Conversion of an old brewery into a 21st century culture and social centre

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ABSTRACT

The decision makers in urban planning face very often a dilemma whether to demolish or retrofit old buildings. Such a dilemma had to be solved during the reconstruction of the campus of the Faculty of Information Technologies at the Brno University of Technology. One of the buildings on the campus (a building that used to be a brewery) was in a really bad shape and the question was whether to demolish it and build a new building instead or to put effort and resources into its retrofit. At that time the Brno University of Technology became a participant in the EU 6th framework project BRITA in PuBs (Bringing Retrofit Innovation to Application in Public Buildings). The decision was made to retrofit the former brewery into a social and culture within the framework of the demonstration part of the BRITA project. The retrofit of the brewery involved a complete change of the building use profile and all the building systems had to be designed from scratch. Sophisticated control and monitoring of the building equipment by means of the Building Management System is used in the Brewery.

1. INTRODUCTION

Buildings in the developed countries account for about 40 percent of energy use and they are the number one consumer of electricity. Since the newly built buildings have to comply with strict energy performance regulations in many countries the biggest potential for energy saving in the building sector lies in the energy retrofits of existing buildings. It is estimated that some three quarters of the buildings we will have in the European Union in 2030 are already built. These existing buildings, which in average lag far behind the energy performance requirements for the newly built buildings, will account for more than 95 percent of primary energy use in the building sector in 2030. This makes energy building retrofits a real challenge in reducing the consumption of energy.

The European Union has supported several demonstration projects aimed at energy retrofits of existing buildings. One of these projects was the EU 6th framework project BRITA in PuBs (Bringing Retrofit Innovation to Application in Public Buildings). Eight public buildings in seven EU countries were retrofitted within the framework of this project. The Czech demonstration building was an old brewery that was converted into a social and culture centre for the students and academics of the Faculty of Information Technologies of the Brno University of Technology. The name “Brewery” refers to the purpose that the building was originally used for, even though it only served as a warehouse in the recent past. The Brewery was the oldest building that underwent retrofit in the BRITA in PuBs project.

2. BEFORE THE RETROFIT

The Brewery is an old industrial-style building in a historical area of the city of Brno. The oldest part of the Brewery was built in the 1770s. A stone with a date of 1769 was discovered during the retrofit in one of the columns supporting the vaulted ceilings on the ground floor. The building has been extended and rebuilt several times during more than 200 years of its history. At present the Brewery consists of two buildings. A four-storey building (designated R building) contains some original building structures dating back to the eighteen century. A two-storey building (designated P building) was build later, but it also has a historical value. The elevations and the photo of the Brewery before the retrofit can be seen in Fig. 1.

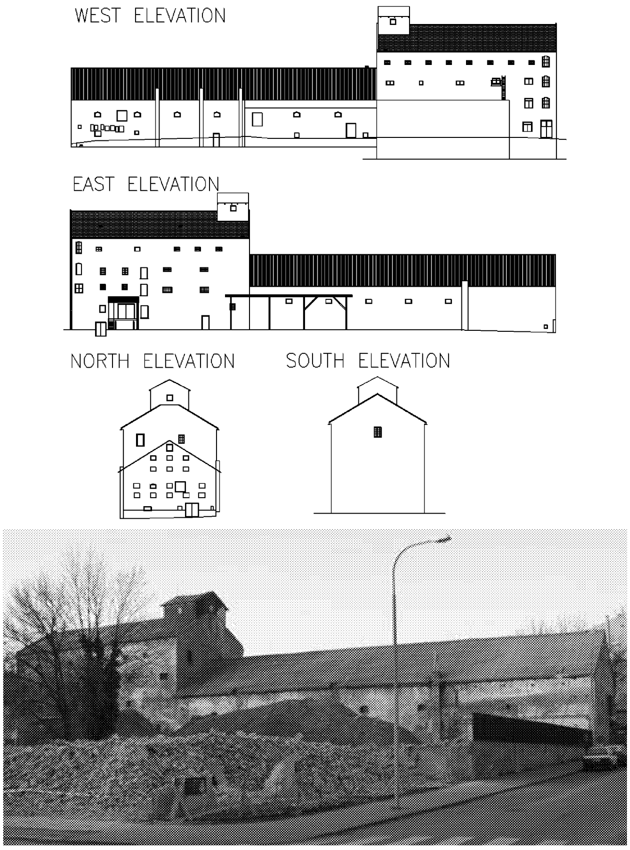

Figure 1: The Brewery before retrofit

The floor area of the Brewery before the retrofit was 2300 m^2. This area increased to 2660 m^2 when the attic of the P building was converted into habitable space. There are two cafeterias, two multi-purpose rooms, a student club, an auditorium and 33 guest rooms in the Brewery.

3. ENERGY SAVING MEASURES

A number of energy saving measures was applied in the retrofit. The passive measures, like additional insulation for the building envelope or replacement of windows are more or less "standard" energy saving measures used in the building retrofits in the Czech Republic. Active measures, like the installation of a Building Energy Management System, integration of photovoltaic cells or use of demand controlled ventilation are quite innovative and have not yet been used in a mass scale yet.

3.1 Building Management System (BMS)

The Building Management System (BMS) is the most important energy saving measure employed in the retrofit of the Brewery. One of the requirements of the investor (Brno University of Technologies) was that the control and monitoring of all building systems had to be integrated into one system with one graphical user interface that would allow easy navigation through different options of the building control, monitoring and maintenance. It was not an easy task because products of different manufacturers of building equipment and technologies use different communication protocols.

The control and monitoring of the Brewery is part of the BMS of the campus of the Faculty of Information Technologies. The BMS integrates control and monitoring of the HVAC systems, artificial lighting, access, security system, fire alarm, closed circuit TV, elevators, etc. The big advantage of such integration is that the information not directly related to indoor environmental conditions can be employed in the control of these conditions (e.g. information about occupancy from the access system can be used to switch on/off heating or cooling).

The advantage of the integrated control will be demonstrated on the situation in the guest rooms. The screen shot of the BMS showing one of the guest rooms is in Fig. 2. The BMS monitors presence of the occupants, opening of windows, air temperatures in the rooms, set point temperatures and the indoor air quality. Based on these inputs the BMS controls ventilation heating and cooling.

The monitoring of occupancy is the most difficult task. The door to all accommodation units can only be opened by a card. Since the occupants are mostly young employees of the Faculty of Information Technologies or the Ph.D. students of this faculty that card is the employee or student identity card. The problem is that most of the accommodation units have two rooms, each occupied by one person. It was necessary to determine which of the rooms is occupied. A card slot (similar to those used in the hotels) is installed in each of the rooms and the occupants are supposed to insert the cards into the slots when they arrive to the room and remove it when they leave. When the card is inserted the room is heated to the set point temperature, when the card is removed the room is heated to a lower temperature (e.g. 15°C).

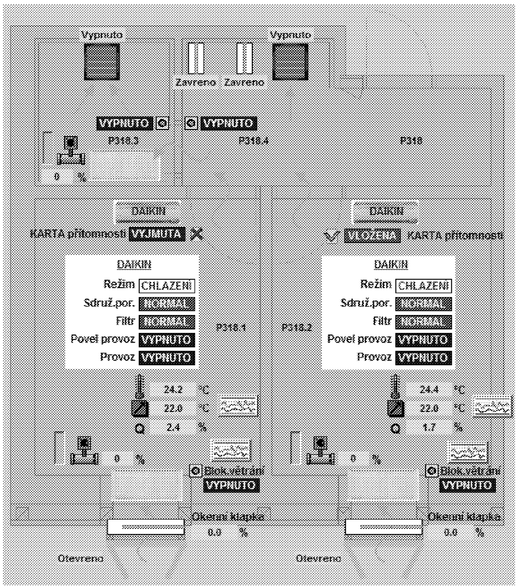

Figure 2: BMS screen shot of one of the guest rooms

Cooling shuts down completely when the card is removed. Theoretically speaking, this approach should work quite well. The problem is that the card slot is not a card reader but a simple switch. Any card (or a piece of cardboard) inserted into the card slot means that the BMS considers the room occupied. This energy-saving feature relies on the accountability of the occupants in this point.

Other energy-saving features are more difficult to breach. There are servo-valves mounted on the radiators of the heating system that are fully controlled by the BMS. Heating and cooling of the room shuts down when the window is opened. The occupants can use the wall mounted space temperature modules to set the setpoint. Ventilation in guest rooms is demand-controlled and it will be dealt with in the ventilation chapter. A VRV (Variable Refrigerant Volume) air conditioning system is can be used for both cooling and heating.

3.2 Heating

A heating plant with two condensing boilers delivers heat for the space heating system, air-handling units and domestic hot water (DHW) heating. Possibilities of using water-to-water heat pumps or combined heat and power (CHP) units were explored in the design phase but they were rejected. Insufficient inflow of water was the reason for rejection of the heat pumps and the small demand for heat in summer was the reason why CHP was rejected.

Individual control of temperature in the rooms is the main energy saving measure on the side of space heating. The Brewery is divided into almost 50 zones with the possibility of individual control of temperature.

3.3 Ventilation

Both balanced mechanical ventilation with heat recovery and demand controlled hybrid ventilation are used in the building.

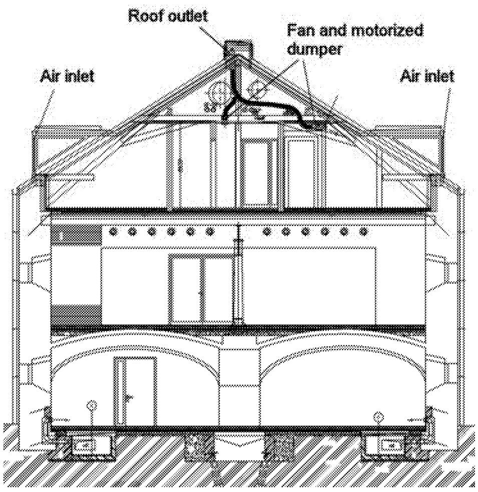

Figure 3: Hybrid ventilation system

Mechanical ventilation is used in the cafeterias, club, auditorium and multipurpose rooms where high air change rates are required. The demand controlled hybrid ventilation system is used in the guest rooms where the ventilation demand varies significantly over the time and from room to room. The hybrid ventilation system consists of an air supply inlet integrated in the window frame, air quality sensor, motorized damper and the axial fan in the exhaust. The hybrid ventilation system is controlled directly by the BMS. The locations of the main parts of the hybrid ventilation system in one of the guest rooms can be seen in Fig. 3.

3.4 Air-conditioning

The central cooling plant has the cooling capacity of 600 kW and provides chilled water not only for the Brewery but also for other buildings in the campus. Most of the cooling load is concentrated in lecture halls, laboratories, and classrooms that (like the cafeterias) operate only during academic year. The main cooling loop supplying chilled water to these buildings does not operate during the summer break and a smaller cooling loop, providing chilled water for server rooms and some offices, is used during that time. Some of the guest rooms in the Brewery are located in the attic directly beneath the roof and space cooling is needed to maintain acceptable thermal comfort in the guest rooms in summer.

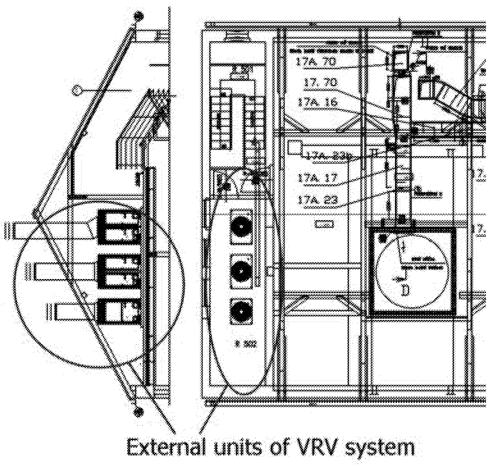

Figure 4: VRV air-conditioning system

Since the small cooling loop operating in summer would not have sufficient capacity to provide cooling for guest rooms a Variable Refrigerant Volume (VRV) air-conditioning system was installed there. The external units of the VRV air conditioning system are located in the attic of the R building in order not to disrupt the historical appearance of the building. Outside air is drawn to the units through the louver-covered openings in the facade and it is blown out trough the vertical ducts (chimneys). The consumption of electricity by the VRV air-conditioning system is measured separately.

3.5 Photovoltaic cells

A grid connected PV system with the peak output of 14 kW is installed on the roof of the R building (Fig. 5). The system consists of 132 monocrystalline PV modules. The building integrated photovoltaic systems could become a good compensation for electric demand of mechanical cooling. A good match of the power production of PV systems and the electric demand of mechanical cooling can be expected and thus the load to the power grid can be reduced. One of the goals of the PV installation at the Brewery is to investigate how well the power production matches the consumption of the VRV air-conditioning system.

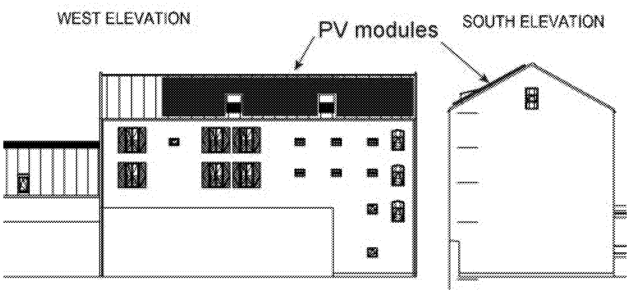

Figure 5: Photovoltaic cell

4. MONITORING RESULTS

One of the tasks of the BRITA in PuBs project was to monitor the operation of the retrofitted demonstration buildings during the time period of at least 12 month. The sophisticated Building Management Systems proved to be a big advantage in this task.

4.1 Indoor environment

Even very sophisticated algorithms of automatic control cannot prevent the building users from foiling the energy-efficient operation of the building. Fig. 6 shows the air temperature and window opening in one of the guest rooms in January 2008. As can be seen, the occupant opened the window on January 1, 2008 and left it open for three days. There is a safety measure implemented in the BMS, which only allows the room temperature to drop to a certain value when the window is open and then the heating system kicks in to prevent the possible damage from freezing. It is cheaper to waste some heat with an open window than to let the heating system and water piping freeze and thus cause an expensive damage to the building.

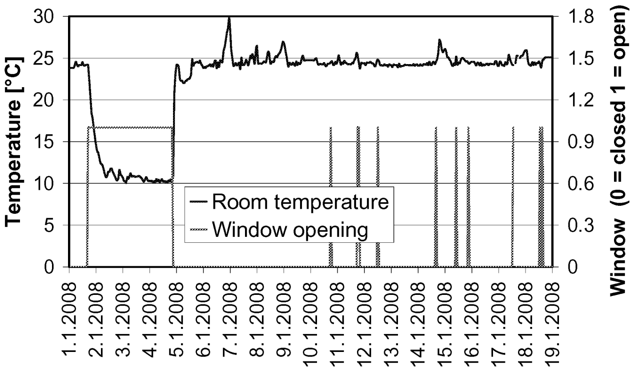

Figure 6: Room temperature and window opening

It can be seen in Fig. 6 that temperature in the room was relatively high in January. It is due to the heating set point that was 24°C during the period. Heating setpoint is another issue where education of users is needed. It is desirable to allow occupants be in charge of the indoor environmental conditions. The occupants, however, should be aware of the fact that their comfort comes at a price even though they may not pay that price directly.

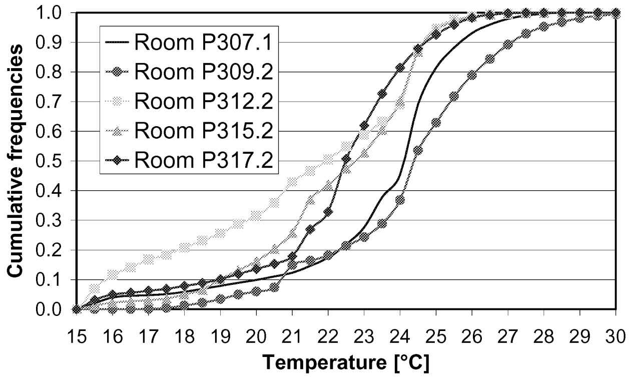

Figure 7: Temperature (guest-rooms in the attic)

The cumulative frequency of room temperatures in five guest rooms located in the attic of P building can be seen in Fig. 7. The cumulative frequencies in the chart are for the time period from September 1, 2007 to April 30, 2008. The rooms P307.1, P309.2 and P312.2 are on the west side of the attic and the rooms P315.2 and P317.2 are on the east side.

As can be seen in Fig. 7 the median of the temperature range was rather high in all five rooms. Operative temperature of 20°C is usually considered in thermal loss calculations in the Czech Republic. Fig. 8 shows the cumulative frequency of temperature for four guest rooms in the R building. Unlike the guest rooms located in the attic (which is of timber-frame construction) the guest rooms in the R building have 1 meter thick external walls made of red bricks. The huge heat storage capacity of the walls has an impact on the distribution of temperatures that lie in much narrower band.

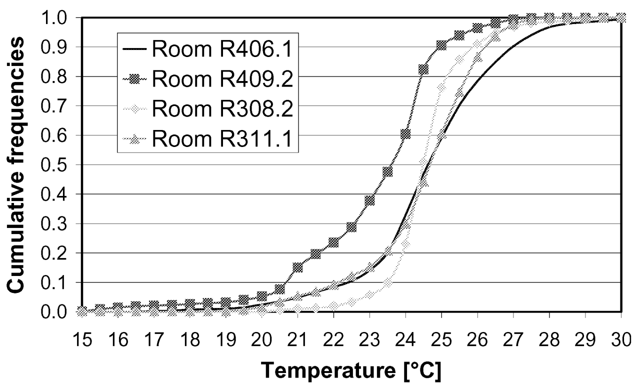

Figure 8: Temperatures (guest-rooms in R building)

4.2 Energy consumption

There are 20 electricity meters and 9 heat meters installed in the Brewery as part of energy consumption monitoring. The consumption of heat during the first year of the Brewery operation (April 1, 2007 to March 30, 2008) can be seen in Fig. 9 and the consumption of electricity is in Fig. 10.

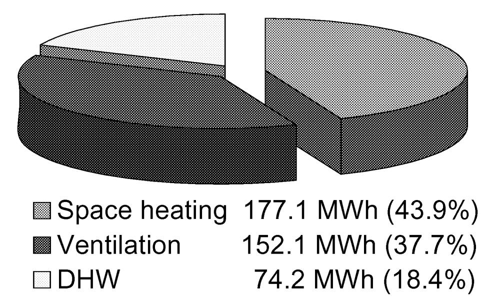

Figure 9: Measured annual consumption of heat

The heat consumption for ventilation represents the heat consumed by air-handling units. The total heat consumption for ventilation is actually higher because the guest rooms have a natural air supply and ventilation heat losses are covered by space heating.

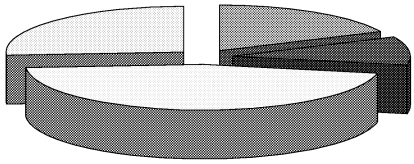

Figure 10: Measured annual consumption of electricity

Table 1: Annual energy consumption

Heating energy consumption [kWh/m² a]	
the Brewery	123.8
University buildings (average)	173.0
Electrical energy consumption [kWh/m² a]	
the Brewery	43.2
University buildings (average)	60.0

The comparison of energy consumption measured during the first year of operation of the Brewery with the average energy consumption of university buildings in the Czech Republic can be found in Table 1. The consumption of both heat and electricity in the Brewery was lower than the average consumption of university buildings.

4. CONCLUSIONS

The existing building stock in the developed countries offers a huge opportunity for energy conservation. The retrofit of the Brewery proved that even a very old building in a really bad condition can be retrofitted into a modern building with reasonable (lower than average) energy consumption. The cost of the retrofit was only a fraction of the cost of a newly built building. Moreover, a lot of embodied energy has been saved by the building retrofit in comparison to demolition and construction of a new building. The passive energy saving measures like additional thermal insulation of the building envelope and replacement of windows was a good step to start with. Not only that such measures reduce the consumption of energy for heating and cooling but they also have a positive impact on mean radiant temperature in the interior and they help to avoid moisture condensation problems. Heat recovery in case of the air handling units ventilating cafeterias showed to be absolutely necessary. The cafeterias operate longer time than originally expected and the consumption of energy for heating and cooling of ventilation air would otherwise be enormous. The sophisticated control and monitoring of the HVAC systems by the BMS is effective but the acquisition costs are still high. The additional value of the monitoring is the huge amount of performance data that can be used in facility management. First results from the monitoring of the photovoltaic system and the VRV air-conditioning indicate that the PV system produces more electricity on the daily basis that it is consumed by the VRV air-conditioning. However, on the hourly basis the production does not match consumption very well since the highest consumption of electricity for air-conditioning occurs in the late afternoon and evening when the occupants return to the rooms.

ACKNOWLEDGEMENT

The work leading to this contribution was supported by the EU commission under contract number TREN/04/FP6EN/S07.31038/503135 and the contribution itself was supported by the Czech Science Foundation under contract number 103/07/0907.

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