Optimization of Atria und Improvement of Planning Tools (ATRIEN II)

Short Report

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Funding

The Research Project was funded by Research Initiative ZUKUNFT BAU of the Federal Office of Building and Regional Planning (File Number SF – 10.08.18.7 – 09.18 / II 3 – F20-09-1-108)

1 Aim of the Project

The aim of the project is to analyze the impact of atria on the energy design and the energy efficiency of a building and to improve the integration of atria in the building. Furthermore planning tools like building simulation and CFD – simulation are tested for their ability and their kind of usage. The results of the research project find their way into a guideline for architects, planners and building managers. The analysis happens exemplary on the building of the LBS Nord, Hannover, Germany. The atrium of the building has transparent facades facing to east, west and horizontal direction, see Figure 1.It is neither cooled nor heated but ventilated by openings in the façade. The building was already analyzed in the research project ATRIEN I which has shown, that it has much potential for optimization due a optimal integration of the atria into the design of the building. The optimization tasks are being realized to show the general prospects for a better integration of atria into the energy design and to enhance the energy efficiency of atria buildings. The difficulties with steady RANS Simulations concerning the effects of wind and dynamic heat transfer in the building where highlighted.

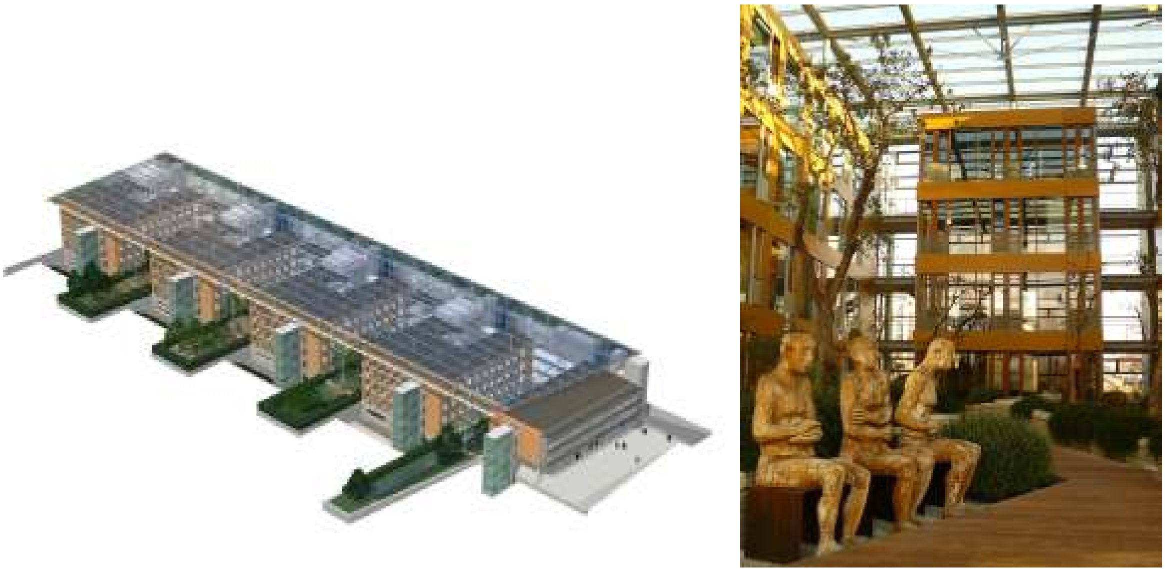

Figure 1: Exterior view of the LBS Nord; View into one atria.

2 Execution of the Research Project

Based on the results from Atria I the building of the LBS in North Kronsberg was studied in more detail, with the aim to implement optimization potentials due a new programmed control diagram for the building management system (BMS). Building simulation and numerical simulation programs support the optimization process and the applications and limitations of these planning tools are demonstrated. The continued monitoring was used to observe the effectiveness of the implemented measures. The metrological investigations include the measurement of temperatures in the atria and the adjoining offices. These measurements were complemented by short-term experiments in which changes in ventilation concepts were tested.

To evaluate the planning tools the results from the measurements have been opposed to the results of the calculations to show their ability and their application limitations.

A Large Eddy Simulation was done to show the effect of turbulent wind at openings on the air change inside atria which cannot be shown with steady RANS Simulations.

3 Results

For in-depth examination of the building it can be shown that there is much potential in reducing heat losses during the heating period, if solar preheated air from the atria is used for the ventilation of the offices instead using the mechanical ventilation with conditioned outside air. Furthermore the temperature of the atrium was limited in favour of the dormancy of the interior planting. Because of that the atrium was ventilated until the temperature reaches 12℃ or below.

The extensive overheating of the atria during the cooling period influenced negatively thermal comfort in offices and caused increased consumption of cooling energy. The ventilation openings were partly not in used since the BMS reacted with delay or the openings, like for example for smoke and heat exhausting system, were not integrated into the control system.

The new concepts for the BMS have been tested in advance. It is shown metrological that the natural ventilation of the offices to the atria during the heating period does not lead to a worse air quality. Furthermore numerical analyzes demonstrate that the mechanical ventilation is not necessary to fulfil the heating demand of the offices.

The LBS adapted the optimized concept for the BMS and integrated all available openings including the openings for the smoke and heat exhausting system in the all-day regular use. Several sensors of the BMS have been added or existing ones repositioned.

In the optimized concept of the ventilation of the atria is depending from the heating or cooling demand of the offices; whereas in the past it was regulated independently from the offices. Now during the cooling period the ventilation of the atria is maximized and night cooling is enhanced using thermal buoyancy effects. In the heating period thedormancy of the plants inside the atrium requires temperature below12℃ what made it necessary to ventilate the atrium. This raised the heat loss of the building unnecessarily. Now the time of the dormancy was minimized and the atrium is only ventilated in the area of the plants to avoid the cooling down of the whole air space.

The operating time of the mechanical ventilation is reduced during the heating period and the occupants should ventilate the offices by opening the windows to the atrium where solar preheated air is available. For the case of insufficient air change the CO_2 – guided mechanical ventilation system starts to operate.

Recapitulatory, through the better integration of the atrium in the energy concept the consumption of heating energy is reduced by 21 %, cooling energy is reduced by 2 % in relation to the average values from the preceding years.. Also the thermal comfort is enhanced.

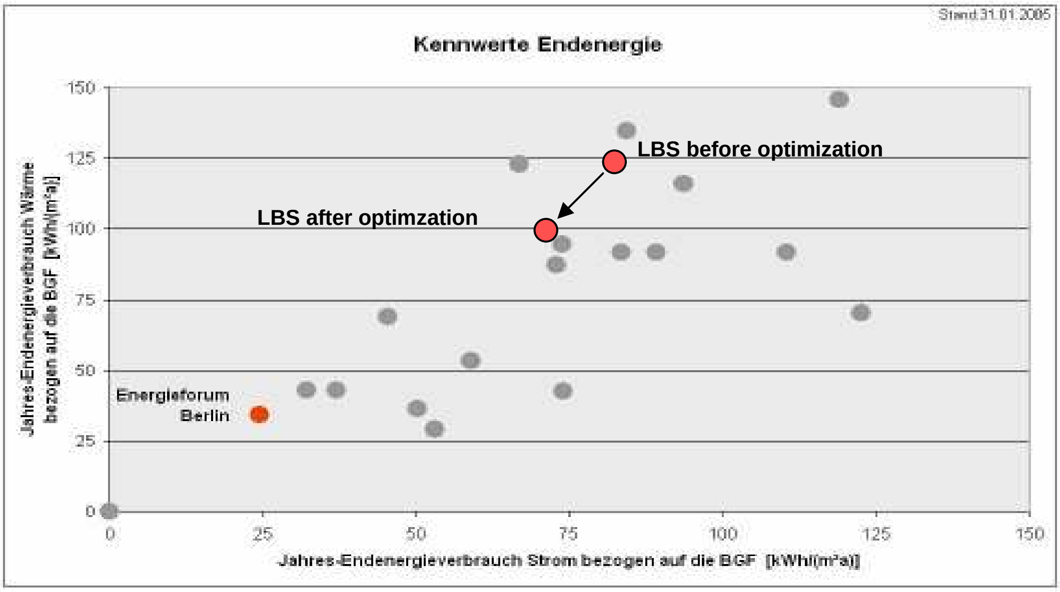

Figure 1: Energy consumption values of different non residential buildings (EVA 2005) Energy consumption values of LBS (Average of the years 2007 – 2010) and after Optimization (2011)

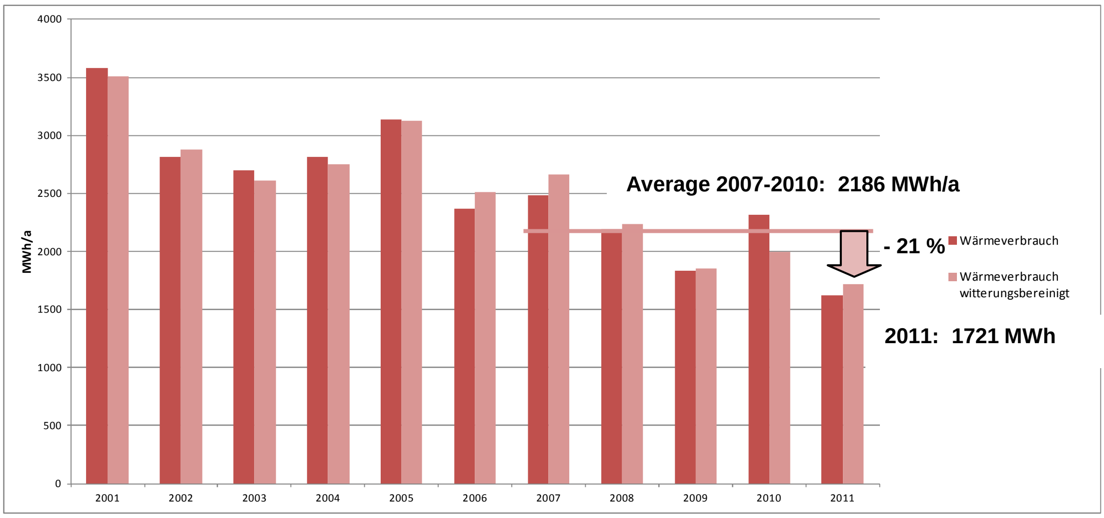

Figure 2: Total Heat Consumption of the LBS building. After Optimization in 2010 the energy consumption was reduced in the year 2011 by 21 % in relation to the average of the years 2007 - 2010.

By using CFD - and building - simulation programs for the design of atria there is a need to take into account the limitations of usage and in which ways it could be used, especially when the temperature level in atria should be predicted. Building simulation can be useful to calculate the boundaries for a steady CFD - simulation, when the effects of unsteady heat flux of the walls should be considered. If the summery indoor climate should be calculated by CFD, the thermal buffer effect is not negligible. Adiabatic boundaries are not suitable for this kind of calculations. The Large Eddy Simulation shows the wind effects on the air change. While it is an well established theory that wind enhances the air change, the simulations show that the pumping effects of an fluctuating turbulent wind can be counterproductive on the air change when thermal buoyancy effects are corresponding. Over that the turbulent effects inside the atria has massive impact on the air change efficiency. It is worthy of discussion how far RANS Methods are suitable for the calculation of wind -influenced effects of buoyancy driven air change in large air spaces.

The overall project of ATRIA I and ATRIA II closes with a guideline to plan and operate atria buildings. The guideline should help to avoid misconceptions and to use the planning tools in a right way. It takes aim to integrate an atria in a predominantly energy efficient way in the whole building. Atria can enhance the energy efficiency due a reduced heat loss during the heating season. But if the summery atria temperatures are exceeding the rising demand for cooling power it can overcompensate the savings in the heating season.

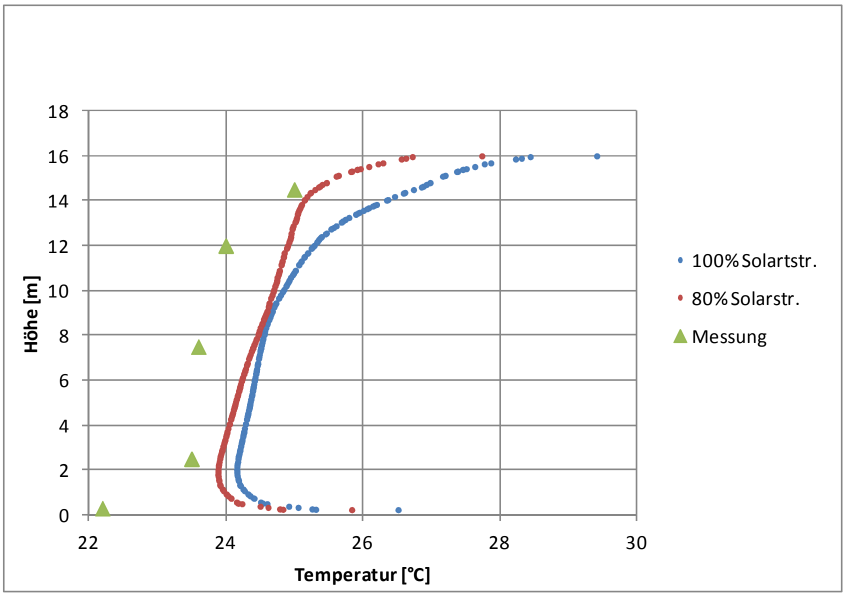

Figure 3: Opposing of the measured atria temperatures to the calculated. Also the temporary heat storage of the atria walls is described by a reduced solar radiation (80 % Solarstr.). For the reduced solar radiation the the measured values get closer to CFD - results. The discrepancy in bottom level shows that the absorbed heat energy is still underestimated.

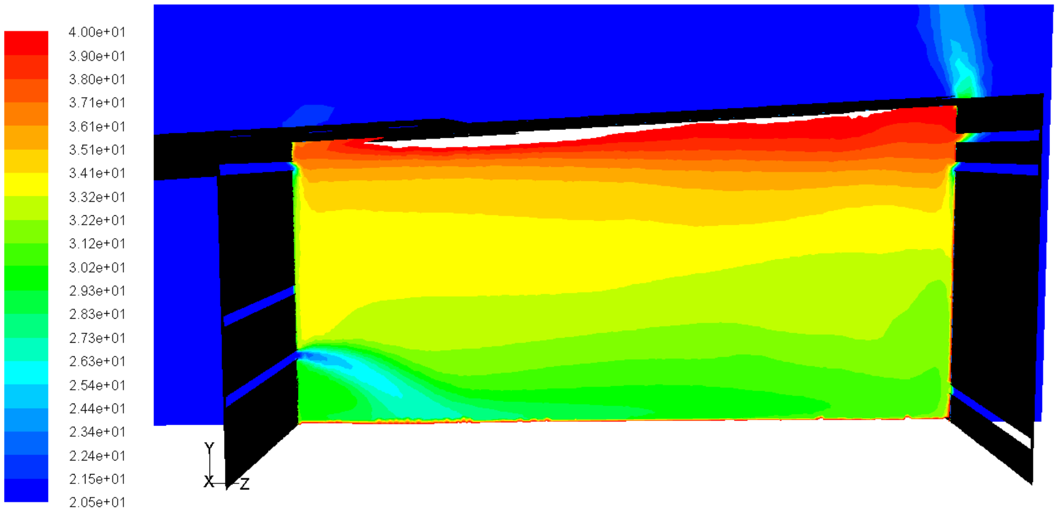

Figure 4: Air temperatures in the atrium under solar radiation and an outside temperature of 21 °C with all openings for ventilation in use