, supplemented with a solar thermal system, will be used to produce electricity using an Organic Rankine Cycle power turbine specialised for low temperature differences. It is also planned to install three wind turbines and a photovoltaic system on the roof and south side to produce

electricity.
The calculated heat requirement is around 327 MWh p.a. and the electricity requirement is 59 MWh p.a. The wind turbines and photovoltaic system combined with the ORC turbine are intended to provide at least the same amount of primary energy. Any surplus energy will be fed into the grid of the electricity supplier.

Construction costs and economic viability

The energy-plus concept enables the primary energy consumption to be reduced by more than 1,000 MWh p.a. Because most of the existing building structure is retained, this saves resources and, by merging the schools, opens up opportunities for optimising room usage through synergy effects.

Educational concept

The intermediate climate zone is envisaged as a flexibly used recreational and communication zone and also provides a suitable space for exhibitions and joint activities. These could include spatially-based experiments, sporting activities, art exhibitions and musical performances. This area will be heated solely by means of passive solar gain and exhaust heat. In particular, this offers children from the primary school the possibility to consciously experience a further climate zone between the heated classrooms and the external area. By creating a biotope or keeping animals in this area, the influence of temperature on people and nature can be conveyed in a tangible manner.

Key energy data

Energy indices according to German regulation EnEV (in kWh/m²a)	before refurbishment	after refurbishment
Heating energy demand		49.90
Overall primary energy requirement		36.20
Measured energy consumption data (in kWh/m²a)	before refurbishment	after refurbishment
Site energy for heating and domestic hot water (dhw)	97.20	
Source energy for heating and domestic hot water (dhw)	25.30	
Total source energy	39.40	
Total energy demand (incl. devices)	102.00	
Energy demand for lighting		5.00
Energy demand for ventilation		2.00
Energy demand for environment		7.00
Energy demand for heating		39.00

Values "before refurbishment" were calculated by using consumption data from 2003 to 2005

Refurbishment costs

Refurbishment costs in €/m²	
Total	7.790.000
Promotion state	3.819.520
Promotion federal state	1.469.047
Capital resources incl. special needs	2.501.433

These figures represent estimated costs

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.