innovative building systems, investigated numerous approaches to restore historic features and negotiated preservation requirements to allow for additional insulation.

The building owner also wanted a demonstration building to showcase the company’s integrated delivery approach to construction. As a design-build-operate-maintain firm, the company was the developer and prime tenant, and self-performed all of the design-build mechanical, electrical, data services, architectural metals and interior architecture services. Construction began summer 2010 and was completed in 15 months.

Key sustainable features include a closed loop ground source heat pump system, radiant heating and cooling for office spaces, demand control ventilation for conference rooms and a high level of daylighting. In the end, the building team restored or recreated most of the beautiful historic elements within the former railcar facility. The building's energy use intensity (EUI)
is more than 40% lower than the ASHRAE 90.1-2007 energy standard. Of the 70,000 ft² facility, roughly 32,000 ft² house the firm’s Inland Northwest hub office, and the other 38,000 ft² house common spaces shared by all tenants and the Innovation Center, an accelerator for sustainable and high-tech businesses. The upper floor (which looks like a mezzanine) was created to increase the net rentable square feet. The building’s ceiling height varies between 19 to 23 ft in the two-story space, and 9.5 to 12 ft. in the spaces with a second level.

The historical and efficient elements of the building, which are highlighted in a walking tour the building owner developed, provide occupants with a unique and invigorating work environment. The open and inviting layout stimulates creative activity that crosses traditional departmental (and company, in the case of the Innovation Center) bounds.

Preservation Meets Efficiency

To honor the building’s rich history, registration on the National Register of Historic Places was pursued. This certification offered federal tax credits, essential to funding the project, yet placed strict requirements on how the team could adapt and modify the structure. Meticulous attention to detail was paid to the restoration of the historical elements of the building. Close collaboration with the Spokane Historic Preservation Office, the Washington State Historical Preservation Office and the National Park Service (NPS) ensured the renovation met all preservation criteria. The brick walls and detailing were one of the more distinguishing features of the building. Twelve different cleaning methods were tested before finding that medium-pressure steam was the solution that did not damage either the brick or mortar.

The original building included 11 pairs of large barn doors that allowed for the entry and exit of electric rail cars. However, when the building was renovated, only one operating pair of barn doors remained. The team removed them and made exact replica car barn doors and hardware for all openings. Several heavy timber trusses had failed and also had to be replicated. In the course of masonry repairs and tuck pointing, the team made color selections to match the original mortar during frequent site visits. Original paint colors were found on remaining wood trim and exactly matched. LEED requirements dictated the majority of the new material selections. All of the furniture (repurposed office and manufactured workstations) was sourced from only 25 miles away. The northwest corner of the building had to be completely rebuilt as a result of being hit by a train. This reconstruction required additional bricks, and the team tracked down the original brick supplier for a near-perfect match.

All 160 windows were replaced with insulated glazing units to match original profiles and details. Seven skylights were installed, creating ample daylighting—a key energy-efficiency feature for the original and restored building. Metal halide fixtures highlight the historical wood trusses, and T8 fluorescent fixtures, some with diffusers, provide the bulk of illumination in non-truss areas. All workstations have LED task lights. The 2006 Washington State Energy Code required a design of 0.73 W/ft² for combined uses, but the actual design was 0.59 W/ft². The lighting control system is microprocessor-based with override switching for bypass of controls for after-hours use.

One of the greatest challenges of achieving a balance between “green” and historic requirements was the need to install code-required exterior wall insulation for energy savings versus the National Park Service’s (NPS) desire to expose as much brick as possible. The building team worked with the regulatory agencies to find a

**E N E R G Y  A T  A  G L A N C E**

![Image](image1.png)

**W A T E R  A T  A  G L A N C E**

![Image](image2.png)

**KEY SUSTAINABLE FEATURES**

- **Water Conservation:** Rain collection tank for sprinkler use, low-flow toilets and urinals, automatic flush valves, automatic low-flow sinks in restrooms, low-flow showerheads, drip irrigation system.
- **Ground Source Heat Pumps:** Ground coupled (closed loop) water source heat pump system.
- **Recycling:** Recycling bins at all desks, along with recycling cans and composting cans at trash collection points throughout the building. During construction, 83% of all construction waste materials were recycled.
- **Daylighting:** Seven skylights and 160 windows; building was originally 100% daylit.
- **Individual Controls:** Task lighting at desks, Occupancy sensors.
- **Carbon Reduction Strategies:** Dedicated resource conservation manager, carpool stalls in front of building, located on a bus route, interior bike storage, locker rooms with showers.
- **Transportation Mitigation Strategies:** Preferred parking for high occupancy vehicles and low emission vehicles; building is located on a bus route.
- **Landscape:** Native plants used.
- **Future Solar PV:** Building design provides for future demonstration 6 kW photovoltaic array. All necessary land use and historic approvals have been obtained. (The city of Spokane limits the size of the rooftop features on a city-designated historic building.)
to analyze the addition of spray-hygrothermal behavior was used the inspiration for much of the building's design. Historic elements, like these large car barn doors that were originally used by trains rolling into the building for maintenance, are the inspiration for much of the building's design. A software program that models hygrothermal behavior was used to analyze the addition of spray-hydrothermal behavior was used the inspiration for much of the building's design. The building team proved that the insulation could be removed without damage to the brick walls to meet NPS requirements. This negotiated win-win was a major part of the successful achievement of what the team intended to demonstrate with this project; that more historic buildings can be saved if renovated into energy-efficient buildings.

**Source Heat Pump System**

The team capitalized on the benefits of the project's location on the bank of the Spokane River, including excellent water flow and consistent temperature of the underground aquifer (from 52°F to 57°F), by building a ground source heat pump bore field to support building heating and cooling systems. The closed loop, water source heat pump system is made up of 25 bores that reach depths of 185 ft. The river in this location “leaks” into the aquifer, which influences the aquifer flow rates and aids the heat transfer in the closed loop.

A cost study found that sizing the bore field to provide 100% of the building's cooling—eliminating the need for a cooling tower—was the most cost-effective system. With Spokane’s heating-dominated climate, this system would also cover approximately 60% of the building's heating needs. The study also showed increasing the bore field to cover 100% of the building’s heating needs was not cost effective. When the water source heat pumps are unable to produce any more capacity due to the limitation of the bore field, condensing boilers supplement the heating water system to provide the necessary extra capacity.

**Radiant Heating and Cooling**

To meet owner and historic preservation requirements for exposing as much of the building's interior structure as possible, the team had to find a solution other than a conventional all-air system with large overhead ductwork. To provide heating and cooling while maintaining the high, open ceilings, the facility uses a hydronic-based system with radiant slabs in perimeter and interior spaces.

Radiant heating has been used for decades with predictable performance outcomes, but radiant slab cooling is less proven. Each hydronic zone is capable of slab heating or cooling depending on the season and space needs. Radiant cooling systems operate at higher temperatures than conventional air system cooling coils. This means that the radiant cooling system, using water from the ground-source heat pump system, requires a much smaller amount of energy used for mechanical cooling. In cooler months, a water-side economizer avoids the need for mechanical cooling completely.

To maintain occupant comfort, the slab remains within the temperatures of 66°F (peak cooling) and 84°F (peak heating) at all times. For all load conditions in between, the system controls the slab temperature between these two limits.

**Common Area Heating and Cooling**

In areas where existing slabs remain, air-to-water heat pumps are used. A partial basement is used to locate all the heat pumps and ductwork to allow building historic elements to be fully exposed.

In areas where exterior walls were not allowed to be insulated due to historic requirements, supplemental perimeter radiant heating (sacing fins) is installed for occupant comfort. Heat pumps connected to the ground source heat pump system are configured with a 100% outside air economizer. Additionally, the facility’s data center recovers waste heat from the servers and distributes it during cold seasons to reduce overall heating requirements. The data center is configured in a hot/cold aisle, which allows the use of evaporative media and transfer air from the neighbor office space for cooling. No mechanical cooling is required, or was installed, for the data center. Two fans pull air from the hot aisle.

One fan is located on the roof and exhausts the hot air during the cooling season. Upon a call for heat, Special care was taken to blend modern design while still preserving the historical integrity of the space. The addition of a second floor increases the net rentable square footage of the building.

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**Building Envelope**

| **Roof** | Single-ply glass fiber-reinforced PVC membrane, fully adhered | Overall R-value: R-28 |
| **Solar Reflective Index** | 69 |
| **Wall Type** | Existing, 3–4 wythe brick load bearing masonry with interior metal studs and 5 in. spray closed cell polyurethane insulation. | Overall R-value: R-23 |
| **Glaizing Percentage** | Approximately 23.6% |
| **Basement/Foundation** | Slab Edge Insulation R-value: R-10 |
| **Windows** | Effective U-factor for Assembly: 0.3 | Solar Heat Gain Coefficient (SHGC): 0.19 |
| **Visual Transmittance** | 43% |
| **Location** | Latitude: 47°39’37” | Orientation: Primarily east-west |

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**FROM TRAINS TO TRUCKS**

In 1907, the SIERR Company, Spokane’s first electric railway system, completed construction on its new facilities to serve the trains in its expansive and growing operations. Although from the outside the complex appears as one contiguous structure, it consists of a series of long, oval car barns with low-sloped roofs. The building walls were constructed with load-bearing brick on a stone rubble foundation. The original SIERR building was 100% daylight. Tall, elongated windows and interior skylights let light deep into the spaces. Cast-iron and timber columns supported heavy timber beams and purlins. Brick platens supported clear-span timber trusses. Railroad cars entered and exited the building through large hinged “car barn” doors and into the repair facilities on rails, some with internal turntables and repair pits below. In 1956 the SIERR building was converted into a truck freight facility, and the building was stripped of its original historical integrity. The warehouse tenant filled in nearly every window, and modified window openings to facilitate loading docks. All skylights were removed, as were the large wooden car barn doors. By 2010, the building had fallen into such disrepair that little was left of the iconic railroad facility but its damaged shell.

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**The construction of the Spokane and Inland Empire Rail Road Building helped advance the western United States’ development of electric interurban and city railroads, and was pivotal in transforming the 1,000-person settlement formerly known as Spokane Falls (Wash.) into modern-day Spokane.**

**Source:** National Trust for Historic Preservation

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**Historic requirements, supplemental perimeter radiant heating (sacing fins) is installed for occupant comfort. Heat pumps connected to the ground source heat pump system are configured with a 100% outside air economizer. Additionally, the facility’s data center recovers waste heat from the servers and distributes it during cold seasons to reduce overall heating requirements. The data center is configured in a hot/cold aisle, which allows the use of evaporative media and transfer air from the neighbor office space for cooling. No mechanical cooling is required, or was installed, for the data center. Two fans pull air from the hot aisle. One fan is located on the roof and exhausts the hot air during the cooling season. Upon a call for heat, Special care was taken to blend modern design while still preserving the historical integrity of the space. The addition of a second floor increases the net rentable square footage of the building.**
a second fan directs the air to the perimeter office space. A heat pump with low wall return (typically used for supplemental cooling for the south exterior zone that the slab cannot fully cool) enables its fan so the hot air is distributed throughout the adjacent occupied perimeter space, which helps to avoid stratification.

**Ventilation**

In areas where radiant heating and cooling is used, ventilation requirements are met by using a dedicated outdoor air system (DOAS). The DOAS equipment consists of a 100% outside air water source heat pump, an exhaust fan and a heat wheel for heat recovery. The DOAS provides all the required occupant ventilation in addition to providing cooling and primary heating.

This heat pump is connected to the ground source loop and supplements primary heating.

The building’s common areas include a number of conference rooms that would normally require individual ventilation control. Because the DOAS system provides additional ventilation air to control the humidity in the space beyond ASHRAE Standard 62.1-2007 ventilation requirements, the spaces surrounding the conference rooms are overventilated. Rather than design ventilation loads for the conference rooms at peak occupancy, the team installed transfer fans that move air from the neighboring open office space into the conference space.

To reconnect the building to the riverfront, the shoreline vegetation was saved and areas were replanted with native materials, creating a beautiful, useable space. A rural urban, public river access for kayak launching was created on the property, and building occupants regularly take advantage of it. Land for a future trail spur was also incorporated into the landscape design.

Non-profits, government organizations and community associations regularly use the building as a venue for events and meetings. Conference rooms are ventilated via transfer fans that move air from the neighboring open office space into the conference space.

Ventilation levels, and coil capacities to heat or cool the full outside air amount that could occur at any time. By focusing on maintaining CO₂ levels and energy use versus other tenants.

**Lessons Learned**

Carefully Estimate First-Year Energy Savings for a Heat Recovery System. Overestimating equipment and thereby a high energy use. In hindsight, the space should have been sub-metered to document the building owner’s energy use versus other tenants.

The transfer fans (in lieu of VRV box dampers) were lower cost, saving money by using smaller equipment, smaller electrical connections, and less roof space. If given the opportunity, the team would choose to use transfer fans again and design the layout to minimize noise.

Radiant Slab Cooling Provides Comfortable Environment. The zoned radiant slab system provides excellent occupant comfort throughout the winter and summer. This was a predictable outcome for heating, but the radiant slab cooling was unproven. There were a myriad of comments from occupants who felt the building was very comfortable throughout the summer.

**Submeter Tenant Space.** It was originally anticipated that the Innovation Center tenants would be office-oriented in their energy use, but that is not the case. The two largest tenants are an ecommerce company with personnel density similar to a call center, and a genomics laboratory with considerable equipment and thereby a high energy use. In hindsight, the space should have been sub-metered to document the building owner’s energy use versus other tenants.

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Transitioning to Sustainable Occupancy

As the building has transitioned to occupancy, the company has started a resource conservation management (RCM) program to monitor and maintain energy savings. RCM takes a holistic approach to energy management by implementing operational and behavioral changes and then tracking the results. A dedicated staffer has been tracking utility data and has made several changes in control sequences based on actual building trends and occupant behavior to guide long-term building operations.

Some changes made after construction ended include changes in temperature setpoints, lighting schedules and HVAC control sequences. Behavior management is also important. The building’s RCM consultant regularly sends reminders about avoiding personal space heaters, dressing appropriately during the winter and turning off individual task lamps when not required.

The EUI has tracked fairly closely to predictions. Currently, the EUI is 55.5 kBtu/ft², compared to the modeled 51.2 kBtu/ft². For the period that the EUI was calculated, the building was only about 90% occupied, so it is predicted that the EUI will increase slightly from what was originally calculated.

The main reason for the higher EUI is that the occupant density in the tenant spaces has been higher than originally modeled. This higher density means more cooling is required and a higher plug load, resulting in a higher EUI. Also, as the building is regularly used outside of normal operating hours for charitable and community events, the added energy use has resulted in a higher EUI.

Cost Comparison

The cost of the building was comparable to constructing a class A office building with some tenant improvements. Satisfying all of the Department of the Interior requirements for National Park Service approval, achieving LEED Gold, and having a ground source heat pump system increased the initial renovation costs. However, the systems installed all have a payback well within the building’s 50-plus year lifespan.

Conclusion

The SIERR building is a test case that demonstrates older buildings can be renovated into high performance buildings while preserving their inherent historic qualities. The renovation of a building nearing condemnation into one that is designed to spur creativity and innovation shows that the most sustainable building is the one preserved.

ABOUT THE AUTHORS

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