URBAN CONNECTIONS

Eckert & Eckert

BY PETER VAN DER MEULEN, AIA, AND CRAIG BRISCOE

Rooftop wind turbines that tower above the Twelve | West building in Portland, Ore., may capture the immediate attention of visitors. But, the people who shop, live or work at the mixed-use high-rise benefit from other sustainable features, including chilled beams. The building in the emerging West End neighborhood demonstrates that it is possible to attain design goals of openness, transparency and providing connections to the urban and natural environment while advancing sustainable performance.

The building, which opened in 2009, includes street-level retail, four floors of office space, 17 floors of housing and five floors of below-grade parking. All office floors were dedicated to ZGF Architects, allowing staff to consolidate under one roof and providing the designers with a blank slate to have total control over the look and feel of the office.

Passive design strategies such as natural ventilation and efficient active systems contributed to the first year's annual energy use intensity of 44.9 kBtu/ft^2 (see note in Energy at a Glance regarding calculation of district chilled water EUI). In addition to the wind turbines, on-site renewable energy sources include a solar thermal array for heating domestic hot water.

Creating a Connection

The double-LEED certified building is located in Portland's emerging West End neighborhood with the vibrant mixed-use Pearl District directly to the north, the downtown business district to the east, and the city's arts and university districts to the south. The site, which was previously used as a parking lot and included a derelict one-story building, was chosen because of the central, transit-rich location and because of the potential to help connect these different districts and inspire further dense development in Portland's urban core. The location also offers views of the city, surrounding hills, Forest Park, the Willamette River, as well as Mt. Hood and the Cascade Range in the distance.

The design team placed a high priority on visual and physical connections with the urban and natural environment through the use of transparency, operable windows, and balconies. While the goal of transparency came with performance impacts, the consultant team worked to balance the trade-offs. Because it was essential that building performance drive the design rather than be applied as an afterthought, the team engaged in numerous cycles of design and analysis to support the evolution of fully-integrated design and performance concepts.

Orientation, Enclosure

These concepts begin with the building massing and orientation, which is 21° off an east-west axis and responds to the city's street grid. This minimizes the challenging daylighting and solar heat gain effects of the east and west façades.

The enclosure design is based on an assemblage of glass planes, which are extended beyond the face of the building to articulate the planes and shelter a series of balconies. Although the building appears at first glance to have all-glass façades, it actually benefits from a

Opposite **Twelve | West, a mixed use high-rise that opened in 2009, includes retail, restaurant, office and residential space. Apartment residents can enjoy sweeping views of Portland from the rooftop. The 7,000 ft^2 roof includes an amenity room, outdoor fire pits, built-in gas barbecues and several seating environments, which allow multiple groups to enjoy the space at the same time.**

Above right **Four wind turbines sit prominently atop Twelve | West, which serves as a demonstration project to inform future sustainable building design. The building also serves as an anchor in a rapidly transforming urban neighborhood.**

Timothy Hursley

BUILDING AT A GLANCE

Name Twelve I West

Location Portland, Ore.

Owner The consortium of building owners includes Gerding Edlen Development, ZGF Architects LLP, Downtown Development Group and other investors

Principal Use Mixed-use
Includes Retail, restaurants, parking, office, apartments

Employees/Occupants Office employees at move-in was 260 people plus 273 apartment units (ranging from studios to three-bedroom units)

Occupancy 95%

Gross Square Footage 550,000 (313,000 housing, 124,527 parking, 89,184 office, 9,727 retail)

Conditioned Space 397,500

Distinctions/Awards AIA COTE Top Ten Green Projects, 2010; LEED Platinum-NC v 2.1 with hybrid v 2.2 compliance, 2012; LEED Platinum-CI v 2.0, 2011

Total Cost
$97,225,989 construction cost
Cost Per Square Foot $180

Substantial Completion/Occupancy
Office occupied in October 2009

significant amount of opaque wall area, which is clad with stainless steel panels or fritted spandrel glazing with insulated wall behind.

The overall transparent glazing at conditioned spaces is just over 48%. The glass is a high-performance, slightly reflective low-e, insulating system (Viracon VRE1-59 with argon gas fill to improve the U-value. Overall U-value was further improved by the use of an all structurally glazed unitized curtain wall system, minimizing the amount of exposed thermally conductive aluminum framing. The unitized curtain wall offers the quality control and efficiency benefits of prefabrication, and the design and performance benefits of a fully customized system.

In the office, interior roller window shades with a metalized surface facing the glass help minimize solar gain and manage glare. The shades are manually operated by the occupants.

Nick Merrick

Salvaged wood from a trolley barn is used here on the walls of the ground floor lobby. Wood is used throughout the building to reflect the surrounding Pacific Northwest.

Lighting

A digitally addressable lighting interface system provides continuous dimming in the perimeter zones to optimize daylighting benefits by dimming and turning off the electric lighting as much as possible. In addition, occupancy sensors sweep lights off by zone, and all workstations employ power strips with switched and unswitched outlets on motion sensors to turn off idle and discretionary plug loads.

LED desktop dimmable task lights are provided at workstations, while ambient office lighting uses T5HO direct/indirect fixtures with 60% up and 40% down. Corridor wall washers also use T5HO lamps, and recessed can downlighting and pendant globes use CFLs.

Unoccupied and low occupancy areas, including exit stairs and parking garage floors are

WATER AT A GLANCE

Annual Water Use 5,793,260 gallons (2011)

ENERGY AT A GLANCE

Annual Energy Use Intensity (EUI) (Site)
44.9 kBtu/ft^2
- Natural Gas 11.6 kBtu/ft^2
- Electricity (From Grid) 20.6 kBtu/ft^2
- District Chilled Water 11.5 kBtu/ft^2*
- Renewable Energy (Solar Thermal and Wind Turbines) 1.2 kBtu/ft^2

Annual Source Energy 94 kBtu/ft^2

Annual Energy Cost Index (ECI) $0.68/ft^2

Annual Net Energy Use Intensity
43.7kBtu/ft^2

Savings vs. Standard 90.1-2004 Design Building 40.5%

ENERGY STAR Rating
Not available for building type

Heating Degree Days (base 65˚F) 4,752

Cooling Degree Days (base 65˚F) 401

Average Operating Hours per Week
Office: 60; Retail: 80; Residential: 24/7

* Chilled water data is based on actual use in ton-hours, converted to kBtu using a conservative 1 kW/ton to account for energy use at the central plant.

SUSTAINABLE FEATURES

Four wind turbines produce about 6,000 kWh of electricity per year. Monitoring of wind conditions and turbine performance will improve knowledge for future projects.

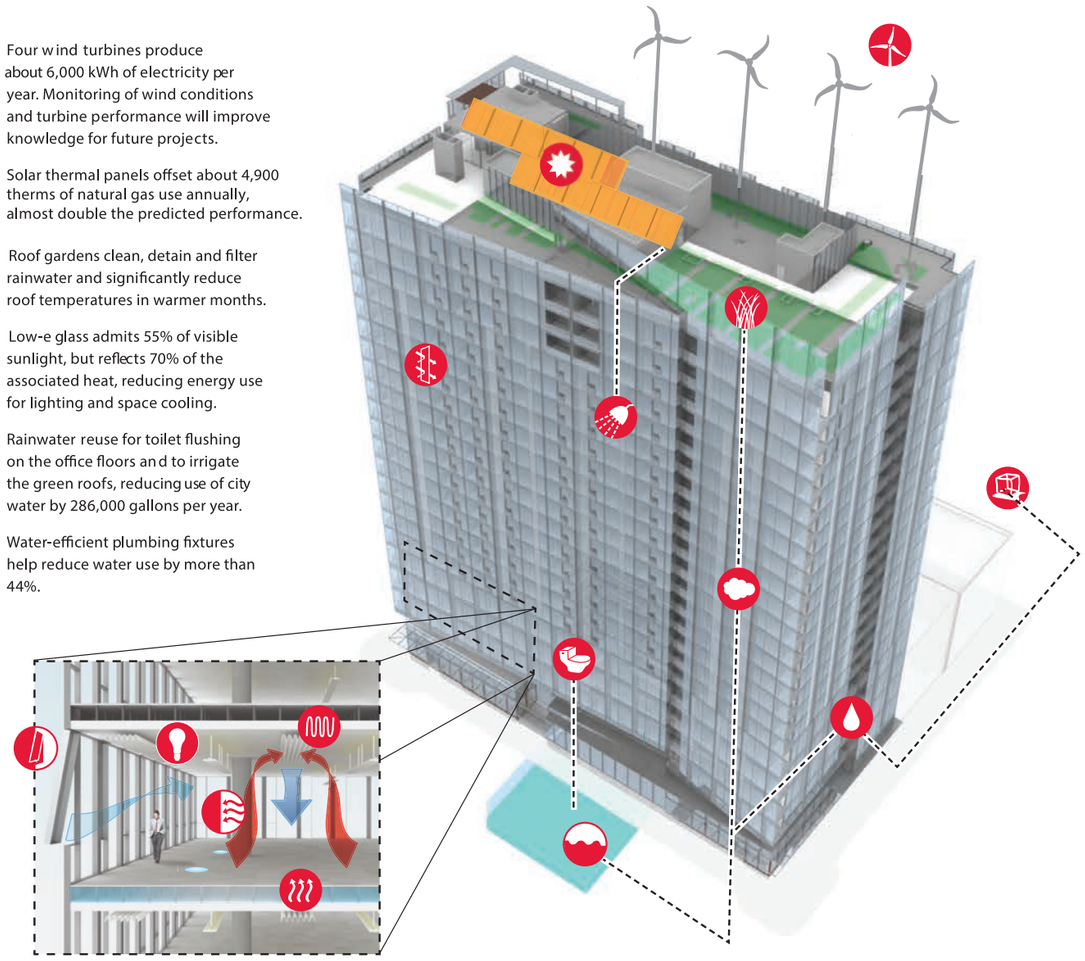
Solar thermal panels offset about 4,900 therms of natural gas use annually, almost double the predicted performance.

Roof gardens clean, detain and filter rainwater and significantly reduce roof temperatures in warmer months.

Low-e glass admits 55% of visible sunlight, but reflects 70% of the associated heat, reducing energy use for lighting and space cooling.

Rainwater reuse for toilet flushing on the office floors and to irrigate the green roofs, reducing use of city water by 286,000 gallons per year.

Water-efficient plumbing fixtures help reduce water use by more than 44%.



Operable windows provide occupants fresh air, cooling, and a connection to the outdoors.

Daylight sensors switch off electric lights when ample daylight exists, reducing lighting energy use by 60%.

Exposed concrete moderates indoor air temperatures. Mass is cooled with cool night air in the summer months and absorbs excess heat throughout the day.

Passive/chilled beams provide energy-efficient cooling.

Underfloor air distribution efficiently delivers moderate-temperature air directly to occupants. Personal adjustable floor vents provide control over ventilation.

Water storage tank temporarily stores up to 22,000 gallons of rainwater and condensate for reuse.

Efficient central cooling plant in the nearby Brewery Blocks provides chilled water for space cooling.

Rainwater harvesting piping gathers 273,000 gallons of rainwater from the roofs.

Thirteen thousand gallons of condensate from the air handler system collects during summer months.

ZGF Architects LLP

BUILDING ENVELOPE

Roof
Type Green roof assembly, fluid-applied rubber asphalt, 6 in. of extruded polystyrene
Overall R-value R-32
Reflectance (Solar Reflectance Index)
73.4, (91) for white cement pedestal mount terrace pavers at walking surfaces

Walls
Type
Stone-veneer metal-framed solid exterior walls
Structurally sealed unitized curtain wall
Overall R-value
Solid Walls R-26.4
Composite Curtain Wall R-2.32
Glazing Percentage 48% overall

Basement/Foundation
Slab Edge Insulation R-value
(2 in. Extruded Polystyrene) R-10
Basement Wall Insulation R-value
(2 in. Extruded Polystyrene) R-10
Under Slab Insulation R-value
None (unheated garage)

Windows
Effective U-factor for Assembly 0.45 overall assembly; 0.26 glazing (argon)
Solar Heat Gain Coefficient (SHGC) 0.33
Visual Transmittance 0.53

Location
Latitude 45.5
Orientation 21˚ west of polar north

Nick Merrick

Daylight, views, operable windows, underfloor air distribution, chilled beams, radiant heating and cooling, CO_2 monitoring and low-emitting materials throughout the tower combine to make healthy working and living environments.

maintained at minimum dimmed lighting levels. Occupancy sensors reduce idle lighting loads on a floor-by-floor basis.

In residences, surface-mounted CFL fixtures provide functional general room lighting. Tenants may provide supplemental and/or decorative lighting.

HVAC

Within the open-plan work space, operable windows provide supplemental ventilation for interior air quality, passive cooling and a connection to the outdoors. A system incorporated into the task bar of all staff computers communicates when conditions are favorable for the windows to be opened.

A blue dot indicates that the exterior conditions are too cool; a red dot indicates that conditions are too hot, and a green dot indicates that exterior conditions are favorable. Employee feedback has been positive and people appreciate the ability to open a window when they feel hot.

Conditioned supply air is provided via an underfloor air distribution (UFAD) plenum, and high central returns to provide efficient and effective displacement airflow. As it is sized for static heating loads only, the UFAD system delivers air directly to the occupied zone near the floor

ENERGY USE, OCT. 2009–SEPT. 2010

	Natural Gas Therms	District Chilled Water Ton-hours	Electricity kWh
Oct 09	1,062	22,185	177,038
Nov 09	5,010	12,690	226,182
Dec 09	8,341	9,351	341,380
Jan 10	8,991	9,966	251,097
Feb 10	5,540	10,585	203,420
Mar 10	5,048	14,463	229,615
Apr 10	3,874	16,901	153,714
May 10	3,683	27,038	207,801
Jun 10	2,944	44,715	177,408
Jul 10	332	82,078	251,325
Aug 10	379	95,654	163,034
Sep 10	4,273	65,140	203,799
	49,477	**410,767**	**2,585,813**

Sherri Diteman

Nick Merrick

Above **The building features two forms of renewable energy production: 1,360 ft^2 of flat plate solar hot water collectors and wind turbines at the north edge of the tower's roof.**

Right **The street level office entry includes a floating staircase that leads to the second floor and the main reception area for ZGF Architects. The firm was the architect for the project, giving it complete control over the design of its new office.**

KEY SUSTAINABLE FEATURES

Water Conservation. Rainwater and mechanical system condensate used for toilet flushing on office floors, to irrigate the green roof and to supply fire suppression storage tank.

Materials. Materials and furnishings reused whenever possible; low-impact, low-emitting, reclaimed or sustainable harvested materials also used; exposed concrete minimizes the use of finish materials; FSC certified wood used throughout office; bamboo used for flooring and casework in apartments

Daylighting. Vertical bands of low-e glazing provides daylight to most areas; facilitated by high floor to floor heights and white ceilings in the office areas. In the apartments, living and bedroom spaces are oriented along the floor-to-ceiling glass curtain wall. Color palettes were selected to enhance daylighting conditions in spaces based on their orientations.

Individual Controls. Controls at each workstation for the underfloor air distribution (UFAD) system, operable windows, metallic-coated roller shades for windows .This system, combined with the operable windows allows for individual control of temperature and airflow. Metallic-coated roller shades allow occupants solar control in their work and living areas. Operable windows in all regularly occupied spaces provide thermal control for building occupants and reinforce connections to the outdoor environment. Continuous dimming ballasts and advanced daylight controls on the overhead lighting are constantly being tuned by the office occupants to decrease energy used for lighting.

Other Controls. Continuous dimming ballasts, daylighting controls on overhead lighting

Transportation Mitigation Strategies. The project is within walking distance of services and employment and is sited to take advantage of existing public transportation, including bus, light rail and street car in downtown Portland. The central location is cyclist friendly, and the project includes secure bicycle storage, showers, and locker facilities to encourage bicycle commuting. The office tenant provides incentives for alternate commuting and only leases 30 parking spaces for 250 employees.

Renewable Energy. Four building-integrated wind turbines and 1,360 ft^2 of flat plate solar hot water collectors (providing 24% of the energy needed to heat the hot water used in showers, hand washing and dish washing).

at more moderate temperatures and velocities than a conventional ventilation system, using less energy and providing better occupant comfort.

Dampered floor diffusers work well within all workstation areas and can be adjusted by occupants to suit their needs for airflow, cooling, and heating. Any areas affected by solar gain or added peak loads receive supplemental cooling via passive chilled beams.

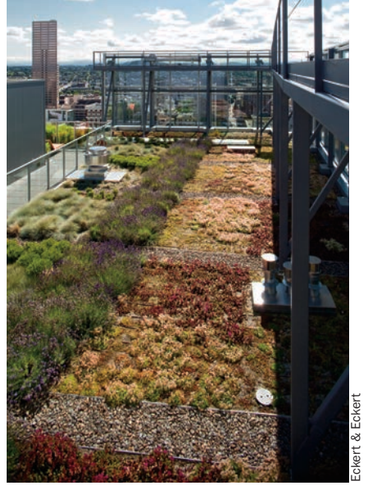
Peak winter perimeter heating loads are addressed with continuous hydronic fin-tube radiators, and peak summer solar cooling loads are met with overhead hydronic passive chilled beams, both fully decoupled from the UFAD ventilation system. These chilled beams are perforated metal fins mounted near the ceiling and chilled with cold water.

Rising hot air is cooled by the chilled beams and then falls again to the floor to keep inhabitants cool. Passive chilled beams save energy over conventional systems by moving energy with water instead of air and without the use of fan energy.

All cooling for the building is provided from a district chilled water system, produced by a district chiller plant located just a block away. Heating is provided by a high-efficiency gas boiler within the building.

The Indigo apartments, located above the office space, are heated and cooled by individual fan-coil units, fitted with high efficiency

Timothy Hursley



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Above left **Occupying roughly a one-half block site, Twelve | West is one of the first significant new buildings to take root in the West End neighborhood—home to a mix of cultural and social organizationss, high-density residential buildings, diverse retail, restaurants and nightclubs.**

Above right **A mix of evergreen, deciduous plants, and seasonal flowering bulbs and grasses are used in a 4,000 ft^2 green roof.**

electrically commutated fan motors and hydronic chilled water coils for cooling. One electronic thermostat with setback capabilities is provided per fan-coil unit, which has dual speed settings (high and low). Operable windows and roller shades offer supplemental methods of ventilation and solar shading for each tenant.

Metering

Parking areas, commercial and retail tenants are each metered separately for all utility services. Domestic water consumption and chilled water flow for cooling are master-metered for residences as a whole and are charged on a prorated basis. Apartments are individually metered for electricity use, including lighting, fans, plug loads and high-efficiency fan-coil motors.

LESSONS LEARNED

Glare Control. Because desks are typically pulled away from the glazing, leaving an area for circulation and casual meeting space, few of the office occupants sit directly adjacent the glass for extended periods of time. This works well as a strategy for thermal comfort, but does not necessarily prevent glare from light penetrating deeper into the space. As a result blinds are often closed to control glare at the warmest time in the day and then remain down, blocking useful daylight after the glare conditions have passed. Tenant education is an ongoing effort to solve this challenge.

Urban Wind Power. The demonstration and research project resulted in less production than anticipated, but continues to provide data and observations that contribute to future projects and policy. The technical challenges of mounting the turbines over occupied space were solved successfully with a series of three vibration dampers for each turbine attached to custom mast mounts. This measure was performed to eliminate vibration noise in some of the penthouse units in the building, located directly below the roof.

Optimizing Cooling for Partial Loads. As part of the early project development, a cost benefit analysis was done evaluating connection to the district chilled water plant versus building a local chilled water plant. Based on this analysis, the owner signed a contract for district chilled water and the project design implemented a variable flow secondary chilled water distribution system for the building.

This system was isolated from the plant service by a plate-and-frame heat exchanger with all of the piping and controls on the plant side of the heat exchanger provided by the district service at the building CHW entry. The district plant service installed parallel 4 in. control valves on the plant side of the system that were controlled to maintain a wide temperature range between the low temperature district chilled water supply and the return water.

The four-story office HVAC and the local retail HVAC systems were all equipped with air-side economizers. This provision eliminated the need for chilled water for nonresidential spaces during the winter, and the residential fan-coil units imposed little if any chilled water load during the winter.

This design left a single demand remaining for chilled water: the office tenant's server room that used a chilled water-based rack cooling system. This load was significantly lower than originally anticipated. As a result, the large district plant control valves could not provide close temperature control to the building's CHW distribution system.

While the office tenant's server cooling system was a fully modulating system, the variation in chilled water supply temperature raised concerns about consistent control. To address this concern, the design team worked with the district plant service to install a third district chilled water valve sized much smaller to permit better temperature control.

Track Strategies Early and Often. The entire design team constantly referred to a detailed tracking matrix of energy efficiency measures with columns for cost, energy savings, energy cost savings, carbon impact, LEED impact and more. Backed up with rigorous energy simulation, this matrix became a key decision making tool, helping to remind the design team of priorities and maintaining focus through value engineering.

Small Changes Can Have Big Impacts. In mid-construction the engineering team identified substantial potential energy savings from upgrading the apartment fan-coil units from standard to electrically commutated motors (ECM). Across 273 apartments the cost was considerable, but the energy savings of 3.1% boosted potential LEED energy points to the degree that LEED Platinum was in reach. Achieving LEED Platinum increased state energy incentives considerably, more than covering the cost of the ECM motors and other key premiums.

Recommended Lighting Levels are not Mandates. After moving into their new offices, staff embraced the controllability of the lighting system and took steps to reduce lighting energy use. Dimming of the entire system up to 15% was possible with no perception of lower lighting levels by the staff. This strategy is made possible in part by a task/ambient approach to lighting in which lighting for critical visual tasks is provided by task lights at the work surface.

Other Lessons Learned

Retail. Operable windows along the street front are attractive to restaurant tenants.

Office. Exposed surfaces provide for an acoustically "live" environment and added a welcomed social brightness in the open plan, leading to good project team interaction. Given the lively space, open plan and very quiet mechanical systems, acoustics are a concern for some employees.

Housing. Thermal mass of the concrete building frame is effective in radiant cooling within the residential units, which have exposed concrete columns and wall surfaces.

The floating wood floors are isolated from the slab by a layer of closed-cell foam underlayment, so impact noise is significantly abated. Floor surfaces are snapped together, not attached to the structure, and are free to expand and contract. A thicker wood base and thresholds at the doorways are required to cover seasonal floor surface movement.

The energy and water metering strategy was developed when the project construction was well underway. This resulted in inefficiency, greater cost, and multiple incompatible systems with no single reporting methodology. Early cooperation from utilities, a mechanical and electrical infrastructure that better facilitates segregation of energy and resource loads, and a single party responsible for integrating resource metering are important for a successful metering strategy.

Rooftop. Extension of the curtain wall parapet provided significant wind screening for terrace dwellers, but also raised the wind disturbance zones that affect turbine production.

The green roof thrives in zones sun-shaded and wind-shaded by the curtain wall.

Water

Water efficiency at Twelve | West is achieved through a combination of conservation and storm water reuse. Due to Oregon's restrictions on use of storm water in residential rental applications, reuse of storm water for toilet flushing was restricted to the office floors. (Local regulations have now been relaxed for residential projects of scale.)

The building has a 50,000 gallon storage tank in the underground garage, part of which is dedicated to fire suppression. The remaining 22,000 gallons is devoted to reuse in irrigation and toilet flushing.

Advertisement formerly in this space.

Advertisement formerly in this space.

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The green roof reduces storm water runoff and the building's contribution to the urban heat island effect, and provides an amenity for the building's residents.

This system, which gathers and filters runoff from the rooftops and condensate from the mechanical system, is projected to reuse 286,225 gallons annually, using 59% of the rainfall from the tower's roof surface. As a result, 100% of the green roof's irrigation needs, and 90% of the office's flushing demands will be met by the volume of nonpotable water collected from the building. (Acutal water metrics are being developed, but data is not yet available.)

The 4,000 ft^2 green roof helps to regulate storm water flow and provides an amenity for building residents. Storm and sanitary sewer systems development charges (SDCs) from the City of Portland's Bureau of Environmental Services were reduced by 30% as a result of the reduced combined sewer contribution. That savings covered 91% of the first cost of the system, vastly reducing the simple 10-year payback period for this investment.

On-site Renewable Energy

An efficient central boiler provides hot water to the office space, retail spaces and apartments. The domestic hot water boiler is supplemented by a 1,360 ft^2 rooftop solar thermal flat panel collector system, which preheats supply water.

Four wind turbines atop the building provide a second source of renewable power for the building. This represented the first U.S. installation of a wind turbine array on an urban high-rise.

The turbines rise 320 ft above ground level and are on hinged masts so they can be serviced. Working with noted Dutch wind energy specialist Sander Mertens, the team took into account urban topography, weather data and seasonable variability of wind directions to estimate energy production.

Together with the inventors of the Gossamer Albatross (a human-powered aircraft), the design team worked in a wind tunnel to develop a general understanding of the anticipated wind behavior over and around the building roof. The 12 ft diameter horizontal axis turbines feature a passive yaw, or rotation system, that orients the turbine blades to the wind. The downward blade design eliminates the need for a tail or other orienting device.

Recognizing the rigor of the design team investigation into this untested application of wind energy, the Energy Trust of Oregon and the Oregon Department of Energy funded the entire system cost of $198,000 through energy efficiency grants and tax credits. The turbines will help advance the application of building-integrated wind power in an urban setting and provide a road map for others.

The turbines were predicted to generate roughly 10,000 kWh per year—the equivalent of 1% of electrical use in the office floors, or enough to power the elevators over the course of a year. Production by the wind turbines has been approximately 60% of what was anticipated, and the system has demonstrated the complexity and challenges of urban wind production.

Wind tunnel studies predicted the minimum mounting height above the roof for the turbines to avoid turbulence effects imposed by the building. The turbines were installed at this position, but additional height to create a margin for error in the measured turbulent zone location was not possible due to physical space constraints.

Given the production data and turbine behavior, it is surmised that the turbines experience some building-induced turbulence effects in winter winds, limiting production. Production by the solar thermal system is better than expected, virtually eliminating natural gas use for hot water over a four-week period in July and August in the first year of operation.

BUILDING TEAM

Building Owner/Representative
Gerding Edlen Development

Architect, Landscape Architect, LEED Consultant ZGF Architects LLP

General Contractor
Hoffman Construction Company

Mechanical, Electrical Engineer; Lighting Design Glumac, Total Mechanical

Energy Modeler Glumac

Structural Engineer
KPFF Consulting Engineers

Civil Engineer
David Evans and Associates

Environmental Consultant
Grant Associates, Portland

Apartment residents have access to a concierge, located at the lobby desk, for booking everything from dinner reservations to dog walking to house cleaning services.

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Performance Monitoring and Occupant Satisfaction

Results from building performance tracking and an occupant satisfaction survey indicate that the building is operating well overall, and have helped identify areas for future improvements to building performance.

Twelve | West operated at an EUI of 44.9 kBtu/ft^2·yr from October 2009 to September 2010, its first year of operation. This performance

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Above **Natural light is maximized in the apartments by orienting living and bedroom spaces along the floor-to-ceiling, glass curtain wall of the building. Operable windows and balconies are included for natural ventilation.**

Right **The 700 ft² amenity room is anchored by a fireplace and includes a kitchen, community dining table and living room furniture that can be rearranged easily for a dinner party or a yoga class.**

was slightly higher than predicted in the original energy models. This is nonetheless well below the Architecture 2030 target in place at the time (49.4 $ft^2 \cdot yr$) and 40% below an ANSI/ASHRAE/IESNA Standard 90.1 2004 baseline.

The sources of energy savings are diverse, but dominated by savings in lighting throughout the building and in space conditioning on the office floors. An in-depth M&V study is planned for the future, which will identify any potential changes in operation or controls to further reduce energy use.

Survey results from the office employees indicate that the building performs well in measures of occupant satisfaction as well. The before-and-after surveys were performed in cooperation with the Center for the Built Environment, using the CBE Occupant Indoor Environmental Quality Survey tool. This standardized survey has been used on hundreds of buildings in the U.S., and offers a simple Web-based interface and sophisticated data analysis tools to simplify the survey process.

Occupant satisfaction with the new office space in Twelve | West is greater than in ZGF Architects previous office space in almost every survey category. Employee satisfaction with thermal comfort, air quality, and the overall building increased significantly in the survey results, while there were more modest gains in satisfaction with office layout and lighting.

Acoustics is one area of concern in the office space. The open office configuration and high proportion of hard surfaces combined with a virtually silent UFAD and passive chilled beam system can make for a noisy work environment for some employees. Possible means of improvement include strategically placed acoustic panels and an active white background noise system. Among the categories in the occupant survey satisfaction with the greatest increase over the previous office space was air quality, thanks in large part to the displacement ventilation system.

No formal survey has been conducted with the apartment tenants in Twelve | West, but indirect indicators suggest that satisfaction is high and many residents cite the sustainable design as a key factor for their decision to rent. Apartment lease-up (when all apartments would be initially rented) was estimated at 12 months, but occurred in six months, despite a depressed economy. Occupancy remains high, with 97% of units typically occupied and 50% tenant retention year over year.

Conclusion

Twelve | West has helped pave the way for retail and restaurant activity in the West End neighborhood, where many boutiques and cafes have opened in recent years. Employee satisfaction with the work space is high and many of the building's energy saving strategies have been effective, including the chilled beams, daylighting and operable windows. ●

ABOUT THE AUTHORS

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Mitchell Dec, LEED AP, provided energy data for this article. He leads the firmwide Energy Services Department at Glumac, in Portland, Ore.