
The Port of Portland Headquarters

The Port of Portland is a government organization responsible for supporting the region's economy and general quality of life through coordinating its air and marine activities, with a particular focus on facilitating efficient air passenger and cargo access to national and global markets. Until 2010, the organization had four different offices spread throughout the city, each with their own insular culture and bureaucratic structure. To improve overall cohesion and efficiency and create a workplace that was conducive to collaboration, the Port enlisted ZGF Architects to design and construct a new headquarters at the Portland International Airport. In addition to bolstering organizational morale, the project was also intended to produce a structure that evidenced the regions proactive commitment to sustainability. Because of the extensive network of runways, outbuildings, and connecting roads that comprise the airport complex, the Port did not have much flexibility in plan. The best available site was previously earmarked for a parking structure so ZGF and The Port got creative. The result is a three-story, 200,000 square-foot office space situated atop a seven-story parking garage. The building was completed on schedule in 2010, at a cost of \$241 million--\$156 million for the parking garage and pedestrian tunnels, and \$85 million for the headquarters. The cost of the project was funded by Port using working capital, airport revenue, and airport revenue bonds. No state or local revenue was tapped to bring the project to fruition¹. The structure is progressive in its sustainability imperatives and several aspects of its construction and design stand out as making essential contributions to its sustainable character.

Living Machine System:

The most prized feature of the Port of Portland building is its integrated Living Machine wastewater treatment system which is comprised of six tidal wetland Living

Machine® cells and a one-pass vertical flow wetland. Of the tidal wetland cells, four are located outside the building entrance and the other two are situated in the lobby atrium with plantings that include bird of paradise, water lilies, and rush². The exterior vertical flow wetland is adjacent to the building. The Living Machine act as a complete wastewater treatment system, collecting 100 percent of the building's consumed water (including grey and blackwater) and treating it for reuse in the toilets and geothermal cooling tower. Influent water is sent to a dual-compartment 10,000 gallon primary holding tank for coarse solids removal and then to a recirculation tank. From there, the water is pumped into the tidal flow wetlands, which complete the first stage of organic water treatment through a series of fill and drain cycles, mimicking the processes of a wetland found in nature³.

The fill and drain cycles provide oxygen to microorganisms on the surface of the treatment media which fosters their rapid growth. The various microorganisms growing in the wetland cells are critical for converting impurities into nontoxic compounds and completing the nitrification process. The second stage of purification occurs in the one-pass vertical flow wetland, where treated effluent is polished as it filters through two microorganism-rich zones, removing any remaining nitrogen and solids. In the final stage, treated water is disinfected using ultraviolet light. Although this step is technically unnecessary, the Portland Port opted for the disinfection system as a precautionary measure. The disinfected water is then sent to a holding tank, where it waits to be distributed for the building's non-potable water demands. In comparison to an office building of similar size, the Living Machine system reduces the Port of Portland's water consumption by a staggering 75 percent, treating and reusing up to 5,000 gallons of wastewater per day⁴.

Eco-roof:

The 9th floor of the building features a 10,000 square ft. extensive tray system eco-roof with a soil depth of 4". Planted with native, drought-tolerant, and low-growing *Sexanguiare*, *Albun*, and *Oreganum*, the vegetated roof creates intact habitat for small

living organisms⁵. At the same time, the sedum was specifically selected for its low attraction level to birds, which would endanger the safety of planes landing on the nearby airport runway. On the other side of the 9th floor, a smaller intensive eco-roof was planted for use by the staff. This roof has a greater soil depth which supports the growth of various shrubs and small trees and functions as a landscaped gathering place. Both roofs act to insulate the building, making it easier to cool, as well as help to treat rainwater. The biggest benefit of the eco-roof, however, is its ability to moderate storm water runoff through retention (water holding) and detention (flow slowing). Reducing the flow rate and quantity of rainwater into the sewer system mitigates the occurrence of stream bank erosion and channel degradation. Furthermore, controlling the rate of runoff prevents the storm water system from overflowing into the waste water sewer system in a heavy downfall. This, in turn, avoids raw sewage contamination of storm water ultimately bound for the region's streams, rivers, harbors, and oceans⁶. The surface of the building not covered by the vegetated eco-roof (35% of the total roof surface) is covered with a reflective membrane to reduce heat absorption and help limit the building's contribution to the urban heat island effect.

Geothermal Heating and Cooling System:

The building's heating and cooling system was designed to operate without the consumption of fossil fuels. Beneath the headquarters foundation, 200 pipes burrow 300 feet into the ground and continually circulate water through a closed loop ground source heat pump system. In the winter, the pipes bring fluid heated by the earth into the building, and send heat from the building back to the earth in the summer months⁷. To absorb excess heat when it is not needed, the building is fitted with a cooling tower fed by water from the Living Machine system. The geothermal heating and cooling system links into a passive radiant panel system, a more efficient thermal system than commonly used in-floor radiant heat. The radiant panels, which are partially concealed by a decorative façade, are suspended below 40 percent of the interior ceiling space, concentrating warm and cool air in places where workers spend the most time as opposed to equal distribution to include underused areas like hallways and secondary

spaces. This combination of thermal heating and cooling systems is the first in the United States and uses 51 percent less energy than a typical commercial space of the same size. Because the HVAC system uses water instead of forced air, the building is surprisingly quiet; so quiet, in fact, that the Port installed a white-noise system that parallels a rise in distracting voice levels⁸.

Energy Optimization:

A number of devices are used to manipulate natural light, bringing it into the building while controlling the glare and heat input of direct sunlight. On the exterior, a sweeping canting curtain wall is comprised of glass panels that alternate between laminated clear and opaque glass. ZGF architects fastidiously modeled the proportions of the glass panels until the right balance between energy performance, natural light infiltration, and noise reduction was achieved, all the while preserving the tableau of the distant mountains and Columbia River. Exterior shading on the south side of the building maximizes southern light while minimizing direct sunlight. Interior solar control is managed by horizontal venetian blinds with specially engineered concave slats that act as miniature light shelves, bouncing direct sunlight up to the ceiling where it is diffused further back into the building⁹. All of the office floors are treated with a high-performance glazing to reduce glare and heat gain inside the work space. The offices are organized into three parallel bars, each with an east-west orientation to maximize daylighting. Two atria with skylights in the core of the building bring natural light into the spaces that lack a directional façade. Advanced lighting controls administer ambient artificial light using dimmers and occupancy sensors, taking into account the time of day and cloud cover¹⁰. These combined features result in a 36 percent energy reduction in the office proper and an astounding 78 percent reduction in the parking garage. Additionally, because the Port has a renewable energy contract for the electricity it does use, no fossil fuels are burned to operate the building¹¹. The Port considered installing

solar panels to carry the building towards self-sufficiency, but space limitations would render their contribution to be relatively low and would not offset the cost of installation. The agency concluded that the renewable energy contract met their sustainability goals adequately and has no current plans to use solar technology for the headquarters.

Secondary Contributions to Sustainability:

The efficiency of the principle operational systems outlined above is the biggest factor in the dramatic reduction of the Port of Portland's carbon footprint, but a variety of secondary features also contribute to the sustainability of the building. In the construction phase, 95 percent of on-site waste was recycled. The headquarters is outfitted with water-efficient fixtures, repurposed, recycled, and rapidly renewable textiles and building materials, no or low-VOC paints and materials, regionally manufactured components, and an under-floor air distribution system that is significantly more energy efficient than traditional dropped-ceiling versions¹².

Most of the furniture in the building is reused from the Port's former headquarters, reborn with new upholstery, fresh coats of paint, and wood refinishing. The office chairs are made to be completely recyclable at the end of their lifespan. The building boasts on-site food composting (via worms!), an office supply reuse program, and a recycling system so accessible that the office has a current recycling rate of 76 percent. The headquarters encourages biking with facilities that include bicycle storage, lockers, and showers for commuters¹³.

Outcomes:

From the outset, The Port of Portland aspired to build a structure that would be LEED Gold certified. Throughout the design phase the architects and engineers worked closely with the suppliers, small businesses, and product developers involved in the project. This close collaboration led to continuous revision and innovation that pushed

individual sustainability targets beyond their original expectations. As a result, the building as a whole exceeded its stated objectives and was accordingly awarded with LEED Platinum certification, the highest green rating available.

The project surpassed other goals as well, particularly in the construction phase when roughly 2,500 individuals were employed for more than one million hours of work, an especially welcome contribution to the local economy at a time when the unemployment rate in Oregon rose to the double digits. Furthermore, the Port's small business contracts represented 24 percent of the total project, nearly twice as many as intended¹⁴.

Another surprise came from the Living Machine water purification system which decontaminates incoming wastewater at quality levels well beyond those mandated by Oregon's Department of Environmental Quality. The measured results, published in a project summary conducted after the building became operational, are listed in the table below¹⁵:

Units (mg/l)	Influent	Target Effluent	Measured Effluent
BOD	190	<10	1.0
TSS	55	<10	2.1
TKN	160	<10	2.2
Turbidity	-	<2.0	0.6

To learn if other features of the building were exceeding original expectations, I spoke with the Portland Port Authority's Lead Project Engineer, Dan Gilkison. When asked about the green roof Mr. Gilkison confirmed that it was healthy and performing well. An unexpected but welcome surprise stemming from the roof installation revealed itself during the first summer that the Port building was operational; bees assembled in significant numbers and used the roof's foliage for pollination. Because bee activity is limited to the areas of the roof that are generally unused by staff, their presence has not

been a problem and the Port plans to set up beehives this spring to accommodate the bees and encourage their return.

Mr. Gilkison also emphasized that the performance of the heating and cooling system was better than anticipated. Because the combination of a closed-loop geothermal and passive radiant panel system was never employed before the construction of the Port Authority's headquarters, there was no concrete data available regarding its likely performance. Thus, many involved in the project (including Mr. Gilkison himself) were uncertain of whether the heating and cooling system would prove to be a worthwhile investment. On the spot thermal readings, however, display temperatures that consistently fall within the target range of 69-74 degrees Celsius, usually clocking in between 70-72 degrees. As a system it is incredibly stable and efficient, providing uniform interior temperatures throughout the building, much to the delight of Port employees.

But operation of the building has not proceeded without a hitch. The first unanticipated glitch, involving the Living Machine, occurred just after employees from all three of the Port's previous offices consolidated into the new headquarters. To prepare for this influx, Port staff fed powdered milk into the system to spur the growth of the bacteria responsible for purifying influent. The Living Machine functioned according to plan in the final weeks of construction so employees were given the green light to move in over two weekends in late April. The first 200 employees moved in without incident but when 200 more arrived the following weekend, the system went into shock and bacteria began to rapidly die down. Browning plants in the system's wetlands (the result of a massive spike in nitrogen levels) provided the first indication that something was amiss and the Port immediately switched the building to overflow and public sewer systems while the problem was being addressed. It was later determined that two factors contributed to the malfunction of the Living Machine; first, the system was designed to work with standard toilets and water fixtures. Therefore, the low-flow fixtures used throughout the headquarters produced more heavily concentrated influent than the system was calibrated to accommodate. The second factor was simply that

not enough bacteria was initially cultivated for the demands of the building. To solve the problem, the Port returned to feeding the Living Machine powered milk for two months following the breakdown. As bacteria grew, diluted wastewater was reintroduced into the system. Incredibly, a mere three months after the initial malfunction, the Living Machine was weaned from diluted wastewater and returned to full function by early July. It has not had any problems since and continues to produce higher-than-expected water quality levels, as mentioned above.

In terms of human use, the lighting control system represented the biggest adjustment for employees. For example, windows on the south façade of the structure were outfitted with automated blinds that adjust according to the intensity of the sun using a computerized sensor on the roof. Unaccustomed to self-regulated lighting controls, employees struggled a bit with perceived comfort. In response to this, the Port has become more lax around allowing people to adjust the blinds according to their preference. Additionally, it took the staff time to become acquainted with daylighting which serves in place of continually operating overhead lights in many parts of the building. Most now understand that daylight is more than adequate for their needs and use task lights as a supplementary lighting source, when necessary. The computerized lighting controls experienced some bugs early on, but reprogramming the system solved the problem and the lighting scheme now functions well.

A major critique of the building can be centered on its overall cost, which totaled \$241 million-- \$156 million for the parking garage and pedestrian tunnels, and \$85 million for the headquarters itself. Mr. Gilkison attributed the high number to the excavation and structural engineering required by the underground pedestrian tunnels, widespread use of glass on the building envelope, as well as the situation of the headquarters on the top floors of the parking structure. But the Port's budget was incredibly large, allowing them liberty to exploit a more elaborate design scheme and use costlier materials. Surprisingly, the high cost of construction was not a result of the various green systems incorporated into the structure. The Port invested a total of \$10 million dollars into sustainable features, representing a mere 10% of the project's total

cost. Unsurprisingly, some of the features will pay for themselves within a few years; the geothermal heating and cooling system has a payback period of 4-6 years and the simple act of consolidating the Port's three main divisions from separate offices into one central structure saves the Authority a whopping three million dollars per year (stemming mostly from eliminating the need for travel between different branches of the Port as well as the organizational and operational costs associated with running three separate offices). One could easily argue that the simple act of consolidation is a sustainable aspect of the project, and certainly the feature that provides the greatest payback. Although the green features of the building only cost \$10 million, the Port did invest more money than anticipated on the Living Machine, as it needed to be adapted to the site as construction advanced. All told, the system cost roughly \$750,000. Maintenance of the system is minimal, but the Port Authority does spend a significant amount of money (\$11,000/month) to comply with DEQ (Department of Environmental Quality) regulations that stipulate water samples be taken three times per week by a certified wastewater treatment operator. Because the Living Machine consistently surpasses DEQ requirements, the Port is attempting to negotiate a decrease in sampling frequency, which, even if lowered to twice a week, would save the Port thousands of dollars per month.

The Port of Portland's headquarters provides a representational glimpse of what is possible in the worlds of architecture and construction. Between the installation of high performance operational systems, scrupulous consideration of the contextual environment, and thoughtful selection of materials, the headquarters yields an energy reduction that translates into a CO₂ savings of 868 Metric Tons per year. As an organization, the Port aims to eventually become a zero waste facility¹⁶.

Since construction of the headquarters was completed in 2010, two notable sustainable building projects have launched and are currently under construction in the United States; The Bullitt Center in Seattle, and the Oregon Sustainability Center in Portland. Both buildings far surpass the U.S. Green Building Council's LEED Gold standard and endeavor to be certified as Living Buildings. If they meet the rigorous

Living Building standards, they will be two of only five in the world¹⁷. I bring up these buildings not to diminish the accomplishments of the Port of Portland's new headquarters, but to underscore the precedent for intelligent, ecologically-minded building design that the Port helped to establish. The placement of the Living Machine in the lobby of the building was the first time the system was incorporated into the interior environment of an office, debunking the myth that the process would be too pungent for use in a public space. This is one of many ways that the features of the building have surprised critics and proved naysayers wrong. The project as a whole evidences what can be accomplished when architects, engineers, and financiers are willing to take risks in design, in people, and in some technologies (both sophisticated and primitive). While not all building projects have a massive budget, as did the Port, the fundamental principle of risk-taking applies nonetheless, and simple adjustments (like using low-flow fixtures) with quick payback periods can be accommodated by most construction budgets. Resistance to these changes is a topic for a different paper, but simply stated, Americans are not conditioned to think in the bigger picture or in the context of the long run. Therefore it is not always intuitive for sustainable features to receive consideration over standard building practices. The Pacific Northwest has always been ahead of the curve, however, and as the rest of the country catches up to the innovation found there, the Port of Portland's headquarters will undoubtedly serve as a model for sustainable buildings throughout the United States.

NOTES

¹ <http://www.bestbusinesscenter.org/recognition/business-directory/port-of-portland-headquarters/>

² <http://metropolismag.com/story/20110214/the-fifth-annual-smart-environments-awards-port-of-portland-headquarters>

³ http://www.livingmachines.com/portfolio/detail/port_of_portland/

⁴ http://www.portofportland.com/NewsRelease.aspx?newsContent=A_2011614171049RCHQLEED35.ascx&topic=Corporate%20News%20Release

⁵ <http://www.portlandonline.com/bes/index.cfm?a=326716&c=51477>

⁶ <http://www.wbdg.org/resources/greenroofs.php>

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- ⁷ http://www.portlandtribune.com/sustainable/story.php?story_id=124216043275524500
- ⁸ <http://metropolismag.com/story/20110214/the-fifth-annual-smart-environments-awards-port-of-portland-headquarters>
- ⁹ http://www.worldarchitecturenews.com/index.php?fuseaction=wanappln.projectview&upload_id=12624
- ¹⁰ <http://metropolismag.com/story/20110214/the-fifth-annual-smart-environments-awards-port-of-portland-headquarters>
- ¹¹ <http://www.earthtechling.com/2011/06/port-of-portland-hq-a-very-green-building/>
- ¹² http://www.worldarchitecturenews.com/index.php?fuseaction=wanappln.projectview&upload_id=12624
- ¹³ http://www.portofportland.com/NewsRelease.aspx?newsContent=A_2011614171049RCHQLEED35.ascx&topic=Corporate%20News%20Release
- ¹⁴ http://www.portofportland.com/Media_HQ_PressKit.aspx
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- ¹⁶ http://www.worldarchitecturenews.com/index.php?fuseaction=wanappln.projectview&upload_id=12624
- ¹⁷ <http://www.fastcompany.com/biomimicry/portland-seattle-duke-it-out-for-worlds-most-nature-inspired-building>