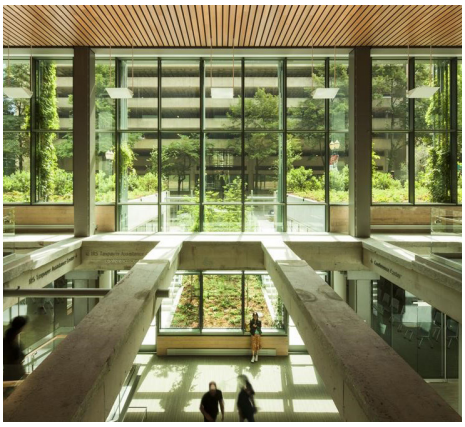
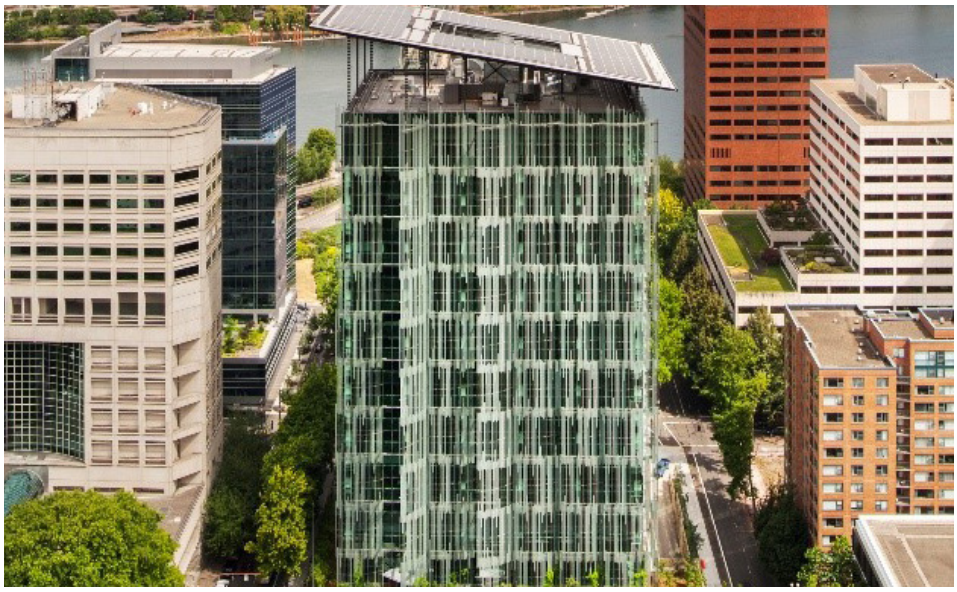
Radiant Cooling and Heating Systems Case Study





Photos: Nic Lehoux Architectural Photography

OVERVIEW

Location: Portland, OR

Project Size: Large Office: 512,474 square feet (SF)

Construction Type: Modernization

Completion Date: May 2013

Fully Occupied: Yes

Building Type: Office

Climate Zone: 4C – Mixed Marine

Totally Building Cost: $136 Million | $271/SF

EDITH GREEN-WENDELL WYATT FEDERAL BUILDING

The Edith Green-Wendell Wyatt Federal Building (EGWW) is an 18-story, 512,474 square foot (SF) office building located in Portland, Oregon. The building houses more than 16 federal agencies, 1,200 federal employees and is operated by the U.S. General Services Administration (GSA). This building was renovated from 2009-2013 and is now one of the most energy efficient large office buildings in the country with updated mechanical, electrical, plumbing and controls systems, which earned the building LEED Platinum Certification. Radiant ceiling panels were selected to heat and cool the building.

The EGWW Building was studied under a California Energy Commission EPIC research project on radiant heating and cooling systems in 2016-2017. While forced-air distribution systems remain the predominant approach to heating and cooling in U.S. commercial buildings, radiant systems are emerging as a part of high performance buildings. Radiant systems transfer energy via a surface that contains piping with warmed or cooled water, or a water/glycol mix; this study focused on radiant floor and suspended ceiling panel systems.[1] These systems can contribute to significant energy savings due to relatively small temperature differences between the room set-point and cooling/heating source, and the efficiency of using water rather than air for thermal distribution.[2] The full research study included a review of the whole-building design characteristics and site energy use in 23 buildings and surveys of occupant perceptions of indoor environmental quality in 26 buildings with 1645 individuals.

Planning and Design Approach

During the planning phase the EGWW building targeted a 60% reduction in energy use compared to the old building and a 60% water reduction compared to Oregon code. These savings result directly from an occupant focused integrated design process that prioritized comfort and energy performance. The facility is designed

1 Thermally Activated Building Systems (TABS) and Embedded Surface Systems (ESS) are located in the floor. Note: Chilled beams also use water distribution but typical 'active' beams provide cooling predominantly by convection by blowing building ventilation air across cooling coils, and were not the study focus.
2 Water transfers thermal energy about 7 times more effectively than air. CBE Brower Study, CEC EPIC 2011 http://escholarship.org/uc/item/7tc0421f#page-1

nbi new buildings institute
CBE CENTER FOR THE BUILT ENVIRONMENT

Team/Owner Details

Owner: General Services Administration – Region 10 NW Arctic Region

Architects: SERA Architects Inc., Cutler Anderson Arhcitects

Construction Manager: GSA Region 10—Pat Brunner (project executive)

General Contractor: Howard S. Wright Constructors, a Balfour Beatty Company

Structural Engineer/Civil Engineer: KPFF Consulting Engineers

MEP Engineering: Stantec Consulting

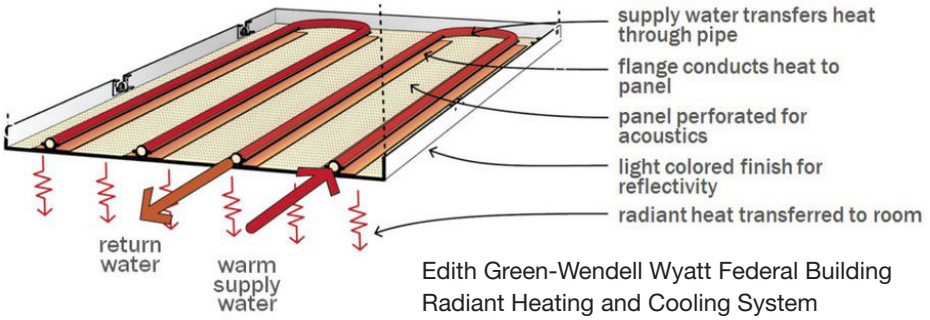
Plumbing Engineer: Interface Engineering

Commissioning: Glumac

Landscape Architect: Place Studio

EnergyStar Score: 97

Energy Use Intensity (EUI)[1]: 38



Edith Green-Wendell Wyatt Federal Building
Radiant Heating and Cooling System

Credit: SERA Architects

to meet the Federal Guiding Principles for High Performing Green Buildings, The Energy Independence and Securities Act and the Obama Administration's directives for agencies to lead by example in environmental, energy, and economic performance.[3] The building was designed to serve as a model for premier GSA offices nationwide and to set the standard for energy efficient office spaces.

Radiant System

To incorporate a radiant heating system into a building of this size the design team made minimizing the cooling load via exterior shading a high priority. Reducing the cooling load on the building is critical in order to meet the thermal comfort needs with a ceiling radiant heating and cooling panel system. The hydronic radiant panels contain 50 miles of piping throughout the building, much of it is fusion-welded polypropylene. As this is not typical construction in this climate zone, the team really focused on correct installation and commissioning to avoid air locks in the panels.

Supplemental Cooling & Ventilation

The building also provides enhanced indoor air quality through use of a 100% dedicated outdoor air system (DOAS) for ventilation as opposed to the majority recycled ventilation air of a typical Variable Air Volume (VAV) system. The DOAS works in tandem with the radiant panels by decoupling the space sensible load and utilizing the DOAS ventilation approach to address the outside air latent load. Heat recovery wheels in the DOAS recover heat from the electrical room exhaust, restroom exhaust, and other building relief systems. In addition, a heat recovery chiller provides cooling to the on-site data center and heat for the radiant panels during the heating season.

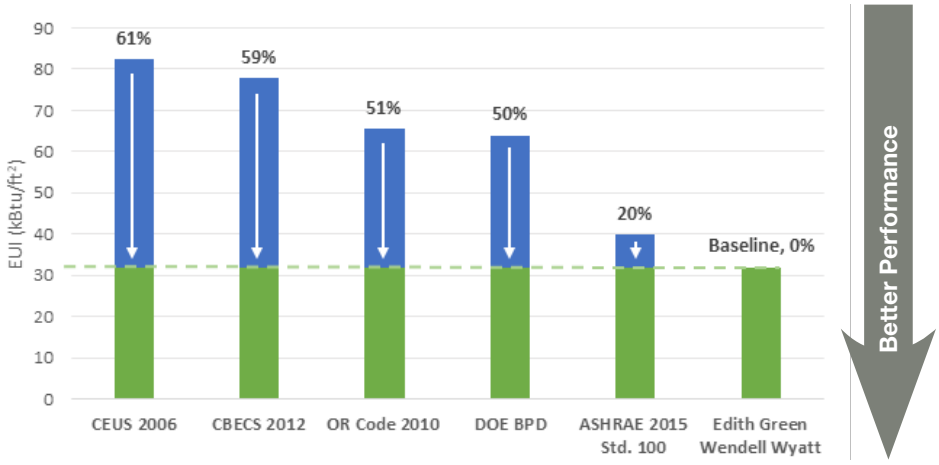


Figure 1: Percent difference of energy use intensity benchmarks compared to the EGWW Building measured performance.

1 Energy Use Intensity (EUI) is a common metric to measure energy consumption in kBtu/square foot/year

3 Executive Order (EO) 13514, "Federal Leadership in Environmental, Energy, and Economic Performance". https://www.fedcenter.gov/programs/eo13514/

"We're proud that this GSA cornerstone building is one of the most efficient office buildings in the country. Our tenants regularly give us feedback about how they enjoy all of the building features, especially the increased exposure to daylight throughout."

Kimberly Gray, GSA Director of Facilities Management Division

Building Energy Use

The EGWW building has a whole building site Energy Use Intensity (EUI) of 32 kBtu/ft^2. Despite the large square footage of the EGWW, the building's energy use is significantly lower than the office-only EUI of the national CBECS[4] and California CEUS[5] existing building datasets by approximately 60% as seen in Figure 1. The EGWW energy use is also lower than the national Building Performance Dataset (BPD)[6] EUI for offices in the same climate zone and the modeled energy use of a new building built to Oregon code by about 50%. The building's EUI of 32 kBtu/ft^2 is also 20% better than the ASHRAE energy efficiency Standard 100 for mixed-use offices, which represents the 25th percentile of lowest energy use targets in the same climate zone. Through a range of factors, including the selection of a radiant system for heating and cooling, the EGWW energy use is exceptionally low for its type and size.

Research Data Set Energy Use

The EGWW building is part of 23 radiant buildings in the full CEC research study where the bulk of the buildings were clear leaders compared to peers in both CBECS and the BPD. Two thirds receiving an EnergyStar score of 90 or above, signifying that these buildings outperform 90% of comparable buildings. The research study set is on par with the high efficiency target set by ASHRAE in Standard 100 and several of the full research dataset buildings even reached zero net energy (ZNE[7]) performance levels (~25 EUI) demonstrating the use of radiant as a path to high performance buildings.

Thermal Comfort Feedback

There was not an occupant survey of indoor environmental perceptions done through the California Energy Commission EPIC research project for EGWW but the GSA notes that, through their own satisfaction survey "The buildings boasts an occupant satisfaction of 75%". The full research study for occupant satisfaction on 26 buildings and 1645 occupant participants shows that radiant and all-air buildings have equal indoor environmental quality, including acoustical satisfaction, with a tendency towards equal or improved thermal comfort in radiant buildings. The full report detailing the occupant satisfaction of other research participants will be available in Fall 2017 at www.cbe.berkeley.edu.

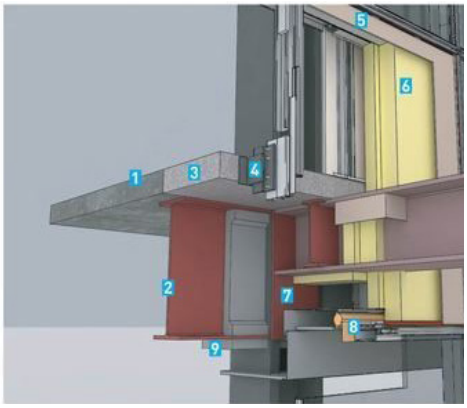
Additional Efficiency Strategies and Features

Envelope

With the capacity of the radiant heating and cooling system in mind the architectural team removed the precast concrete façade and created a high performance glass curtainwall system that optimizes daylighting and significantly minimizes heat gain. The west side of the facade is a series of aluminum "reeds," which shade the building from the most intense, direct sun. The curtainwall on the south side has fixed sunshades that mitigate glare and solar gain to support the radiant system. Other additions to the envelope include walls of insulated spandrel with continuous insulation that have a value of R-25. An optimized window-to-

4 U.S. Energy Information Agency Commercial Buildings Energy Consumption Survey (CBECS)
5 California Commercial Energy Use Survey (CEUS)
6 U.S. Department of Energy Building Performance Dataset (BPD)
7 ZNE buildings annually produce onsite energy from renewables equal to or greater than their annual energy use.

Façade Detail



Credit: SERA Architects

1 Existing concrete slab
2 Existing slab
3 New concrete floor slab
4 Curtainwall gravity joint
5 Aluminum closer panel
6 Mineral fiber batt insulation
7 Welded steel support panel
8 Sunshade
9 Fire proofing

Photo: Nic Lehoux Architectural Photography

wall ratio was designed into the space with triple-laminated glass and 8 inches of thermofiber insulation below the sill. The roof is built-up 6 inch concrete with a very high reflectivity and R-value of R-40.

Lighting and Daylighting

The split-level entrances in the building created a distinct opportunity for daylighting and connectivity for the public space. At the base of the building an existing floor slab was removed to bring daylight from the upper, plaza level to the lower, ground level, which has been reconfigured with conference space. The exterior façade includes light shelves that direct daylight 16 feet into the building. An advanced, optically enhanced, lighting control system automatically adjusts to available daylight to reduce electric lighting energy use by 40% over Oregon Code.

Renewables

The roof hosts a 13,000 SF photovoltaic array that is capable of generating 200,000 kWh of energy over the course of a year. In addition, solar thermal panels provide 30 percent of the building's hot water.

Role of Radiant in High Performance

Although a radiant system is not solely the driver of good energy performance it can be an important part of an integrated approach from design and technology selection through to occupancy and operations. In California, low-energy outcomes rely on strategies to address the HVAC system which represents the highest proportion of commercial building energy use (32%).[8] This research found the majority of the study set buildings (96%) were pursuing high levels of LEED certification, where reduced energy is a requirement. This mirrors the findings in the largest database of ZNE buildings where more than half of ZNE buildings in North America use a radiant system,[9] and in a survey of 29 advanced ZNE and near ZNE buildings in California where 11 include radiant systems.[10] Both the Edith Greene Wendell Wyatt Federal Building and the full research data set use far less energy than various benchmarks (EGWW uses 20-60% less and the full research data set uses 22-27% less) and radiant is part of that outcome.

This case study is part of a project focused on energy and occupant factors within the larger study Optimizing Radiant Systems for Energy Efficiency and Comfort. Additional case studies and the full research findings on energy use and occupant perceptions of the indoor environment will be available in Fall 2017 at cbe.berkeley.edu/research/optimizing-radiant-systems.htm and at newbuildings.org. The larger study will include design optimization, cost assessment and savings opportunities and will be available on the CEC EPIC site in 2018 at energy.ca.gov/research/new_reports.html.

Funder: California Energy Commission (EPIC Project 14-009)

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8 California Commercial Energy Use Survey (CEUS) 2006 http://www.energy.ca.gov/ceus/
9 New Buildings Institute Getting to Zero Database http://newbuildings.org/resource/getting-to-zero-database/
10 TRC and PG&E, ACEEE 2016 http://aceee.org/files/proceedings/2016/data/papers/3_636.pdf