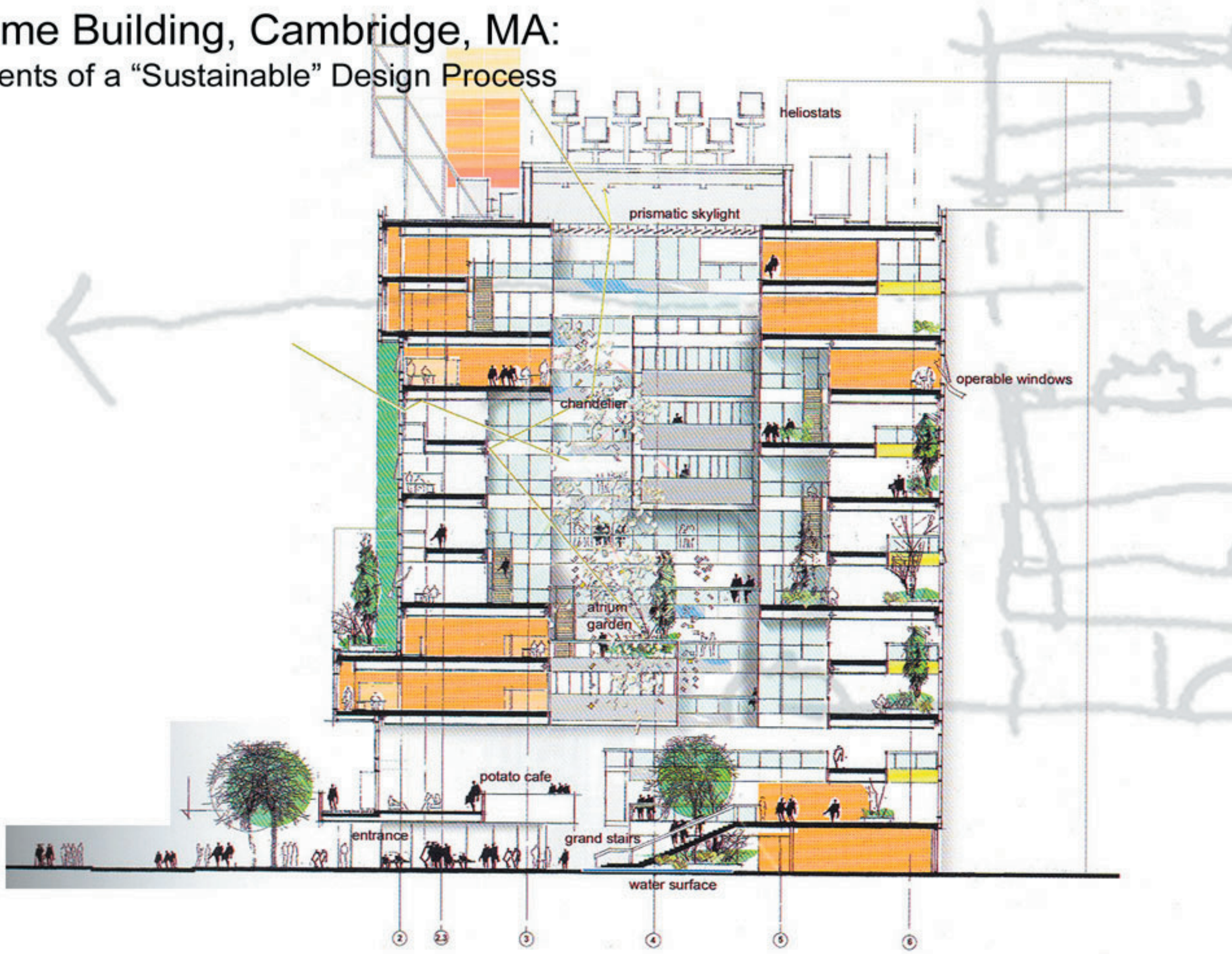
Genzyme Building, Cambridge, MA:

Components of a “Sustainable” Design Process



DEVELOPER: Lyme Properties of New Hampshire purchases 10 acre brownfield site and begins remediation

[MASTER] PLANNER: Urban Strategies of Toronto runs competition for mixed-use development

COMPETITION: Biotech firm Genzyme CEO Henri Termeer is already a committed client.

ARCHITECT Behnisch, Behnisch & Partner, of Germany and LA, begins working with ENGINEER Buro Happold of UK and NY.

Behnisch, Behnisch & Partner chosen for competition. GENERAL CONTRACTOR Turner Construction Company selected.

LOCAL ARCHITECTURAL PARTNER: Next Phase Studio, of Jamaica Plain, Mass.

WORK
DEGW,
LIGHTING CO
Bartenbach Li

sustainable design process

"How did they do it?" The Genzyme building defies barriers with a design process dependent on select variables: lease security, enlightened management, design expertise, research capabilities, interpersonal familiarity.

daylighting strategies

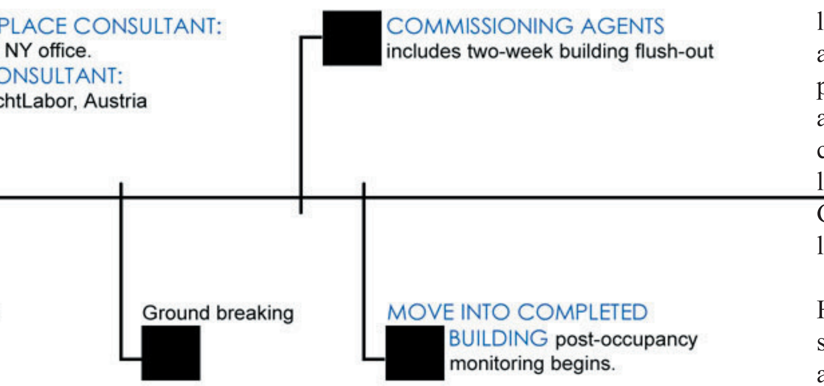
A multi-faceted lighting system was designed to optimize natural lighting while controlling solar radiation and glare. A system of seven heliostats on the roof reflect light into the atrium through fixed mirrors. Prismatic chandeliers both reflect and deflect the sunlight in the atrium space. Vertical lamellars create a light wall in the atrium, while horizontal lamellars control light on the perimeter south wall. This wall deflects the direct sunlight to reflective ceilings while diffusing light into office spaces. Lighting sensors monitor the natural lighting levels and dim the artificial lighting appropriately.

ventilation strategies

A large atrium relies on the stack effect to exhaust the building. Fresh air is available through operable vents in selected areas with a unique four-foot deep, inhabitable double-skin façade. If an occupant opens a window in an office, the air conditioning turns off automatically. Some windows are automated to open for night cooling. Mechanical ventilation delivers and exhausts air in the offices.

additional sustainable strategies

- The heating/ cooling system uses waste steam from a nearby power plant.
- Indoor gardens provide humidity and social space.
- Rainwater catchment reuses water in roof garden and evaporative cooler.



In critically examining the Genzyme building, one must explore the intent and effectiveness of its sustainable goals. This report asks three main questions:

1) What were the successes and hurdles in executing sustainable design process?

2) The ventilation and daylighting technologies are non-standard U.S. – how are they functioning?

3) How effective are the other "green" applications in the building?

Design Process

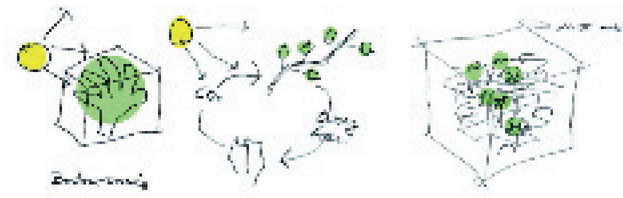
The Genzyme Building, a competition-winning design by German firm Behnisch, Behnisch and Partner, features astute lighting and ventilation technologies alongside a plethora of sustainable strategies, effectively executing "green" design in the US. This raises the question, "How did they do it?" Environmentally-conscious architecture often carries stigmas of an earthy aesthetic, higher costs, and undefined testing methodologies. The Genzyme building defies these barriers with a design process dependent on select variables: lease security, enlightened management, design expertise, research capabilities, interpersonal familiarity.

What set of conditions nurtured the seeds of sustainability?

In 1998, developer Lyme Properties purchased the 10 acre brownfield site and began remediation. In Genzyme's case, all of the soil was left in place and capped with the building's foundation. Next, Master Planners Urban Strategies of Toronto administered a competition for the mixed-use development, which consisted of a "hotel, housing, life science labs, office space, shops, restaurants, underground parking and open space." (Gould) The site goals include enhancing pedestrian life, creating a variety in building forms, and avoiding the sense of a homogenous corporate campus. "The competition brief had not stipulated sustainable design, but left room for it." (Gould) Within the competition jury, Genzyme CEO, Henry Termeer, committed to a relatively long-term lease with Lyme Properties.

Having a secured client proved pivotal to the execution of a sustainable design for several reasons. First, "Genzyme [is] an international company with image and worker comfort

photo sources: 1-Behnisch



Conceptual Diagram

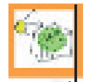
in mind and a Dutch CEO already open to sustainability" who served on the competition jury. (Gould) Secondly, Genzyme, being a long-term tenant, had motivation to invest in the building's sustainable technologies, above and beyond Lyme Properties' capacities. "If you create an open environment that makes employees feel good, the measure of the increased **productivity** is incredible," [Termeer] says, "People feel more creative and there is less turnover; people lose time when they are uncomfortable. We can justify the capital expense based on this." (Gould)

The building is designed as a "city within a city", concentrating on the individual's interaction with other people and his environment. Integration of gardens and control over one's lighting and climate enhance the occupant experience.

What were the hurdles in executing sustainable design? How were they overcome?

Amongst the designers, the key component to instilling confidence in the clients and contractors was experience – implying a good reputation and demonstrable projects. Engineer Tony McLaughlin, of Buro Happold, is a respected expert in the field, having successful projects with similar systems (such as Wessex Waterworks). Behnisch, Behnisch and Partner has designed multiple projects with heliostats, emphasizing that most of the technologies used are not new, just new to the US. The designers had to convince the contractors, who did not have experience installing certain systems, that they were build-able, operable, and economic.

A rigorous testing and research process proved the lighting and ventilation systems were both functional and superior to conventional design. Lighting consultants Bartenbach LichtLabor of Austria designed for maximum daylight penetration via a variety of technologies and reflective surfaces. Engineering firm Buro Happold (located in the UK and New York) is unique compared to many US firms in that it has the computational and physical testing and analysis capabilities required for a building with an atrium, double façade, and no mechanical humidification.



design process

"Green" design features are often eliminated because of budget constraints. How was this avoided?

In any project, budget constraints tug at the threads of the ambitious design fabric, threatening to unravel brilliant intentions. The Genzyme case was no exception, thus the design team had to demonstrate that the systems were mutually dependent on eachother, therefore one could not be displaced without affecting the others. For example, the designers had to resist the contractor's suggestion to change the concrete frame to a steel construction, citing that the concrete's thermal mass was vital to the success of night cooling in summer.

The contractor, Turner Construction, has made great strides in developing its green construction practices in a few recent projects. Their well-established relationship with Genzyme made Turner a logical choice for contractor and construction company. Turner learned how to install certain components for the first time while deciding that other suggested systems were not feasible. The Boston division of Turner Construction has the advantage of nation-wide offices from which it may draw on the expertise. As is the job of any contractor, Turner strove to keep the project within budget and on time, resulting in sub-optimal conditions for certain components, such as the vertical lamellar development and curtain wall selection. Turner lacked experience constructing two proposed systems, the raised floor and radiant ceilings, which were value engineered out of the final design.

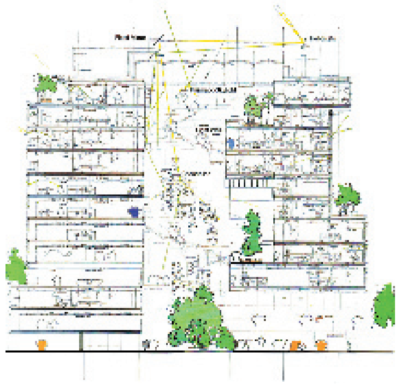
The architects also issued green specifications to insure the use of ecologically-responsible products and fulfill LEED requirements. Manufacturers and contractors responded to the challenge of meeting these sometimes unfamiliar specifications.

What is design team's role once construction is completed?

photo sources: 1-Behnisch

Completing the design and construction represents the majority of the labor required to execute a sustainable building, yet the commissioning and management determine the execution of the design intent. In addition to the intense commissioning process required for LEED certification, Genzyme's own engineers are collecting data and fine-tuning the high-performance building. The extensive building management system must be calibrated to reduce disturbance to occupants, determining the optimal dead-band in which temperature and light may fluctuate without response from the building's systems.

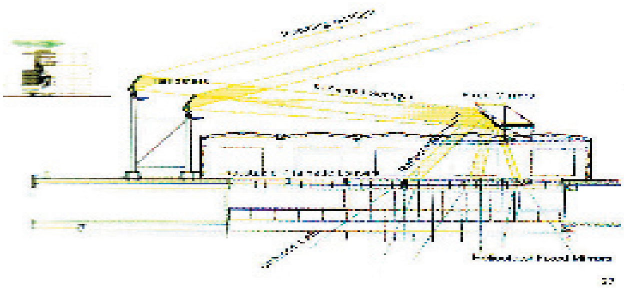
In conclusion, the effectiveness of the design process was dependent on the dedication of the individuals on the design team. The integrated design approach, including architect, engineer, client, and consultants from the initial design

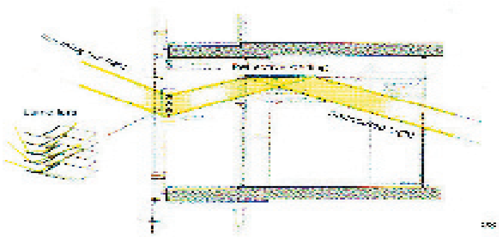


Lighting

What were the basic goals during the design process?

Bartenbach LichtLabor of Innsbruck Austria sought to bring natural lighting into as much of the building as possible. "Specifically, at least 75% of the building had to receive 2 percent daylight, and all workspaces had to have direct visual contact with the outdoors" (Architecture, 64)





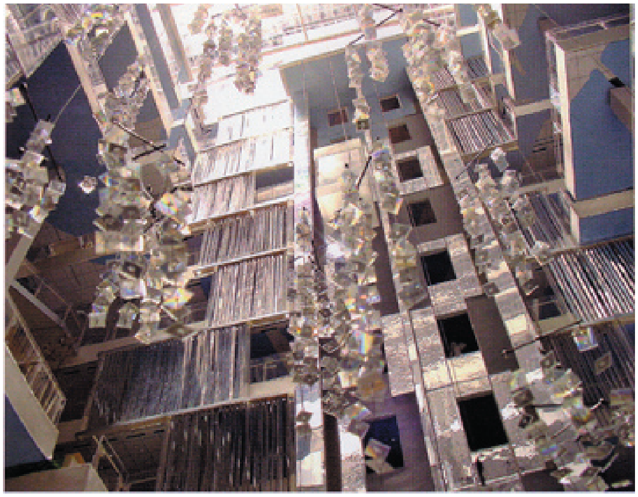
What are the main components of the lighting system?

Seven heliostats on the north side of the roof direct light to fixed mirrors on the south side. Light then is directed through a system of prismatic louvers made of milled acrylic. The louvers mechanically adjust to deflect UV light while diffusing natural lighting into the atrium. A chandelier composed of the same prismatic acrylic hangs in the atrium and also reflects and diffuses light deeper into the building. This moving chandelier, specifically designed for the building by Bohman Solar, casts rainbows throughout the atrium space. A light wall composed of vertical lamellars helps to both reflect light back into the atrium and allow light to pass through to the inner spaces, while providing views into the atrium. Reflective flowers on the ceiling redirect natural light form the atrium when available and artificial light from spotlights when needed. On the ground floor of the atrium, a reflective water pool continues the light distribution process.

Along the curtain wall, horizontal lamellars are mechanically adjusted by the control system. While the smooth surface reflects light up to reflective ceilings, the perforated surface sends diffuse light directly into the adjacent space. During full anti-glare mode, the lamellars can be completely closed, providing maximum shading.

Glass partitions separate working spaces, while allowing sunlight to be directed deep into the building.

photo sources: 1-Behnisch



How is the lighting system controlled?

The lighting system is fully automated, combining natural and artificial lighting. Sunlight and weather are measured by a weather station and the information is used accordingly. However, there is a dead-band for the system so the lighting is not continuously changing when clouds pass over, etc. While the system is programmed to maximize natural lighting, the artificial lights in the atrium are never turned off automatically during the day, providing at least 10% of the lighting needs. The automated system can be overriden manually to meet specific needs of individuals. For example, the shades can be lowered to eliminate any glare or the lights can be turned off for a presentation.

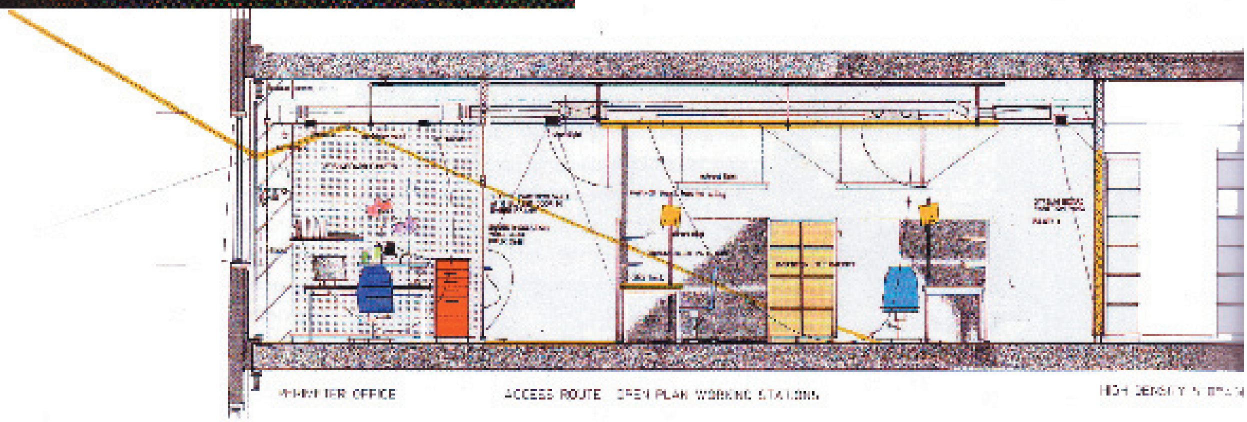
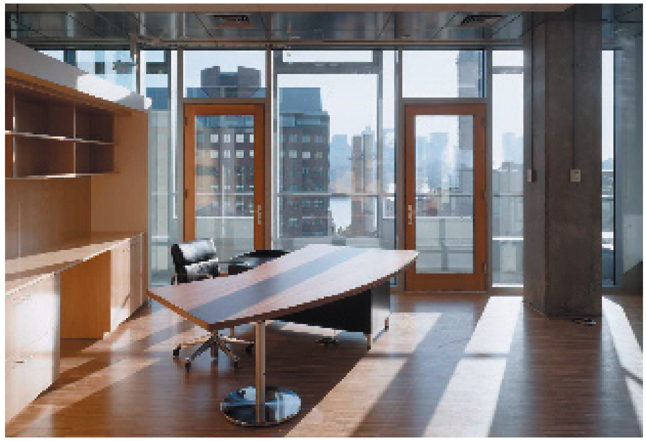


photo sources: 1-Behnisch, 2-Rick Ames, 3-Brown



How is this system working?

The system is projected to save 40% on electrical needs. Genzyme engineers are closely monitoring the system, but it is still in the fine-tuning stage.

In informal interviews, the employees all expressed their appreciation for the natural lighting and outdoor views provided by the system. However, there were a few concerns:

1. The lighting sensors sometimes malfunction and dim the lights in spaces that are inhabited.
2. To provide light deep into the building, most of the dividers are made of glass. While some enjoy this setup, others feel that it is distracting—especially in a meeting setting. In meeting rooms, there are curtains that can be pulled. However, when we tested these, the space felt much smaller and less pleasant.
3. The shades are loud when they adjust. This can distract employees or cause problems with meetings and conference calls.
4. The prismatic chandeliers cast moving rainbows around the building. While quite beautiful, again, some were concerned about distraction during meetings.

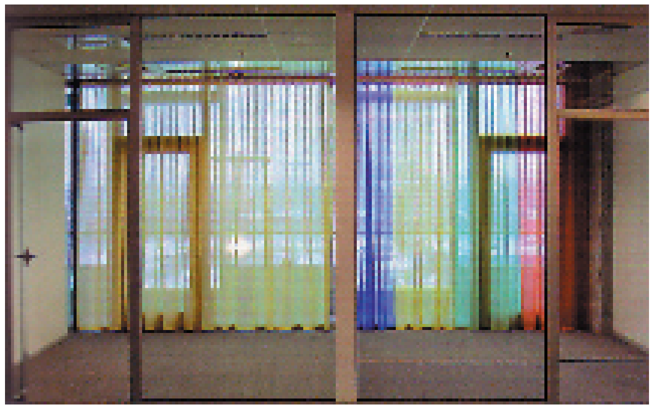
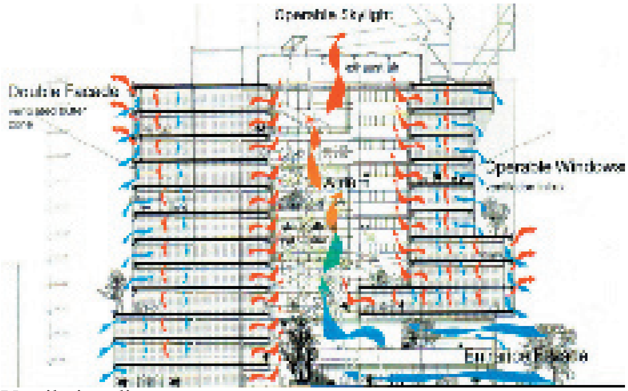
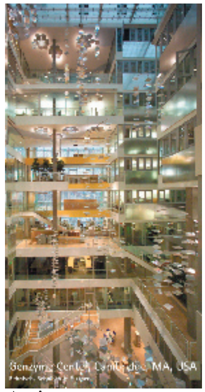


photo sources: 1-Rick Ames



Ventilation diagram


Atrium


Indoor Garden

Ventilation Analysis

The Genzyme building can be compared to a human body: sensory input from a roof-top weather station allows it to respond to environmental conditions by adjusting its lighting and ventilation systems. In addition to the mechanical air delivery system, the three main features that drive air through the building are the twelve-story atrium, the four-foot deep double façade, and the operable curtain wall windows. The ventilation system is a combination of user (manual) control and building management system's (automatic) control. How do these two coincide for comfort and energy savings? How might the resulting spaces serve to enhance occupant experience?

Ventilation Design Process: Calculated Risks

How was the ventilation system designed confidently?

The design process for hybrid ventilation (natural and mechanical combination) requires extensive environmental simulation in order to take calculated risks. Although this process is often expensive and time-consuming, it is entirely necessary to ensure that the building will perform as expected. In the case of the Genzyme building, engineers were able to eliminate a humidification system, calculating that the necessary humidity would be supplied by the people, plants, and water feature. The design process consisted of Computational Fluid Dynamics (CFD) models on select portions of the building; full-scale mock-ups of the façade, and manual calculations. It is estimated that the cost invested in the testing process will be recovered in the operational cost of the building in energy savings and occupants' increased well-being.

Atrium

Besides creating a beautiful space, how does the atrium result in a more comfortable space and energy savings?

The atrium provides light, air, views, and social spaces, bringing the building to life and venting air through the stack effect.

Occupants have control over their climate through thermostats and operable windows. In informal interviews, only one of six occupants reported uncomfortable temperatures. One useful suggestion: the management should send out a short email identifying "five things you need to know" about how to operate the building.

The atrium provides several opportunities for energy-saving techniques such as night-cooling and heat exchangers. First, the windows on the first floor may automatically open at night to flush out the building and cool the concrete frame, using its thermal mass to absorb the heat loads during the day, thus reducing the air conditioning demand. Secondly, during winter, the heat exchangers at the exhaust fans warm the incoming, mechanically delivered air.

How did the designers deal with fire codes that usually prohibit such a large continuous vertical open space?

In some areas, a glass wall separates the office floor plate from the atrium. Areas open to the atrium use standard roll-down fire shutters at the atrium perimeter. Over-sized exhaust fans at the top of the atrium pull smoke out of the building. The engineers struggled with the fire codes committee, urging them not to require an overly powerful exhaust system to prevent creating negative pressure that would make it difficult to open lower-level exit doors.

photo sources: 1-Behnisch. 2-Behnisch, 3-Rick Ames


Loggia lower vent


Loggia

How is the atrium functioning now?

Despite a thorough and rigorous modeling process, a building is destined to encounter unpredicted hurdles in operation. During the winter, the temperature differential drives the stack effect at such a high rate, that great negative pressure is created within the atrium. The curtain wall, although it is of higher quality than the base system in the US, has a thin thermal break compared to those in Germany; thus the management is now using thermal imaging to manage air infiltration at the lower levels. Having only been occupied during winter months, the atrium's summer performance is yet to be determined.

Inhabitable double façade

The four-foot inhabitable gap double façade (the "loggia")covers 32% of the building, adjacent to both private, enclosed offices as well as open office plan space. Conceptually, the outer, single-pane glass layer provides a buffer against the climate extremes, moderating the temperature fluctuations at the inner, double-pane glass. How does the space perform in different orientations, varying seasons, and as a social space?

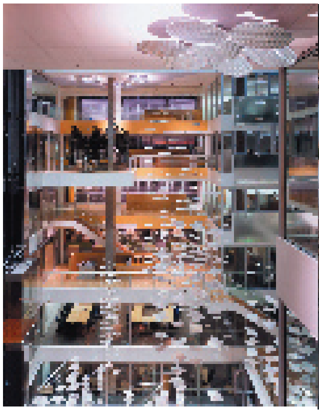
Does it make sense to apply the loggia on all façade orientations?

The placement of the loggia on all sides of the building appears to assume that the performance at all orientations, at all seasons will be desirable. Yet closer investigation reveals that the outer layer of spectrally-selective glass varies in transmittance according to orientation, admitting the most light on the north side and reflecting most on the south.

How does the loggia perform as an energy-saver or social space throughout the year?

The façade serves different purposes as the seasons change, while always acting as a moderator. In the winter, the airspace traps both the heat radiating from the building and the solar gain, acting as an insulator. Although the space does not fall below freezing, it is still too cold in winter to inhabit. Spring and fall are the optimal conditions for use of the loggia because of the variety of conditions that may exist. The lower vents may be manually opened and the top vents are automatically controlled with the assistance of the thermostat in the space. The doors to the loggia may be manually opened for more cooling and airflow in the office. Or, the doors may be shut and the vented cavity keeps the inner building façade at a much lower temperature than the outer façade. During this time, it can be assumed that the loggia temperatures will be comfortable to inhabit. In the summer, the loggia will be sealed off from the offices and be continually vented to keep the inner window cooler than the outer window. The south, east, and west loggias are assumed to be too hot to inhabit during the summer. In conclusion, a tighter seal at the vents would allow for greater insulative properties, and the loggia is probably an inhabitable social space on moderate spring and fall days. This poses the question, does the material expenditure pay itself off in energy savings? Also, does the loggia afford any social space not provided by the gardens, huddle rooms, and coffee areas already provided?

photo sources: 1-Rick Ames

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Additional Technology

What are some of the other 'green' aspects of the building?

A garden and photovoltaic cells are located on the roof. These were added late in the design. The cells provide enough electricity for about one or two rooms and it seems likely that the main motivation for them was LEED certification.

Gardens are also located throughout the building, providing pleasant common spaces and humidity for the entire building. Additionally, the gardens have soil sensors to detect irrigation needs.

Stormwater is collected into two separate tanks. The first provides water to the gardens while the second supplements the evaporative cooling towers, saving thousands of gallons of potable water each year.

Other water-saving technologies incorporated in the building are the waterless urinals and dual-flush toilets.

The building's central heating and cooling systems run on steam that is byproduct from the electrical plant that is located next door. The steam translates directly into is heat in the winter and powers absorption chillers in the summer.

And finally, there are charging stations for electrical cars located in the parking garage.

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photo sources: 1-Rick Ames