2016 ASHRAE Technology Awards Submission

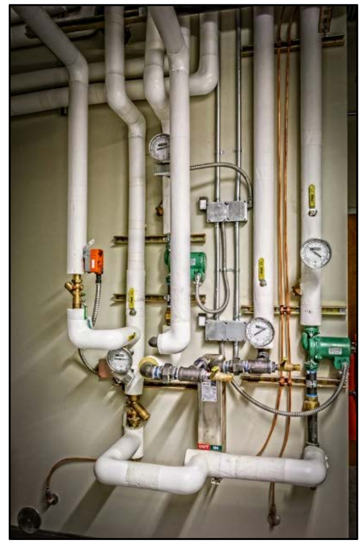
Introduction

The CSHQA office building is an adaptive reuse of a 1950's railway warehouse as an architecture and engineering design studio. The 18,962 sf single story structure went through long periods of vacancy for several decades and would be best described as so nondescript that most locals had to be reminded that it was there. CSHQA had been looking for a building in the downtown district to relocate and after evaluating the structural integrity of the building they felt it would make a good home for the business, with some improvements. These improvements included accomplishing the remodel targeting LEED Platinum Certification with a budget comparable to a typical new construction, class A office space. The budget for the project was $2.2 million. The project achieved LEED Platinum Certification in 2015.

Environmental Impact

Geothermal: The primary HVAC system is water source heat pumps arranged in a traditional boiler/tower configuration with a regional twist. The city of Boise is fortunate to be located in an area known for volcanic activity. Geothermal hot water wells, located in the foothills outside of town, supply a municipal distribution system with 170-degree F hot water. The water source heat pump system uses this district geothermal in place of a boiler for heat addition to the source loop. The system also makes use of this resource to generate domestic hot water, and provide some supplemental space heating at the perimeter.

The Geothermal Energy Association defines geothermal hot water as a clean, renewable resource. As a renewable resource, the use of geothermal hot water could offset the EUI rather than add to it. The energy usage values provided under the Energy Efficiency portion include the geothermal usage in the EUI values. Of the total energy used by the building Geothermal accounts for 29%.



Geothermal Heat Exchanger

Refrigerants: All of the water source heat pumps use R-410A refrigerant which is considered a non-ozone depleting refrigerant with low life cycle, global warming potential. The LEED energy and atmosphere credit 4 weighted average score for the system was 84.6 which is 15% lower that the threshold for credit compliance.

Brownfield: Many potential building sites are overlooked or abandoned due to possible contamination from previous industrial activities. Redevelopment of these urban “brownfield” sites rather than developing “greenfield” sites helps to slow urban sprawl and decrease the environmental impact of new projects. The site the office building is located on is listed on the Idaho DEQ registry as being a brownfield. This can be verified at the Idaho DEQ website on the registry with ID #5715.

Innovations

Radiant Slab Manifold Display

Radiant Heating and Cooling: The CSHQA office building is the first commercial building in Idaho to use radiant slab heating and cooling. The slab system is supplied with hot or cold water by an array of water to water heat pumps. Operation has been on a seasonal basis to offset baseline heating and cooling loads with the supplemental air system meeting peak demands. The slab control strategy is predictive rather than reactive due to the thermal inertia of the floor mass. The slab is “charged” during the night on a schedule that allows the thermal inertia to meet the peak load later in the day.

Following initial occupancy, the lead mechanical engineer, commissioning agent, and the controls contractor collaborated to fine tune the control system for the precharge control strategy.

Piping: In an effort to keep construction costs down, almost all of the source loop distribution piping is plastic. Normally, this piping would be concealed by a drop ceiling so appearance wouldn't be a concern but, the drop ceiling was also eliminated in an effort to reduce costs. Outside of the mechanical room all piping 2" and smaller is PEX. With the mechanical piping exposed to view, the PEX piping needed to be supported continuously in a neat arrangement. It was decided to use inexpensive cable tray to support the PEX tubing where it was exposed. The result has the appearance of a single pipe and it blends well with the other utilities.

CPU Exhaust: Historically, personal computers in an office environment account for somewhere between 20 and 25% of the internal cooling loads. The main method of treating these loads is to size cooling equipment with enough capacity to treat the additional waste heat generated by this equipment. In recent years the power requirements for monitors have been dropping due to LCD and LED technology, while the power requirements for CPU's have been rising due to faster chipsets and graphics card technology. This shift in generated cooling loads has made it easier to capture the majority of waste heat at one source (CPU) rather than two (CPU and monitor). The intent of the CPU exhaust system is to capture the heat generated at the source so it can be managed rather than treat the load at the space level.

The CPU Exhaust System is a network of exhaust ductwork routed throughout the building and along the spine of each group of cubicles to each workstation. The exhaust duct is connected to a centrally located variable speed fan. The fan selected for the CPU exhaust system uses an electronically commutated motor so the speed can be controlled using direct feedback from a pressure transducer without the use of a VFD. The discharge of the fan is fitted with two dampers and branch ducts. When the building is in heating mode the airflow is routed through the exhaust side of the energy recovery wheel on the DOAS. When the building is in cooling mode the airflow is routed to the outside.

Each personal computer is fitted with a warm air collector box and small control damper. The damper is open when the computer is on and closed when off. Each collector box is connected to the exhaust ductwork under the desk. With a damper at each personal computer, the system can operate using a variable air volume strategy to reduce fan energy. The exhaust fan varies speed to maintain constant negative static pressure in the ductwork during occupied hours.

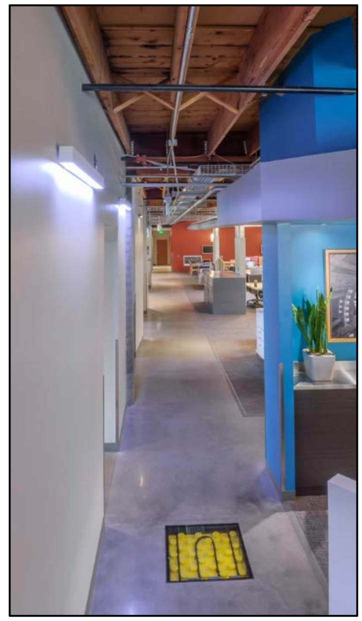

CPU Collector Box

The primary benefit to the CPU exhaust system is the savings in reduced cooling costs. A personal computer in an architectural and engineering office has the potential to produce 340 btuh peak with the use of graphic intensive programs. This value was measured at the CSHQA office by using a watt meter connected in line with a computer workstation operating BIM software. The estimate for this project including diversity is a savings of two tons of cooling with every work station connected to the system and the occupancy of the office at maximum capacity.

IAQ and Thermal Comfort

CPU Exhaust: One of the secondary benefits to the CPU exhaust system has been related to ventilation. Each computer work station requires 19 CFM of exhaust to maintain cooling in the CPU. With the exhaust and equivalent amount of make-up air linked to the operation of the computers at each workstation, the system has been functioning as a method of demand controlled ventilation. The first thing each person does when they come in in the morning is turn on their computer hence telling the ventilation system they require fresh air. Another secondary benefit is that the CPU's are located in the breathing zone in each cubicle. The removal of contaminants is optimized as a result.

Ventilation, Heating and Cooling: Ventilation, and supplemental heating and cooling of the main office spaces is provided by a roof mounted water source heat pump. This unit operates most of the time in 100% outside air mode on a DCV control strategy using CO2 sensors. During shoulder seasons this unit provides space conditioning mostly in economizer mode. This unit also operates periodically to provide supplemental cooling late in the day during peak summer conditions. The shower and toilet rooms are ventilated with a dedicated 100% outside air, energy recovery ventilator.



Exposed Utilities and Radiant Slab Display

Comfort: Since moving into the new office space, CSHQA has instituted a new "shorts in the office" policy to permit the cooling setpoint to be raised to 78 degrees F. With this policy change expected during design, the CLO value was set at 0.55 and the metabolic heat production rate was set at 1.2. The summer condition PPD was calculated to be 6%. For winter conditions the heating set point is 70 degrees F. Winter CLO value was set at 0.85 and the metabolic rate is the same as summer. The winter condition PPD was calculated to be 8%. Shortly after moving into the new office there were some control system debugging issues to resolve so there were some complaints the first winter due to set points not being maintained consistently. The first summer there were also complaints because some staff felt the office should be kept at the same temperatures they use at home. Some staff even expressed that the set points should be 76 degrees heating in the winter and 72 degrees cooling in the summer because that's what they use at home. CSHQA has had to educate staff about set points and energy efficiency. After three years in the new space and consistent set points for most of that time, the staff complaints have tapered off and most agree that 78-degree F cooling set point is not unreasonable.

Operation and Maintenance

Building Control Systems: The CSHQA building HVAC is controlled by a direct digital control system. The operator is a staff engineer who can modify the software as needed to facilitate low or no cost improvements to energy efficiency. Most buildings this size would not have the resources available to assign skilled staff to ongoing energy efficiency measures and maintenance. CSHQA has the resources and has made the commitment to this effort.

Maintenance: Compared to large metropolitan areas like Portland, Chicago, or San Francisco, Boise is a relatively small community and it is somewhat isolated geographically. Contractor and maintenance skill set in the area is not conducive to using exotic components or methods. The challenge was to design the HVAC and lighting systems using equipment and methods they are familiar with. After 3 years in the building, the design concept has proven to be well suited to local skill set for maintenance. The most complex component in the system is the closed circuit cooling tower. It is shut down in late fall and reopened in mid spring because the ventilation unit is configured for economizer cooling if required.

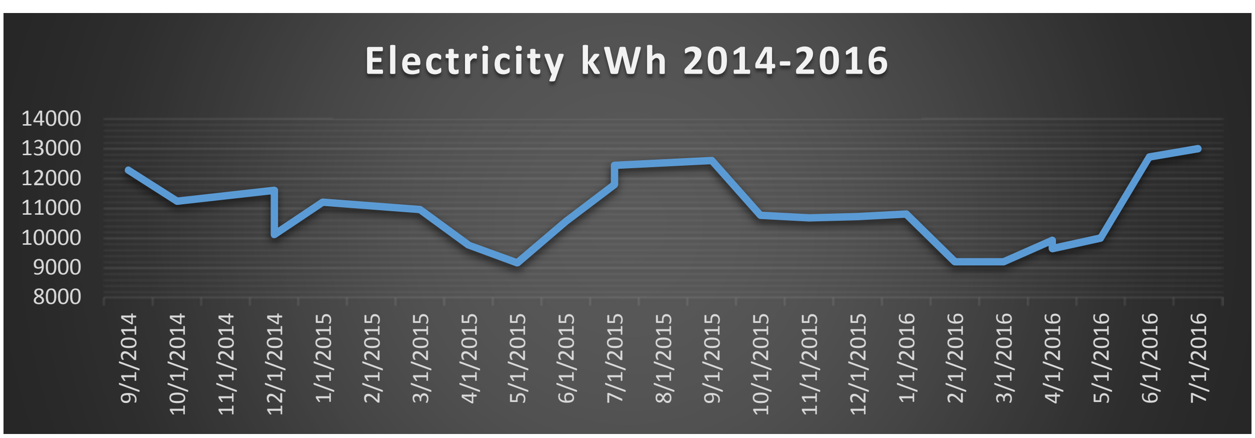
Energy Efficiency

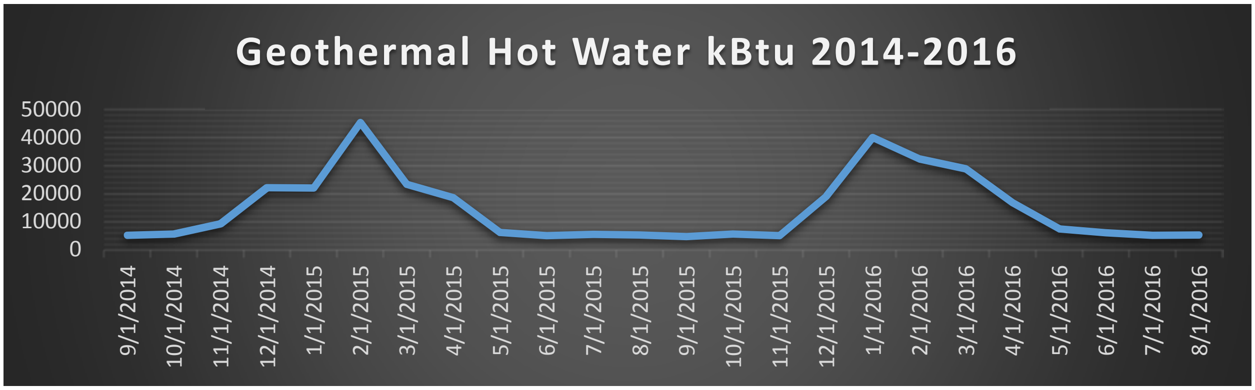
Energy Modeling: Six different HVAC systems were evaluated during schematic design. Each system was developed far enough in concept to perform a construction estimate and evaluate performance with an energy model. The WSHP/radiant slab design was compared against WSHP/radiant ceiling panels, WSHP rooftop units, water cooled VRF, air cooled VRF, and air cooled packaged RTU's with some air cooled VRF. The WSHP/radiant slab system performance was 42% better than the baseline system. Most of the design phase modeling was performed using Energy Pro software. Some minor modeling and checks were performed using Carrier HAP. Measurement and verification used the calibrated model option and an Energy Plus model was generated for this purpose.

Energy Performance:

The energy usage data demonstrates the performance of the building during the past year.

2015-2016 Site Electricity Usage	129,240 kWh/yr
2015-2016 Site Geothermal Usage	176,437 kBtu
2015-2016 Site EUI (Office / National Median)	32.5 kBtu/SF / 82.6 kBtu/SF (-61%)
2015-2016 Source EUI (Office / National Median)	84.1 kBtu/SF / 213.5 kBtu/SF
Carbon Footprint (Energy Star Portfolio Mgr.)	43.3 MTCO2e/yr.





Energy usage prior to occupancy is not available for comparison because the building was unoccupied for several years.

Building Envelope: The original building is constructed with CMU and brick exterior walls on a raised concrete slab. The roof is framed with rough sawn lumber and timber beams. Fenestration had not been replaced since the building was originally constructed. The old rail car loading doors were constructed of corrugated sheet metal on wood frame and were still in place. The gaps around these doors were as much as 3 inches in places. The walls were uninsulated and the roof assembly was insulated with R19 foil faced batt. There were no interior finishes other than paint splatters on the floor left behind by a previous tenant.

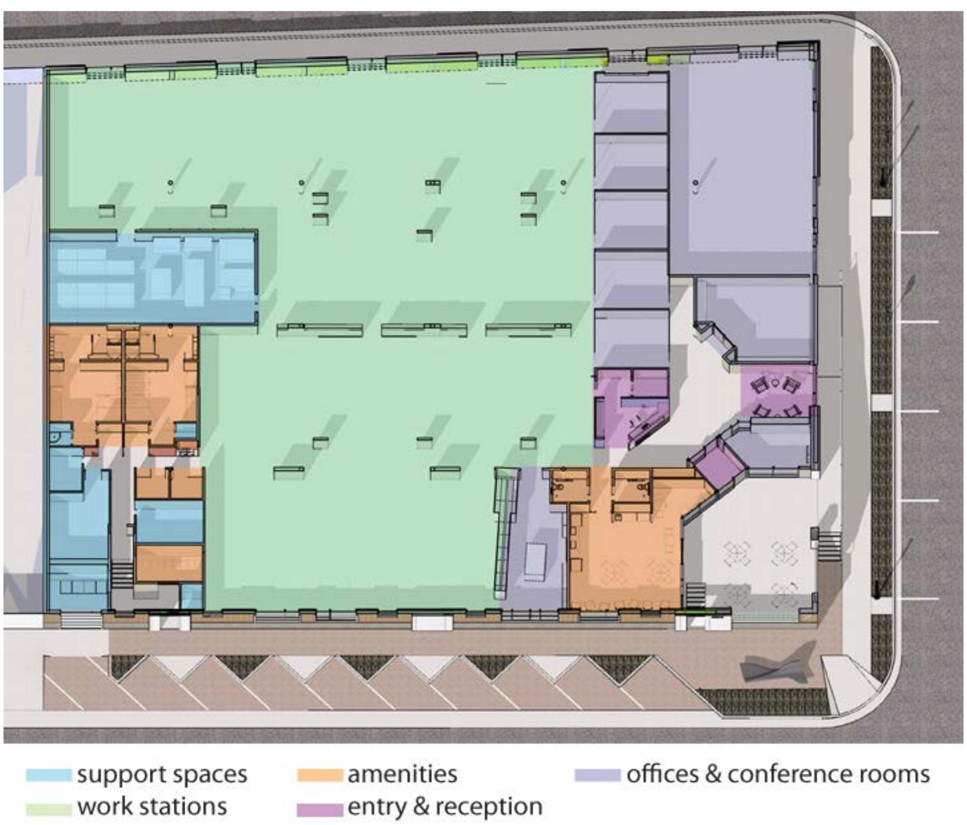
The envelope was upgraded to exceed ASHRAE 90.1 2007 baseline using the trade-off option. The existing R19 batt from the roof assembly was removed and reinstalled at the exterior walls by adding a wood frame wall inboard of the existing CMU. The resulting wall assembly was increased to R22.5. The roof was reinsulated with R30 continuous board insulation over the existing roof deck. The new roof membrane is TPI with an Energy Star initial solar reflectance rating of 0.87. The existing window and rail car loading door openings were infilled with new storefront NFRC labeled as U-0.37 and SHGC-0.6.

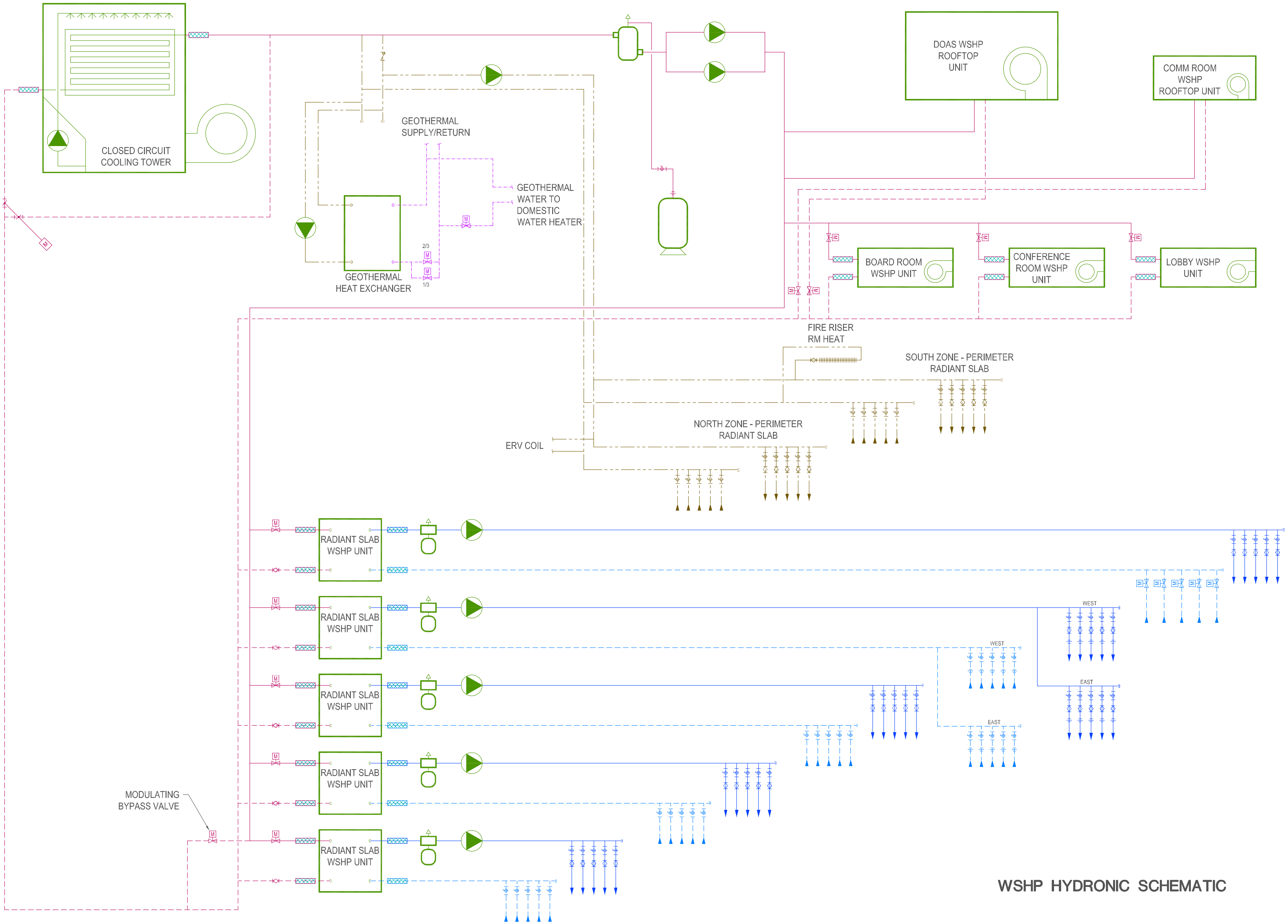
Daylighting: The central, open design studio for 80 staff extends from north to south walls. The midpoint between the walls is over 60 feet from an exterior wall so skylights were seen as a necessity. The daylighting concept was modelled with SPOT to optimize the distribution of natural light while minimizing penetrations in the roof.

<u>Lighting</u>: High efficiency, high frequency, electronic, dimmable ballast fluorescent fixtures are spaced throughout the design studio for consistency and even lighting. All other fixtures are LED in conference rooms, break room, exit signs, accent lighting, and restrooms. Daylight harvesting and lighting systems are centrally monitored, then dimmed or turned off with local daylight and occupancy sensors, and a central lighting control panel.

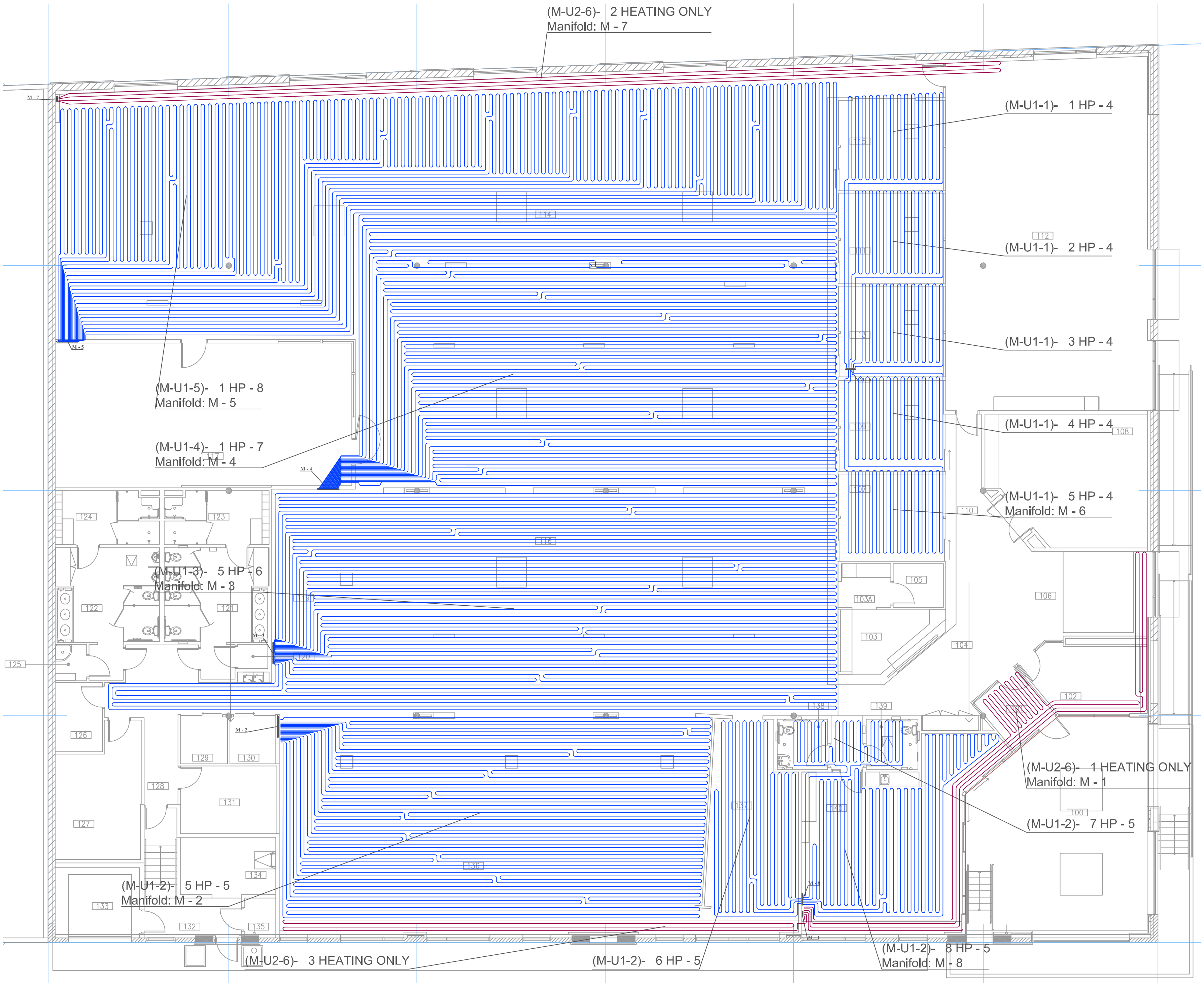
Cost Effectiveness

One of the objectives of the project was to demonstrate that an existing building can be remodeled to be energy efficient within a comparable budget to construct a new building. The final cost per square foot to complete was approximately $116/SF without design fees. The design fees for the project have not been calculated because all design labor was in house. By assuming design fees to be 8%, the cost to construct would have been $125/SF. This is comparable to most new construction office buildings in the area. While 32.5 kBtu/SF may not be net zero, the project does demonstrate that an energy efficient design is achievable within a modest budget.





WSHP HYDRONIC SCHEMATIC



(M-U2-6)- 2 HEATING ONLY
Manifold: M - 7
(M-U1-1)- 1 HP - 4
(M-U1-1)- 2 HP - 4
(M-U1-1)- 3 HP - 4
(M-U1-5)- 1 HP - 8
Manifold: M - 5
(M-U1-4)- 1 HP - 7
Manifold: M - 4
(M-U1-1)- 4 HP - 4
(M-U1-1)- 5 HP - 4
Manifold: M - 6
(M-U1-3)- 5 HP - 6
Manifold: M - 3
(M-U2-6)- 1 HEATING ONLY
Manifold: M - 1
(M-U1-2)- 7 HP - 5
(M-U1-2)- 5 HP - 5
Manifold: M - 2
(M-U2-6)- 3 HEATING ONLY
(M-U1-2)- 6 HP - 5
(M-U1-2)- 8 HP - 5
Manifold: M - 8