



BUROHAPPOLD
ENGINEERING

A LEED PLATINUM TOWER THAT'S
THE GREENEST IN THE WORLD

THE TOWER AT PNC PLAZA, PITTSBURGH, PA

SMARTER GREENER

LEED PLATINUM CERTIFIED

VISION

PNC Bank is a pioneer in environmentally responsible development and operations, with the largest portfolio of LEED-certified buildings of any company worldwide. With its new headquarters building, PNC aspired to create “the world’s greenest office tower,” foster workplace innovation, and contribute to a vital downtown district in Pittsburgh.

CHALLENGE

Establishing a new benchmark for high-performance office towers, one that exceeds LEED Platinum criteria, required a rigorous exploration and testing of advanced design strategies. By applying digital design and modeling tools as well as investing in full-scale mockups of key building components, the project team identified the optimal form, orientation and building systems for The Tower.

SOLUTION

Analysis of a broad array of factors informed the design—from prevailing city winds and solar orientation to workplace habits and interior air quality. Passive design strategies—focused on the building’s form, orientation and enclosure—paired with energy-efficient active systems for optimal performance. An automated double-skin facade allows daylighting throughout the workspace, working in tandem with a central solar chimney providing natural ventilation.

VALUE

The integrated design brings natural light to more than 90% of work areas, and allows natural ventilation of workspaces for up to 42% of the year—reducing energy use by as much as 50% and providing a healthy, supportive environment for PNC’s employees. Equally important the open, welcoming tower is a good neighbor to downtown Pittsburgh, spurring renewed investment in the area.



The Tower at PNC Plaza Pittsburgh, Pennsylvania

Owner:
PNC Bank, National Association

Design architect:
Gensler

Construction Manager:
P.J. Dick

Structural and MEP Engineer:
BuroHappold Engineering

Facade Consultant:
Heintges & Associates

Sustainability Consultant:
Paladino & Company

Tenant:
PNC, and street level retail

Developer:
PNC Realty Services

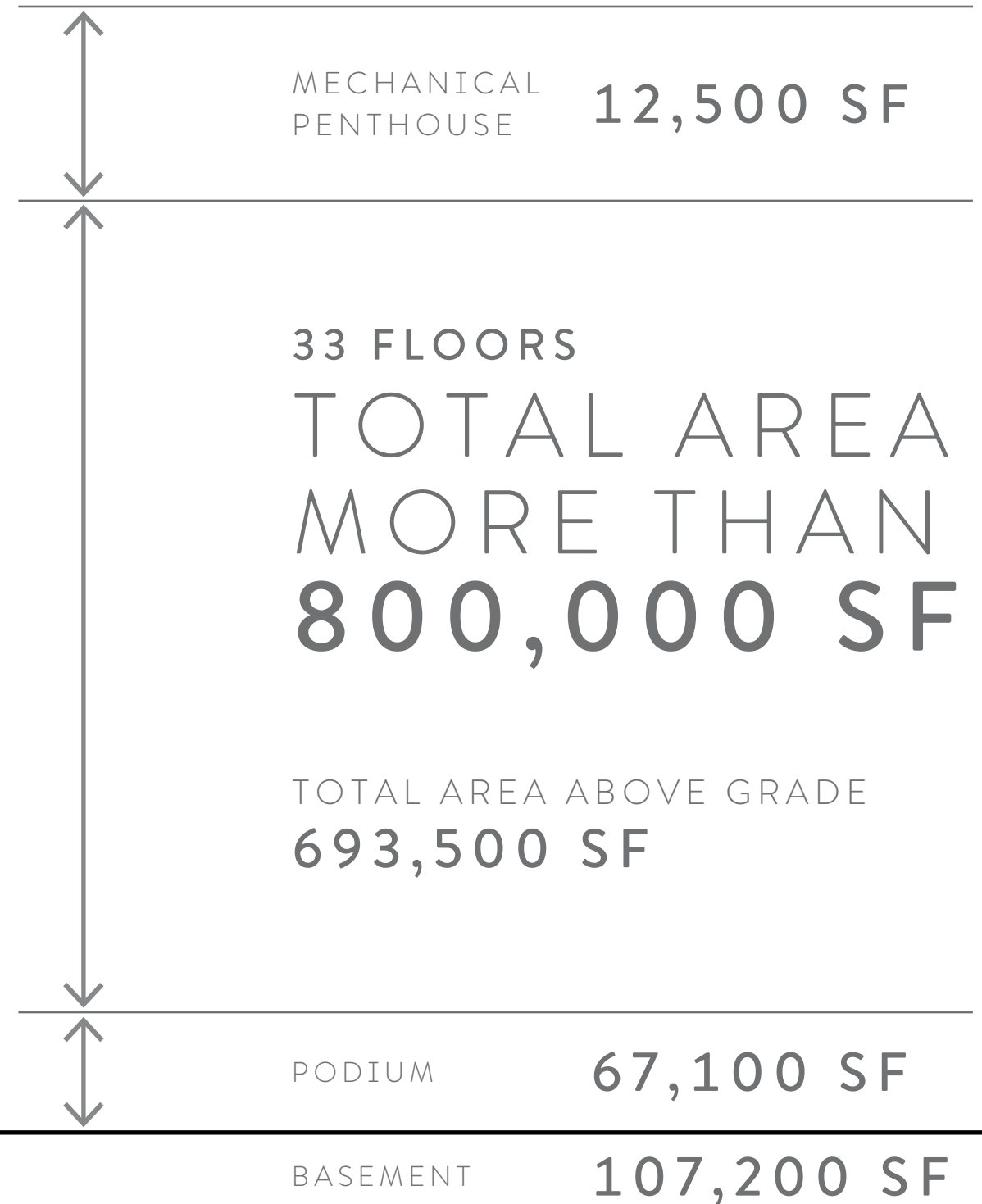
BUILDING FACTS

Image: Gensler



NORTH ELEVATION

WEST ELEVATION



PROJECT GOALS AND ASPIRATIONS

THE THREE PILLARS

As a leader in environmentally responsible business practices, PNC embraced three central goals that drove The Tower's design.

ENERGY RESPONDERS

50% reduction in energy use compared to a typical office building (2007 version of the ASHRAE 90.1 standard).

42% of the year that The Tower will operate with natural ventilation (based on temperatures below 62°F and humidity under 60%).

92% portion of total floor area that is naturally lit (at an expanded illuminance level of 150 lux).

77% reduction in potable water use achieved through advanced treatment and recycling systems.

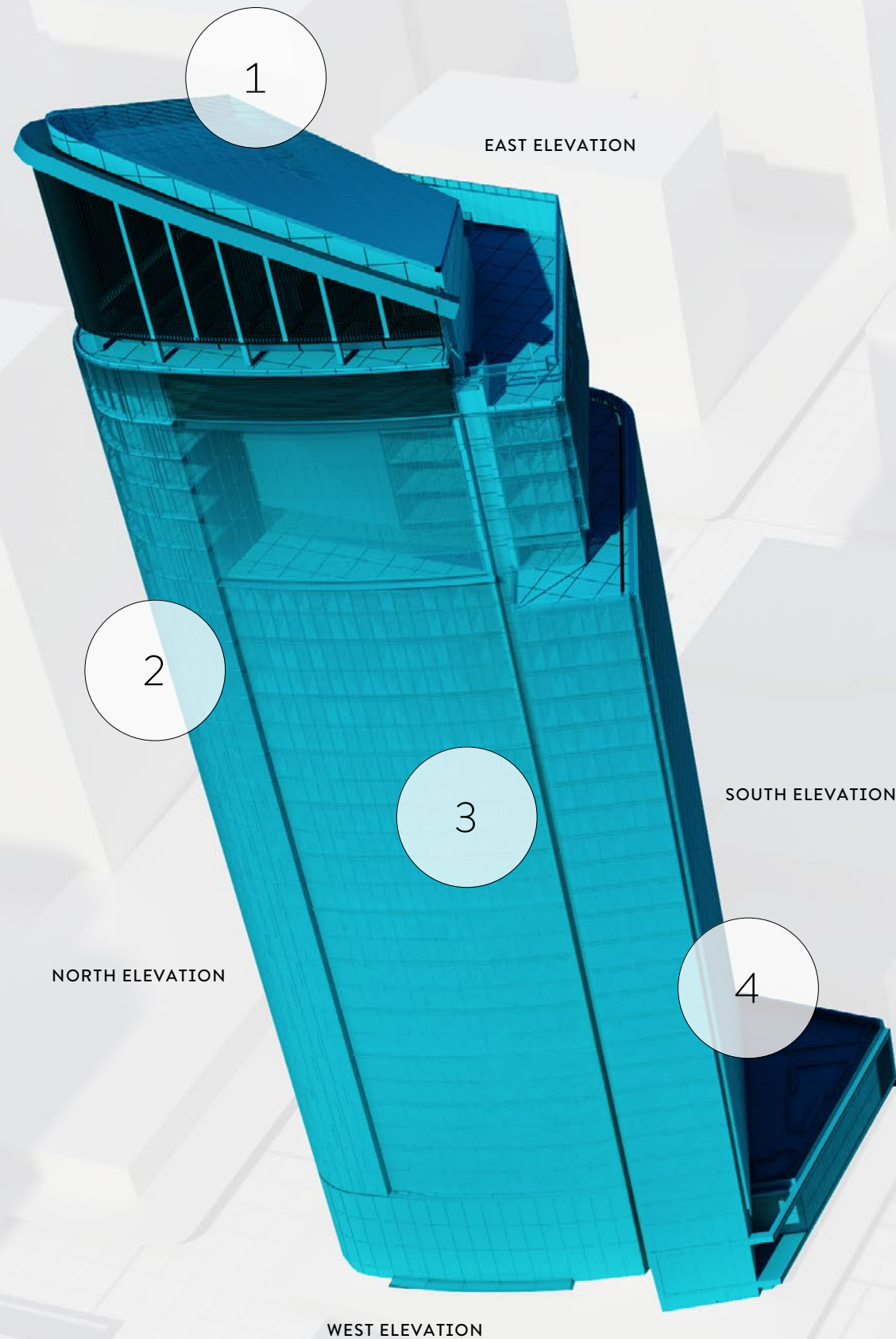
- The Tower raises the bar for sustainability development encouraging others to follow.

WORKPLACE INNOVATOR

- Custom-designed workstations with stilted legged seating and privacy screens allow air to circulate while low above-desk partitions allow in natural light.
- Operable doors, localized thermostats, and automated blinds allow employees to adjust light, air and temperature in their work areas.
- The integrated design maximizes employees' access to fresh air, natural light, and amenities—workplace characteristics shown to improve staff satisfaction and reduce absenteeism and churn.
- Each two-floor “neighborhood” shares a double-height, column-free collaboration space with city views and natural light.
- Computational fluid dynamics modeling confirmed that the furniture layouts would allow natural ventilation to reach nearly all office occupants.

COMMUNITY BUILDER

- The Tower at PNC Plaza is a catalyst for renewed investment in downtown Pittsburgh.
- The open, transparent lobby creates an “urban room” and engages the surrounding streets and neighborhood.
- The Tower's form and overall transparency—made possible by the building's innovative systems—underscores a sense of connection with the city.
- The Tower is one of six properties that PNC has committed to the Pittsburgh 2030 District, a community of high performance buildings in downtown Pittsburgh that aims to reduce energy and water consumption and transportation emissions by 50% by 2030.
- The building's water treatment and recycling system will divert the majority of The Tower's storm and waste water from Pittsburgh's sewer system, reducing its impact on the city's infrastructure.
- At the 28th floor, a five-story-high, column-free indoor park offers a place for respite amidst expansive city views.



PASSIVE FIRST

To achieve the highest level of performance and reduce The Tower's energy demand, BuroHappold focused first on passive strategies that could handle as much of the remaining energy demand as possible. Active building systems were then designed to bring The Tower to optimal performance.

1 FORM

Shape top of The Tower for optimal solar chimney performance, and architectural form.

2 ENCLOSURE

Integrate double-skin facade for added thermal buffer and natural ventilation.

3 ZONES

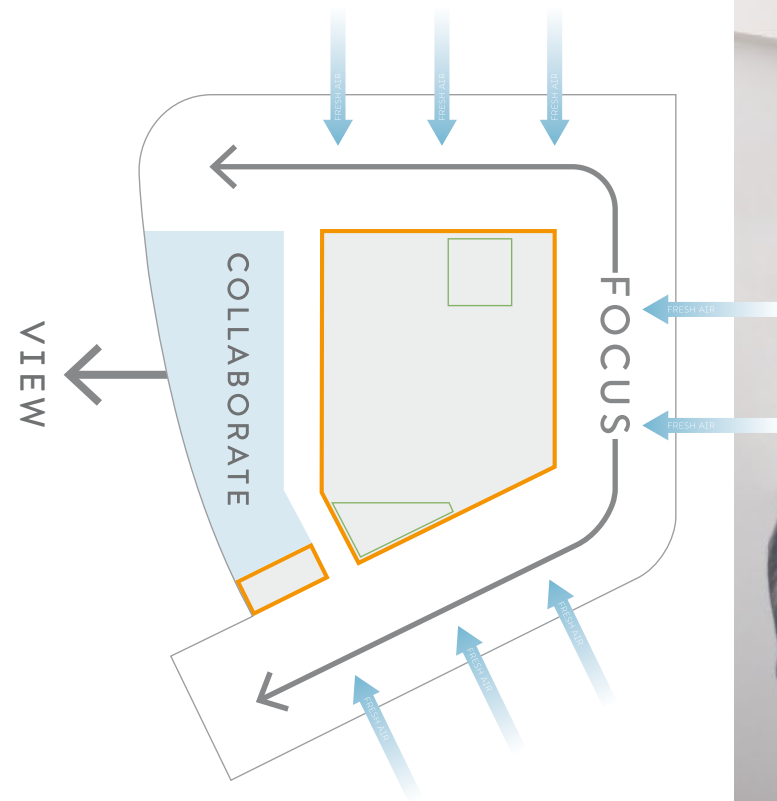
Divide The Tower into a vertical stack of smaller working communities. Introduce a gradient of thermal zones, buffering the west facade.

4 ORIENTATION

Reduce the typical lease span and orient the south facade for optimal daylighting.

2 STORY NEIGHBORHOODS

The Tower is divided into “neighborhoods” comprising two floors joined by double-height collaboration spaces. These west-facing shared spaces enjoy city views and work to buffer the rest of the floor from afternoon sun.

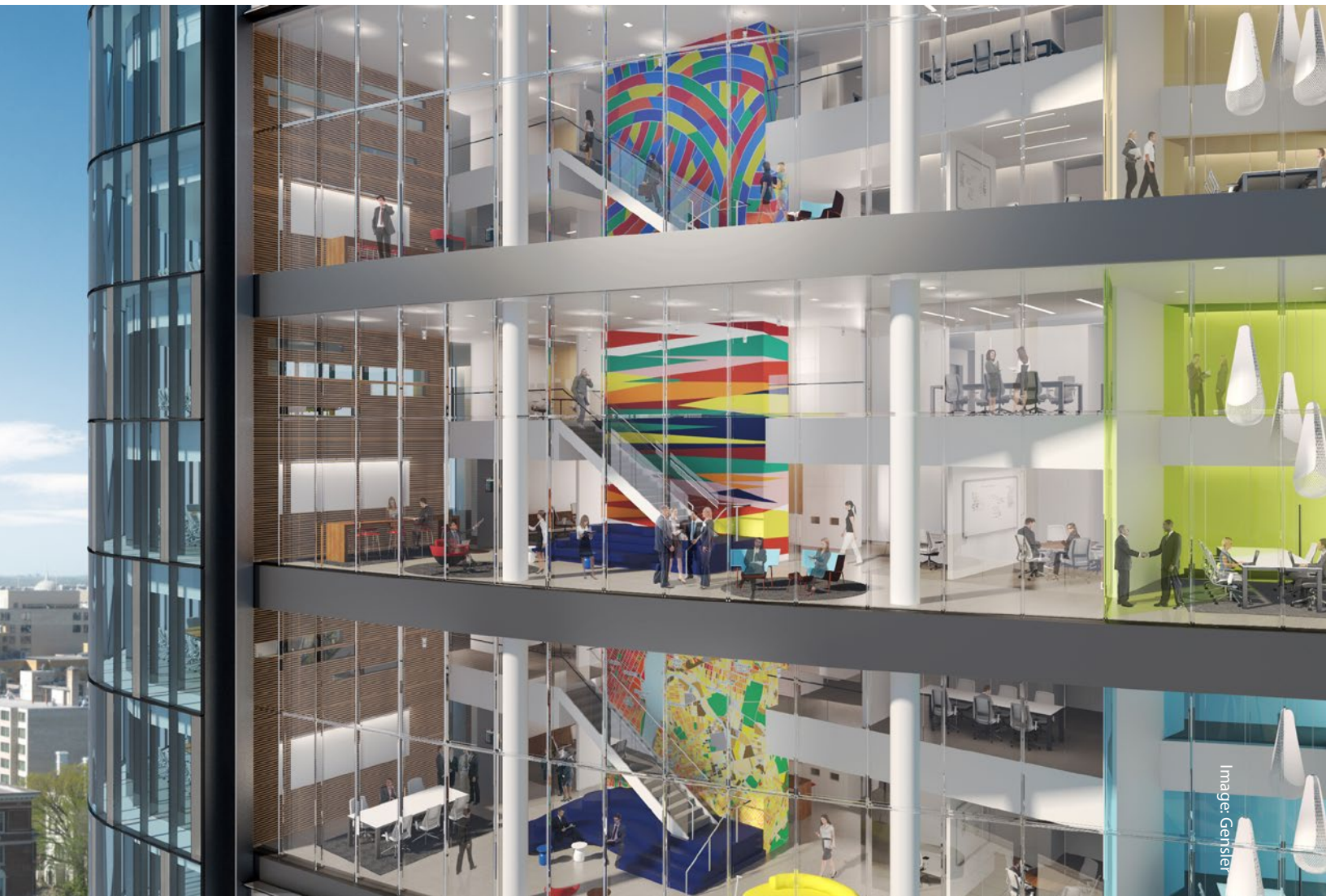


STRATEGIC LOCATIONS OF PROGRAM



Image: Genster

DOUBLE-SKIN FACADE



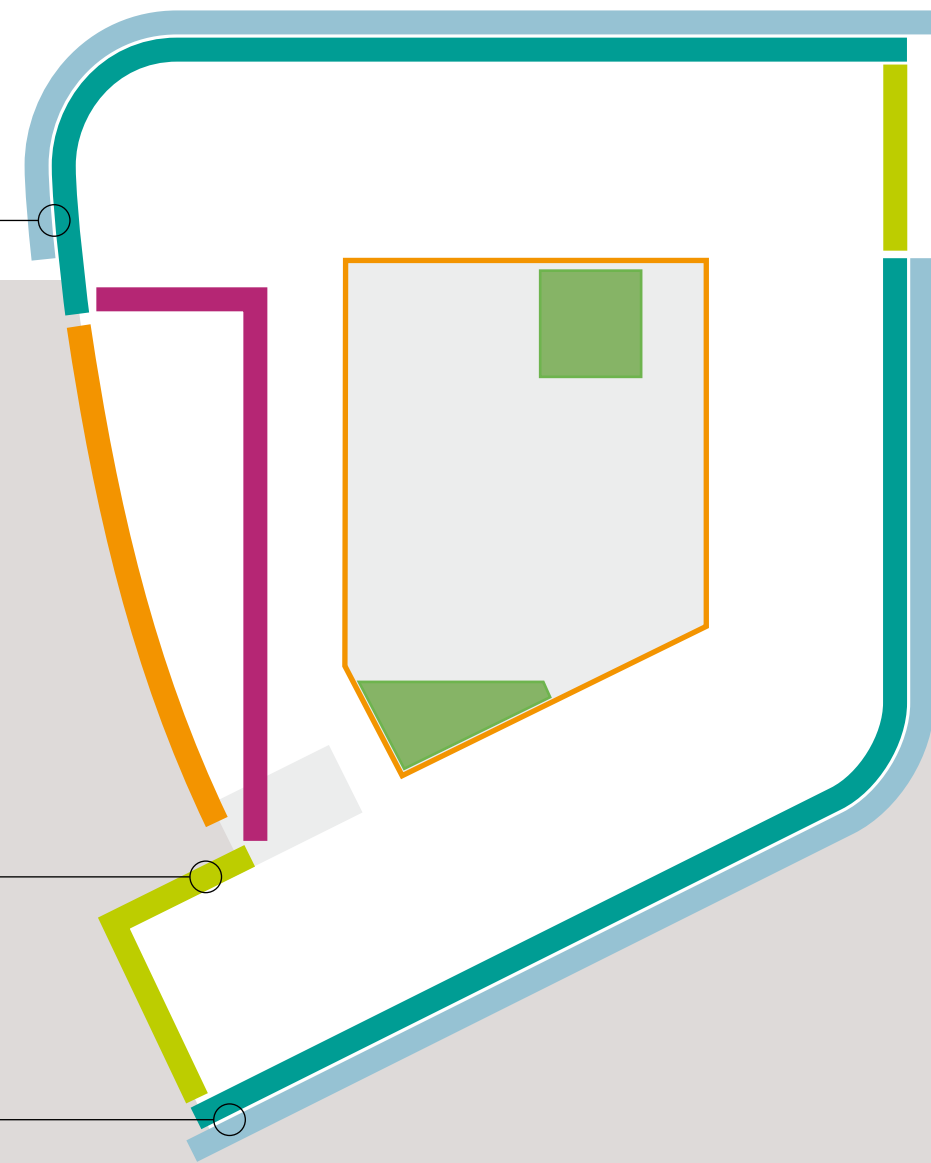
The Tower advances the use of double-skin facades in the United States, employing two different types of double-skin facade assemblies to enclose more than 90% of the building. It currently is the country's only fully-automated double-skin facade.

Conceptually, the building is wrapped in a double wall that compresses and expands at different conditions.

The operable double-skin facade defines a wide, 30-inch cavity that insulates the building and facilitates natural ventilation. "Popper" windows in the exterior skin and "flopper" vents in the interior skin, open automatically to allow fresh air in.

A "skinny" double-skin facade, with a much narrower cavity, insulates other parts of the building.

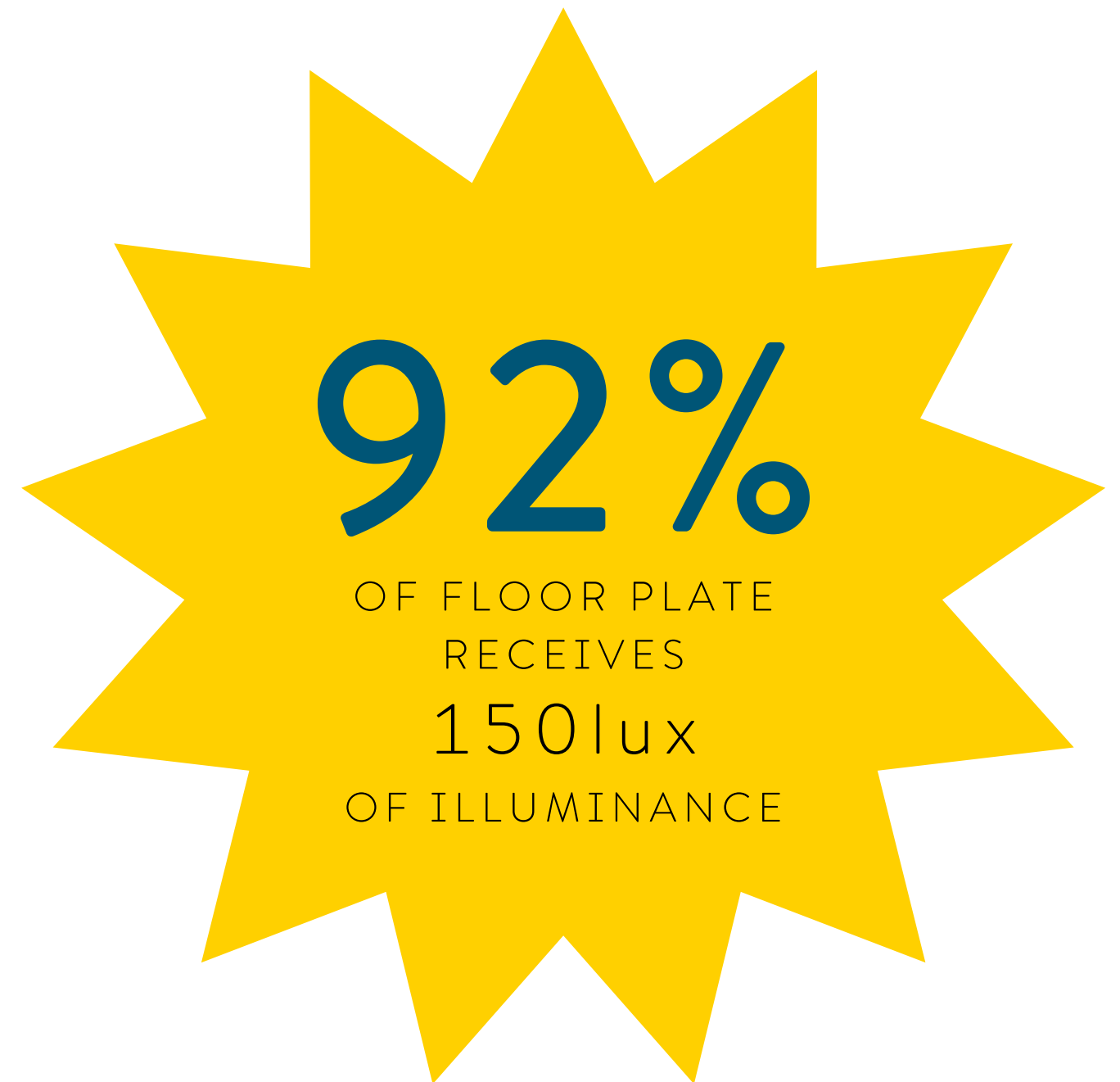
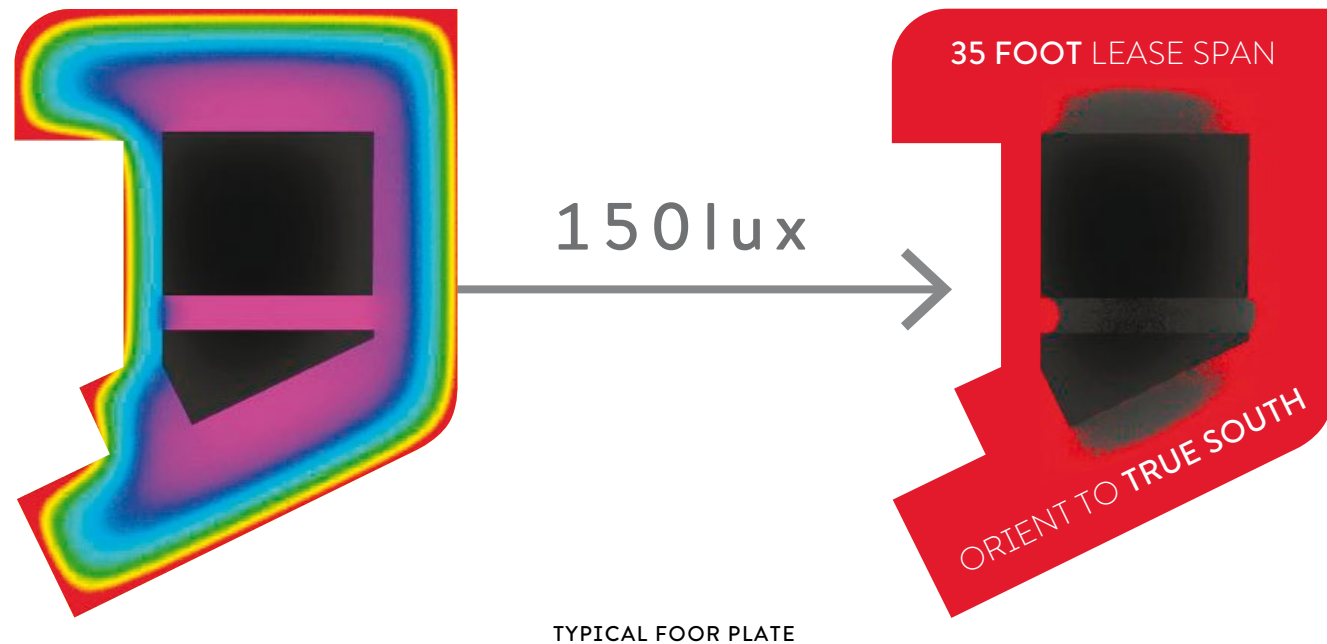
Blinds set between the two window walls reduce glare and heat gain without blocking daylight or views to the outside.



- DOUBLE FACADE OUTER LAYER
- DOUBLE FACADE INNER LAYER
- CABLE WALL
- SKINNY DOUBLE FACADE
- ATRIUM INNER WALL

ALTOGETHER BRIGHTER WORKING

WHAT IF THERE WERE NO
ELECTRIC LIGHTS REQUIRED?



The reduced lease span, oriented to true south, allows 92% of the floor plate to reach an illuminance level of 150 lux with daylight alone, while 67% achieves an illuminance level of 300 lux, the conventional measure. 150 lux is considered sufficient for most office tasks.

THE SOLAR CHIMNEY

A BUILDING THAT BREATHES

Composed of two vertical shafts within the building core, topped by a 5,000 square foot glass box angled southward towards the sun, the solar chimney helps to heat and ventilate The Tower with minimal energy. On warm days, the solar chimney creates a draw, pulling fresh air in through the operable facade, up through the shafts, and out through the top—providing natural ventilation without the use of mechanical fans. During cooler weather, the skylight box preheats air before it is drawn into the building. The Tower is one of the first high-rises in the U.S. to incorporate a solar chimney.

- The solar chimney and operable double-skin facade work together to heat, cool and ventilate The Tower.
- **Natural Ventilation:** When outdoor conditions are ideal, primarily during spring and fall, both the poppers and floppers open to allow fresh air into the occupied spaces.
- **Cooling:** During warm weather, the poppers will open while the floppers remain closed. This allows fresh air to enter and cool the cavity, helping to maintain indoor temperature.
- **Heating:** On cold days, the poppers and floppers will remain closed allowing the double-skin facade to provide an extra layer of insulation.

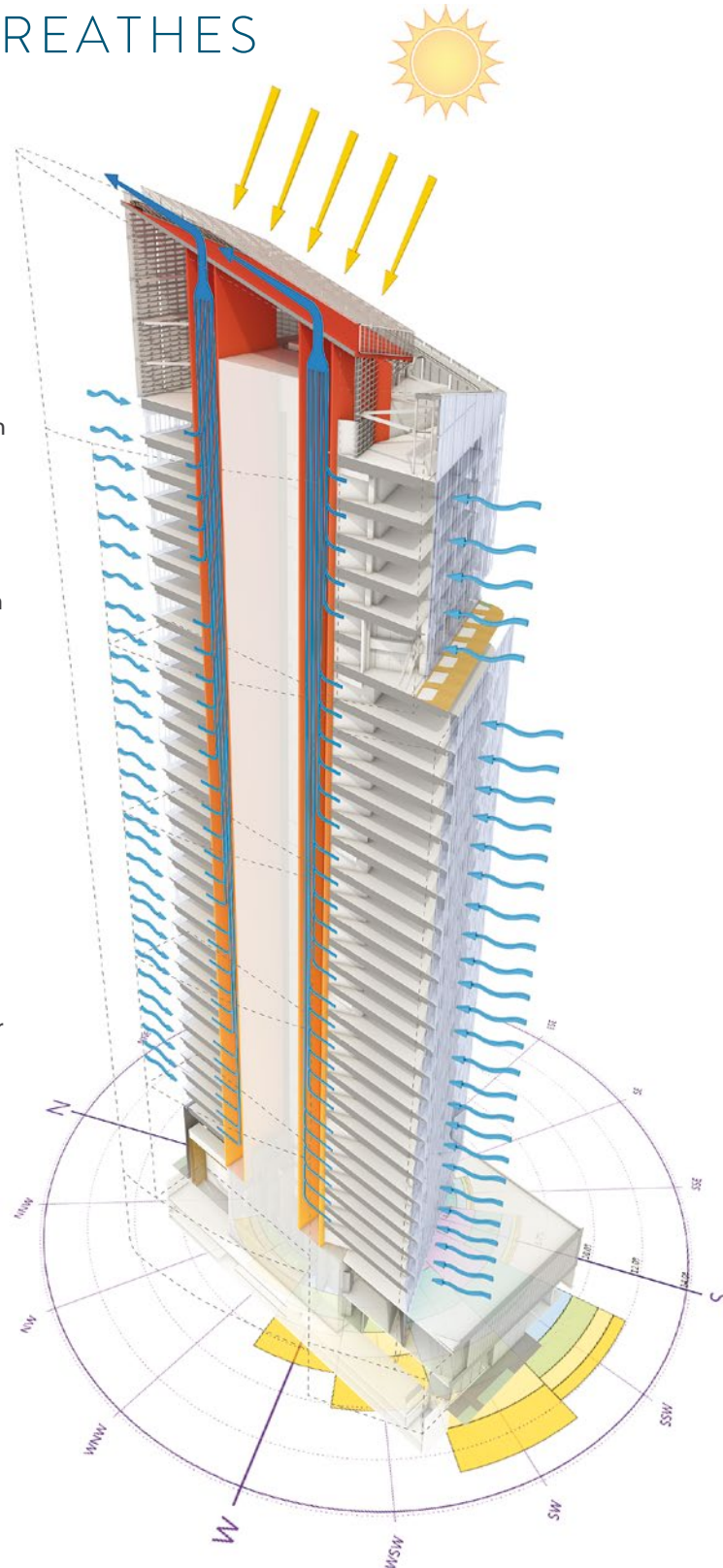


Image: Gensler

11%

PERCENTAGE INCREASE PRODUCTIVITY OF OCCUPANTS (RANGE FROM 1% TO 11%) IF GIVEN ACCESS TO NATURAL VENTILATION (FAST COMPANY, MAY 2011)

150%

BASED ON A CORNELL STUDY, PERCENTAGE INCREASE IN TYPING OUTPUT ALONG WITH A 44% REDUCTION OF ERRORS IF OFFICE TEMPERATURE INCREASED FROM 68° TO 77°.

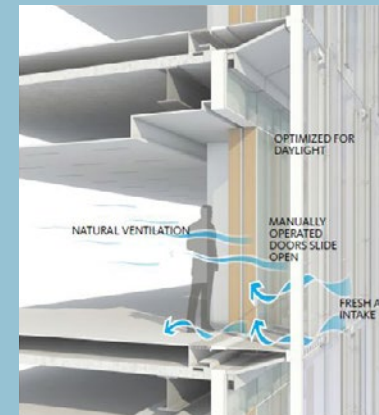
42%

PERCENT OF WORKING HOURS THAT THE BUILDING IN PITTSBURGH COULD RUN IN PASSIVE NATURAL VENTILATION MODE.

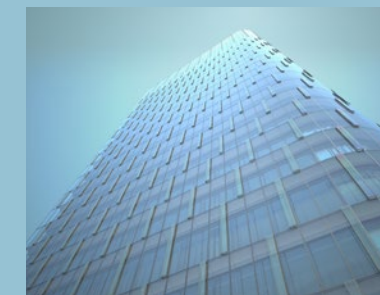
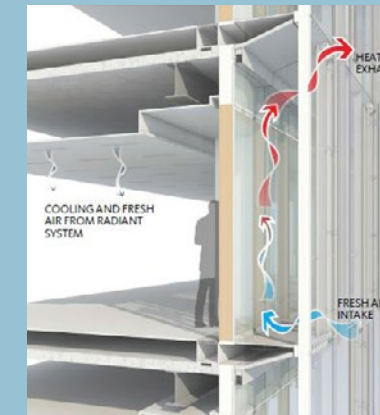
(BASED ON TEMPERATURES BELOW 62°F AND HUMIDITY UNDER 60%)

80°F

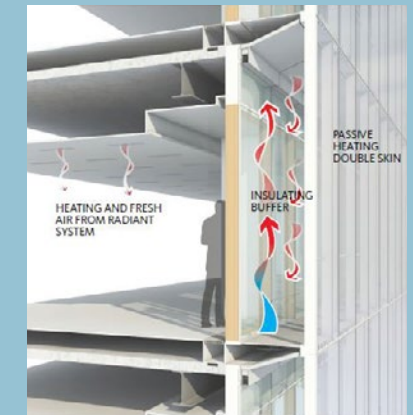
ASHRAE GUIDELINES ALLOW UPPER LEVEL OF TEMPERATURE SET POINT TO BE RAISED FROM 75°F TO 80°F, IF OCCUPANTS HAVE ACCESS TO OPERABLE WINDOWS.



PASSIVE MODE
A NET-ZERO DAY



HEAT FLUSHING MODE
SUMMER



THERMAL BUFFER MODE
WINTER

Images: Gensler

ACTIVE SYSTEMS

These passive design strategies work in tandem with active systems—including dual-wheel energy recovery air handlers, high-efficiency condensing boilers and chillers, and an efficient dual-temperature chilled-water system—to provide optimal interior comfort with minimal energy use

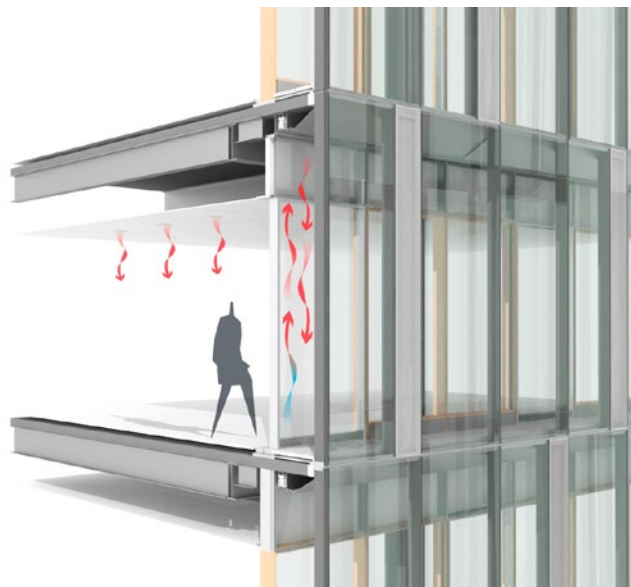
On office floors, active chilled beams send a mix of fresh air and warm room air over a chilled coil to cool and ventilate the space with minimum energy. Water runs through the chilled beams, cooling the surrounding air and creating a convection cycle: as the cool air falls, hot air rises and is chilled by the beams.

The dual-wheel, energy recovery air handling system uses exhaust air leaving the building to efficiently heat or cool and humidify or de-humidify air entering the building, depending on weather conditions. Radiant panels at the façade mitigate heat losses to the outside with minimal fan energy and optimize thermal comfort for the occupants.



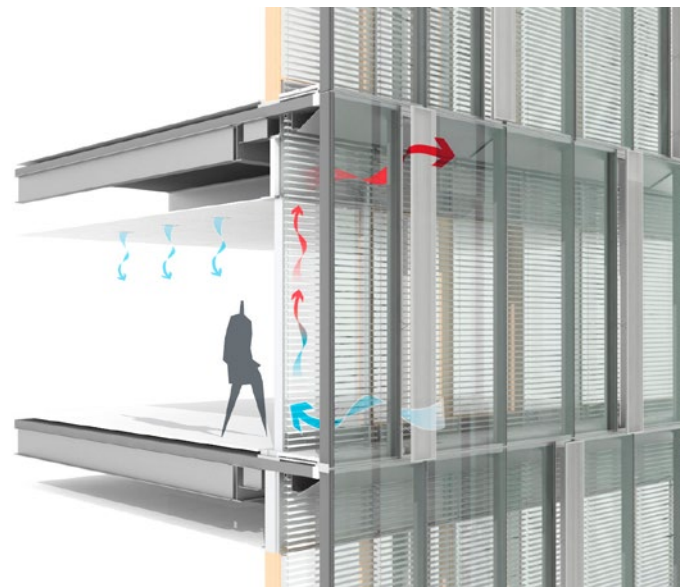
Image: BuroHappold Engineering

DOUBLE SKIN FACADE ACTIVE MODE



Images: Gensler

MECHANICAL COOLING MODE (WINTER)



MECHANICAL COOLING MODE (SUMMER)

OTHER FEATURES

STRUCTURAL

The northwest and southeast corners have unobstructed views thanks to the cantilevered structural slabs. Long-span steel construction supports the two-story, column free collaboration spaces along the western facade.

An efficient steel framing system braces roof columns along the perimeter and supports the suspended, tilted concrete slab and glass skylight composing the top of the solar chimney.

A curved steel truss spanning approximately 100 feet, supports the five-story 28th-floor atrium, and suspends the cable-net enclosure.

Lightweight concrete reduces column loads and the amount of structural materials required. The top 100 feet of the building is perforated to reduce structural resistance required for wind loading.

LOCALLY SOURCED / RECYCLED MATERIALS

Structural steel and rebar contain 35-60% recycled content and was fabricated within 500 miles of the project site, reducing the carbon emissions associated with transportation.

The concrete mix uses locally quarried aggregates and sand and incorporates 25% fly ash.

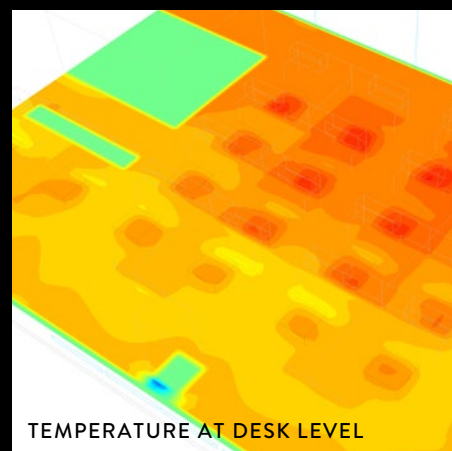
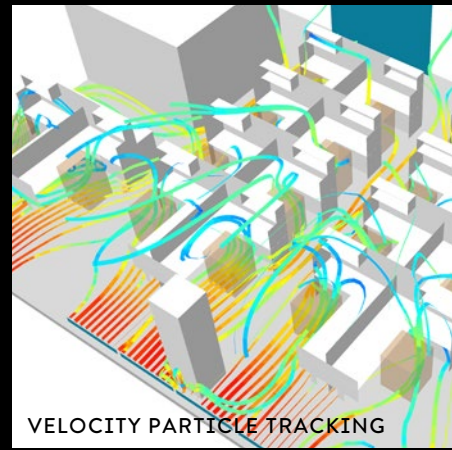
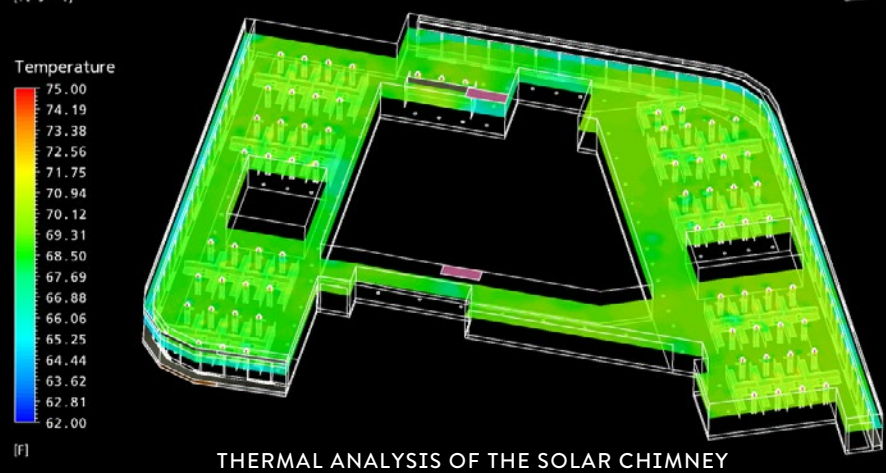
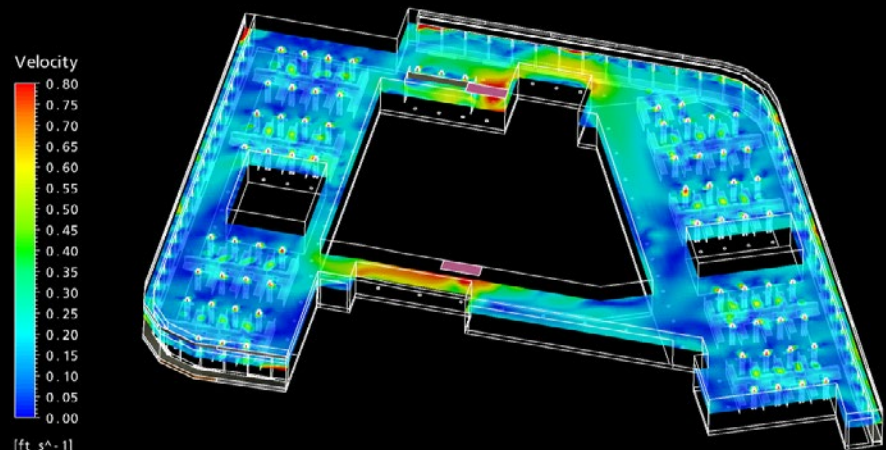
EMBODIED CARBON AND ENERGY ANALYSIS

These design strategies reduced the structure's embodied energy by 68% and the embodied carbon by 71%.

WATER STRATEGY

An advanced water treatment system including membrane ultra-filtration, carbon filtration and ozone disinfection, has the potential to save 77% water use compared to a typical building.

Treated water is used to flush toilets, supply the cooling system, and water the landscape, reducing potable water usage by 4.5 million gallons annually and nearly eliminating discharge to city sewers.



Images: BuroHappold Engineering

The project team used computational fluid dynamics modeling and dynamic thermal analysis conducted by BuroHappold to evaluate and optimize The Tower's design balancing factors including energy performance, interior comfort, urban presence and return on investment.

A 1,200-square-foot mock-up was constructed to test design decisions, building technologies and materials against performance goals in real time, refine details, and facilitate project cost estimating and decision making. The mock-up, which covered the double-skin facade, radiant panel technology and chilled beam system, and the automated blind and lighting systems, allowed the team to identify and resolve issues, avoiding costly delays during construction, and provided insights that will inform ongoing building operations and maintenance.

BuroHappold's modeling expertise also facilitated The Tower's design and construction coordination. A steel fabrication model built in Tekla allowed for more competitive and accurate steel bids, and facilitated construction administration. Custom interoperability tools streamlined the transfer of modeling analyses into Revit, enhancing the team's ability to coordinate and manage design changes effectively. The geometrically complex roof was built using a Revit model that integrated structural and MEP systems with the architectural design.

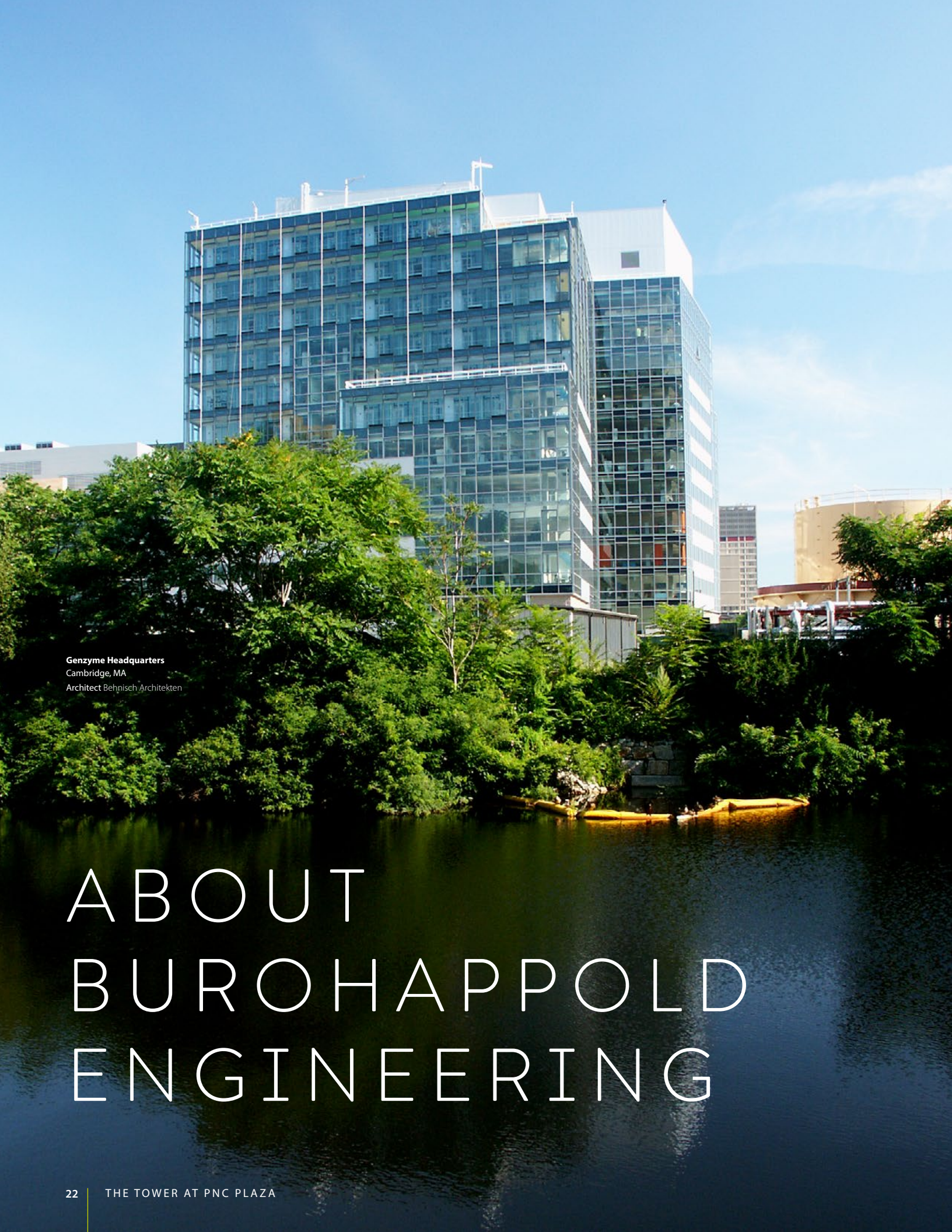


FROM MODELING TO MOCKUP TO CONSTRUCTION



Images: David DeNoma

THIS PAGE:
IMAGES SHOWING THE MOCKED-UP
SECTION OF THE TOWER AT PNC PLAZA
BUILT TO TEST THE TECHNOLOGIES
AND SYSTEMS



Genzyme Headquarters
Cambridge, MA
Architect Behnisch Architekten

ABOUT BUROHAPPOLD ENGINEERING

FACTS

5 OFFICES IN NORTH AMERICA

- BOSTON
- CHICAGO
- LOS ANGELES
- NEW YORK
- SAN FRANCISCO

Projects from top right

The Tower at PNC Plaza
Pittsburgh, PA
Architect Gensler

888 Boylston
Boston, MA
Architect FXFowle

**Yale University School
of Management**
New Haven, CT
Architect Foster + Partners

**GlaxoSmithKline Headquarters
at 5 Crescent Drive**
Philadelphia, PA
Architect Kendall/Heaton Associates
and Robert A.M. Stern Architects

Described by our clients as 'passionate', 'innovative', 'collaborative': BuroHappold Engineering is an independent, international engineering practice that over the last 40 years has become synonymous with the delivery of creative, value led building and city solutions for an ever changing world. Having worked on every continent, our clients include more than 90% of the world's leading architectural practices and we have collaborated with global organizations such as the United Nations, The World Bank and UNESCO. Through our global community of driven, world leading engineering professionals we deliver elegant solutions for buildings and cities that seek to address the major problems facing societies today.

Our North America practice, which includes offices in New York, Boston, Chicago, Los Angeles and San Francisco has completed a broad range of work—from high-performance renovations to advanced facade design for higher education, cultural, commercial and health-science clients—garnering over 100 awards for design and engineering.



Images (clockwise from top right)
Gensler, FXFowle, Chuck Choi Architectural Photography,
Francis Dzikowski/Esto, Anton Grassl

