Projektinfo **06**/2017

Detailed information on energy research

Servers heat office building

A heat pump cools the in-house data centre and at the same time, it provides heat in the new building

BINE
Information Service

The Züblin construction group set high standards for the extension of their headquarters: in terms of construction, energy efficiency and sustainability. In operation, the energy consumed for heating and cooling is below the calculated values. The high-performance data processing centre housed in the building provides enough thermal energy to heat the building. The thermal comfort leads to a high level of satisfaction of the occupants. Most of the energy – far more than planned – is consumed by artificial light.

It was a central concern of Ed. Züblin AG to achieve the highest certification of the German Sustainable Building Council (DGNB) for its new Z3 building in Stuttgart. The building was to create a high-quality work environment for around 250 employees, and be as energy-efficient and innovative as possible in terms of its features. On the one hand, it serves as a figurehead and on the other, as a prototype. This is because the company develops and implements many such major projects at home and abroad. The experience gained from the research project can be put to use in consulting and planning. The German Federal Ministry for Economic Affairs and Energy financed a scientific monitoring with the necessary additional measuring equipment, well-grounded user surveys as well as various innovative components.

An architectural competition ensured the high quality of its design and the urban development link to the two existing company buildings. The five-storey reinforced concrete skeleton structure was realised within 15 months. The workspaces are arranged along the façade of the compact building. Glass walls separate the office rooms from the corridor, so that areas deeper within the building also receive their fair share of daylight. The exterior walls consist of prefabricated timber

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frame elements, which were transported to the construction site with windows, solar shading and a sheet metal covering, and were installed there. Projecting and recessed strips of untreated larch wood structure the façade in a vertical direction and contribute to shading. Externally fixed Venetian blinds provide for protection against the sun. With an average U-value of 0.4 W/m²K including the windows, the façade meets passive house requirements. A photovoltaic system installed on the green roof further improves the energy balance.

Two chillers for the data centre

The data centre requires about 200 MWh of cooling. At low outside temperatures, free cooling can be used for the most part, and at higher outside temperatures, the chillers increasingly cover the required cooling supply. One unit is designed for heat pump operation, the other for cooling operation. During the winter months, the heat pump covers the cooling requirements of the data centre and simultaneously heats the building; this is when operation is most efficient. During the summer months, both chillers work in conjunction.
The heat demand of the building is low due to the high quality of the insulated building envelope and is almost completely covered by waste heat from the data centre. As a backup for heat supply, the combined heat and power plant of the neighbouring building is used, which is otherwise used mostly for domestic hot water heating. The heating as well as the active cooling of the office spaces is carried out primarily by capillary tube mats plastered onto the ceilings. Due to their low thermal storage capacity, they react relatively quickly and are therefore integrated into the individual room controls.

Fresh air and light regulated as required

The ventilation of the building is based on a hybrid concept. At ambient temperatures close to room temperature, the ventilation system in the office area is switched off, but the rooms are then to be manually ventilated via the windows. In the case of higher differences between outside and room temperatures, the office area is automatically ventilated with a timer. The ventilation system has a highly efficient heat and cold recovery system as well as the option of adiabatic exhaust air humidification for passive cooling. The rooms towards the interior and in the basement are only machine-ventilated. This is controlled by CO_2 sensors in the meeting rooms. A ground-coupled heat exchanger and the option of free night cooling via the ventilation system raise the energy efficiency of the system.
Solar shading, lighting as well as the room temperature are presence-controlled and can be set individually using the room operating panel. Users can use a web interface to see detailed information on the operational parameters of their rooms. For example, the interface informs users about the current operating state of the ventilation system with a corresponding indicator to manually ventilate by opening the windows.
In the office rooms, only high-voltage floor lamps with direct and indirect light shares are used, which automatically adjust themselves depending on presence and ambient brightness. When the office is not occupied, presence detectors will power off the sockets to which the floor lights are connected. This prevents stand-by consumption. The lighting of the corridors and adjacent rooms also depends on presence and brightness.

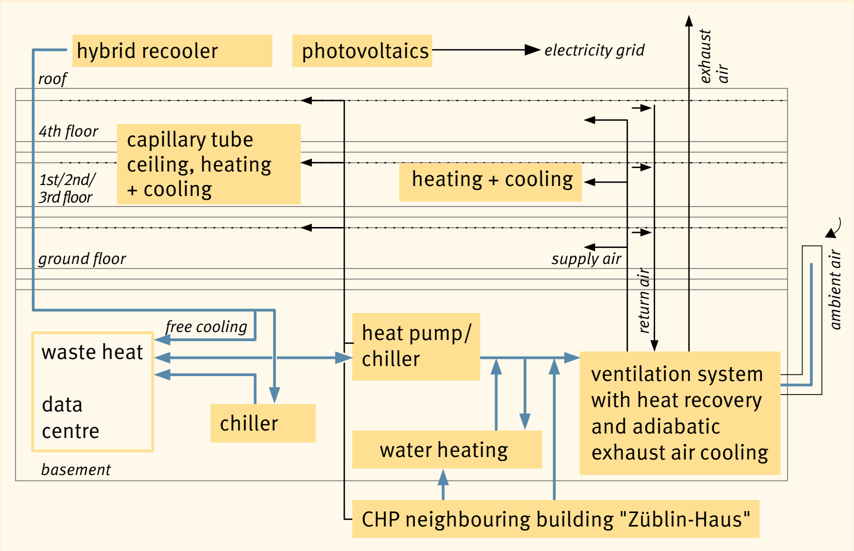

Fig. 1 *Technology concept for heating, ventilation and cooling*

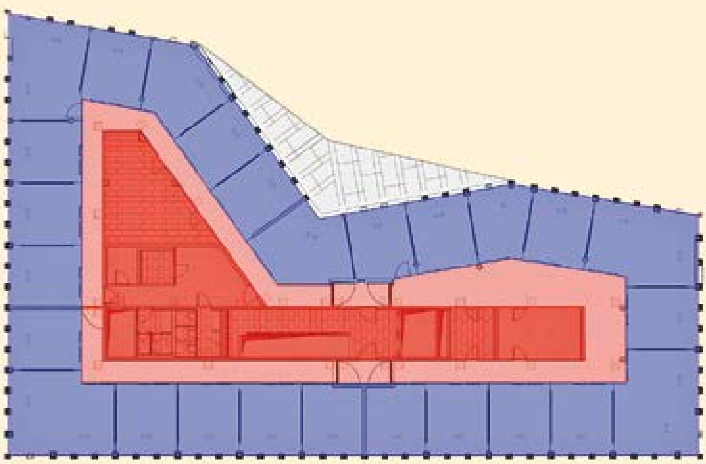

Fig. 2 *Floor plan of the third storey: The staircase, corridors, meeting rooms, copy rooms, IT rooms, kitchenettes and toilets are located in the inner zone (red).*

Occupants satisfied with indoor environment

Two online surveys (in summer and in winter) conducted by scientists at the Fraunhofer Institute for Building Physics IBP showed a high level of occupant satisfaction with thermal comfort and light conditions – regardless of the season. The effect of the solar shading system was also rated „mostly positive“. The question of user friendliness of the solar shading system was answered mostly with „less satisfied“. While users were satisfied with the illumination intensity on the work surfaces, they were not quite as happy with the overall illumination intensity in the office. This is because the floor lamps illuminate the workspaces at selected points, while the rest of the room is much darker, resulting in uneven lighting. The functionality and intelligibility of building automation were evaluated as neutral. The occupants saw room for improvement for sensitivity of the presence detectors for the individual room control, as well as for the sound insulation of the single-glazed walls and doors between the office areas and the corridors. The latter was confirmed by acoustic measurements.

Monitoring exposes outliers

Z3 features an extensive array of meters and measurement points. This offered the scientists at the Research Centre for Sustainable Energy Technology at the University of Applied Sciences Stuttgart (HFT) very good prerequisites for a detailed analysis of the building in operation.

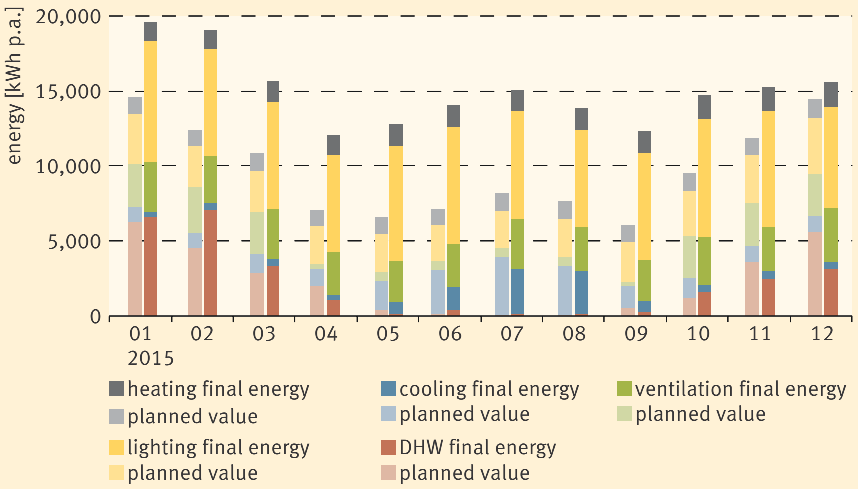

Fig. 3 *Final energy consumption 2015 sorted by consumption categories and compared to planned values*

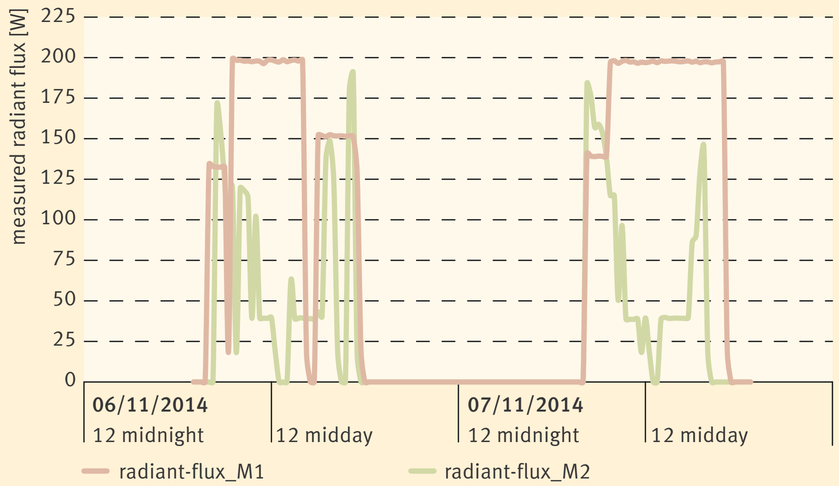

Fig. 4 *Comparison of lighting intensity profiles in two test rooms: In room M1, the staff taped off the sensors and parts of the lighting to manipulate the dimming function because they were dissatisfied with its performance.*

The final energy consumption for heating and cooling is largely consistent with original calculations. However, the lighting partially consumes three times as much as assumed and is therefore responsible for exceeding the planned overall demand. The consumption of the ventilation system exceeds the planned values as well. Because both ventilation and lighting are powered by electricity, they are even more pronounced in the primary energy balance with an evaluated factor of 2.6: with a total of 44.8 kWh/m^2 p.a., the measured value for 2015 falls below the EnEV requirements as valid at the planning stage by 65 %, but is about 72 % higher than the planned requirements calculated in accordance with DIN V 18599.
For the ventilation system, measured and planned values are largely identical between October and March, but it consumes significantly more than calculated during the rest of the year. The reason for this is that the users did not use the provided window ventilation in a targeted manner, and the operator therefore decided to use the ventilation system continuously instead. This nearly doubled consumption in the annual balance.

A focus on the lighting

Lighting is a prominent factor in the energy balance of highly insulated buildings, especially in offices. The floor lamps at the workspaces are largely responsible for the high power consumption in Z3. As soon as one of these floor lamps is supplied with power, i.e. when an office is occupied, it causes a base load of approx. 30 W. The lamps cannot be precisely set to a desired illumination value, which often results in the users maintaining the preset maximum value. Readjustments, taping off the sensors or connecting to a non-presence-controlled socket increased energy consumption significantly in some cases.
Significant energy savings would be possible by optimising the solar shading controls or the mechanism itself. The extremely low proportion of daylight reaching the offices when the blinds are lowered leads to an increase in the amount of artificial light produced by the dimmable lighting system. This also affects the operating time of the lighting for the interior circulation areas. According to the plans, these areas should be supplied with daylight through the glass walls of the offices.
During monitoring, it was noticed that a permanent base load occurred in one storey when the lighting was on, which should not be the case due to presence control. In 2014, this accounted for almost half of the lighting consumption on that floor. This is caused by problems in the bus communication of the lighting control; a solution is currently being worked on.

New components tested

In the research project, the building developers and scientists also endeavoured to gather experience with innovative components. Alternative shading systems were therefore tested for test rooms. However, neither coated slats nor fixed slats with a PV coating proved better than the conventional system. The idea of directing daylight from the roof into the interior corridors via glass fibres proved problematic over longer distances. With the exception of the coated slats, the tested components are not being further developed by the manufacturers.

Linking measurement data from different sources

The scientists at HFT Stuttgart are continuing to develop the EmTool software with the project funds. The program allows for the combination and processing of measurement data from different sources, preferably from building management technology and mobile measurement technology. This is made possible with automated fault monitoring and plausibility analyses. Smart algorithms can be used to rapidly access data stored in databases. Data from different sources and saved in different locations are synchronised. The direct connection to the databases of the building management technology via interfaces that were developed in-house helps lower requirements of data retention.
So far, this program has only been used at the university. As of spring 2017, it will be further developed for a research project on a property owned by the company Bosch.

Saving energy in data centres

Data centres are among the biggest energy hogs in the information and communication technology sector. Their complexity is increasing and the overall number is rising steadily. According to an investigation conducted by the Borderstep Institute, data centres in 2015 consumed some 12 billion kWh, that is two percent of the total electricity consumed in Germany. In light of this, various research projects are trying to find ways to raise the energy efficiency of new and existing data centres. Scientists from five countries examined how data centres could be supplied almost entirely with renewable energy in the EU-sponsored RenewIT project, which was concluded at the end of 2016. The prerequisite for this is a significant prior reduction in energy consumption through optimal building design, IT management, low-loss power distribution, optimisation of cooling and the use of heat recovery. The online RenewIT tool was developed using the results. The most important parameters of a data centre can be entered, allowing for a quick and easy assessment of how different measures and concepts affect its overall energy consumption. A newly developed monitoring tool helps operators monitor the performance of the data centre and the operation of the power and cooling supply.
The TEMPRO (Total Energy Management for Professional Data Centers) project, which was recently launched under the auspices of the University of Oldenburg, is striving to achieve a more efficient use of energy and raw materials in data centres. Partners from research, industry and municipal administration are participating. Instead of analysing the ongoing operation of a data centre as would be common practice, the TEMPRO team are following a more holistic approach: they are examining the whole life cycle of the equipment, from raw material production to recycling. In this way, they hope to reveal further saving potentials.
From 2011 to 2014 and as part of the IT2Green technology programme, the German Federal Ministry of Economics and Technology (BMWi) had already funded research projects in the topic complex of „Computing Centres and Clouds“ that focussed on how data management and a smart distribution of information loads could help improve the energy efficiency of data centres.

Project participants

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- **Energetic evaluation of the air conditioning:** Biberach University of Applied Sciences (HBC), Institute for Building and Energy Systems, Prof. Dr Roland Koenigsdorff, www.hochschule-biberach.de/web/ige

Links and literature (in German)

- www.projektinfos.energiewendebauen.de
- www.tempro.uni-oldenburg.de
- www.renewit-project.eu
- www.green-it-wegweiser.de

- Genswein, M.; Arold, J.; Biesinger, A. , Trinkle, A. et al: Ressourceneffizientes Gebäude für die Welt von Übermorgen. Forschungsprojekt REG II. Project report. Part 1 and part 2. FKZ 03ET1035F; 03ET1035G. Ed. Züblin AG, Stuttgart (ed.). University of Applied Sciences Stuttgart (HFT). Centre for Sustainable Energy Technology (zafh.net) (ed.). 2016. 382 pages

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