For more than 50 years, the Power House provided steam to a dozen buildings in downtown St. Louis via three large coal-fired boilers. Decommissioned in 1980, the Power House stood empty for three decades because the large vertical building with a relatively small footprint confounded developers who wanted to repurpose it. Although recognized as a landmark by the National Register of Historic Places, the Power House literally was a shell of its former self.
Cannon Design scouted the Power House in 2006 for its regional office, which was then located in leased space in a downtown skyscraper. Despite the Power House’s known issues, the firm was attracted to its history, central downtown location and 26 ft tall windows.

To decide if the project would be cost effective, Cannon Design determined market rates for this type of space and used them to set a maximum for the budget. The firm concluded that holding to a tight budget and squeezing a strong design out of the project would achieve multiple goals and highlight the talents of its designers, architects and engineers.

Owning property is not in Cannon Design’s culture, and the cost of this project was a dominant concern in its early planning stages. Accommodating 32,000 ft² of office, conference, and support space for approximately 120 employees in an 85-year-old building was a significant challenge to the leader team.

For example, new floors needed to be added without compromising the integrity of the Power House’s interior space and its 26 ft tall arched, cathedral-like windows.

Given the magnitude of the design challenges, it would have been easy to let the original Power House remain vacant and build a new green-field facility. Instead, restoration has breathed new life into the historic building without altering its outward appearance. Cannon Design’s team also used the opportunity to adopt the building industry’s new models of project delivery and new technologies to improve the process of building design.

**Restoring, Repurposing**

The interior, which was essentially an empty shell, was completely rehabilitated with new HVAC, plumbing and electrical infrastructures. The original steel structure was reused, allowing a set of eight columns and related truss work to be preserved.

The massive concrete foundations for the boilers were repurposed as exposed walls for conference rooms. Exterior modifications included historically accurate replacement of the original single-pane windows with highly thermally efficient windows in their original masonry openings, and the creation of a 3,500 ft² urban garden complete with a rainwater collection system and a storm water retention pond.

The final design dramatically alters the interior volume while respecting the integrity of a beautiful and historic building. Two new floor plates were added above the main level inside the building to make use of its tall volume and to accommodate the required functional program. The new floors

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**Building At A Glance**

<table>
<thead>
<tr>
<th>Name</th>
<th>Cannon Design Regional Offices, Power House</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>St. Louis</td>
</tr>
<tr>
<td>Owner</td>
<td>Cannon Design</td>
</tr>
<tr>
<td>Principal Use</td>
<td>Office</td>
</tr>
<tr>
<td>Employees/Occupants</td>
<td>120</td>
</tr>
<tr>
<td>Occupancy</td>
<td>80%</td>
</tr>
<tr>
<td>Gross Square Footage</td>
<td>32,000</td>
</tr>
<tr>
<td>Conditioned Space</td>
<td>32,000</td>
</tr>
<tr>
<td>Distinctions/Awards</td>
<td></td>
</tr>
<tr>
<td>Illuminating Engineering Society, Award of Merit, 2009</td>
<td></td>
</tr>
<tr>
<td>Steel Erector’s Association of America, Project of the Year, 2009</td>
<td></td>
</tr>
<tr>
<td>Buildings Magazine, Project Innovations Award, Citation of Excellence, 2009</td>
<td></td>
</tr>
<tr>
<td>Society of American Registered Architects (SARA), National Award of Merit, 2009</td>
<td></td>
</tr>
<tr>
<td>Contract Magazine, Interiors Award 2010, Sustainable Design</td>
<td></td>
</tr>
<tr>
<td>Interior Design Magazine, Best of 09, Award of Merit</td>
<td></td>
</tr>
<tr>
<td>American Institute of Architects, Honor Award for Interior Architecture, 2011</td>
<td></td>
</tr>
<tr>
<td>Architectural Record, Good Design is Good Business Award, 2011</td>
<td></td>
</tr>
<tr>
<td>When Built</td>
<td>1928</td>
</tr>
<tr>
<td>Major Renovation</td>
<td>2008</td>
</tr>
<tr>
<td>Renovation Scope</td>
<td>New MEP systems, interior and interior structure; remediation of asbestos, lead and pigeon droppings</td>
</tr>
<tr>
<td>Total Renovation Cost</td>
<td>$6 million</td>
</tr>
<tr>
<td>Cost Per Square Foot</td>
<td>$187.50</td>
</tr>
</tbody>
</table>
imperative to strictly regulate temperatures in the exterior zones along the walls. This enhances employee thermal comfort and also enables everyone to have a window view. The open office design presents some sound privacy challenges, which were mitigated using a white noise cancelling system.

To preserve openness and daylight for the occupied studio area, the support space is compactly arranged against the inner two building walls. Bear on the existing steel columns, eliminating the need for new vertical structures. The floors cantilever out above the floor below, but do not touch the north and east elevations.

This cantilever design of the floors reduced the need to tightly control heating and cooling in exterior spaces. Employees are located in the interior core spaces of the building and away from the walls. At the same time, an open floor plan without interior walls between desks allows panoramic views to the outside.

Therefore, when the outside temperature rises or falls, it’s not
The elevator, exit stairs, toilet rooms, kitchenettes and copy/workrooms are all neatly concealed from the main volume along the southern walls. A full model shop, materials and design libraries, and a conference room occupy the lower level.

One of the more intriguing design concepts for this building is that the Power House doesn’t hide its mechanical systems. Instead, it shows them off via an exposed ceiling plenum. The elimination of a ceiling saved costs, created more open space and enabled a teaching environment. Occupants can see the variable air volume terminal units, ducted air transportation systems and heating coils.

During meetings or charettes, it’s easy to point to ceiling components as examples of a certain engineering system. This teaching tool has been a valuable asset for guests and students who visit the Power House.

Cannon Design used an integrated, holistic approach at every stage of the restoration process to incorporate many sustainable features. The Power House received LEED Gold certification from the U.S. Green Building Council in July 2009.

**Energy Use**

In the first year of building occupancy, the actual kBtu/ft²·yr was 47% less energy used than forecasted by the ASHRAE/IESNA Standard 90.1-2004 baseline model building. The first year’s energy use index was 96.5 kBtu/ft²·yr. High-efficiency plumbing fixtures and

### BUILDING ENVELOPE

<table>
<thead>
<tr>
<th><strong>Roof</strong></th>
<th>White ENERGY STAR roof</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Walls</strong></td>
<td>Existing brick</td>
</tr>
<tr>
<td><strong>Windows</strong></td>
<td>Existing windows replaced with high efficiency windows</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>Latitude 38.6°N</td>
</tr>
<tr>
<td></td>
<td>Orientation Most windows face east and north; some face west</td>
</tr>
</tbody>
</table>

### ENERGY AT A GLANCE

- **Annual Energy Use Intensity (Site)**: 96.51 kBtu/ft²
  - Natural Gas: 41.35 kBtu/ft²
  - Electricity: 55.16 kBtu/ft²
- **Annual Source Energy**: 228 kBtu/ft²
- **Annual Energy Cost Index (ECI)**: $1.76/ft²
- **Savings vs. Standard 90.1-2004 Design Building**: 47%
- **Heating Degree Days**: 4,758 (avg)
- **Cooling Degree Days**: 1,534 (avg)
rainwater recollection translated to an estimated 33% reduction in water use as compared to a standard building’s estimated water use.

Engineers not associated with the original design conducted fundamental commissioning to ensure systems started up and worked appropriately. Cannon Design engineers have ongoing access to the direct digital control system on their computers to monitor the function and performance of the HVAC systems.

When looking at a graphical representation of the first year’s energy use, there is a noticeable spike during the initial move-in and occupancy period. This was due in part to the move-in and building flush-out processes. The building flush-out involved overventilating the building with 100% outside air that, at a minimum, kept the interior below 60% relative humidity and above 50°F during the entire process, even during unoccupied periods.

By rapidly changing the air inside the building with outside air, the contaminants introduced into the air during construction and move-in activities are removed, creating

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**HISTORY OF THE POWER HOUSE**

Despite the grand success of the St. Louis World’s Fair in 1904, by the early 1920s St. Louis’s population began to decline. In 1923 an $87 million bond issue was passed, a milestone of civic progress for the city.

As part of the bond, the Municipal Services Building, designed by local partnerships Study and Farrar, became part of the plan to breathe new life into downtown. The Power House, as it came to be known, provided coal-fired steam heat to a dozen downtown city buildings, including the civil and municipal courts, Kiel Opera and City Hall.

The Power House is listed on the National Register of Historic Places as locally significant for community planning and development. Engineering News Record once wrote of the project, “This is the largest, most varied and best planned program of municipal improvements ever attempted by an American city.”

The Power House remained an important building in the city until 1980 when it closed. It remained vacant for more than 25 years and became best known for the trees growing on its roof.

Cannon Design purchased the building for its new offices, realizing it would require significant and rigorous design analysis to get the building back into shape while preserving its history. The building was in serious decay, but its exterior shell and original structure steel were fundamentally sound.

The Power House’s landmark Revival Style exterior has been fully restored and every component of the building’s interior is new and designed to current life-safety codes. The project achieved LEED Gold certification.
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healthier air quality for employees. Anecdotal evidence shows an almost immediate drop in employee absenteeism upon moving into the Power House.

This could be attributed to many factors (new building, strong downtown location, etc.), but also is likely connected to the improved air quality and high quality indoor environment. However, one key lesson learned from this experience is that it is better to do a building flush-out during mild temperatures, to reduce building HVAC energy loss if possible. Since the initial move-in, natural gas and electricity use have stabilized to predictable levels.

**Sustainability**

The Power House’s sustainability features extend beyond energy conservation. The building offers natural daylight to 92% of its occupied space. Forty percent of the building materials used for the project were manufactured regionally.

The building’s exterior shell and original structure were found to be fundamentally sound. Its “revival style” exterior, featuring tall arched windows on two street façades and terra cotta detailing, has been fully restored. The interior was fully remediated, removing layers of pigeon droppings and lead paint that covered the floors and steelwork.

The project reused 98.6% of existing walls, floors and roof structure and 92% of construction waste was diverted from landfills and recycled. Renewable energy credits were purchased to offset 35% of the building’s energy consumption to promote the development and use of renewable energy.

The building is easily accessible via public bus and commuter rail lines serving downtown. Additionally,
employees have access to indoor bike storage spaces and showers.

A green cleaning service helps maintain good air quality, and all cleaning products used are Green Seal certified. China and glass replace disposable plates and paper cups.

The building’s lower level opens onto a 2,500 ft² urban garden. Rainwater is captured for irrigation of the native vegetation garden and for power washing the windows.

**Realizing Benefits**

Since the renovation/restoration, the building has become a source of pride for nearby residents and commuters. The building’s gallery space offers stunning views of downtown and is often used as an event space. The space hosts events such as the 2011 AIGA Design Week local sustainable design seminar, and Cannon Design’s annual “Exhibit A: Art By Architects” auction that benefits nonprofit institutions in St. Louis. In this way, the Power House moves beyond sustaining itself and helps to sustain its community.
After the first year of building operation, the total annual costs for operating the facility, including financing costs for the purchasing and construction costs, were calculated and found to be the lowest costs on a dollar per square foot basis of all of the 17 Cannon Design offices worldwide.

Other, less tangible, indicators show this building works well. Within weeks of initially moving in, employees began commenting about feeling more productive at work. They said they felt better during the day, and it was much easier to collaborate in the open office environment. Employees seem generally

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**LESSONS LEARNED**

**No Challenge Is Too Large**  The Power House proves that just because others consider the project too daunting doesn’t mean you can’t find success. Numerous developers passed on the chance to rethink the Power House. It is now one of our firm’s most prized projects.

**Sustainable Design Saves Money**  We and our contractor found in many instances that sustainable construction saved money. For example, our contractor realized sorting the construction waste for recycling caused them to be more efficient on site with disposal of construction waste, which meant they saved on landfill fees. We also found that early collaboration with the contractor paid great dividends in terms of reduced change orders and cost predictability.

**Building Flush Outs**  may heighten energy use initially but are valuable. It’s best to do them during mild temperatures to lessen building energy loss, if possible.

**Reduce Occupied Perimeter Zones**  By pulling the open floor plate of the occupied zones away from the exterior walls, nearly everyone has visual access to the large windows and views to the exterior from an “interior” zone. This removes the challenges associated with maintaining tight temperature control of occupied perimeter zones. Drafts, glare, cold walls, etc., are virtually eliminated by locating working zones nearly exclusively in an “interior” zone.

**High Efficiency Equipment**  Using highly efficient condensing boilers allowed the heating equipment to be located in the lowest level of the building and the flue and combustion air intake to be routed through the side wall of the building. This eliminated the need for a flue shaft running up the building to the roof and louvers on the side of the building for combustion air.
happier about being at work. Most small heaters and fans have disappeared. The use of carbon dioxide sensors to control filtered outside air for ventilation has successfully resulted in an environment that is comfortable, odor-free and energy efficient. The building’s high performance design also serves as a powerful recruitment tool for Cannon Design.

So much discussion about buildings comes down to how much building systems cost, but at the end of the day perhaps a more pressing question should be: Do they work well for the people who live and work in them?

ABOUT THE AUTHOR

Gerald G. Williams, P.E., LEED AP, Member ASHRAE, is vice president of engineering for Cannon Design’s St. Louis office. He serves on the ASHRAE Handbook—HVAC Applications committee. Williams teaches graduate students in environmental engineering and sustainable design as an adjunct professor at Missouri Science & Technology University.

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