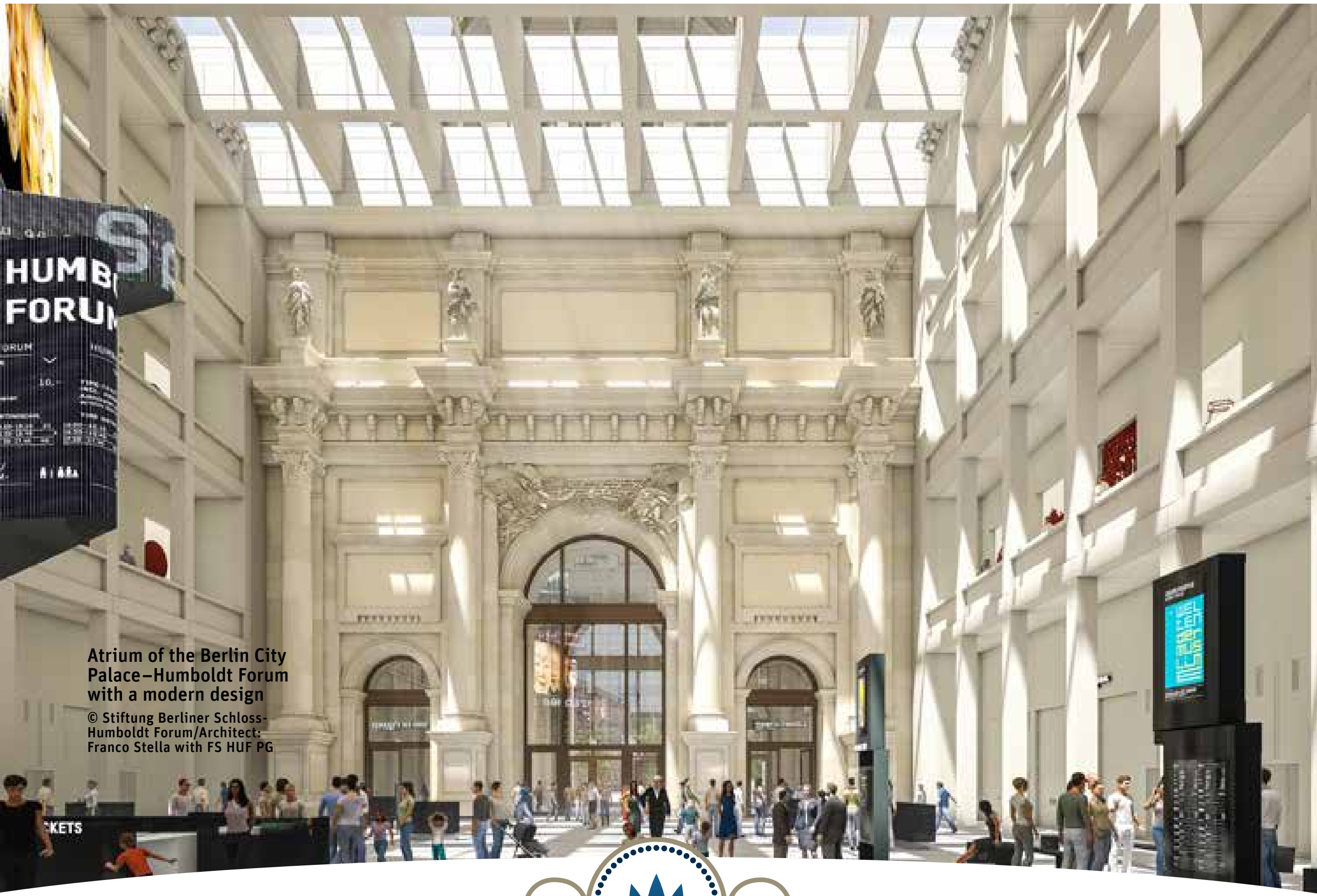

Atrium of the Berlin City Palace–Humboldt Forum with a modern design
© Stiftung Berliner Schloss-Humboldt Forum/Architect: Franco Stella with FS HUF PG

FIT FOR A KING

By **Donald Stubbe**, Project Engineer,
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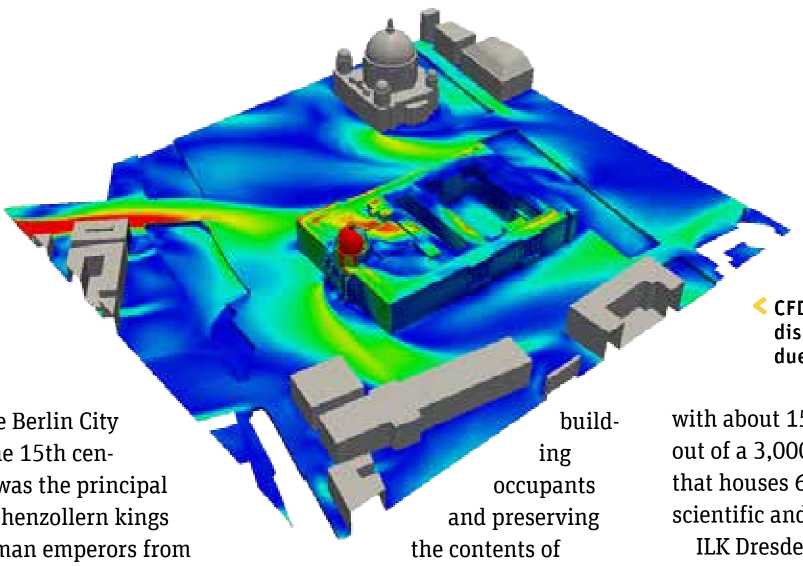
Designing the climate control system for the reconstruction of the historic Berlin City Palace required meeting many, often conflicting, requirements for energy conservation, human comfort, artistic preservation and cost. ILK Dresden engineers used ANSYS Fluent simulation to guide development of a design that matches all of these objectives.



CFD simulation results display pressure distribution due to wind load.

Construction on the Berlin City Palace started in the 15th century. The building was the principal residence of the Hohenzollern kings of Prussia and German emperors from 1701 to 1918. Heavily damaged in World War II and later destroyed by the East German government, today this important historic site is being rebuilt with three façades in the original design, and the fourth façade and interior in a new design by Franco Stella. The building, to be called the Berlin City Palace–Humboldt Forum, will house a museum of non-European art, a live theater, a movie theater, an auditorium and two restaurants. It is scheduled for completion in 2019.

Sustainability and energy efficiency were top priorities in the design of the building's heating, ventilation and air-conditioning (HVAC) systems. European regulations mandate that buildings constructed after 2014 consume 25 percent less energy than the previous state of the art. ILK (Institute of Air Handling and Refrigeration) Dresden was given the task of validating the HVAC system's ability to meet energy-efficiency regulations, while at the same time ensuring the comfort of building occupants and preserving the contents of the museum galleries. ILK Dresden engineers used ANSYS Fluent computational fluid dynamics (CFD) software to simulate the initial design and investigate alternatives. They proposed changes in the design that will provide 10 to 20 percent improvements in comfort and energy efficiency while maintaining the energy efficiency and cost of the original design.

INTERDISCIPLINARY EXPERTISE

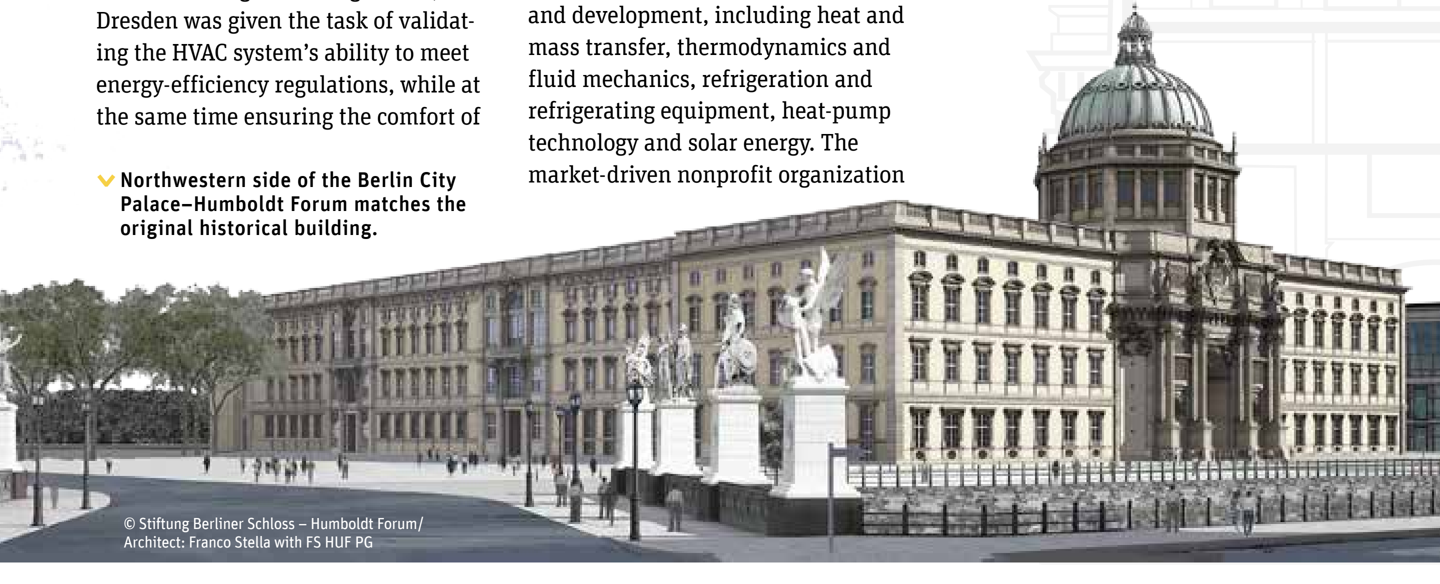
Triggered by the special challenges involved in this application, the building's owner asked ILK Dresden to develop an optimized equipment configuration to meet the requirements. ILK Dresden was selected for this project because of its interdisciplinary expertise in many fields of research and development, including heat and mass transfer, thermodynamics and fluid mechanics, refrigeration and refrigerating equipment, heat-pump technology and solar energy. The market-driven nonprofit organization with about 150 employees operates out of a 3,000-square-meter facility that houses 60 experimental and 25 scientific and technical labs.

ILK Dresden chose ANSYS Fluent for this project because the software has been proven and validated beyond other alternative solutions to the point that ILK engineers and its clients have complete confidence in the accuracy of its results. The software package also provides the full range of physical models needed to handle virtually any building simulation challenge.

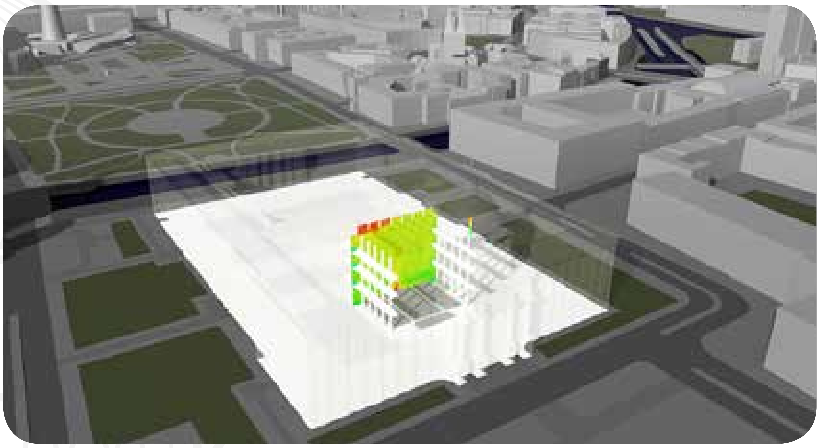
The simulation incorporated room air flow coupled with heat transfer and a solar radiation model. The engineers used climate data provided by the Deutscher Wetterdienst as boundary conditions for the simulation.

ILK Dresden engineers collaborated with the Dresden University of Technology (TUD) to make wind-tunnel measurements on a small scale model to validate the simulation of pressure

Northwestern side of the Berlin City Palace–Humboldt Forum matches the original historical building.



"Sustainability and energy efficiency were top priorities in the design of the building's HVAC systems."



Pressure distribution in isoplanes

distribution due to wind load around the building. ILK Dresden engineers modeled the air distribution system, including the supply air volume, velocity and temperature, as well as the physical locations of the supply diffusers and air-return registers. The manufacturers of each of the fans delivered detailed performance specifications, including fan characteristics that provided airflow as a function of pressure.

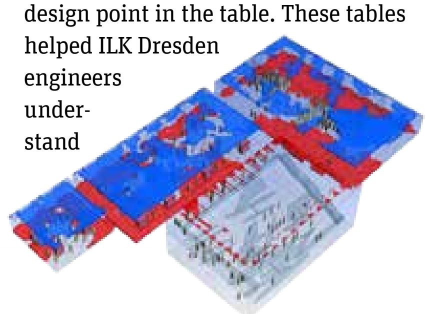
Engineers performed numerical simulations of the airspace in various exhibition, performance and meeting rooms for different usage scenarios and ambient conditions. For example, ILK Dresden engineers simulated one exhibition hall with different numbers of people as heat sources. They paid special attention to worst-case scenarios, such as the hottest and coldest days that could be expected in the Berlin climate.

The CFD simulation generated complete airflow patterns, including velocities and distributions of variables such as pressure and temperature, at all areas in the building. For spaces where the most critical concern is human comfort, engineers carried out simulation of room temperature, humidity and air velocity with particular attention to the draft risk as outlined in ISO 7730. ANSYS CFD provided graphics showing temperature mapped as color contour charts across horizontal sections at various levels above the floor. These results not only made it possible to determine the cooling performance of the design but also provided information that helped in understanding the reasons behind the design's performance.

ITERATING TO AN OPTIMIZED DESIGN

While the initial design met energy efficiency requirements, it did not perform as well as desired in the areas of human comfort and artwork conservation. ILK Dresden engineers performed design exploration using ANSYS Workbench to increase performance in areas in which the original design was weak. First, for each parametric study, engineers determined input and output variables. For example, where air velocity was too high in a particular space, they defined the location, dimensions and mass flow rate of the air supply as inputs, and air velocity in the critical space as the output. Then they assigned design points with different values for input variables.

When engineers clicked "Update All Design Points," ANSYS Workbench automatically triggered Fluent to solve each of the design points. The values of the variables were displayed for each design point in the table. These tables helped ILK Dresden engineers understand the sensitivity of the output to each of the input variables. This information was used in creating additional design iterations.



Constant values of relative humidity in selected areas of the building

CFD simulation played a key role in helping ILK Dresden engineers optimize the many, and often conflicting, requirements of the climate-control system. Engineers are confident that the palace will meet all requirements, including energy conservation, comfort, artistic preservation and costs.

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