BETTERBRICKS
Bottom line thinking on energy.

OHSU CENTER FOR HEALTH AND HEALING: A POST-OCCUPANCY EVALUATION

PROJECT OVERVIEW AND TEAM

OWNER: RIMCO, LLC

DEVELOPER: Gerding Edlen Development

LOCATION: Portland, Oregon

BUILDING TYPE: Mixed Use: wellness, medical research, clinics, surgery, classrooms, ground floor retail, underground parking

SIZE: 417,000 gross square feet

COMPLETION DATE: October 2006

UTILITIES: Portland General Electric, Northwest Natural Gas, Energy Trust of Oregon

ARCHITECT: GBD Architects

STRUCTURAL ENGINEER: KPFF

MECHANICAL ELECTRICAL PLUMBING DESIGN & ENERGY MODELING: Interface Engineering

COMMISSIONING AGENT: Interface Engineering

GENERAL CONTRACTOR: Hoffman Construction

LEED CONSULTANT: Brightworks

BUILDING MANAGEMENT: CB Richard Ellis

COST: $145.4 million

OHSU CHH Solar Panels

Photo Credit: Brian Libby

INTRODUCTION

The Oregon Health Sciences University Center for Health and Healing (CHH) possesses a prominent place in Portland's skyline, anchoring the Portland Aerial Tram, whose two 79-passenger cars travel 3,300 feet from the university's South Waterfront campus to the main Marquam Hill campus, 500 feet above. The CHH also maintains a significant position in the City's portfolio of green buildings. Occupied October 2006, it was developed with goals to provide cutting-edge health and wellness technology in an environmentally responsible building.

Gerding Edlen Development challenged its design team to reduce the capital required for the building's mechanical systems by 25 percent, while outperforming the Oregon energy code by 60 percent (as measured by energy expense). According to the Energy Trust of Oregon, the resulting building set a record for the number of energy saving strategies integrated into the facility. Innovative design strategies, combined with effective use of tax credits and incentives, saved over $3 million of the initial $30 million mechanical, electrical and plumbing (MEP) systems budget, and a recent post-occupancy evaluation and measurement and verification report documents building energy performance 48 percent better than a calibrated LEED Baseline model on an energy cost basis and 33 percent better as measured by energy units (while recommending further tuning of building operations as an approach to further performance).

> A recent post-occupancy evaluation revealed energy performance 48 percent better than a calibrated LEED Baseline model.

A two-day kick-off eco-charrette identified significant green goals beyond the energy performance/cost reduction challenge: 100 percent capture and use of rainwater falling on the building and a minimum 50 percent reduction in potable water use; providing significant amounts of power and chilled water on-site from a combined heating/cooling and power plant; and treating all sewage on site and reusing that water for non-potable uses.

The project team met these complex challenges, demonstrating that building performance can be increased at the same time that costs are reduced. As of February 2009, the Center for Health and Healing remained one of only 50 LEED Platinum Buildings in the country and (arguably) the most complex building in the country to have achieved this rating. Reinvestment of MEP savings, energy efficiency incentives, and the value of the Oregon Business Energy Tax Credit, made it possible to reach this level of performance with a net premium less than three percent of total project cost.

OHSU Center for Health & Healing Exterior

INTEGRATED DESIGN

The project team employed a highly collaborative integrated design process to deliver increased building performance. The following discussion of energy performance is from BetterBricks' perspective, which emphasizes integrated design solutions across climate, building use, building design, and the choice of efficient systems.

CLIMATE

At the start of the design process, temperature, rainfall, groundwater and wind flow data were analyzed to identify climate loads, evaluate passive energy resources, and to explore possible integrated design strategies.

USE

The complex building program: a three-story underground parking garage that provides approximately 660 parking spaces for patients and staff; eight floors devoted to physician practices, surgery, and imaging centers; four levels dedicated to education and research; three floors devoted to a comprehensive health and wellness center which includes a full gym, four lane lap pool, therapy pool, cardio and weight training areas; was evaluated in a manner similar to a spec office building, where every use is expected to pay its own way. The design team considered temperature, lighting, and ventilation comfort criteria as required for each occupancy and tuned their design assumptions accordingly. As a result, they relaxed temperature ranges in circulation areas and reduced lighting levels for lobbies, stairwells, and corridors.

BUILDING DESIGN

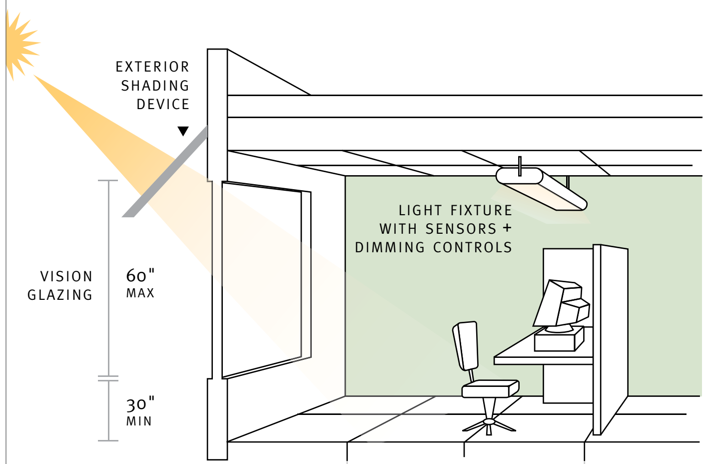
The building was designed with its long axis on an East-West orientation, and the team employed models to evaluate the impact of solar loading and how various shading strategies would affect daylighting and solar temperature gain, both initially and as additional South Waterfront buildings were developed. Modeling also informed decisions about the amount and location of building mass and operable windows, to facilitate passive heating and cooling, ventilation strategies, and daylighting. Heating, cooling, lighting and ventilation loads were calculated for the various design strategies and baseline energy use was predicted.

Daylighting models and the energy model informed decisions about placement of sunshades and the stair tower ventilation that helped reduce cooling loads (downsizing saved approximately 30 tons of cooling capacity). These capital savings were reinvested in PV panels that were integrated into sun shades.

SYSTEMS

- High efficiency boilers and chillers
- Displacement ventilation in examination and office spaces
- Fan-wall, an array of smaller fans replacing a single large fan, occupying less space (and leaving more leasable space available, providing higher efficiency and lower connected loads, equipment redundancy (from multiple fans), and lower first costs.
- Chilled beam cooling, reducing fan energy use 20-30 percent
- Use of variable frequency drives on pumps and motors to carefully match HVAC output with demand
- Building commissioning, including field verification of all energy using equipment

INTEGRATED DESIGN STRATEGIES AND FEATURES



Interface Engineering's CHH Daylighting Diagram

- Circulation of reclaimed rainwater and ground water in concrete slabs, for radiant cooling of ground floor atrium and lobby
- Solar collector trombe wall occupies 15th & 16th floors: 190 foot long by 32 foot high solar heater. Warm air collected from the surface of the wall is circulated through the building during the winter, reducing energy use.
- Rejected heat from the microturbine central plant is captured and used in the building to preheat domestic hot water. It is also stored in the first floor slab and the health-club swimming pool when thermal storage of excess heat provides load-shifting benefits.
- Hallway and stairwell occupancy sensors to ensure that electric lighting is used only when needed
- Daylighting passive heating, cooling, and natural ventilation of the stairwells.
- Heat recovery systems, incorporated into laboratory and general exhausts and returning gym air through the locker rooms.
- Demand controlled ventilation (DCV) using carbon dioxide sensors and occupancy sensors, so spaces are not over ventilated or overlit when not in use.
- The chilled beam system allows a smaller HVAC system than a conventional forced air approach.
- Displacement ventilation is used in core exam and office areas to reduce air contaminant levels and to eliminate supply air reheat
- Night flush cooling, using outside air, until one hour before daily occupancy
- Occupancy sensors in lab exhaust systems to avoid dumping conditioned air outside when labs are not in use

POST-OCCUPANCY EVALUATION / MEASUREMENT & VERIFICATION

Late 2008, after two years of occupancy, Interface Engineering prepared a measurement and verification report as part of a broader Post-Occupancy study funded by the building owner, Gerding Edlen Development (project developer), the Northwest Energy Efficiency Alliance, and Portland State University. Utility bills from November 2007 through October 2008 were collected and analyzed. (Utility bills generally provide a better picture of building energy performance after the first year of occupancy.) The original LEED energy model was updated and calibrated to approximate the building's current energy use: the modeled building lighting, HVAC, and occupancy schedules were aligned with actual schedules, and the density of building occupancy, and the magnitude of plug loads were assessed and the energy model inputs were adjusted accordingly.

Overall Energy Use

Energy billing data for one year was divided by the gross square footage of the building, resulting in units of kBTU/sf-yr (thousands of BTUs per square foot per year), generally referred to as an energy use index (EUI).

Overall Energy Use (EUI)	Calibrated LEED baseline		Actual		Reduction in Use	
Purchased Energy	(kBTu/sf-yr)	%	(kBTu/sf-yr)	%	(kBTu/sf-yr)	%
	215	100	145	67	70	33

Building energy use is 33 percent better than predicted for a baseline building (calibrated to actual schedules, occupant density, and plug load) on an energy units basis. As mentioned earlier, building energy performance is 48 percent better on an energy cost basis, a benefit from the use of the microturbine cogeneration plant, where natural gas (less expensive than electricity) is used to produce electricity and heat). Additional, valuable information about building performance can be learned by isolating electrical and gas consumption and by separating the performance of the building from the central utility plant.

Electrical Use

CHH electrical use can be disaggregated in a number of ways. Overall electrical use is 30 percent less than predicted by the calibrated LEED baseline model and is supplied from three sources: 72 percent is purchased energy, 27 percent is produced by the microturbines in the central heating and cooling plant, and one percent comes from the photovoltaic arrays. Comparison of overall electrical use to the baseline model provides a picture of the relative efficiency of electrical energy use.

Electrical Use (kWh)	Calibrated LEED baseline	Actual		Reduction in Use	
	kWh	kWh	%	kWh	%
Purchased Energy	11,845,774	6,021,431	72	5,824,343	49
Microturbine Production		2,269,519	27	NA	
Photovoltalc Production		50,378	1	NA	
Total Electric	11,845,774	8,341,328	100	3,504,446	30

It is also important to note that the combined performance of the microturbines and PVs, added to the building efficiency improvements, has reduced the amount of purchased electricity by 49 percent, relative to the baseline model. Purchased electricity is the resource that is included in the building's EUI (energy use index). The amount of natural gas used in the central plant to generate electricity is tracked as part of the natural gas consumption and is incorporated into the EUI calculation as gas, rather than electricity.

Gas Use

One of the complicating factors when considering the energy performance of the Center for Health and Healing is that its electrical and gas consumption is integrated with the performance of the microturbines in the central heating and cooling plant. While overall EUI data facilitates comparison with other buildings and the baseline model prepared for this building, important resolution is lost allowing building performance to be considered independently of plant performance.

The combined gas consumption of the plant and the building is 18 percent less than predicted by the baseline model. However, while central plant consumption of gas is close to what was modeled by the design engineers, building consumption is significantly lower.

Gas Use (therms)	Calibrated LEED baseline	Actual		Reduction in Use	
	Therms	Therms	%	Therms	%
Building Gas Use	491,614	79,606	20	412,008	84
Microturbine Use		321,124	80		NA
Total Gas	491,614	400,730	100	90,434	18

A likely explanation for the large reduction in building gas consumption has emerged from Interface Engineering's measurement & verification analysis: equipment plug loads are much higher than anticipated, reducing the building's heating load (energy consumption by building equipment adds heat to the space). The original energy model used a blanket figure of 0.75 W/sf for office space and 1.0 W/sf for the Lab spaces. The POE determined that all offices had additional equipment installed beyond what was initially assumed. Private offices had an average measured power density of 1.25 W/sf and open offices 1.5 W/sf. In this building, there are certainly opportunities to reduce these loads, but when a building is not owner occupied—where the full range of interrelated decisions affecting energy use are made by the same organization—such measures may be hard to implement.

With the building heating load lower than expected, gas consumption by the microturbines should also be lower than the design calculations. The measurement and verification process determined that the microturbines had been programmed incorrectly at the time of start up. Reprogramming will allow them to effectively follow the building's thermal load, reducing the amount of electricity used by the central heating and cooling plant.

This is one of the benefits of the recent measurement and verification study: performance data is now being used by the design engineers and building and central plant management to modify the plant and building operating sequences to improve overall performance. It is expected that the project EUI will continue to fall.

LESSONS LEARNED

Submeter Critical Loads

In order to derive the maximum benefit from M&V activities and to have a better chance of understanding performance, it is important to submeter critical loads. In a building as complicated as the CHH, whole building data can establish a benchmark, but does little to help understand the performance dynamics of the building. Along with decisions about submetering, a protocol needs to be developed for data logging and analysis, and how the resulting information will be used for continuous improvement. However responsibilities are distributed among designers and operators, analysis of building performance at a more detailed level than the whole building is required.

Use Simulation Models to Assess Design Strategies (Not to Set Energy Budgets)

While hourly energy simulation and other performance modeling tools such as computational fluid dynamics and daylight modeling and analysis are important resources to evaluate design alternatives and to inform design and development decisions, they are not tools that are designed to predict real world energy use. There are too many variables and too many unknowns to expect these tools to do more than support decisions by indicating the relative levels of performance, given certain assumptions about design alternatives.

Innovative Designs Require the Sophisticated Use of a Broad Array of Tools

It is not unusual to find that new algorithms and hand calculations may be required to estimate the integrated performance of new strategies. Sophisticated users, people who have both designed with these tools and analyzed building performance, may find that their analysis aligns more closely with actual performance than when the same tools are used by less experienced analysts. However, even such familiarity with the tools may be offset by the need to push the capabilities of each tool to model the performance of newer building performance strategies that were not anticipated when the models were developed.

Design and Operating Assumptions Need to be Well Documented and Broadly Understood

Once design decisions have been made, it is important to document the operating assumptions that lead to those decisions. Whether the latest automated process, or a finely engineered passive system, it is critically important to prepare detailed documentation of operating sequences. Ensure review and evaluation of the sequence of operations required to operate the building as designed and provide fully informed input if adjustments need to be made.


Photo Credit: Interface Engineering

Building Commissioning

The Successful Design of High Performance Buildings is a Team Activity

Dennis Wilde, a principal at Gerding Edlen Development discussed lessons learned from the CHH project, in an article he wrote for High Performance Buildings. A number of these lessons spoke to managing the team process required to develop high performance sustainable buildings.

"Everyone is under the spotlight, not just the architects. Both the MEP consultant and general contractor must feel invested in the outcome from the beginning, neither can take a "sit back and wait" attitude. And commissioning agents and building facilities managers must be involved early.

And, value to user is critical—the user is seldom effectively considered in the design process. It's not just optimizing the programming, consider the user experience."

One of the implications of Dennis' comments is the importance of engaging facility management and building operators (with their particular perspective on the user experience) with design engineers, early in the development process so that productive relationships among them have been established prior to start up, commissioning, and operation.

Look for Benefits from Smarter, Simpler Systems

He also speaks about making choices from among complex and simple systems, when striving for increasingly higher levels of performance:

"The building's complex operations took considerable time and expense in the commissioning process. Most of the building's systems were monitored through the direct digital control (DDC) system, and in the early months of commissioning, the system was painfully slow.

The team acknowledged that many of the building's technical features were quite complicated and pointed to features like the solar heater, with no moving parts, as a goal that every new building should strive towards.

Future design of more sustainable buildings should aim to be smarter and simpler. We habitually build buildings full of mechanical equipment that's seldom used and systems that do not complement each other. Why not get creative?"

SOURCES

Engineering A Sustainable World: Design Process and Engineering Innovations for the Center for Health & healing at Oregon health Science University, River Campus, Interface Engineering, Inc., October 2005

Dennis Wilde, Rx for Platinum, High Performance Building, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Winter 2009, pages 6-16

OHSU Measurement and Verification Report, Prepared for Gerding/Edlen Development Company and Northwest Energy Efficiency Alliance, Andrew Craig, Interface Engineering, January 6, 2009

CONTACTS AND RESOURCES

ENERGY TRUST OF OREGON:
www.energytrust.org

GERDING EDLEN DEVELOPMENT:
www.gerdingedlen.com

GBD ARCHITECTS:
www.gbdarchitects.com

BETTERBRICKS:
www.betterbricks.com/design

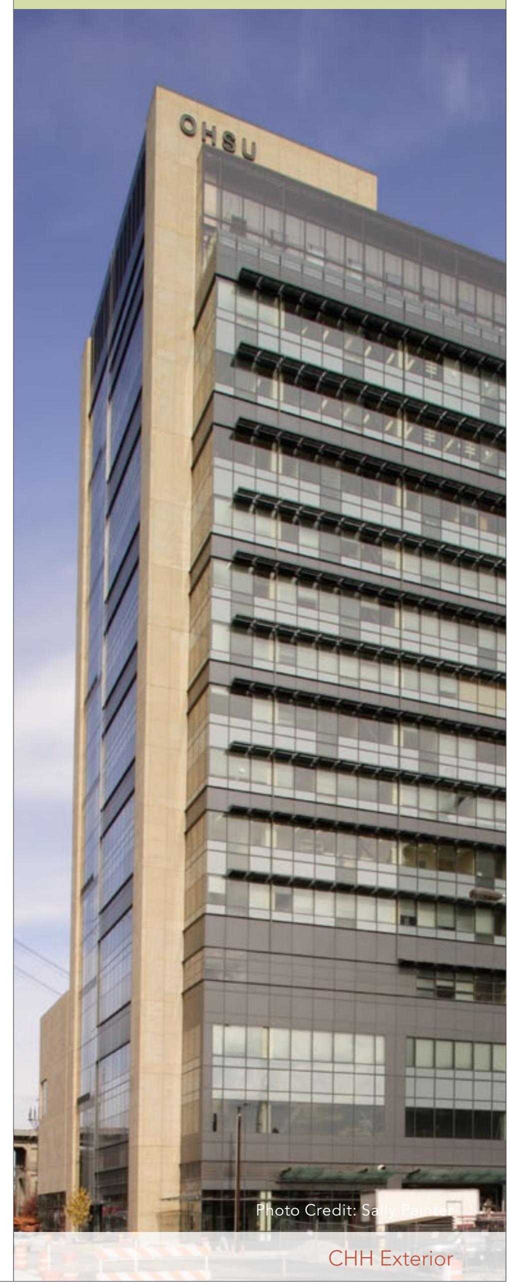


Photo Credit: Sally Painter

CHH Exterior