Optimizing A LANDMARK

BY CHARLES FOREMAN AND CHRIS LOWEN, P.E., MEMBER ASHRAE
Clad in a new envelope of glass and steel with a sloping rooftop solar parasol, the Edith Green-Wendell Wyatt (EGWW) building bears little resemblance to the white concrete façade of the original 1970s building. Exterior shading and radiant systems provide excellent comfort and energy efficiency. But energy-optimized buildings can’t be handed over “as is” at completion and be expected to thrive. A year of post-occupancy commissioning proved key in transforming this federal building from an energy hog to a high performance workplace.

Energy savings goals for the building were specified by the project’s funding source, the 2009 American Recovery and Reinvestment Act (ARRA). The federal stimulus funding required energy savings of 30% over ASHRAE/IESNA Standard 90.1-2007, and a 55% reduction in fossil fuel energy over a 2003 Commercial Buildings Energy Consumption Survey (CBECS) baseline. The building team pursued an integrated design approach, which began with a building skin optimized for energy efficiency via innovative envelope shading devices, optimized window-to-wall ratios, and excellent daylighting.

Hydronic radiant panels meet the remaining heating and cooling loads, supported by a dedicated outdoor air system. To reduce potable water use, the team implemented rainwater reuse by adapting an existing, unused basement shooting range into a 165,000 gallon rainwater storage tank.

On the roof, 13,000 ft² of photovoltaic panels create a distinct signature on the skyline. The dramatic transformation of the building’s exterior appearance has captured the attention of passersby and created a landmark in downtown Portland.

With the U.S. General Services Administration (GSA) as a driver, the project team fostered a cooperative process that resulted in cost savings, quality improvements, and optimum ongoing building performance. Innovative commissioning and energy modeling helped enhance system design, installation, and eventually operation.

**Project Conception**

The need to modernize the existing building to save energy, improve comfort, and meet modern blast resistance guidelines was obvious. The GSA also saw EGWW as an opportunity to test innovations in project delivery and deliver a better building as a result.

With a mandate to be a “learning team,” design and construction

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**BUILDING AT A GLANCE**

<table>
<thead>
<tr>
<th>Name</th>
<th>Edith Green-Wendell Wyatt Federal Building</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Portland, Ore.</td>
</tr>
<tr>
<td>Owner</td>
<td>General Services Administration</td>
</tr>
<tr>
<td>Principal Use</td>
<td>GSA offices</td>
</tr>
<tr>
<td></td>
<td>Includes Central data center, federal courts, and office space</td>
</tr>
<tr>
<td>Employees/Occupants</td>
<td>1,520</td>
</tr>
<tr>
<td>Expected (Design) Occupancy</td>
<td>1,530</td>
</tr>
<tr>
<td>Percent Occupied</td>
<td>99%</td>
</tr>
<tr>
<td>Gross Square Footage</td>
<td>512,474 ft²</td>
</tr>
<tr>
<td>Conditioned Space</td>
<td>438,952 ft²</td>
</tr>
<tr>
<td>Distinctions/Awards</td>
<td>2013, LEED 2009-NC, Platinum; 2014 GSA Design Honor Award; 2014 Tall Building in America Award</td>
</tr>
<tr>
<td>Total Cost</td>
<td>$136 million</td>
</tr>
<tr>
<td>Cost per Square Foot</td>
<td>$247</td>
</tr>
<tr>
<td>Substantial Completion</td>
<td>May 2013</td>
</tr>
<tr>
<td>Substantial Occupancy</td>
<td>February 2014</td>
</tr>
<tr>
<td>When Built</td>
<td>1974</td>
</tr>
<tr>
<td>Major Renovation</td>
<td>2010 to 2013</td>
</tr>
<tr>
<td>Renovation Scope</td>
<td>Total core and shell renovation and tenant improvement</td>
</tr>
</tbody>
</table>
professionals worked together in shared office space, initially in the building itself, to improve communication and rapid testing of ideas. Integrated building information modeling (BIM) also fostered communication, and resulted in a final model that will be a resource for the GSA in the future. Approximately $1 million in design and construction cost savings resulted from this delivery model, part of which funded post-occupancy building optimization and monitoring services by the project team, what the project team calls “aftercare.”

**Results**

The project reused nearly all of the existing structural elements, significantly reducing the embodied carbon compared to a conventional building. In the first full year of operation, the building recorded a 39% energy cost reduction and 45% energy use reduction compared to Standard 90.1-2007. In addition to the building performance, the design team credits the integrated design process with cutting reduction in requests for information (RFIs) by more than half (measured against comparable projects by the same architect) and cutting the paper used for architectural contract documents by 92%.

**Expanded Commissioning**

Beyond review of design documents and functional testing, the commissioning authority—an EGWW project team member from early design to after occupancy—saw the commissioning process as a continual process of discovery and communication. Identifying potential challenges ahead of time and seeking out solutions with the team is part of the process.

One of the most important tasks was to help the contractors understand exactly what they were
installing. A subcontractor will obviously know how to install their individual scope, but helping the entire team understand the whole system yielded ideas to save costs or identify potential problems.

The commissioning work on EGWW was informed by past project work on major radiant heating and cooling systems at both the Twelve | West mixed-use building in Portland, Ore. (High Performing Buildings, Spring 2013), and the Wayne L. Morse U. S. Courthouse in Eugene, Ore. In an early design review, the commissioning team raised a question about the radiant panel layout in which panels were distributed evenly across the ceiling.

The team felt, based on published design guidelines and project experience, that at least half of the panel area should be concentrated in the outer 4 ft of ceiling adjacent to the glass to adequately meet perimeter heating loads. The team performed a detailed thermal comfort study as part of the scheduled commission agent design review.

Analysis using software developed by the Center for the Built Environment at the University of California, Berkeley, revealed the potential for a wider than normal temperature differential at the perimeter. The design was revised as a result, and the study was shared with tenants to help them better appreciate the range of comfort zones and how that data might inform where people sit.

The mechanical system at EGWW has 50 miles of pipe, much of it fusion-welded polypropylene, which is not yet part of typical construction in the Pacific Northwest. Correct installation is key to avoiding air locks in the radiant ceiling panels, so the commissioning team worked with the general contractor to schedule time at the beginning...
By contrast, in a radiant system, thermostats must be within the outer third of the space to sense perimeter loads, but not under a heating source. Radiant systems have slower reaction time than typical air heating systems. Working with the controls contractor, adjustments were made to the thermostat programming for quicker response.

These issues and countless others were worked out during weekly commissioning meetings held throughout the construction process. At the height of construction, the meetings included 20 people who were responsible for a team of 200 people working on site.

**Commission the Users**

The project team anticipated some occupant surprise at an HVAC system that is silent and has relatively little air movement. The team describes moving from an air system to a radiant system as being “like going from a breezy beach to a still pine forest next to a cool pond.” Both can be comfortable, but the contrast might be jarring.

The architect and owner launched an effort to ensure a smooth transition to the new building. A

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**KEY SUSTAINABLE FEATURES**

**Water**
- A 165,000 gallon rainwater cistern (a former rifle range) holds water funneled from roof.
- Predicted water savings of 61% compared to code.
- Captured rainwater is reused for low-flow toilets and fixtures, landscape irrigation and mechanical cooling. Proportion of overall water consumption dedicated to mechanical system cooling decreased from 16% to 9% after renovation.
- Storm water mitigation strategies.

**Materials**
- Reduction of 92% in paper used for architectural contract documents.
- Nearly 100% of structural elements saved.
- Construction waste divergence rate of 87%.

**Daylighting and Shading**
- Daylight penetration and energy-efficient electric lighting systems with advanced controls reduce lighting energy by 40% compared to Oregon code.
- Roof canopy shades uppermost floors.
- Steel shading devices minimize solar heat gain on south, west and east elevations.

**Transportation Mitigation Strategies**
- Two blocks from major public transit line.

**Other Major Sustainable Features**
- Rooftop photovoltaic panels (184 kW).
- A 100% dedicated outdoor air system.
- Heat recovery ventilator.
- Hydronic radiant heating/cooling ceilings.
- Collocated data room with heat recovery chiller.
- Demand-control ventilation for high occupancy rooms.
- High-efficiency task lighting, appliances and A/V equipment.

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The building’s existing façade was transformed into a curtain wall with “reeds” on the northwest face that stretch up the entire 18-story height of the building. On the southwest and southeast faces, integrated sunshade/light reflectors provide daylighting and shade.

of installation to work with the subcontractors and optimize what they called “the first mile of pipe.”

This early commissioning effort helped ensure the remaining 49 miles of installation went smoothly. The building engineers report that the radiant system piping and controls are working smoothly, and that no leaks or air entrainment in the lines has been identified.

Another focus of the team was proper placement and programming of thermostats. In a typical air-based mechanical system, a thermostat would be placed by the door for convenience, relying on the relatively even mixing of conditioned air for accurate readings.

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**FIGURE 3**

**TYPICAL TENANT FLOORPLAN**

Representative space plan showing office layout with daylight in mind. Private offices to the interior on most façades.
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week-long series of classes on the building helped users understand the features of the building and know what to expect in terms of new operational policies. These sessions allowed the project team to emphasize the reasons that decisions were made, and to explain performance targets that led to policies such as no desk fans or heaters, and centralized printers that people might have to walk further to reach.

Occupant response to the building has been overwhelmingly positive. The project team attributes this, in part, to the education process and to occupant buy-in that resulted from the effort.

The team finds it gratifying to see occupants who are passionate about contributing to the building’s goals and are patient with all of the changes. The GSA has plans for ongoing occupant education to maintain comfort and building performance. For example, emails were sent during the spring to remind building users to close blinds on east-facing windows in the evening for control of solar gain early the next morning.
Energy modeling for EGWW went well beyond that for most buildings, in part because the performance requirements were federal mandates, and because the GSA places strong emphasis on tracking and reporting actual project performance. The detailed modeling effort included trying to account for unknowns as the project progressed, anticipating the impact of different program options through sensitivity analysis.

To reinforce this approach, the energy team communicated potential energy performance as a range of percentage savings rather than a specific number. This way, the project team was able to feel confident it could meet energy goals even if the team secured a tenant with a need for a large data center, extended occupancy hours, or other energy-intensive demands.

As the project progressed and occupants were secured, the energy model was updated to reflect the actual federal tenants. To develop an understanding of the occupants, the architects developed an email survey for office managers asking about a range of topics, from working hours to equipment used. Three large government bureaus make up...
the majority of building occupants, simplifying the effort somewhat, but collecting such detailed occupant data was still a significant effort.

Tenant needs and practices are surprisingly diverse. Some bureaus do their work with laptops, and some with less efficient desktop computers. Another bureau, the Forest Service and Bureau of Land Management, with its focus on fieldwork, typically has low overall desk occupancy.

Some occupants have flexible schedules and are only in the office four days a week. To address this complexity, the model includes five different groups of office occupants, 35 different space types, three different occupancy schedules, three equipment profiles, and three lighting profiles, all combined in a total of 210 unique energy use scenarios.

Operating Results
The EGWW building has a robust energy monitoring system with dedicated reporting for end uses, making performance tracking straightforward. The team has been pleased to see actual overall energy cost track within 1.6% of the model during the first year of operation.

As expected in any project, the end uses differ slightly from the model. In the end, the modeled and actual cooling energy use track closely, plug and lighting loads are lower than predicted, and heating use is slightly higher.

One insight from the detailed performance data is that the higher heating energy use reflects, in part, the performance of the lighting control system. Current modeling practices tend to underestimate the lighting and plug power reductions achieved by modern lighting controls and plug load management. Based on energy tracking for EGWW and other projects, energy savings for these strategies can be as much as an additional 40% beyond what may have been anticipated. This is good news for lighting and plug energy use, but overall lower internal loads, will increase heating energy.
On another recent project for the energy modeler, the lighting system, with daylight responsive dimming and vacancy sensors, outperformed modeled performance by 100%. This is good news for lighting energy use, but means overall lower internal loads, which increases the heating load.

Heat recovery is a major energy efficiency measure at EGWW, and is incorporated into two key systems. The first is total energy heat recovery wheels in the dedicated outdoor air systems that recover heat from the electrical room exhaust, restroom exhaust, and other building relief systems. The second is a heat recovery chiller that provides cooling to the on-site data center and heat for the radiant panels during the heating season.

During a typical commissioning period, a building will have relatively little internal load, and it is difficult to optimize heat recovery systems when there is little heat to recover. Consequently, during the first year of occupancy, heat recovery was a major focus of the commissioning team in working with the building operators to tune the building, which is also referred to as the “aftercare” process.

Aftercare
On many projects, construction ends along with the contract, compelling the design and construction team members to transfer their design intent to operators as best they can and move on. The aftercare process implemented by GSA at EGWW retained the project team well into post-occupancy to smooth the transition from construction to operation. For the commissioning team, that meant the opportunity to work with the building operators for over a year, meeting weekly to optimize systems, solve problems and transfer knowledge.

Just as the occupant experience is different with radiant heating and cooling, building operators need to change their approach if they are more familiar with air-based systems. At EGWW, operators had to learn to solve temperature complaints without the use of air systems. The year of overlap between teams was invaluable both for energy performance and for the comfort of occupants.

Of all the innovations and lessons learned on the Edith Green-Wendell Wyatt project, one of the most broadly applicable lessons is that high-tech buildings need post-occupancy design team involvement to avoid falling out of calibration. The commissioning team is an advocate for aftercare, but thinks it’s most appropriate or necessary for complex projects, new-builds or significant modernization.

The performance results at EGWW prove the value of ensuring the first year of occupancy becomes another phase of the design and construction process. The operating net energy use intensity (EUI) for the project is 34.6 kBtu/ft²·yr (not including energy used from the on-site solar PV), in range of the projected EUI of 30 to 35. This compares especially favorably with the pre-project EUI of 75.5 kBtu/ft²·yr.

Energy performance improved as systems came into tune over the course of a year, ensuring that the promise of rigorous analysis, data-driven design and sophisticated construction came to fruition. Throughout the process, the GSA and EGWW team demonstrated and proved an essential model for public and private sectors.

ABOUT THE AUTHORS

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