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THREE SANCO2 INSTALLATIONS

INVESTIGATING CO_2 HEAT PUMP WATER HEATING SYSTEMS IN THE PACIFIC NORTHWEST

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TIMBER RIDGE APARTMENTS CASE STUDY

THE BUILDING

Timber Ridge Apartments, situated on 4.8 acres in La Grande, Oregon, offers residents breathtaking mountain views from all sides. This affordable housing complex in Oregon Trail Electric Cooperative (OTEC) service territory. The project was developed by Community Development Partners and is owned by the Northeast Oregon Housing Authority. It comprises 82 units across 12 two-story buildings. Completed in September 2023, Timber Ridge is targeting Earth Advantage Platinum and Net-Zero Certifications. To attain 25% reduction in energy consumption, the developer implemented several conservation measures including installing LED lighting, HVAC mini-splits, and central heat pump water heaters.

La Grande is in climate zone 5B, with cold winters (average low of 24°F in January), and hot dry summers (average high of 85°F in July).

An on-site solar installation will help offset utility costs for the building owner.

OTEC (Oregon Trail Electric Cooperative) and Bonneville Power Administration provided rebates of $15,000 for the system and $5,000 for the monitoring equipment.

Three SANC02 heat pumps outside the community center

FEATURES

Residents at Timber Ridge enjoy a range of amenities, including pickleball and basketball courts, a community garden, and an enclosed community center space. The community center also hosts the Eastern Oregon Head Start preschool program, offering valuable services at no cost to attendees.

Exterior of one of the 12 apartment buildings at Timber Ridge

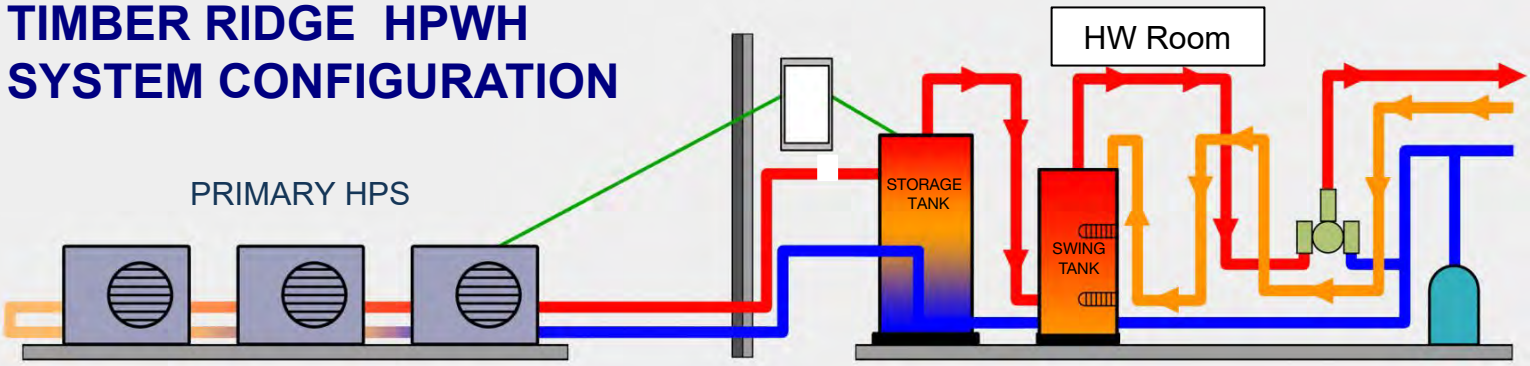
MEASUREMENT AND VERIFICATION

Due to unforeseen project adjustments, the measurement and verification data for this project is not being collected.

SYSTEM DESIGN

The SANCO2 system was installed in September 2023 in the Timber Ridge community center building. The system has three SanC02 HPWHs and a 505-gallon storage tank. In the event of freezing or heavy load, the electric resistive heating elements in the swing tank will provide trim heating. Freeze control measures include 1” insulation on the exterior piping. After commissioning the system, the manufacturer recommended installing an internal heat trace to prevent condensate and pumps from freezing. Before this recommendation was implemented, a sub-zero weather event led to a power outage which caused a failure of two of the three recirculation pumps. In Spring 2024, two replacement recirculation pumps were installed to repair this system. BPA engineers recommended installing uninterruptible power supply as the backup power for the heat trace tape, as well as installation isolation valves to mitigate power failure, provide freeze protection, and easily isolate and drain the system for maintenance.

TIMBER RIDGE HPWH SYSTEM CONFIGURATION



Monitoring the initial startup of the three SanCO2 heat pumps

The control unit for the HPWH system

505-gallon storage tank in the community center

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BONNERS FERRY APARTMENTS CASE STUDY

THE BUILDING

Located in Bonners Ferry, Idaho, this apartment complex was constructed in 1972 and provides long-term, low-income housing. It is served by the City of Bonners Ferry municipal electric utility. The complex consists of three buildings with six units for a total of 18 units. Current owners, acquired the property in 2021 and have since implemented various energy efficiency measures including replacing aluminum windows with vinyl and installing a new HPWH systems in each apartment building.

Bonners Ferry is in climate zone 6B, with an average low of 22°F in January, and average summer high of 84°F in July.

The project cost $37,231 and received $19,812 in rebates

The anticipated payback for the project is 12.4 years

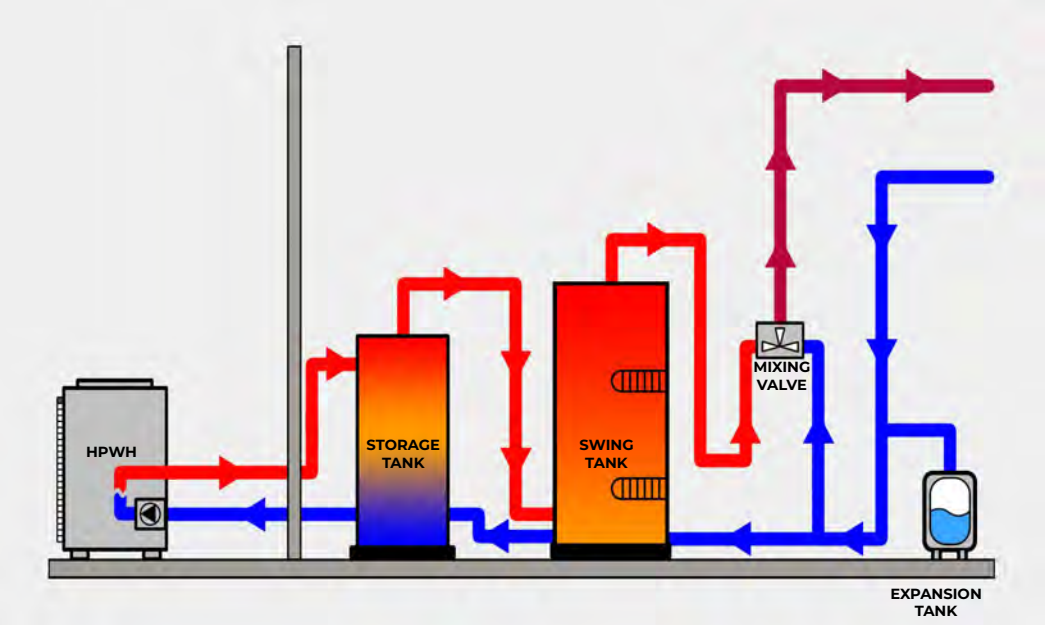
Estimated annual energy savings of 36600kWh, translating to approximately $3,000 in cost savings

A SanC02 heat pump installed on an exterior apartment wall.

CONNECTING TO REBATES

The owners were able to access multiple rebate programs from Bonneville Power Administration and from the City of Bonners Ferry for their energy-efficiency upgrades.

BONNERS FERRY SANCO2 GS4-45HPC



IMPACTS

The existing 55-gallon electric resistance tank was left in place as a swing tank, adding heating capacity and storage when the SanC02 system was installed. This addressed residents' earlier complaints about inadequate hot water and resulted in improved satisfaction.

SYSTEM DESIGN

This system was installed by a local plumber. Each HPWH system is located in the building's unconditioned boiler room. SanCO2 equipment can operate as low as -20°F, however, these systems are designed to operate as heat pumps for temperatures as low as -5°F to -10°F with a freeze protection control and a water release valve designed to open to prevent water freezing within the pipes of the unit. Heat trace tape has been applied to all exterior pipes as well as those in the boiler room. Should the ambient temperature temperature drop below the control point, the electric heating elements in the swing tank will provide electric resistance trim heat to ensure that hot water is still delivered to the building.

MEASUREMENT AND VERIFICATION

The retrofit involved installing the SanCO2 HPWHs alongside the existing equipment, which shifted most of the hot water demand to the HPWHs and significantly enhanced the efficiency of domestic hot water production. Each of the three buildings was equipped with one HPWH which consumed between 89-98% of the system's total energy use with system COP of 1.8, 2, and 2.3 during the winter monitoring period.

"Installation of a HPWH system in Bonners Ferry will result in significant energy savings when compared to electric resistance heating."

- EVAN GREEN, ECOTOPE

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JOHN FOX PLACE

CASE STUDY

THE BUILDING

This new construction, seven-story apartment building in Seattle City Light service territory offers 104 apartments for individuals and families making 30% to 60% of the King County Area Median Income. This is the first all-electric building designed by the Low Income Housing Institute. The apartments range from studio size up to 3-bedrooms and there are plans for an early-learning daycare facility on the first floor.

A major goal of this project was to fulfill requirements of the Washington State Housing Finance Commision 4% bond program, based on Evergreen Sustainable Development Standard v3.0, which required incorporating two additional Washington State Energy Code C406 measures than were required by code.

Seattle is in climate zone 5C, with mild,wet winters with an average low of 36°F in January, and dry summers with an average high 72°F in July.

Seattle City Light provided a rebate of $52,000 in support of this project.

This is the first HPWH system used by the Low Income Housing Institute in Seattle.

Estimated annual payback of $12,904.00

EC02 285-gallon insulated storage tanks

"The energy goals of this project were to provide a reliable water heating system, with redundancy and simple controls, while reducing owner and tenant utility costs."

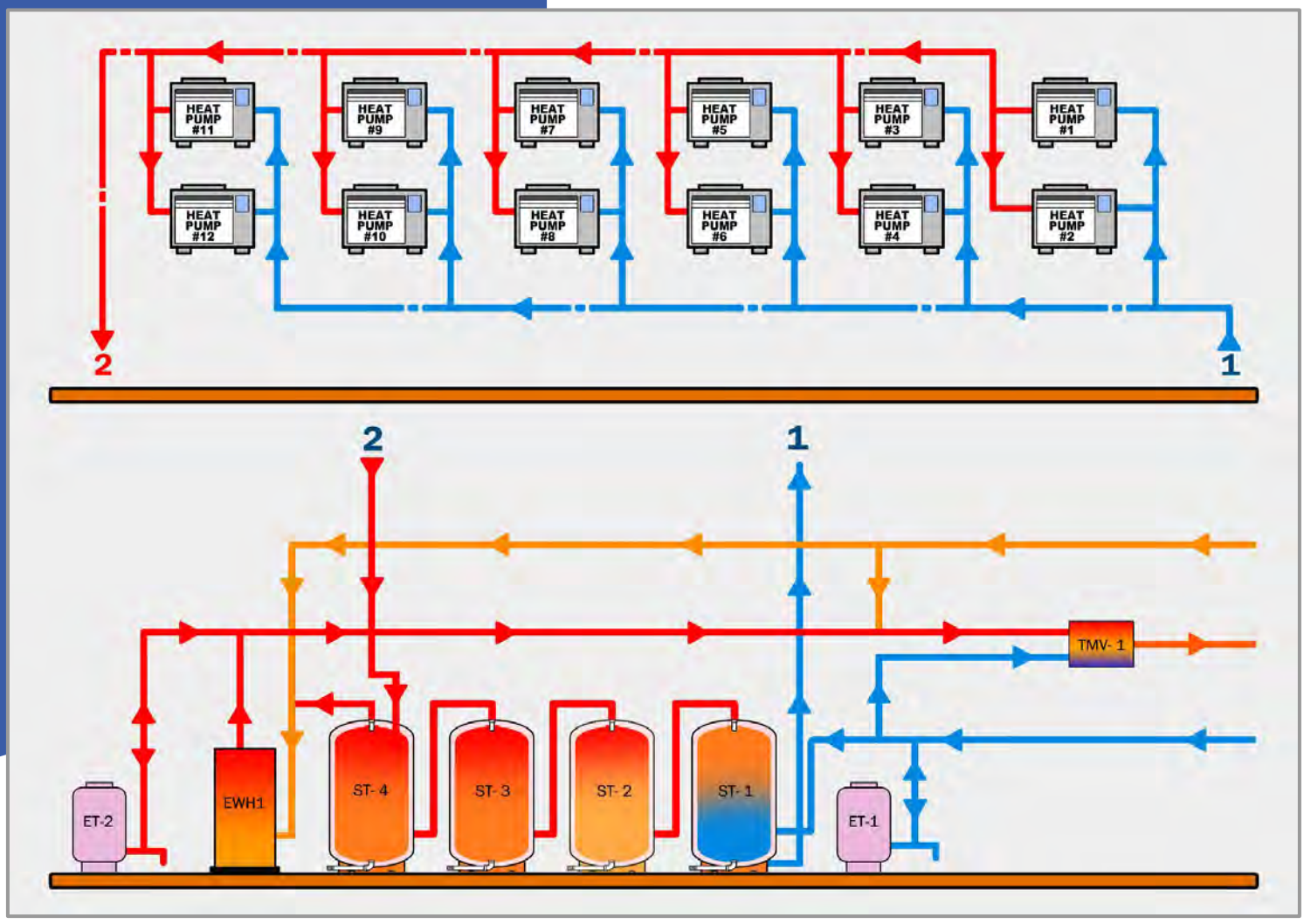
- DAVID REDDY, O'BRIEN360

SYSTEM DESIGN

Uniquely this entire system, including 12 SanCO2 HPWHs and four 285-gallon insulated storage tanks (1140 gallons total storage), is located in an interior mechanical room. The design aligns with the NEEA AWHS v8.0. Greenheck 6000 cfm sidewall fans with VFD are utilized for HPWH room ventilation and humidity control, adjusting fan speed based on temperature differentials. An ECO2 systems staging controller is custom programmed to manage the ventilation fans' speed based on room and outside air temperatures.

MEASUREMENT AND VERIFICATION

The HPWH system was monitored for 27 days. During this period, the calculated system COP was 1.7, which was significantly lower than the expected QPL listed value of 2.6. A few key issues that contributed to the reduced performance were: 1) missing balancing valve, 2) alarm-triggered state changes, and 3) installing the system in a small mechanical room. The missing balance valve caused the swing tank to consume 65% of the plant's total energy instead of the projected 5-20%. Additionally, one of the systems entered an alarm state which triggered a shutdown of four other units, contributing to the reduced system efficiency. Finally, the installation of the units in a small mechanical space led to a 9% decrease in system COP due to poor ventilation. The installation of a balancing valve is in process, and adjustments to the controller settings to prevent alarms from triggering a shutdown have been resolved. There is nothing that can be done at this time to improve the ventilation in the current installation, but future designs should prioritize outdoor installations or locations with proper ventilation and factor in a 10% performance derate when mechanical rooms are used.



CONCLUSIONS

Timber Ridge, an exterior installation that was designed without the manufacturer's review, experienced two heat pump failures during an extreme cold weather event and accompanying power outage. For better outcomes the recommendations are: 1) a plan for loss of site power in low temperatures, 2) a UPS backup power for electric heat tape, and 3) isolation valves installed for the storage tank to the outdoor unit.

Bonners Ferry, also an exterior installation, has been operating as expected and has not experienced failures to date. Due to local code requirement, freeze protection valves were installed on the heat pumps, and the property owners wrapped the exterior pipes in freeze tape for added protection. This project demonstrated the successful installation of the HPWH with a supplemental electric resistance unit that can effectively handle the domestic hot water heating load. The results highlight the potential for similar retrofit applications to enhance energy efficiency in multifamily buildings.

At John Fox Place the HPWH equipment was installed in a mechanical room inside the building. Installations within a buffer zone or mechanical room on the interior of buildings reduce or eliminate the need for freeze protection. Despite the issues encountered with the installation, the lessons learned from this project are paramount to future installations. The monitoring period highlighted several contributing factors to the low system COP, and the team was able to identify preventative measures to improve the performance of this installation and future installs.

The problem of split incentives was avoided since the building owners pay the bills and and at all three sites the owners received the rebates. The C02 exterior installations in cold climates 5b and 6b appear to perform well and to meet expectations for hot water delivery provided that adequate freeze protection is incorporated into the system design.

Timber Ridge	Bonners Ferry	John Fox Place
Community center and 6 units served	18 units served	104 units served
3 HPs	3 HPs	12 HPs
505 gallons storage	119 gallons storage	1140 gallons storage
150-gallon electric water heater swing tank with 15kW of electric resistance elements	55-gallon existing electric resistance tank used as swing tank	200-gallon, 18 kW for elements swing tank heating capacity