As the first building on what could potentially become an entirely net zero energy campus, the Portland Community College (PCC) Newberg Center represents a pioneering model for higher education institutions. Sustainable features are integrated building blocks of the design rather than attachments. The end result is a form expressive of its passive design strategies—from the curtain wall to the use of the ventilation stacks as an organizing element in the building. But the more important outcome is PCC’s engagement in living within the building’s energy footprint, educating themselves and students about energy-saving behavioral changes—such as wearing seasonally appropriate clothing—and the larger issue of environmental stewardship.

**Goals**

When the PCC Newberg Center was conceived, an overarching goal was to provide convenient access to higher education for the surrounding community. In recent years PCC noted an upward trend of high school graduates from the Newberg area commuting to PCC’s Sylvania Campus, which required a 40-mile round-trip trek along a traffic-congested highway.

The Newberg Center now meets those local needs, reduces travel-related greenhouse gases, and provides accessibility to those without an automobile. PCC aspires to make its entire Sylvania Campus net zero energy, so it was logical to begin the effort with the Newberg Center, which is a satellite to the Sylvania Campus. Designing and operating a living laboratory to test new energy conserving strategies also allows facilities personnel to become acquainted with different maintenance requirements before applying them on new buildings. While the Newberg Center has not yet achieved net zero energy, designers expect that continued monitoring and adjustment will eventually result in the facility using less energy than it produces.

**Site**

Newberg is in Oregon’s wine country and has historically been an agricultural landscape with rolling hills and small farms. The site offers abundant access to daylight, pastoral views, and fresh air.

**Design Team Integration**

The design team focused on four areas of sustainable design: creating a highly efficient envelope, maximizing passive strategies, using efficient systems, and engaging building users.

**Energy Goals**

Simple strategies are used to meet the project’s aggressive energy goals: minimize loads, provide efficient systems and use renewable energy. After all measures were initiated, the project team considered renewable energy to offset demand. Minimization of loads began with an analysis of a similar baseline building’s energy demand distribution. For a Baseline code building, the most significant loads were split between heating, plug loads, lighting and fan energy (Figure 2). The highest energy demand loads became obvious opportunities for reigning in consumption. For the Newberg Center, this meant targeting electric lighting, plug loads and space heating.

The indoor design comfort conditions were another important part of the puzzle. Engaging PCC in energy-saving behavioral changes, creating a highly efficient envelope, maximizing passive strategies, using efficient systems and engaging building users.

**GROUND ZERO**

BY DOUG REIMER, AIA; AND JOHN MCMICHAEL, P.E., MEMBER ASHRAE

The design team for the Newberg Center focused on four areas of sustainable design: creating a highly efficient envelope, maximizing passive strategies, using efficient systems, and engaging building users.
such as encouraging building users to wear seasonally appropriate clothing, allowed the team to design the building with an expanded temperature range.

As a result, the heating setpoint was reduced from 69°F to 68°F and the cooling setpoint was increased from 72°F to 75°F for classrooms and offices. The cooling setpoint for the commons space is 82°F and the heating setpoint is 68°F. (A typical building might have a heating temperature setpoint of 70°F and 75°F for cooling.)

Load Reduction Strategies

Super Envelope. Representing one-fifth of the total energy demand, space heating became an important focus. The team worked from the outside in to reduce heating demands, and created a highly efficient envelope through the use of a structurally insulated panel system (SIPS). The resulting R-values for the roof and walls are R-47 and R-31 respectively.

Glazing is double pane argon filled with a U-value of 0.29. The glazing percentage was kept to a value that balanced aesthetics and daylight with energy goals. After several computer simulation models were run, the team settled on a final value of 30%.

Building Orientation. A classic east-west building orientation maximizes opportunities for capturing solar energy, while the north/south dimensions take advantage of natural ventilation schemes. The south side’s multiple purpose rooms, commons and building circulation space feature large overhangs to protect openings from glare and provide covered outdoor spaces that can be used even during the wet winters.

This design limits solar heat gain during the summer and maximizes it during the winter. Harvesting the winter time solar energy also helps reduce the heating portion of the energy demand distribution.

Daylighting. A sloped ceiling system with commercially available skylights and acoustical ceiling tiles that wash the classrooms and open office spaces with even, diffused daylight eliminates the need for electric lights during the day.

Natural Ventilation. Taking advantage of the Pacific Northwest’s climate, the building incorporates natural ventilation and passive cooling articulated by the ventilation stacks that organize the circulation spine.

Plug Loads. The main source of plug loads are the computers used for instruction and administrative work. The design team proposed laptop computers, a reduction in the number of vending machines, and a non-refrigerated water fountain to limit plug loads. Switched outlets (which could be shut down via occupancy sensors or timers) were considered, but the concept received some pushback from equipment suppliers for vending machines and PCC’s IT department.

For other loads, PCC committed to purchasing ENERGY STAR-certified appliances whenever possible. Plug load savings in the metered data is significantly better than predicted (about 40% lower).

Design Tools. Engineering software used for the design analysis included:

• Load analysis: calculations for heating and cooling loads;
• Computational fluid dynamics analysis: verified opportunities and control strategies for natural ventilation;
• Energy modeling: provided LEED calculations and assisted in sizing the renewable energy source;
• Modeling transient response to radiant systems: predicted conditions. Additionally, the street median landscaping includes bulbs, shrubs and trees requiring no long-term irrigation system, and surface water from the entry plaza and parking lot is directed into planting beds and swales to limit irrigation water use.

The City of Newberg has a municipal reclaimed water district in place giving the college confidence that it will eventually be extended to their site. Financial tradeoffs during design eliminated a proposed rainwater catchment system and, instead, irrigation lines were laid with purple pipe to provide seamless future integration into the City of Newberg’s reclaimed water system.

WATER AT A GLANCE

Not Available. (Water use data is being investigated to examine discrepancies.)

WATER CONSERVATION, MANAGEMENT

The Newberg Center’s predicted water use is 49.2% less than code through the installation of high efficiency faucets and toilets. A weather based irrigation system controller using drip irrigation with high efficiency heads reduced water consumption by more than 50% for the site compared to 1992 Federal Energy Policy Act requirements. Additionally, the landscape design team chose a dense and diverse selection of native shrubs and trees planted in locations reflecting the natural hydrology of the site. Faced with challenging clay soils, which are slow draining in the winter and have a low water capacity during the summer months, the design team selected drought tolerant plants well adapted to these conditions.

ENERGY AT A GLANCE

Annual Energy Use Intensity (EUI) (Site) 33.2 kBtu/ft²
Electricity (From Grid) 27.8 kBtu/ft²
Renewable Energy (PV) 5.4 kBtu/ft²
Annual Source Energy 93 kBtu/ft²
Annual On-Site Renewable Energy Exported 17.9 kBtu/ft²
Annual Net Renewable Energy Use Intensity 9.9 kBtu/ft²
Savings vs. Standard 90.1-2004
Design Building 50.3%
Heating Degree Days (Base 65°F) 5,346
Cooling Degree Days (Base 65°F) 539
Annual Hours Occupied 4,200

FIGURE 1 FLOOR PLAN

1 Reception
2 Testing Lab
3 Office
4 Open Work Area
5 Computer Lab
6 Classroom
7 Commons
8 Multi-Purpose Room

FIGURE 2 ENERGY USE BASELINE BREAKDOWN COMPARISON

Energy Savings (Oregon Code)
Space Heat (Electric Resistance)
Space Cooling
Pumps and HVAC Auxiliary
Fan Energy
Domestic Hot Water
Exterior Lighting
2.1% 21.3% 21.3% 19.4% 19.4% 10% 0.3%
11.5% 21.5% 21.5% 19.4% 19.4% 9.9% 0.3%
0.4% 21.5% 21.5% 19.4% 19.4% 9.9% 0.3%
3.3% 21.5% 21.5% 19.4% 19.4% 9.9% 0.3%
4.1% 21.5% 21.5% 19.4% 19.4% 9.9% 0.3%
4.1% 21.5% 21.5% 19.4% 19.4% 9.9% 0.3%
18.4% 21.5% 21.5% 19.4% 19.4% 9.9% 0.3%
5.5% 21.5% 21.5% 19.4% 19.4% 9.9% 0.3%
6.2% 21.5% 21.5% 19.4% 19.4% 9.9% 0.3%
temperatures for comfort calculations; and

- Spreadsheets for calculating thermal response of the concrete slab and exposed concrete shear walls at the interior.

**System Design Solutions**

**Classroom Conditioning.** One of the most interesting features of the building is the natural ventilation scheme. Because the prevailing winds have a propensity throughout the year to be from the north or south, it was intuitive that winds impacting the north side of the building would provide good wind pressure. Stacks located up high take advantage of less disturbed pressure. Stacks along building would provide good wind impacting the north side of the south, it was intuitive that winds have a propensity through the scheme. Because the prevailing winds have a propensity through the building, one of the most interesting features of the building is the natural ventilation scheme.

**OCCUPANT SURVEY**

A post-occupancy evaluation of the PCC Newberg Center was conducted from July to September of 2013. Through a series of interviews with faculty, teaching staff and students, one primary theme emerged—the importance of occupant education. Users are critical to achieving the building’s high performance goals. Over 75% of occupants indicated they were satisfied or very satisfied with ceiling fans help increase air movement and maintain the overall operative temperature. Heating for classrooms is accomplished using a radiant floor slab. This provides an efficient means of distributing the heat, and avoids the use of fan energy for other than minimum ventilation. The radiant slab system is complementary to the low-temperature water produced by the air to water heat pump (approximately 90°F to 115°F). Each classroom has its own temperature control zone.

**Administrative Area Conditioning.** Space conditioning is similar to the classrooms. The private office and conference rooms each have their own operable louvers.

**Commons/Study Conditioning.** Space conditioning in these larger areas follows a similar concept to the classrooms. However, because of the lager space, air movement with traditional “paddle” fans took on a very large form with multiple, slow turning blades. The fans can be adjusted made to match the comfort needs.

**Computer Room Heat Recovery.** A water source heat pump is provided to cool the computer room and transfer heat to other areas of the building. During winter conditions modeled during design, this approach can provide about 6% of the total heating load. A water source heat pump (approximately 90°F to 115°F). Each computer room and transfer heat to other areas of the building.

**Domestic Hot Water.** Hot water for the building is heated via a heat pump water heater and an electric water heater, which serve the main toilet rooms, comfort rooms each have their own operable louvers.

**Figure 3**

SUSTAINABLE STRATEGIES

- Sky lights and daylighting controls in classroom maximize use of natural light and lower energy use by 15%
- Stacks along building spine heat up the building mass.
- Automatic dampers and exterior louvers provide natural ventilation to common area with assistance from large fans
- Radiant slab heats building to 68°F

**BUILDING ENVELOPE**

Roof Type Structural insulated panel with standing seam metal roof
Structural insulated panel with metal panel siding
Structural insulated panel with modified bituminous membrane
Overall R-value 8.46 at 75°F, 8.47 at 40°F
Reflectivity SRI 78 (membrane)

Walls Type Structural insulated panel with brick veneer
Structural insulated panel with metal panel siding
Overall R-value types 1 and 2: R-30 at 75°F, R-31 at 40°F
Glazing Percentage 30%

Basement/Foundation Slab Edge Insulation R-value R-11
Under Slab Insulation R-value R-11

Windows Effective U-factor for Assembly 0.29 for glass; 0.46 for assembly
Solar Heat Gain Coefficient (SHGC) 0.54
Visible Transmittance 76%

Location Latitude 45.29
Orientation East-west

The commons area can be expanded into the meeting rooms, offering flexibility for classroom use and event space. Local art on the screen wall hides the vending machines and recycling area. Beneficial to cool the building mass. This aids in limiting temperature peaks in the space during the day.

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the heat pump cannot maintain the desired temperature.
The heat pump water heater is piped upstream of the electric water heater and takes heat directly from the building, using a refrigeration cycle to heat water. The overall efficiency is better than when compared to electric resistance heating.

**Thermal Mass.** Mass elements of the building consist of the radiant floor slab and concrete shear walls. The primary cooling of the concrete mass is performed with a night flush where classroom ventilation dampers open and turbine ventilators activate.

When the weather is warmer and the cool night time period is limited to a few hours, water in the radiant slab tubes are cooled with fans located in an air to water heat exchanger in the main air-to-water heat pump on the roof. This effectively gives more exposed surface area to dissipate heat gathered during the day.

When the flushing fans are turned off, the temperature rises, but not as high as the initial condition. This control scheme initially used the room space temperature sensors to terminate the night flush. This strategy successfully limits the space temperature to 77°F on a 93°F day. This feat was also accomplished without mechanical cooling. Although the enrollment for summer is less than other times, the building is still operational.

The radiant system was designed so chilled water from the air-to-water heat pump could be pumped through the slab. This feature is intended only to be used when there is exceedingly hot weather for an extended period or other unforeseen conditions. To date it has not been used.

**Daylighting.** Daylight is critical to a net zero building. Because the classrooms and open offices use more lighting energy than any other area in the facility, the most important component of the Newberg Center daylight design is the classroom and open office space skylight systems.

Small aperture skylights allow 300% more daylight into the space compared to vertical glazing of the same area, while also minimizing heat gain. Further, skylights allow daylight into a space regardless of time of day and sun angle. This provides more daylight into a given space for more hours of the year and provides a diffused nature to the light quality inside the building.

Each classroom is equipped with four 6.25 ft² skylights; each in a pyramidal sloped ceiling, designed to diffuse daylight throughout. At the bottom of the aperture is a remote operated louver connected to photocell controls that can be closed to reduce heat gain or to darken the classroom.
areas. In select areas, such as toilet rooms and circulation areas, LED down lights are used.

The classrooms and administrative articifial lighting system is designed to provide light where it is needed most, at the work surface. Lighting the specific task, rather than the general space, eliminates fixtures and keeps energy demands low.

The lighting system is connected to automated controls that respond to daylight levels and occupancy sensors that turn off lights when the space is not in use. Electric lighting leads for the Newberg Center represent just 6.2% of the building’s energy load compared to 21.5% for standard buildings built to code.

Energy Performance
Data collected from April 2012 to March 2013 (Figure 4) show the building is extremely energy efficient, but does not quite reach the net zero goal. The gross energy use intensity for this period was 33.2 kBtu/ft², while the net EUI was 9.9 kBtu/ft². The building exported 17.9 kBtu/ft² of electricity during this time period. Reasons include:

- Lower than expected output from the photovoltaic panels (a 30 kW bifacial solar panel array integrated into the building’s exterior canopy and a 75 kW rooftop solar array). The predicted value from the total for net zero evaluation. The EUI change for this was approximately 2.1 kBtu/ft²-yr;
- The backup boiler was running unnecessarily due to the defrost mode of the air to water heat pump cooling down the heating water. Controls have been adjusted to take this into account; and
- Heating energy for the air-to-water heat pump was more than predicted (Figure 5). This machine has a dedicated kWh meter installed on the electrical feed to it. Future steps for verification will include documenting the real-time efficiency of the unit, especially as it relates to the defrost cycles.

Commissioning
The project was fully commissioned as part of the certification process, and included lighting, heating, ventilating, domestic hot water and renewable energy systems.

As a result of the commissioning process the following adjustments were made:

- The radiant slab was originally specified to provide an optimum start to bring the building up to temperature just as occupancy began. Because of the mass of the slab, it was difficult to coordinate the transient response, and the slab operation was changed to keep it active 24/7. Because of the additional heating energy discovered on the air-to-water heat pump mentioned above, additional scrutiny on this item may be warranted. Some opportuni ties for shutting the system down later may exist.
- The night flash system used room temperature as the original criteria for terminating the sequence in summer time cooling. This was later made more effective by using the slab temperature.

![Image](image-url)

**Figure 4** Energy production, use (kWh)

<table>
<thead>
<tr>
<th></th>
<th>PV Energy Production</th>
<th>Energy Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr 2012</td>
<td>7,328</td>
<td>9,440</td>
</tr>
<tr>
<td>May 2012</td>
<td>11,476</td>
<td>6,960</td>
</tr>
<tr>
<td>Jun 2012</td>
<td>11,059</td>
<td>4,240</td>
</tr>
<tr>
<td>Jul 2012</td>
<td>12,404</td>
<td>8,920</td>
</tr>
<tr>
<td>Aug 2012</td>
<td>12,368</td>
<td>4,880</td>
</tr>
<tr>
<td>Sep 2012</td>
<td>10,348</td>
<td>4,720</td>
</tr>
<tr>
<td>Oct 2012</td>
<td>6,097</td>
<td>6,560</td>
</tr>
<tr>
<td>Nov 2012</td>
<td>3,006</td>
<td>14,480</td>
</tr>
<tr>
<td>Dec 2012</td>
<td>2,142</td>
<td>14,880</td>
</tr>
<tr>
<td>Jan 2013</td>
<td>3,171</td>
<td>19,360</td>
</tr>
<tr>
<td>Feb 2013</td>
<td>4,385</td>
<td>11,680</td>
</tr>
<tr>
<td>Mar 2013</td>
<td>8,369</td>
<td>8,880</td>
</tr>
<tr>
<td>Totals</td>
<td>92,151</td>
<td>110,000</td>
</tr>
</tbody>
</table>

![Image](image-url)

**Figure 5** Energy Use Comparison Apr 2012–Apr 2013

- Lighting
- Renewable
- Other

Class walls that are used as marker boards can be moved out of the way to open up the meeting rooms to the commons area.

The entry hall leads to the commons area and the classrooms, and has abundant daylight and fresh air.

The design team worked with the City of Newberg to reroute an existing city bus line to provide a stop at the Newberg Center. Portland Community College offers a shuttle bus between the Newberg Center and the Sylvania Campus.

The project was fully commissioned as part of the certification process, and included lighting, heating, ventilating, domestic hot water and renewable energy systems.

As a result of the commissioning process the following adjustments were made:

- The radiant slab was originally specified to provide an optimum start to bring the building up to temperature just as occupancy began. Because of the mass of the slab, it was difficult to coordinate the transient response, and the slab operation was changed to keep it active 24/7. Because of the additional heating energy discovered on the air-to-water heat pump mentioned above, additional scrutiny on this item may be warranted. Some opportunities for shutting the system down later may exist.
- The night flash system used room temperature as the original criteria for terminating the sequence in summer time cooling. This was later made more effective by using the slab temperature.

![Image](image-url)
Construction and Operating Costs

The Newberg Center was funded as part of a $374 million bond measure. As a public institution with a deep environmental commitment, PCC wanted to show that sustainability is not only for private, big-budget institutions—but that it can, and should, be done on a public budget to create sustainable spaces accessible to all socio-economic groups.

The Newberg Center was seen as a pilot project for PCC to understand sustainable building strategies not previously used on its campuses and to have a tangible project that moves the college towards creating a net-zero campus.

LESSONS LEARNED

The Commissioning Process Should Extend to at Least One Year Post-Occupancy.
- Passive Systems Change Seasonally: The commissioning process took approximately one year, starting early in construction, and then finishing shortly after occupancy. In spite of these efforts, some issues do not become apparent for several months down the road. An example is a problem with a boiler and energy recovery unit that was discovered by the MEP designer in a follow-up visit several months after job completion.
- Design Team Engagement Remains Important: After initial occupancy, the users and design team members undertake other projects. The design team is most familiar with how things should work, and simple tasks such as examining BAS trend logs or a single site visit can spot a problem with a piece of equipment that could potentially reset the net zero counter.

- Adjusting the radiant slab to occupancy mode 24/7 had the unintended consequence of putting the heat recovery ventilator in occupancy mode 24/7, which wasted energy by ventilating the space off hours unnecessarily. This was revealed by studying specific trend logs.

- Diligence in checking the trend logs after the commissioning process revealed that the boiler was turning on unnecessarily.
- Solar resource in year one was 10% lower than in an average year, again revealed by examining trend logs.

Having an Advocate in the Building is Crucial. Once building occupants understand how the systems are supposed to work, the design team gained assistance in bringing potential problems to light. A specific example involved the failure of natural ventilation louvers to open for the night flush operation.

Dedicated Energy Manager in the Facilities Group. It is important that key facilities personnel who become familiar with the project have the ability to check on systems from an energy perspective.

Net Zero Design Criteria Have Aspects Similar to Standard HVAC Design Criteria. Net zero design relies on statistical data regarding average and extreme weather occurrences. Sizing of renewable energy production is synonymous with sizing air conditioners for maximum cooling. Actual weather data can differ and similar questions occur with respect to safety factor and budget.

As such, the net-zero aspects were a mission-based rather than economics-based decision. The simple payback for the proposed facility, with all net-zero aspects combined, is 20.2 years (incentives not included).

The total project cost (land excluded) was $7.2 million, with a building construction cost of $4.7 million. Additional funding for 75 kW solar array was designated as a result of a state law that requires that public entities spend 1.5% of the total construction cost on renewable energy technology. To offset some of the energy-efficiency cost measures, the Newberg Center was also enrolled in the Energy Trust of Oregon’s Path to Net Zero pilot program and received approximately $83,000 in incentives.

Conclusion

The Newberg Center is an example of the type of energy efficiency that higher education and other users can expect when applying fundamental energy saving techniques such as natural ventilation, radiant heating, innovative daylighting and passive energy concepts. As the building occupant survey shows, this performance can be achieved and still maintain user comfort and create a space that students and the public can enjoy.

ABOUT THE AUTHORS

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