The 45,000 ft² Brower Center has received a LEED Platinum rating with a score of 65 out of 60 possible. It is the first building of its kind in Berkeley and one of fewer than 10 such buildings in northern California. The Center includes a restaurant, meeting rooms, a theater, and office space for environmental and social action organizations.

Energy Efficiency
Overall, the building is predicted to use more than 60% less energy than the average U.S. building of similar use, without taking credit for the energy use production of the onsite 66 kW PV system. Compared to the more stringent California Title 24 prescriptive building baseline, the Center is modeled to be 44% better than baseline.

HVAC and Whole Building Design
Energy efficiency gains were provided by a combination of HVAC and whole building design strategies and technologies. The majority of the building has no compressor-based cooling; skin loads have been minimized and all cooling is provided through indirect evaporative cooling from a cooling tower. Dehumidification is not provided nor required in this climate where high humidity only occurs on cool days; in a typical year, only one hour exceeds a dew point of 63°F, which is equivalent to an RH of 65% after the air is heated to the inside space temperature. The building uses an in-slab hydronic radiant heating and cooling system, which absorbs heat or cooling from the space as needed.

It uses hydronic heat transfer, which is more efficient than transferring heat through air. Traditionally, air is heated or cooled in an air handler and fan energy is used to distribute that air to the space. Due to the much higher heat capacity of water, hydronic technology uses far less distribution energy to provide or remove heat.

The system has the significant benefit of eliminating reheat entirely, as well as the significant benefit of eliminating reheat entirely, as well as the significant benefit of eliminating reheat entirely, as well as the significant benefit of eliminating reheat entirely, as well as the significant benefit of eliminating reheat entirely, as well as the significant benefit of eliminating reheat entirely, as well as the significant benefit of eliminating reheat entirely, as well as the significant benefit of eliminating reheat entirely, as well as the significant benefit of eliminating reheat entirely, as well as the significant benefit of eliminating reheat entirely, as well as the significant benefit of eliminating reheat entirely, as well as the significant benefit of eliminating reheat entirely, as well as the significant benefit of eliminating reheat entirely, as well as the significant benefit of eliminating reheat entirely, as well as the significant benefit of eliminating reheat 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well as reducing the supply airflow down to ventilation only.

During warm weather, the office space thermal mass is precooled at night using the cooling tower and the radiant in-slab system. This controls strategy increases off-peak electrical use slightly, but decreases peak electrical use, which reduces the burden on local utilities.

This approach also captures cooler night temperatures to maximize the indirect evaporative cooling available from the cooling tower. The building only has compressor-based cooling in the lateral system act as springs, highly damage-resistant structure. A lateral structural system uses post-tensioning cables in highly damage-resistant structure. A lateral structural system uses post-tensioning cables in

A floor diffuser provides easy adjustment by occupants. Leakage from the underfloor plenum ensures a minimal ventilation rate even if closed.

The ground floor of the building houses the conference center, art gallery and restaurant. These spaces, with rapidly varying occupant and ventilation loads, are served by high efficiency water source heat pump systems that use the cooling tower and boiler for heat rejection and injection, respectively. A minor amount of heating is recovered from the heat pump loop when the conference rooms and theater are cooling.

Other key approaches are indirect evaporative cooling via the cooling towers for tempering of ventilation air, natural ventilation by operable windows and skylights throughout, and displacement ventilation via the raised floor and high placed relief grills and windows.

Lighting, Building Envelope Strategies

Several daylighting strategies were used to achieve close to a 100% daylit building. A narrow floor plate was designed to maximize daylighting and natural ventilation.

Lightshelves, overhangs and other envelope features were incorporated to achieve the optimized shell. A high performance skin was designed to optimize usable daylight for lighting the interior, while reducing solar heat gain and reducing the need for heating and cooling.

Local photocell controls are used throughout with fully dimmable electronic ballasts for automatic dimming of the super T-8 lights when daylighting allows. Dual mode occupancy sensors (IR and ultrasonic) ensure that lighting is shut off when areas are unoccupied, and an astronomical clock ensures that exterior lighting comes on after sunset throughout the year.

High-slag concrete reduced cement use by 70% in the foundations and 50% in the superstructure. A lateral structural system uses post-tensioning cables in flexural walls and frames to create a highly damage-resistant structure.

The post-tensioning cables used in the lateral system act as springs, allowing the building to flex, then pull back to its original alignment.
**Indoor Air Quality**

The building’s HVAC system provides 100% outdoor air (no recirculated air) for the office spaces. The office spaces use a combination of natural ventilation and a radiant floor system for heating and cooling, with a CO₂ sensor system for demand controlled ventilation.

The dedicated outdoor air handlers operate continuously to provide 100% outdoor air to all office spaces during building operating hours. The air-handling units meet MERV 13 (ASHRAE Standard 52.2-2007) filters to ensure dust and particulates do not enter occupied space.

The top floor of the offices has operable windows at the perimeter and the interior in addition to operable skylights. A narrow floor plate was used to maximize natural ventilation and daylighting.

**BuilDing Envelope**

<table>
<thead>
<tr>
<th>Location</th>
<th>Latitude: 37.9</th>
<th>Orientation: Long axis of building is east-west, following city grid</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Roof</strong></td>
<td>Type: Continuous foam insulation over concrete</td>
<td>Overall R-value: R-30.3</td>
</tr>
<tr>
<td></td>
<td>Reflectivity: 0.3 (aged value as modeled; PV array shades majority of roof)</td>
<td></td>
</tr>
<tr>
<td><strong>Walls</strong></td>
<td>Type: Metal frame</td>
<td>Overall R-value: R-15</td>
</tr>
<tr>
<td></td>
<td>Glazing percentage: 20%</td>
<td></td>
</tr>
<tr>
<td><strong>Basement/Foundation</strong></td>
<td>Bottom of first floor slab R-value: R-11</td>
<td>Continuous between bottom floor and underground parking garage</td>
</tr>
<tr>
<td><strong>Windows</strong></td>
<td>U-value: 0.425 (including frame)</td>
<td>Solar Heat Gain Coefficient (SHGC): 0.38</td>
</tr>
<tr>
<td></td>
<td>Visual Transmittance: 0.7</td>
<td></td>
</tr>
</tbody>
</table>

On the lower office levels, the perimeter spaces have operable windows for natural ventilation when the occupant desires it. However, during the colder winter months the occupants are not likely to open their windows. As a result, each office space floor receives ventilation air via a raised floor displacement ventilation system.

The two rooftop ventilation air handlers supply outdoor air to the entire building, both the raised floor spaces and the non-raised floor ground level. Each air handler has a hot water coil to temper the air to 72°F, and a cooling coil fed from the condenser water loop to temper the air to 75°F during the warmer periods (indirect evaporative cooling).

Each office floor has a demand control (CO₂ based) ventilation system. CO₂ sensors are located at the entry to the relief shaft (which vents spent air to outside) on each floor.

Displacement ventilation is provided through the raised floor. The dedicated outdoor air handlers operate continuously to provide 100% outdoor air to all office spaces during building operating hours.

Each air handler has a VFD, and should any CO₂ sensor indicate CO₂ levels above an acceptable limit, the air handler fan will speed up to supply more ventilation air.

The temperature setpoint in the zones during the winter is 70°F and 78°F during the summer. Without any compressor cooling for the majority of the building on warmer days, air temperature exceeds this by 1°F to 2°F; however, in the cooling season, comfort has been maintained without difficulty. The combination of radiant surface temperatures, mass precooling, and the accessibility of operable windows appears responsible for successfully providing occupant comfort with a wider air temperature band.

Occupant health and comfort also is enhanced by the use of low emitting materials that reduce the quantity of indoor air contaminants that are odorous or potentially irritating.

**Operation and Maintenance**

Several design strategies have reduced maintenance and operation costs.

- Daylighting reduces the need for lighting maintenance; often lighting is turned off by dimming and/or occupancy sensors.
- The system is connected to a BMS and Building Dashboard allowing for quick diagnosis of equipment status, alarms, and maintenance items. The BMS also allows users to analyze output and make informed decisions or adjustments regarding operations.
and energy use. It is a tool for ongoing optimization and identifying future investments.

- System level metering provides accurate energy consumption of the major mechanical systems and other end-use applications.

Commissioning this building included extensive trend analysis to confirm the sequence of operation, system integration and performance. Trending was conducted in heating and cooling seasons, which allowed for tuning the building and finding the “best-fit” setpoints for building operation. Commissioning also included a comparison of the measured energy use to the modeled energy use. This analysis looked for optimization, not just proper operation.

**LESSONS LEARNED**

Commissioning is not optional. Commissioning is required for all but the simplest systems, and is critical for these non-traditional systems. Problems can be missed during commissioning, such as a manifold valve incorrectly wired and controlled as if in a different space, but the commissioning still allowed the problem to be more quickly discovered. In addition, commissioning provided a functional test framework to use in the troubleshooting.

Systems unfamiliar to contractors warrant exceptional care. Several minor problems with the rainwater catchment system added up to a significant chronic problem over the first year. Issues ranged from a failed level sensor to an incorrect emergency fill valve control (a backup required to allow for toilet flushing, when rainwater is not available) to physical leaks in the tank.

While the rainwater catchment system is simple, it still needed considerably more commissioning attention than more complex hydronic systems in the building, therefore, system complexity is not necessarily the key indicator of the amount of commissioning or construction administration effort needed.

**Cost Effectiveness**

The actual energy consumption from June 2009 to May 2010 is 42.4% better than the baseline model (with lower ventilation loads in baseline model). The actual building used 1,220,000 Ktus of natural gas and 325,700 Ktus of purchased electricity for the year, totaling 1,546,000 Ktus annually.

Investigation has found the high actual gas use primarily reflects higher than modeled ventilation rates for an onsite restaurant. The baseline numbers are from the final Title 24 modeling and have not been updated to account for the additional outdoor air.

In December and January a heating control issue resulted in the unintentional heating of some spaces. In response, portions of the heating system were placed in manual mode for a month, resulting in higher gas use as the problem with the controls program was corrected.

The natural gas contribution is 80% of the total energy use and the electricity contributes to 20% of the building total energy use; natural gas use is expected to be lower this year with all control problems now corrected.

The total actual energy cost from this same time period is $26,309.26. This total cost includes taxes and surcharges. The breakdown is $12,610 for natural gas and $13,729 for electricity.

The calculated paybacks are based on the Proposed Building Utility Performance generated from the eQuest model and the project cost estimates. Due to limited
Information, payback was calculated for the pumps and lighting only.

The pumps with variable speed drives have an annual operating cost savings of $3,205 and an initial investment of $10,000 yielding a three-year simple payback. The lighting system has an annual operating cost savings of $16,860 and an initial investment of $75,000 yielding a four-year simple payback.

Environmental Impact

The building was designed to have very low energy and low carbon output MEP systems, and an on-site PV system. The on-site PV is a grid-intertied system, so when it generates surplus power on peak solar days, that power is sold back to the grid, reducing the net building power bill.

Well-designed MEP systems, efficient use of building space, and a conscientious concrete specification were all key features to realizing lower emissions on a per person basis. Some of the most important environment strategies were:

- Selection of a previously developed urban site.
- Water conservation and water runoff control by use of rainwater catchment and water efficient plumbing fixtures.
- Low energy use.
- The use of public transportation is heavily emphasized by replacing the existing public surface parking lot with a smaller below-grade public parking lot. The site is located one block from the Bay Area Rapid Transit system (BART) and 12 different bus lines. The Brower Center does not provide any parking, except for leasing two parking spaces from the city for two hybrid car share vehicles.
- The building is equipped with a sophisticated monitoring and display system that tracks the environmental performance of the building in real time and highlights its features for the public. The Building Dashboard features an interactive display located in the lobby.
- The use of fly ash—an industrial by-product—reduced the embodied energy and carbon footprint of the building by 40%. This is the first building in the Bay Area to use high-slag concrete on such a large scale.

B U I L D I N G  T E A M

Building Owner/Representative
Equity Community Builders LLC

Architect
Solomon

General Contractor
Cahill

Mechanical Engineer, Energy Modeler
Integral Group

Electrical Engineer
IDEAS

Structural Engineer
Tipping Mar

Civil Engineer
Moran Engineering

Landscape Architect
Loioss and Ubbelahde Landscape

LEED Consultant
Siegel & Strain

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