INTERNATIONAL SOLAR CENTRE BERLIN - A COMPREHENSIVE ENERGY DESIGN

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ABSTRACT

The International Solar Centre is a unique development in Berlin, combining a historic building and contemporary architecture to create 20 700 m² of customised office workspace. The building promotes a sustainable energy economy achieved through a low energy concept. This concept comprises a high thermal insulation of facades and windows, innovative glazings and shading systems and a natural ventilation system during summertime. About 15 % of the heating demand and 100 % of the cooling demand is covered by a seasonal heat storage underneath the building which is combined with a heat pump and a concrete core heating and cooling system. Photovoltaic panels with an area of 500 m² and an electric peak power of 55 kW will produce an estimated 46 MWh per annum. First results show that the main objective of the project – an primary energy consumption for heating and electricity of less than 100 kWh/(m²a) – was reached, i.e. lied 10 % under the limit set.

INTRODUCTION

The International Solar Centre Berlin (finished in summer 2003, 55 Mio. € investment costs) opposite of the Ostbahnhof, joins a growing number of urban development projects in the immediate surrounding area called “MediaSpree”, some of which are under construction or have already been realised. On a floor area of 20 700 m², the building offers space for a total of 800 workplaces and the Berlin EnergieForum exhibition area to companies and organisations active in the growth market of renewable energy and energy efficient consumption. The building is located on the Stralauer Platz in Berlin-Friedrichshain, and because of its position directly across the Ostbahnhof, offers a good connection to the city’s public transport system. The International Solar Centre Berlin consists of a previously existing warehouse building, two newly built, L-shaped side wings and a glazed atrium, see figure 1. The building is accessible from Stralauer Platz through an “entrance tunnel” which leads to the atrium.

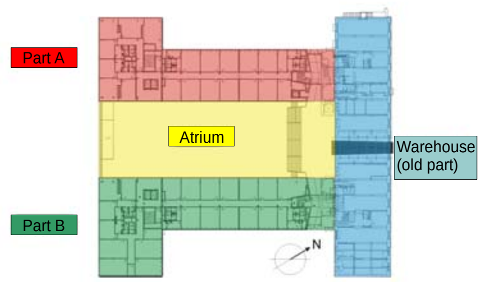

Figure 1. Ground-floor plan of the International Solar Centre Berlin.

The new part was designed by Bothe, Richter, Teherani architects, Hamburg, see figure 2. It has eight stories with multifunctional office area and a variable floor plan. The office area can be divided axially (1.3 m) depending on the requirements of the renter. The approximately 1200 m² sized atrium can be used for large events such as exhibitions and conventions. Conference rooms are available on the ground floor of the building next to the atrium.

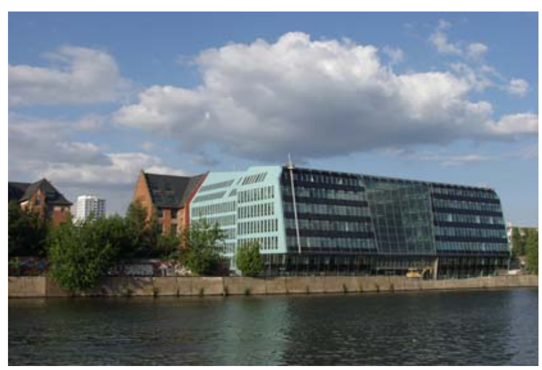

Figure 2. International Solar Centre Berlin.

The warehouse was built in 1906 by Reimer Körte as the central magazine of the city’s gasworks. During the construction of the new building, the warehouse was renovated as a historical monument by the Berlin architects Jentsch and is also part of the energy concept (figure 3).

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Figure 3. View in the atrium.

Table 1 shows the area balance of the building. The area of the atrium is included in the east and the west part of the new building.

Table 1. Area balance of the building.

East part [m²]	West part [m²]	Warehouse [m²]	Total [m²]
7 6000	7 100	6 000	20 700

ENERGY CONCEPT

The aim of the concept is to realize a low-energy standard with a primary energy demand of less than 100 kWh/(m²a), see Table 2 [1]. The characteristic energy values of the building comprise the heating demand and the electric demand for heating, cooling, ventilation and lighting. The energy consumption of the office equipment like computers, printers and photocopiers is excluded.

Table 2. Characteristic energy values of the building.

Heating demand	≤ 40 kWh(/m²a)
Total endenergy demand (heating and electricity)	≤ 70 kWh/(m²a)
Primary energy demand (heating and electricity)	≤ 100 kWh/(m²a)

A further goal of the project is to visibly use energy technology components (photovoltaic, small fuel cell) which have just left the laboratory and reached the production or pilot production stage.

BUILDING ENVELOPE

The surface to volume ratio of a building has a deciding influence on the heating demand. By closing the inner courtyard of the building with a high performance glazing, a very good A/V ratio of 0,15 m^{-1} was reached. The atrium is heated to a temperature of 15 °C during wintertime. The insulation layer of the building comprises the new building, the warehouse and the atrium. The insulation of the façade of the new building consists of 16 cm stone wool, the roof and the slab are insulated with 20 and 16 cm of extruded polystyrol. Because of preservation reasons the walls of the warehouse are insulated on the inside with 8 cm of stone wool. The windows with an orientation to the east, west, south and the horizontal are glazed with a high performance glazing with high insulation (U_w = 1,1 W/(m²K), low solar energy transmission (34 %) and high light transmission (68 %). To reduce cold bridge effects at the windows, the glazings are insulated with stainless steel spacers and the frames have a U-value of less than 2,0 W/(m²K).

BUILDING VENTILATION

During summertime, a natural ventilation system which includes the 40.000 m³ Atrium is used to provide the adjacent offices with fresh air and to automatically cool off the concrete ceilings at night, see Figure 4. The atrium is naturally ventilated by two 50 m² openings with vertical louvres. The air inlet is located at a height of 3 m at the south end, and the outlet is located at a height of 30 m at the north end of the atrium. The openings consist of a field of vertical louvres which are controlled by the building automation system. Every second window of the new building is equipped with chain motors and controlled by a natural ventilation system. The windows are opened during nighttime, depending on the wind speed, rain, the room and ambient temperature.

For the heating period, an energy efficient mechanical ventilation system with a heat recovery wheel (efficiency: 80 %) is activated in the new building, see figure 5. Because of the sound emissions from the Stralauer Platz it is necessary to ventilate the warehouse with a mechanical ventilation system for the whole year. The preservation demands have also been taken into account. Only a simple exhaust ventilator in combination with sound insulated, passive air inlets can meet these requirements. To reduce the ventilation heat losses in the warehouse a heat pump obtains the energy provided in the exhaust air. In this way the ventilation heat losses are reduced by 25 %.

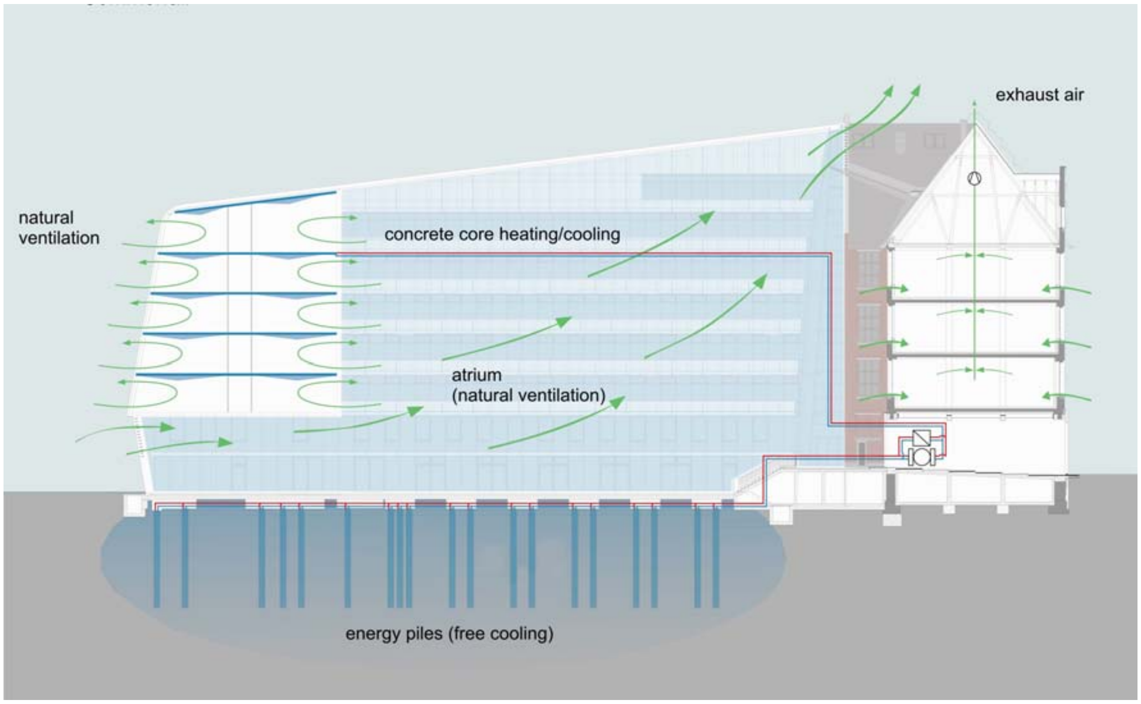

Figure 4. Energy concept: summer, daytime.

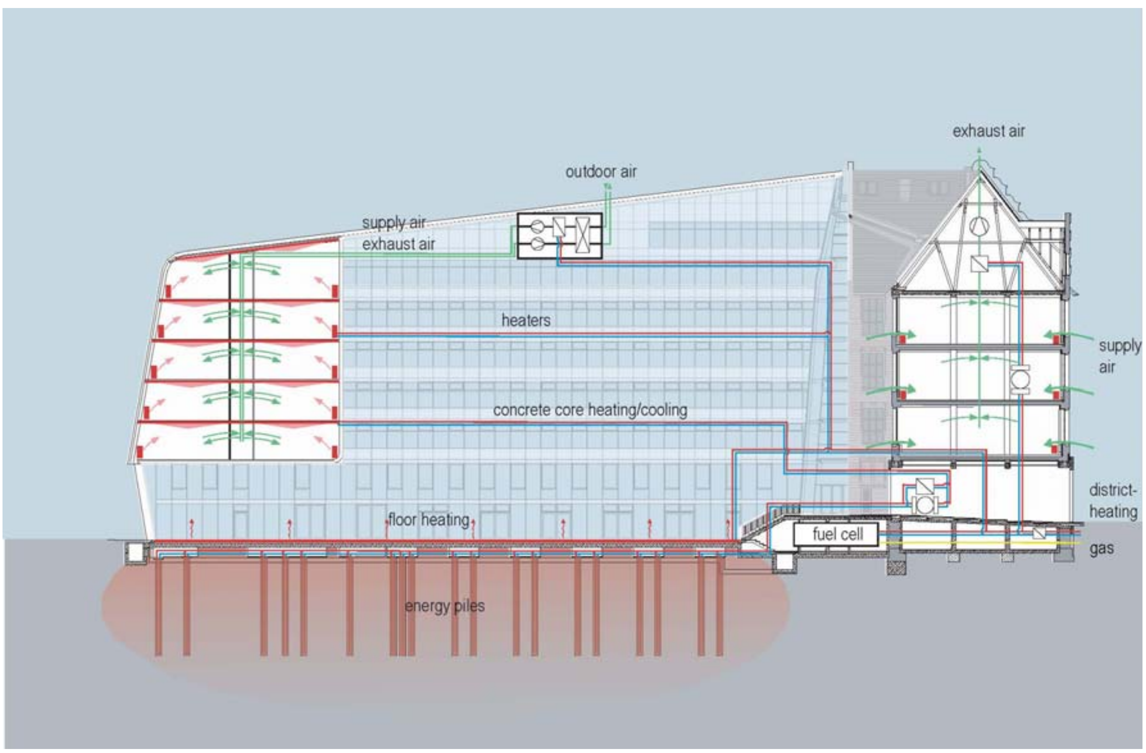

Figure 5. Energy concept: winter.

ENERGY SUPPLY

About 15 % of the heating and 100 % of the cooling demand is covered by a seasonal heat storage underneath the building which is combined with a heat pump and the concrete core heating and cooling system of the building. Because of static reasons, the building had to be founded on concrete piles, see figure 6. 196 of these piles were equipped with polyethylene tubes with a total length of 8 800 m and used as a ground heat exchanger ("energy piles"). During the heating period, the heat pump is used on the primary circuit side to extract thermal energy from the ground via energy piles, which is then raised to a higher temperature suitable for heating purposes. While the average temperature to be found in the concrete foundations is between 4 and 14 °C, the heat pump generates temperatures of 27 °C, which is suitable for the concrete core cooling and heating system of the building. This system consists of plastic tubes which are placed in the middle of the floor slab and has an area of 4000 m².

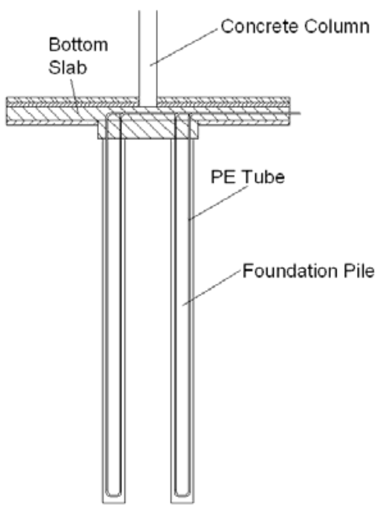

Figure 6. Section of the foundation piles.

In summertime, the temperature level of the water which circulates through the energy piles is used via heat exchanger directly with a temperature of 18 °C in the concrete core cooling and heating system ("free-cooling"). The energy potential is increased as the ground is cooled further through heating with the heat pump in wintertime. Thermal simulations predicted that 85 MWh of heating and cooling energy will be stored in the ground and that there will be no influence on the temperature field of the surrounding ground.

Photovoltaic panels with an area of 500 m² and an estimated peak electric power of 55 kW will produce around 46 MWh per annum. A small fuel cell will demonstrate the possibilities of future domestic energy systems, see table 3.

Table 3. Energy supply of the building.

	Electricity [kW]	Heating [kW]	Cooling [kW]
District heating		885	
Heat pump (exhaust air)		46	
Heat pump (energy piles)		107	
Energy piles			150
Photovoltaic	55		
Demonstration Fuel cell	0,8	2	

OFFICE MODULE

Figure 7 shows a section of an office module at the south façade of the building. The high performance glazing with solar transmission of 34 % makes it possible to use an internal shading system with daylight reflection. The slats of the shading system have a special shape and a high reflective surface. Depending on the position of the sun, the shading system either reflects the sunbeams to the ambient (summertime) or in the office (wintertime). The glazing with a high visible light transmission, in combination with the internal shading system with daylight reflection, give a great potential to save electric energy. This energy saving potential is used by a coordinated lighting concept. A light sensor dims the artificial lighting located close to the façade, depending on the amount of daylight. The artificial lighting in the corridors is controlled by a motion sensor. It is possible to open the windows all year. An indicator at each window frame shows if the ventilation system with heat recovery is working (wintertime) or if it is desirable to open the window to have natural ventilation (summertime). The user has a great influence on the different components of the energy concept. For this purpose, a manual of the building was given to each user. It describes the energy concept, the different operating elements and the users options for adjusting thermal comfort and energy consumption.

On the occasion of the 25th year's issue of the scientific journal *Bauphysik* published by Ernst & Sohn, the planning team of the International Solar Centre Berlin was awarded with the first place for its comprehensive energy design [2].

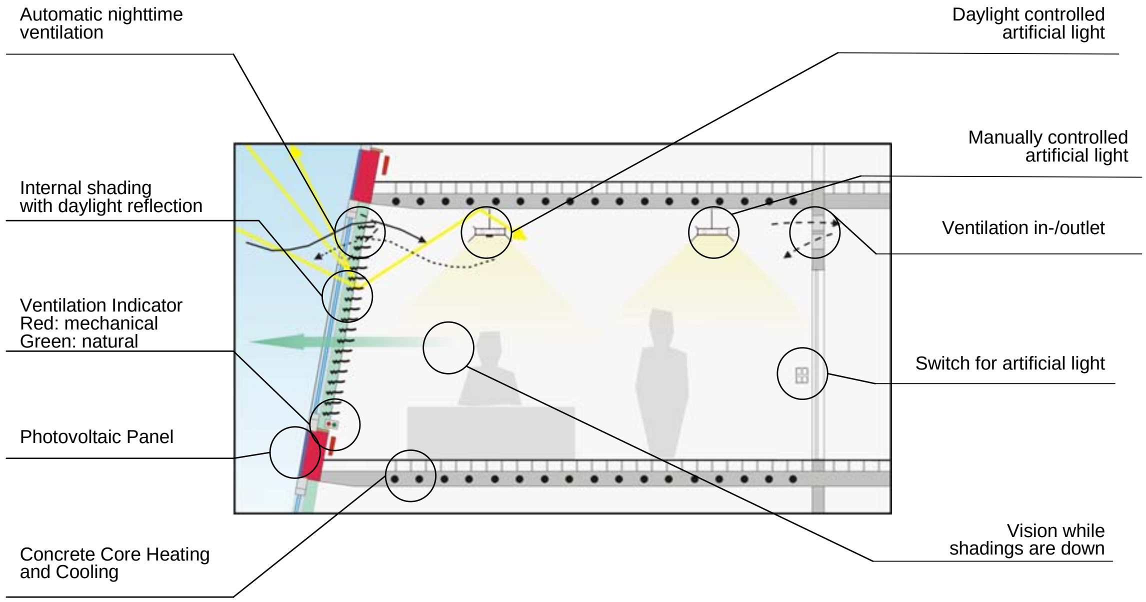

Figure 7. Section of an office module

MONITORING

In order to pave the way for energy savings and utilizing solar energy in non-residential buildings, the Federal Ministry of Economics and Labour (BMWa) has established a support programme called "Solar Optimized Building", known as SolarBau [3]. In subsection 3, SolarBau supports the planning and evaluation of demonstration projects. The Institute of Building and Solar Technology is member of the SolarBau team and is doing scientific monitoring in the International Solar Centre. The main goals of the project are the detailed analysis of the energy demand of the building, the energetic efficiency of the renewable energy systems and the thermal comfort in the building.

In the summer of 2003, the building was handed over to its users. The occupancy level currently lies at about 65% (summer 2005), which is a sound percentage, considering Berlin's current vacancy rates. The building monitoring began in the fall of 2003. In 2004, the main objective of the project - an energy consumption for heating and electricity of less than 100 kWh/(m²a) - was reached, i.e. lied 10 % under the limit set, sehe figure 8. Although the heat consumption of 50 kWh/(m²a) was 25 % higher than calculated, an overall primary energy demand of 90 kWh/(m²a) was reached in 2004. Missing time programs, along with some problems concerning heat recovery, were to blame for the higher heating demand [4].

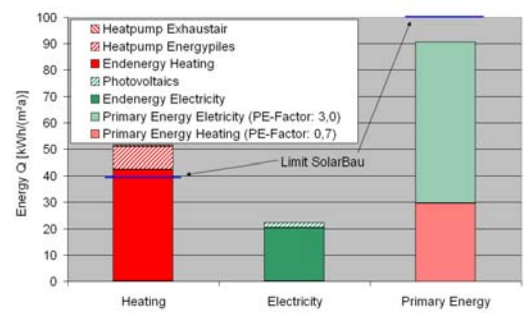

Figure 8. Energy demand in 2004.

However, this increased demand was more than compensated by the higher energy output achieved by the energy pile heat pump (176 MWh). The SPF of the heat pump was 5.4. As figure 9 shows, the average return flow temperatures were between 6.4 and 15 °C. During summertime, when the concrete core cooling system is connected via heat exchanger (“direct-cooling”), a SPF of 24.5 was reached. The average return temperatures were between 13 and 17 °C. Problems with the building control during summer 2004 lead to a low operating time and cooling energy output of 30 MWh.

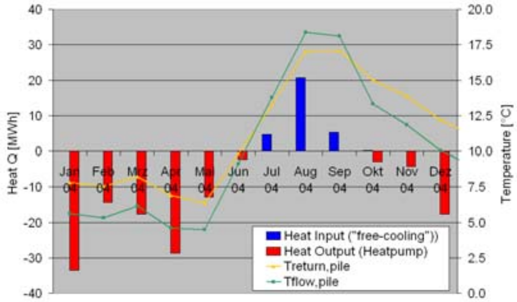

Figure 9. Energy balance of the energy pile system.

In 2004, temperature measurements in all 54 rental areas took place. The temperature statistic in figure 10 shows that almost all rental areas did fulfill the thermal comfort limits defined in DIN 4108 (German Regulation). It says that the room temperature can be above 27 °C in 10 % of the operating time. Analyses suggest that the temperatures above 27 °C occurred because temperature sensors were not calibrated and the flow temperature of the concrete core cooling system was too high. Based on measurements and thermal simulations in terms of building monitoring, suggested solutions (for instance new control strategies) were developed, and were implemented in the fall of 2004.

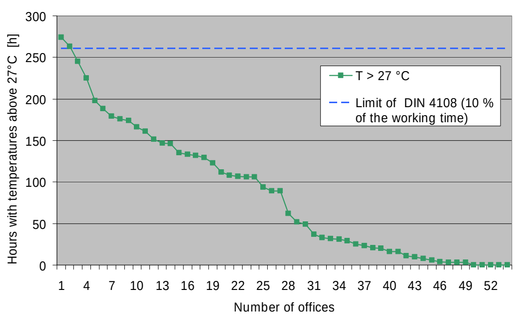

Figure 10. Thermal comfort in the offices.

First measurement results of 2005 show the positive effects of the energy and comfort monitoring and the cooperation with the building's facility management. The energy demand was reduced by 33 %. During the first three years of operation, the total savings in energy costs will reach 35 000 €. The example of the EnergieForum Berlin shows that the energy designer should not only support the design, planning and construction of a new building, but also evaluate the commissioning process and the first years of operation.

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