ASHRAE TECHNOLOGY AWARDS APPLICATION FORM (Page 1)

APPLICATION MUST BE COMPLETE TO BE CONSIDERED FOR JUDGING

(Required for Society-Level Competition)

(For ASHRAE Staff Use Only)

I. Identification (0 Points)

Name of building or project: Sitka Public Library Deep Green Carbon Neutral Retrofit

II. Category - Check one and indicate New, Existing, or Existing Building Commissioning (EBCx)

	New	Existing	EBCx
☐ Commercial Buildings	☐	■	☐
Institutional Buildings:			
☐ Educational Facilities	☐	☐	☐
☐ Other Institutional	☐	☐	☐
☐ Health Care Facilities	☐	☐	☐
☐ Industrial Facilities or Processes	☐	☐	☐
☐ Public Assembly	☐	☐	☐
☐ Residential (Single and Multi-Family)			

III. Project Description (0 Points)

1. Type of building or process: Existing Library Expansion
2. Size – gross floor area of building (ft. sq. or m. sq.): 12,366
3. Function of major areas (such as offices, retail, food services, laboratories, guest/patient rooms, laundry, operating rooms, warehouse/storage, computer rooms, parking, manufacturing, process, etc., or industrial process description:

   Library
4. Project Design Period: 06/2013 (Begin date (mm/yyyy)) to 02/2016 (End date (mm/yyyy))
5. Project Occupancy and Operation Period: 01/1967 (Begin date (mm/yyyy)) to Present (End date (mm/yyyy))
6. ASHRAE Standards referenced during design (this information will not be shared with the Judging Panel):

   ASHRAE 62.1, ASHRAE 90.1, ASHRAE 15

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1. Name of Building or Project: Sitka Public Library Deep Green Carbon Neutral Retrofit

2. Entrant (Required to be an ASHRAE member with significant role in project):

a. Name: Oram, Shawn

Last First Middle

Membership Number: 8141739

Chapter: Puget Sound

Region: XI

b. Entrant's Design Firm/Company: Ecotope, Inc.

c. Address (including country): 1917 First Avenue, Suite 300

City	State	Zip	Country
Seattle	WA	98101	USA

d. Telephone: (O) 206-322-3753 Email: shawn@ecotope.com

f. Entrant's Role in Project: Principal

g. List the names of Design Team Members (A maximum of three may be listed; only ASHRAE members will be recognized as team members)

1. Shawn Oram
2. Henry Odum
3. Colin Grist

3. Certification of entrant (0 Points) (If multiple entrants, all must be listed on this form)

I certify the information submitted is correct, and that this entry satisfies the requirements of the ASHRAE Technology Award competition.

Typed Name: Shawn Oram Title: Principal, Head of Engr

Signature: Shanti Oram Digitally signed by Shanti Oram DN: C=US, E=shawn@ecotope.com, O="Ecotope, Inc.", CN=Shanti Oram Date: 2019.04.24 11:40:40-07'00' Date: 04/24/2019

4. Building Owner's release (0 Points) (Building Owner cannot be the same person as the Entrant)

I certify that I am the owner or the authorized representative of this project, and hereby grant permission to ASHRAE to use all the enclosed data and information in the judging and subsequent publicity of this project.

Typed Name: Dan Tadic Title: City Engineer, CBS

Signature: Date: 4/24/2019

(Signatures must be on form submitted to ASHRAE)

Company: City and Burough of Stika (CBS)

Address: 100 Lincoln St.

City	State	Zip	Country
Sitka	AK	99835	USA

Telephone: (O) 9077473294 Email: dan.tadic@cityofsitka.org

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5. **Engineer of record:** Required unless a written explanation is provided why the engineer of record will not grant his/her consent.

I consent to the presentation of this project for consideration in the ASHRAE Technology Awards Program.

Typed Name: Jonathan Heller   Title: President

Signature: Jonathan Heller Digitally signed by Jonathan Heller
DN: C=US, E=jonathan@ecotope.com, O=Ecotope, CN=Jonathan Heller
Date: 2019.04.24 10:23:55-07'00'   Date: 04/24/2019

(Signatures must be on form submitted to ASHRAE)

Company: Ecotope, Inc.

Address: 1917 First Avenue, Suite 300

City	State	Zip	Country
Seattle	WA	98101	USA

Telephone: (O) 206-322-3753   Email: jonathan@ecotope.com

The topics below should be addressed on separate pages and formatted according to the requirements listed in the overview.

1. **Energy Efficiency (15 Points)**
2. **Indoor Air Quality (15 Points)**
3. **Innovation (15 Points)**
4. **Maintenance & Operation (15 Points)**
5. **Cost Effectiveness (15 Points)**
6. **Environmental Impact (15 Points)**
7. **Quality of Presentation (5 Points) (No response required)**

Return Completed Application to your Chapter Technology Transfer Committee Regional Vice-Chair.

For additional information, contact:

Candace DeVaughn
Chapter Programs Manager
678/539-1128
cdevaughn@ashrae.org

Project Description

Built in 1967, the Sitka Public Library (formerly the Kettleson Memorial Library) has served the City and Borough of Sitka, Alaska for over 50 years, during which time it has undergone two major renovations. Most recently, a 2016 expansion added 4,800 ft^2 to the building – increasing the heated floor area by 63 percent, up to a total of 12,500 ft^2. Before to the renovation, the library relied on fossil fuel heating; but with costs rising the City had an interest in removing the library from its dependence on oil. Switching the building entirely to electricity brought up a new issue – the nearby hydroelectric dam had been experiencing capacity issues due to growing electrical demands from the city since it is Sitka's primary source of electricity. Therefore early in the design, the team set an ambitious target to eliminate reliance on heating oil without increasing the building's existing electrical load.

Several energy saving measures were selected accomplish this goal which focused on a deep green low energy retrofit. Reducing the heating load and designing an efficient mechanical system was the primary goal, but the team also had to also manage the existing electric load before introducing new loads to the system. While the project more than doubled the floor area, the total energy usage was reduced by a factor of three (EUI dropped from 99 to 32 kBTU/ft^2/yr). All fossil fuel consumption was eliminated, the heating load transferred to the electrical meter, and only increased the electric consumption by 32 percent. Utility costs were nearly cut in half and since all primary electricity in Sitka is hydropower, carbon emissions were eliminated. This project is an innovative example of what is required to transition existing building stock into high performing, carbon neutral buildings.

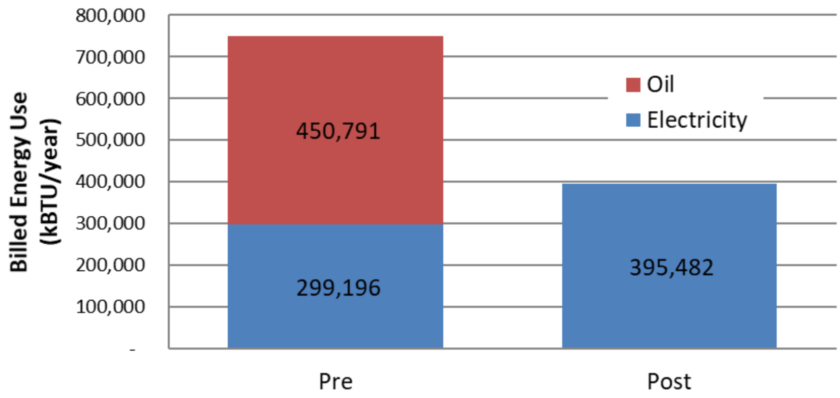


Figure 1: Sitka Public Library Billed Energy Use, Pre- and Post-retrofit

Feedback from occupants has been very positive. The significant noise reduction associated with radiant floors, combined with low operations and maintenance impact of the mechanical systems have proven very effective to achieve deep green retrofits. Altogether, the system redesign contributes to annual operating savings of $9,500. After a year of occupancy, the Energy Use Index (EUI) decreased to 32 kBTU/ft^2/yr which is one third of the national average for libraries.

Energy Efficiency

Sitka Public Library's 4,800 ft^2 expansion and deep green retrofit in 2016 increased the total heated floor area by 63 percent but eliminated oil consumption and maintained nearly the same electrical consumption. Energy conservation measures selected for this project focused on a combination of load reduction, high performing mechanical systems, and managing the existing electric load. Super-insulated walls, a fully insulated foundation slab, a heavily insulated roof, and triple pane windows deliver a very stable thermal environment. These load reduction techniques allow the library's heating system to remain off during much of Sitka's temperate winters. Internal gains from occupants, lights, and plug loads to keep the building warm for a large portion of the year.

Ventilation is provided by a Dedicated Outdoor Air System (DOAS) that utilize ECM fans and an 80 percent effective heat recovery core to recover heat from the warm return air (further reducing the heating load of the building) before being exhausted outside. Space heating was accomplished with variable refrigerant flow (VRF) heat pumps coupled to hydronic heat exchangers with radiant floor distribution in large open spaces and air-side wall cassettes in smaller rooms.

The domestic hot water load is served by a heat pump water heater and distributed by low-flow fixtures. All lighting has LED fixtures with dimming controls. Cooling is accomplished using natural ventilation with operable windows that improve indoor air quality and take advantage of the mild summers in Sitka.

Table 1: Summary of Energy Measures

Measure	As-Designed
Envelope	Super Insulation: R-30 Walls, R-50 Roof, R-20 Slab, Triple Glazed Windows
Space Heating	Variable Refrigerant Flow (VRF) heat pumps with radiant floor distribution in large open spaces and wall cassettes in smaller rooms
Ventilation	Dedicated Outdoor Air System with 80 percent sensible energy recovery from the exhausted indoor air
Lighting	100 percent LED Fixtures with dimming
Water Heating	Heat pump water heater for domestic hot water production
Water Fixtures	Low-flow plumbing fixtures

Energy bills were collected before construction (2011 to 2013) and after construction (2016 to 2017), annualized results for overall energy use and costs are shown in Table 2. Main takeaways include:

- Annual energy use normalized by total square footage (EUI) dropped from 99 to 32 kBTU/sf/yr.
- Oil, which was 60 percent of the preliminary energy use, has been eliminated
- Electric use has increased by 32 percent – but while adding space conditioning to the electric load and increasing the heated floor area by 63 percent
- Estimated $9,500 annual savings in utility costs (Figure 3)

Table 2: Building Area and Billed Energy Use, Pre- and Post-Retrofit

Sitka Public Library	Area (ft^2)	Oil Use (Gal/yr)	Electrical Use (kWh/yr)	Billed EUI ($kBTU/ft^2/yr$)	Energy Savings
Pre-Retrofit (2011-2013)	7,567	3,234	87,689	99.1	
Post-Retrofit (2016-2017)	12,366	0	115,909	32.0	68 percent

After the renovation, the annual energy use normalized by total square footage (EUI) was cut by factor of three, from 99 to 32 kBTU/ft/yr. This puts Sitka Public Library at one third of the national average for libraries. The new library is carbon neutral and saves 72,377 lbs/yr of CO_2 over the pre-retrofit building.

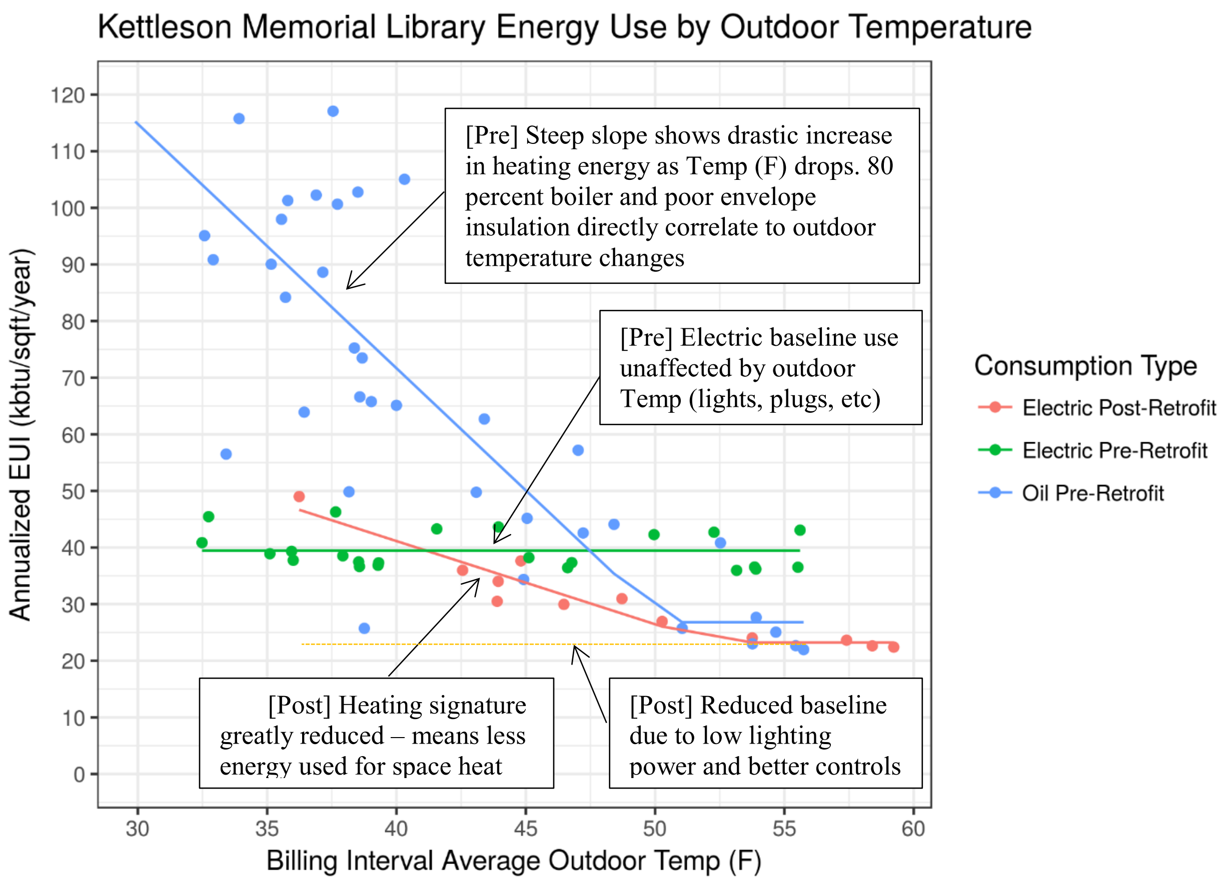
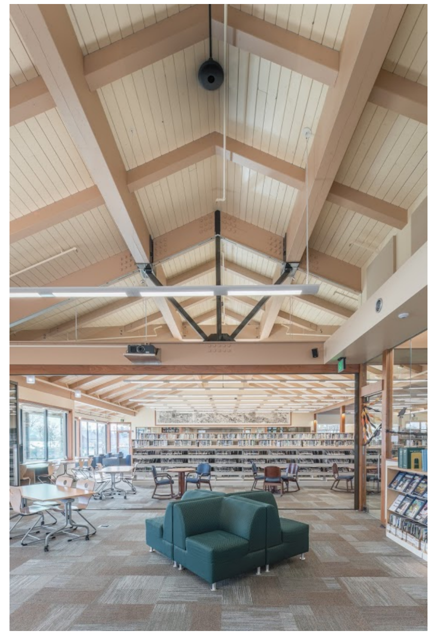


Figure 2: Weather Normalized Building Energy Use – Pre and Post-Retrofit

Indoor Environmental Quality



The Direct Digital Control (DDC) system allows the building manager to see how the building is operating and provides full control over the mechanical systems to optimize the indoor environment. Zonal temperatures, thermostat setpoints, carbon dioxide levels, radiant floor temperatures, and relative humidity readings are all displayed real-time at the control station. The radiant floors, paired with a super-insulated envelope, keep the large spaces at an even temperature during the winter months. It is evident that the warm slab in the children's reading room is an inviting place to sit for young legs.

Minimum outside air-flow rates are provided continuously while spaces are occupied. Outside air quantities were calculated to meet ASHRAE 62.1 standards for each space using ventilation effectiveness of 1.0 with over-head supplies. Outside air is filtered with MERV 13 filters and CO_2 controls modulate the ventilation air to match the daily ventilation requirements.

Innovation

The Sitka Public Library's low energy outcome is a result of the design team's application of integrative design practice and innovation. Innovative featuers include:

- *Process Cooling Heat Recovery to Radiant Floor:* The library program consists of a dedicated computer lab which is a high density space with high internal gains associated with occupant, lighting, and desktop computers. The heat recovery VRF heat pump system allowed the design team to couple the computer lab space conditioning with the main library radiant floor system. Waste heat from the computer lab heat pumps is transferred to the hydronic refrigerant-to-water heat exchangers, thus reducing the VRF cassette energy usage.

- *Process Cooling Heat Recovery to DHW:* The library Domestic Hot Water (DHW) heating use an integrated heat pump water heater with ducted connections. Intake air to the DHW heat pump was set up to pull waste heat from the high ceiling area above the adjacent server room. The server room is cooled with a ductless VRF heat pump system located in the occupied zone. The room is set up to thermally stratify, where heat can be pulled to the heat pump water heater for the building's hot water and temperature maintenance loads.
- *High Efficiency Energy Recovery Ventilation (ERV):* Sitka is a heating dominated climate (7,191 Heating Degree Days) located in a small coastal community exposed to extreme weather events. To save signifant heating energy, the team tightly sealed the envelope and installed a high efficiency, balanced ERV system. The design team selected a built up counterflow ERV to achieve high levels of heat recovery efficiency (80 percent sensible) and low fan energy (0.5 CFM/watt). All public bathrooms and other typical exhaust sources were routed through the ERV to enable a balanced ventilation system and recover as much heat form the exhausted air as possible.

Operations & Maintenance

The City of Sitka requested a low energy and low maintenance library for this renovation. The radiant floor heating system, consisting of one hot water buffer tank and a variable speed pump covers 80 percent of the heated floor area and does not have any filters or fans to clean. The VRF system serves back of house spaces with traditional cassettes for archive storage, offices, and admin spaces. Limited indoor cassettes require less routine maintenance to clean the filters and service the units. The ERV systems have easy to access filter boxes with MERV 13 filters.

Cost Effectiveness

This expansion coincided with an end-of-life replacement of the existing mechanical equipment. Instead of replacing like-for-like, a portions of the construction budget was concentrated on improving the envelope, through 50-year energy conservation measures. With this, the building's heating load was cut in half, bringing the design mechanical capacity to 780 ft^2/ton. Long term investments, such as envelope measures, lead to a reduction in the mechanical system capacity which not only makes the upfront costs smaller, but keeps costs down when the building must replace its mechanical equipment at the end of its useful life. The utility costs for the library were cut in half after the expansion, keeping money in the local economy rather than importing fuel from abroad.

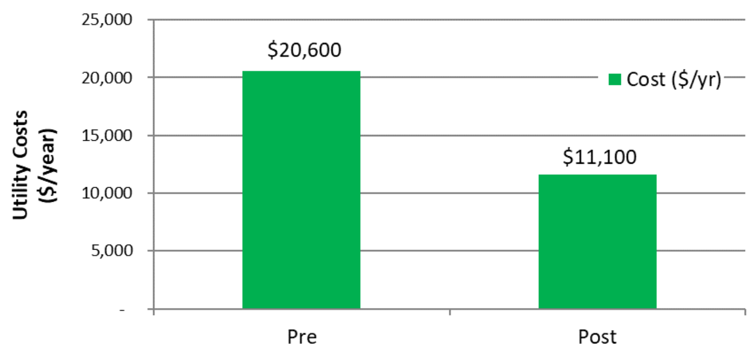


Figure 3: Sitka Public Library Annual Utility Costs

Environmental Impacts

Due to limited capacity of the City's hydroelectric dam, removing the library from its dependency on fossil fuels was not a straightforward task. As oil prices rose, many private and public buildings within the City switched from fossil fuels to electric or wood heating sources. As buildings shifted to the electric grid, the existing system became taxed and capacity limited. Seeing this electrical demand increase, the City invested over $140 million to raise the level of the Blue Lake Dam in order to expand their hydropower resources.

Taking a snapshot of this building's transition to the electrical grid, in a secluded city with constrained infrastructure, provides a glimpse into how the greater US should work towards a carbon-neutral, energy efficient built environment. The transition from fossil fuel heating to electrically heated buildings cannot be accomplished without energy reduction measures. The electrical grid in many parts of the US does not have the ability to handle heating loads currently served by fossil fuels. Shifting away from fossil fuel heating must coincide with an investment in load reduction measures (envelope insulation), energy recovery ventilation, and efficient heating systems.

Lessons Learned

- Work in remote sites has its own set of challenges. Costs are very high for equipment which has to be shipped in from abroad. This leads to longer lead times and almost doubles the costs of typical construction compared to in-city costs. The lesson learned is that local costs should be investigated before setting budgets.

- Water hammer was a problem on this system's plumbing system layout, it was discovered that the water hammer arrestors were undersized and installed in the incorrect location. This was addressed post construction by installing larger air cushions. The lesson learned is to review design assumptions when specifying water hammer arrestors, contractors rarely understand the background on these systems. We recommend having a knowledgeable product representative review and confirm the application of water hammer arrestors.

- Variable speed radiant floor pumps were set up incorrectly on intial installation. Commissioning activities discovered that the pumps, as installed, were not able to meet the temperature differentials required for the design. These were rebalanced and set up to achieve the required temperature differentials for proper operation of the radiant floor. The lesson learned is to ensure designers understand the newest technologies and their control capabilities.

- VRF hydronic (refrigerant-to-water) heat pump units claim higher water temperature capability than what is achievable. We found these hydronic heat pumps were capable of producing 108 degree F water, which is acceptable for a radiant floor application, but much less than the stated 115 degree target temperature. The lesson learned is that designers should understand how these hydronic heat pumps operate and verify manufacturer claims on performance characteristics.

- Destratifying ceiling fans were set up with line-of-sight wall controllers that were not functional within the layout of the library. Fan controllers had to be replaced with longer range wireless controls (Wi-Fi enabled). The lesson learned is to review the ceiling fan layouts and confirm the associated controllers can communicate as laid out.

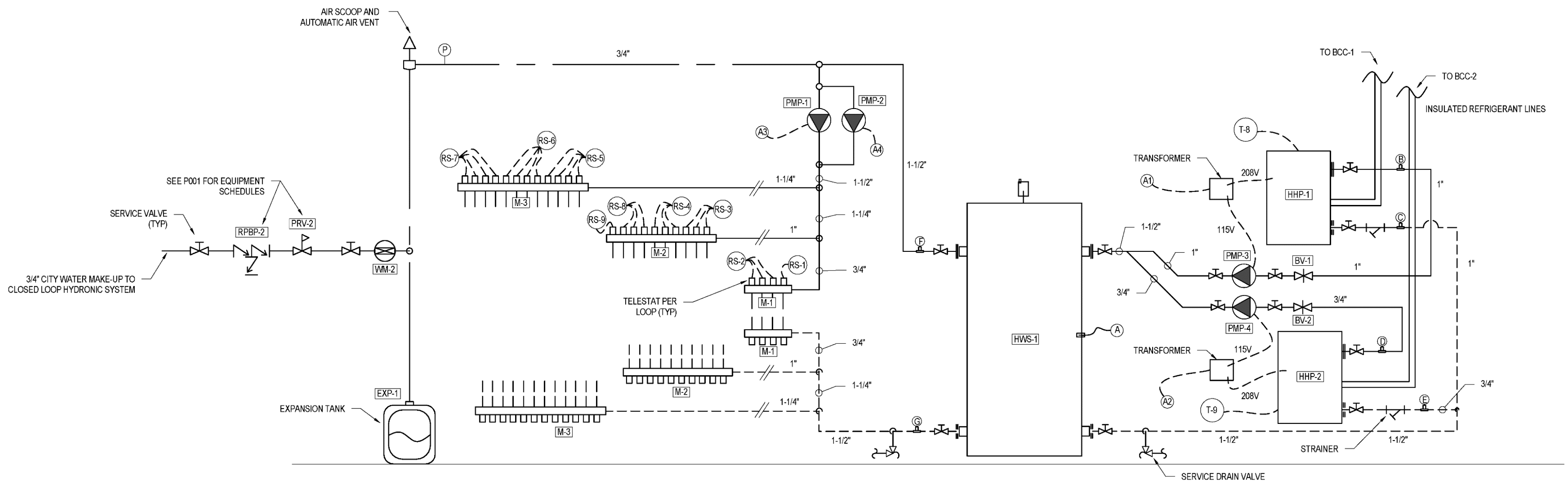


Figure 4: Hydronic System Schematic