Projektinfo **17**/2015

Detailed information on energy research

Great climate for old writings

Refurbishment and expansion of Nuremburg City Library also offers more comfort for visitors

BINE Information Service

The new Central Library combines the book collections that were previously spread across several locations. Luitpoldhaus, which is located in a listed ensemble of buildings in Nuremberg's old town, has been rebuilt and expanded. The project aim of undercutting the requirements of EnEV 2007 for new-build schemes by at least 30 % has been exceeded. However, the high demands placed on the indoor environment for archiving and exhibiting medieval manuscripts made the task extremely tricky.

Originally constructed in 1911, Luitpoldhaus has been used as the City Library since it was rebuilt following its destruction in World War II. The supplementary floors now added as part of the renovation enable the building to regain its original volume before its extensive destruction in 1945. A newly inserted block connects Luitpoldhaus with the adjacent library building in the listed former St. Catherine's Monastery. The book collections can now be merged together with those belonging to the previously outsourced Music Library and the extensive collection of ancient manuscripts to form a Central Library.

The city had set itself ambitious goals with the project, including in regards to the energy characteristics. The renovation and expansion of the building was intended to show that, even given the very difficult initial conditions such as the state of the existing building, the listed inner-city location and high indoor environment requirements, it is still possible to achieve an energy-efficient refurbishment that undercuts by at least 30 % the levels prescribed at that time by the German Energy Savings Ordinance (EnEV) 2007 for new-build schemes. The concept sought to achieve this goal not just in terms of the structure and architecture but also regarding the building physics and technology. For example, the building now features excellent external thermal insulation and large windows with solar shading that allow plenty

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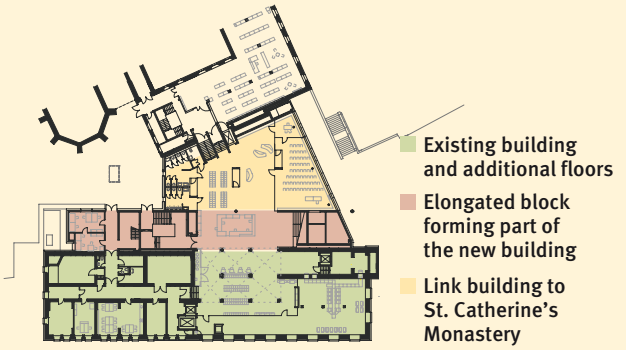

Fig. 1 *Ground floor plan with foyer and "Learning World"*

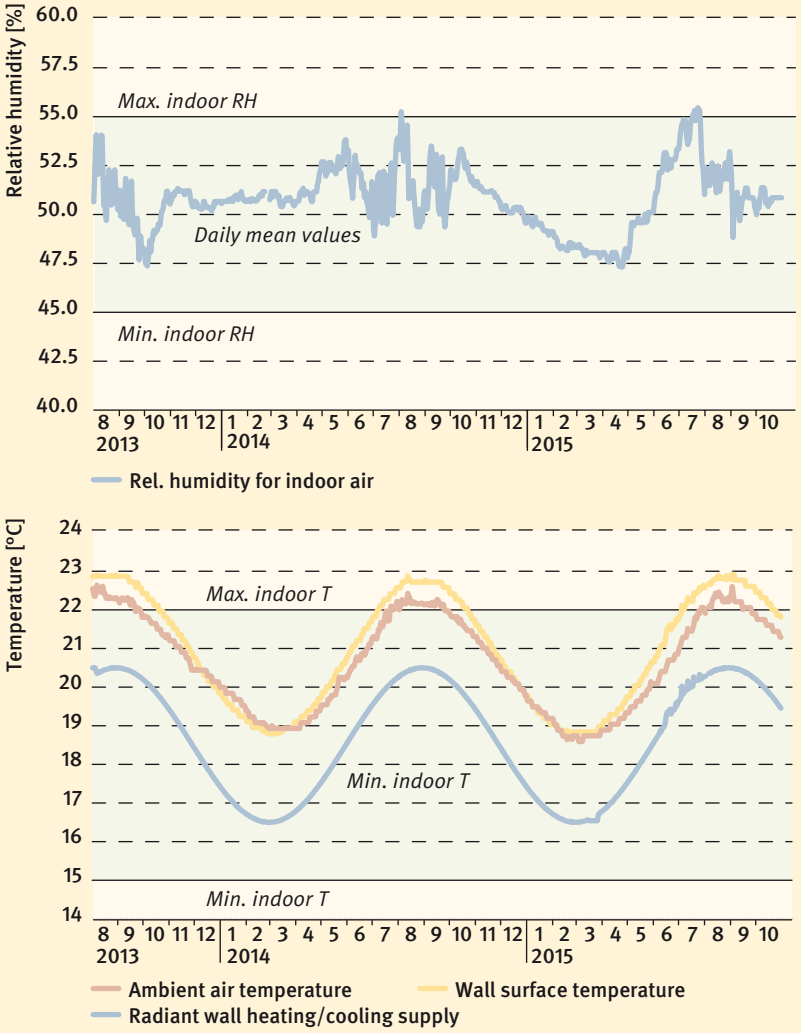

Fig. 2 *Measurement results for the indoor environment in the manuscript stacks in the basement, August 2013 to October 2015. The target values for the indoor air temperatures are slightly exceeded by between 0.2 and 0.8 K during the summer months.*

of natural light into the building but prevent heat from entering in summer. District heating supplies the underfloor heating system with warmth and groundwater cools both the air supply for the publicly accessible library areas and the cooling ceilings in the office spaces on the top floor, which for structural reasons is executed using a lightweight structure. The public areas have a central ventilation system with heat recovery. The office spaces are ventilated manually using the windows.

An appropriate setting for valuable manuscripts

Valuable collections, such as letters from Albrecht Dürer, were previously housed from a conservation point of view in totally inadequate conditions. As part of the renovation, it was therefore intended to create appropriate indoor environment conditions for storing them. The stringent requirements for the indoor environment are ensured with largely passive structural and minimised technical measures. A conventional solution with compression chillers and dehumidification would firstly lead to rapid humidity and temperature fluctuations during the course of the day, which would subject paper, parchment and leather to considerable stress. Secondly, such an alternative would also require a relatively high energy expenditure and would not be fail-safe.

The concept therefore provides the following measures for the sensitive historic collections (stacks, reading room and exhibition space): monolithically constructed room boundary surfaces with thermal insulation on the exterior side of the sensitive areas and sorptive lime plaster on the inside surfaces; utilisation of groundwater for cooling or heating the wall surfaces via capillary tube mats; decentralised ventilation system with heat and moisture recovery and an air exchange rate of only 0.1 h^{-1}, and three small window openings in the reading room to provide views outwards. Almost complete isolation from the outside climate is therefore achieved in the stacks combined with a high thermal mass for buffering the temperature and humidity.

The ventilation and air conditioning for the reading room and exhibition space were particularly challenging. This is where visitors are expected and complete isolation from the outside climate is not possible. Hygienic indoor environmental conditions must be ensured. Nevertheless, high demands are also placed on the indoor environmental parameters in these rooms. Also to be considered are internal loads caused by lighting and computer systems. A special ventilation unit with adiabatic evaporative cooling and sorptive dehumidification as well as drying of the salt solution with solar heat (20 m^2 solar thermal system) handles the necessary tasks for air-conditioning the supply air. Cooling is achieved using the adiabatic evaporation effect. In winter, the supply air has to be additionally moistened as required with water vapour.

Books as moisture buffers

The hygric storage behaviour of books and the surrounding structure of the well-insulated archive spaces have a large impact on the indoor humidity. Paper can store large amounts of moisture and thus significantly contributes to stabilising the indoor environment. The scientists involved expanded an existing simulation model to include books as a component. This made it necessary to determine the hygric characteristics of the books. Since the manuscripts being stored consist of very different types of papers and bindings, the moisture-related characteristics of three books were examined and measured by way of example. This made it possible to test whether the requirements for maintaining a constant indoor environment could be met with the planned heating, ventilation and air-conditioning system in combination with the "book buffering". Simulation calculations showed that without the effect of this book buffering, the relative humidity would vary between 30 % in winter and 65 % in summer. It is only through the influence of the book and wall buffering that the variations between summer and winter can be mitigated to such an extent that the desired range for air-conditioning can be achieved.

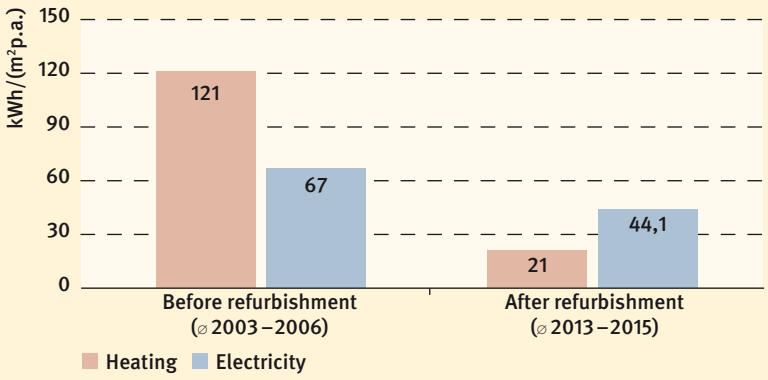

Fig. 3 *Average final energy consumption measured for heating and electricity before and after renovation*

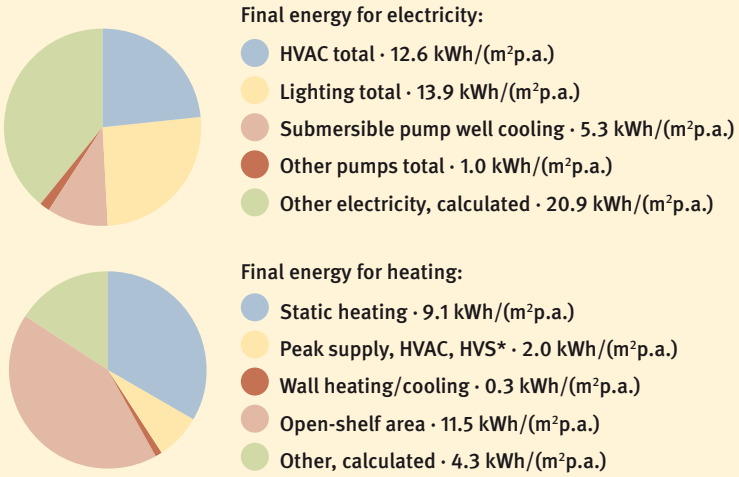

Fig. 4 *Distribution of the measured consumption of electricity and heat energy (2014). Some of the electrical loads are not recorded separately, such as the electricity consumed by lifts, individual pumps and users. Heating, ventilation and sanitation (HVS)* manuscript reading room*

Historic manuscripts in safe hands

The measured ambient air temperatures differ only very slightly from the specifications, in summer by a maximum of 0.8 K (Fig. 2). The values for the relative humidity lie within the desired range for the entire measurement period. The plant technology designed with the help of hygrothermal simulations has proven itself in combination with the passive concept.

The energy concept has proved successful

The new Luitpoldhaus was opened to the public in October 2012. This is when the intensive monitoring also started with monitoring and analysis of the energy consumption and the initial adjustment of the building operation. This was carried out in order, on the one hand, to check the energy consumption forecasts and thus the calculation and planning tools and, on the other hand, to identify and correct weak spots, particularly in relation to the control parameters.

Despite the increase in the museum's size, the heating and electricity consumption was significantly reduced relative to the unrenovated building. After the renovation, the specific heat consumption is now only about 18 % of the consumption prior to the renovation; the specific electricity consumption now amounts to about 66 % of the previous consumption (Fig. 3).

The indoor air quality in the publicly accessible library spaces is deemed to be good. The CO_2 concentration varies between 400 and 1000 ppm.

Indoor environment in archives

How can valuable book collections made of paper, parchment and leather be kept safe? It is important to achieve an indoor environment that does not fluctuate, coupled with narrow upper and lower limits. A maximum relative humidity (RH) of 55 % must be strictly maintained to prevent mould from forming. The design team and the responsible employees from the City Library have set individual target values for the indoor environment in all sensitive rooms in Luitpoldhaus used for historic collections. The indoor environmental target values for the stacks amount to 18 °C for the air temperature and 50 % for the relative humidity, with a tolerance between 15 and 22 °C and between 45 and 55 % relative humidity. The requirements for the manuscript reading room are similar. In the summer months, higher indoor air temperatures are tolerated with a maximum of 24 °C. The primary parameter is always, however, the relative humidity.

Monitoring reveals optimisation potential

At the beginning of the monitoring, problems were initially experienced with changed data point designations, electricity meters and the availability of data. It is therefore advisable to constantly check systems, data points and target value settings not just at the beginning but also during the building's ongoing operation. In addition, all corrections to the system parameters should be carefully recorded. The indoor environmental requirements in the sensitive areas with the historic collections (relative humidity tolerance ± 5 %) require permanent monitoring. Although the sensors used correspond to the latest building technology with relative humidity tolerances of ± 3 %, the tolerance range is nevertheless very high for the stringent requirements. This therefore makes it essential to check the sensors and, if necessary, recalibrate them.

Amongst others, the monitoring revealed that the well pump, underfloor heating and air conditioning and ventilation (HVAC) systems were not correctly adjusted. Since its commissioning, the well pump ran permanently at full capacity so that the amount of water pumped initially exceeded the planned pump rate several times over. Moreover, the continuous operation had a negative effect on the life of the pump and the power consumption. Since June 2015, the pump switch and the operating concept have been optimised. An initial comparison of June 2014 and June 2015 shows that 75 % of the well water has been saved and the power consumed is less than 20 % of that consumed in the same month in the previous year.

In the first winter, the relative humidity in the public part of the library partially fell below 25 %. This was mainly due to the not optimal interaction between the underfloor heating and ventilation. Due to room temperatures that were too high, the air volume increased and the indoor air humidity reduced. The ventilation system for the manuscript reading room sometimes ran continuously, although the building management system (BMS) had set a time program. The interface for the manufacturer's HVAC control systems did not initially work with the superordinate BMS system.

The malfunctions have now been solved and the indoor environment meets the expectations. Only the electricity consumption has scope for optimisation.

Climate control with passive measures

The long-term storage of archive material also formed part of a research project conducted by Lausitz University of Applied Sciences. The indoor environmental requirements for archives are subject to very strict limits regarding the temperature and humidity, which need to be largely satisfied with passive measures and with only little use of air conditioning technology.

The researchers first of all looked for materials that were suitable in terms of their hygroscopic behaviour, and measured their sorptive characteristics. Commercially available building materials, plasters and sorptive materials such as timber, building panels and recycled products were included in the investigations. In a further step, they focussed on developing specific formulations for hygroscopically active materials, for example based on cement, lime, magnesium oxide and magnesium salts. In addition to the composition of the building material, the surface structure of the room boundary surfaces also influences the moisture balance of the building material and the connected space. The hygroscopic behaviour of commercial building materials can be modified with additives. In addition to the measurements in the laboratory, measurements were also conducted in two large archive rooms in the Federal State Archives in Magdeburg. Here cement-bonded particle boards were used.

Experimental studies depicted the influence of wall heating systems for storing and releasing moisture. Acting as buffers, the walls release moisture during the day when the wall surfaces are heated to higher temperatures and there is a simultaneously larger air change, enabling them to reabsorb moisture during the night when there are cooler temperatures, so that the relative humidity does not exceed the specified values.

Another component of the work was the use of partitions and their effect on the relative humidity. These walls, which contain loose-fill materials, act as coupled thermal and hygric buffers. The sorptive characteristics and characteristic features of building materials and products are now available as data.

Project participants

- **Project management:** City of Nuremberg, Baureferat/Hochbauamt, Urs Wenzel, Eva Anlauft, urs.wenzel@stadt.nuernberg.de, eva.anlauft@stadt.nuernberg.de, www.nuernberg.de
- **Monitoring:** Georg Simon Ohm Technical University Nuremberg, Institute for Energy and Buildings, Prof. Dr.-Ing. Wolfram Stephan, Florian Büttner, ieg@th-nuernberg.de, www.ieg.th-nuernberg.de
- **Architect:** Baum Kappler Architekten GmbH, Nuremberg, Andreas Baum, Dirk Vollrath, www.baum-kappler.com
- **Building climatology and thermal simulations:** Wolfgang Sorge Ingenieurbüro für Bauphysik GmbH, Nuremberg, Wolff Fülle, Thomas Metzger, www.ifbsorge.de
- **Humidity simulation:** TU Dresden, Institute of Building Climatology, Prof. Dr.-Ing. John Grunewald, www.tu-dresden.de/bauklimatik
- **Research project on passive climate control:** Lausitz University of Applied Sciences, now called Brandenburg University of Technology Cottbus-Senftenberg, Prof. Dr.-sec. techn. Horst Stopp, Dr.-Ing. Peter Strangfeld, peter.strangfeld@b-tu.de, www.hs-lausitz.de/fakultaet8.html

Links and literature (in German)

- www.enob.info/en
- Stephan, W. (Bearb.); Büttner, F. (Bearb.); Dodenhöft, V. (Bearb.): Verbundprojekt Energieoptimiertes Bauen EnOB. Wissenschaftliche Begleitung zum Projekt Generalsanierung und Umbau des Luitpoldhauses für die Stadtbibliothek Nürnberg – Monitoring und wissenschaftliche Begleitung. Abschlussbericht. FKZ 0327431N. Technische Hochschule Nürnberg. Institut für Energie und Gebäude (Hrsg.). [2015]
- Stadt Nürnberg (Hrsg.): Generalsanierung und Umbau des Luitpoldhauses für die Stadtbibliothek Nürnberg. Schlussbericht. FKZ 0327431A. 2013

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76344 Eggenstein-Leopoldshafen
Germany

Author
Micaela Münter

Contact · Info

Questions regarding this Projektinfo brochure? We will be pleased to help you:

+49 228 92379-44
kontakt@bine.info

BINE Information Service
Energy research for application
A service from FIZ Karlsruhe

Kaiserstraße 185-197
53113 Bonn, Germany
www.bine.info

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