Pier 91 Tune-Up Audit Report

Final Draft

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Summary

The Smith Cove Building at Pier 91 is a large commercial building (128,097 SF) with the main use as a cruise ship terminal. The building has electric and gas service, which is paid by the tenant, Cruise Terminals of America (CTA). The building was constructed in 2009 and the equipment dates from that time. This report includes findings from a walk-through audit (January 2024) and a controls and trends review (May and June 2024), and a billing analysis. Also, the report builds on the analysis and work completed during the first building tune-up in February of 2020.

A billing analysis and energy end use breakdown is presented. The major result is increased natural gas consumption over time, including significant natural gas use throughout summer months.

Then, modifications to the building are presented. First, Seattle Building Tune-up measures were identified and corrected prior to the publication of this report. Next, recommended energy efficiency measures are described, including new measures identified by the billing analysis. Finally, equipment upgrades are suggested to help decarbonize Smith Cove and comply with future performance legislation. **If all measures were implemented, it would be possible to install enough solar panels on the roof to get the building to net zero on an annual basis.**

Energy savings estimates are provided for energy efficiency measures, including the work that was implemented for the Seattle building tune-up. Combined with cost estimates which include work from Ecotope and from the Port of Seattle, a simple payback is calculated for each measures. Finally, the simple payback is compared with estimated measure life to determine whether each measure would be required to be part of an “investment criteria” lifecycle cost assessment (LCA). A summary of our results is shown in Table 1.

Table 1. Estimated Simple Payback, analyzed energy efficiency measures

Package	Measures	Simple Payback (yrs)	Meets LCA requirement?
Tune-up	HVAC-1-1 Zone tune-up	3.2	No (complete)
Tune-up	CO2 Sensor Replacement and Sequence Update	3.0	No (complete)
HVAC controls	Correct summertime natural gas heating	0.4	Yes
Envelope	Repair leaking skylights	56.7	No
HVAC controls	Upgrade AC unit controls	3.6	Yes
Lighting	Exterior Wallpack LED replacement	32.1	No
Lighting	Occupancy sensors in intermittent occ. Space	20.5	Yes
Lighting	Dimmable LED Lobby lighting	32.8	No
HVAC	Install Destratification Fans: Entrance Hall Only	311.3	No
HVAC	RTU VFDs	10.7	Yes
Renovation	DOAS + Heat Pump HVAC Retrofit	52.1	No
Renovation	Heat Pump Water Heaters	140.0	No
Renovation	Net Zero	31.5	No

Future Work

Additional work is needed to fine-tune cost estimates for the energy efficiency measures. Preliminary values were provided by the Port of Seattle. In some cases, the provided values contrast with Ecotope's knowledge of similar, on-going projects. This report combines Ecotope's experience with the Port of Seattle's estimates.

Second, measures have been evaluated in isolation from each other, so the cumulative effects are not included in this report. Next, the life-cycle cost analysis has not been completed.

Some of this future work depends on how CTA and the Port intend to implement measures. The Port has a goal of achieving net zero by 2040. Starting soon and phasing changes in over time would allow conditions to be monitored and changes to be optimized before being applied to the whole building. For example, it is likely that the capacity of the rooftop units can be reduced if dedicated outdoor air units with heat recovery are installed. Implementing this effort first would allow monitoring and "right sizing" of the replacement heating & cooling units. On the other hand, phasing the work also impacts the project costs.

Portfolio Manager Review

The Energy Star Portfolio manager account for the Smith Cove Pier 91 terminal building was reviewed per the guidelines of the Seattle Tune-up Ordinance. Notably, the building is part of a campus which includes several uses and buildings. The Portfolio Manager record records data for the whole campus, only the transportation terminal detail information was reviewed for purposes of the ordinance. While the building has its own dedicated gas service, meter 1277905, the tenant pays both gas and electric bills to the Port, which holds the accounts. The Port of Seattle manager reports that electric meters 729009 and 729003 serve the terminal building. As part of the tune-up, the Port sustainability coordinator updated the building's floor area and shared the meter data with the City of Seattle.

Facility Summary

The total conditioned area of the building is approximately 128,097 SF. Part of the building tune-up included floor area review by the Port of Seattle who identified that the original floor area (143,000 SF) was much too large. The EUI calculations and energy savings analysis were adjusted midway through the project to account for this difference.

In its primary capacity as an international port of entry and cruise ship terminal, Smith Cove includes a large entry hall, federal border patrol offices and security checkpoints, baggage handling areas, terminal waiting areas, and support staff offices. During the off season, the public portions of the building are used for event rentals. There is 1 small office that is occupied year-round.

The facility exterior includes approximately 20,600 SF of covered illuminated space. The parking areas adjacent to the building are not associated with the CTA and, therefore, not included in our tune-up or this audit report.

Envelope Summary

Pier 91 is a steel framed structure built on piers over Elliot Bay. Construction documents were not provided for the building, given its construction circa 2007 compliance with the 2006 Seattle energy code can be assumed. Typical values would be R30 roof, R30 underfloor insulation, R21 metal walls, and 0.40 u-value for windows. Windows are aluminum double framed units throughout. Elevations are not available for determining the window to wall ratio, but it is estimated at 12-15%, a typical value for commercial buildings.

Mechanical Summary

1. Schedule: The HVAC systems are operated seasonally with daily occupancy (4:30a-5p) 6 days a week during cruise season (April through October) and just 6 hours per week of occupancy during the rest of the year (average). When the building is rented for special events, the HVAC is turned on for set up, event day, and take-down. Exhaust fans and domestic hot water systems are interlocked with the HVAC occupancy schedule.

2. HVAC-1-1: Serves the office spaces, break room, staff restrooms and other support spaces on the 1st and 2nd floors. This unit includes a variable speed supply fan, and two power exhaust fans that are not on VFDs. It also includes a DX cooling section, and an 82% efficient modulating gas furnace, with a 100% outside air economizer. Minimum outside air percentage is set at 0%, a result of the last tune-up controls effort. Demand control ventilation (DCV) is included to control the outside air damper along with the economizer cycle. Supply air temperature reset logic is also provided.
3. HVAC-2-1,2,3,4,5: Serve the ticketing areas on the second floor and are all constant volume. They all include a DX cooling section, power exhaust fans, and 100% outside air economizers. Minimum outside air percentages are set at 0%, a result of the last tune-up controls effort. The controls also include demand control ventilation.
4. AHU-1-1 & AHU-1-5: Serve the baggage handling area on level 1 providing both ventilation and heating. Both units include 80% efficient modulating gas furnaces, 100% outside air economizers, and are constant volume. Minimum outside air damper positions are set at 0%, which is reasonable since large roll-up doors are often open when the space is occupied. No cooling. There are three electric duct heaters in the supply ductwork from AHU-1-1 that are controlled by zone thermostats. The controls also include demand control ventilation and the minimum outside air percentages are set at 0%.
5. AHU-1-6 & AHU-1-7 Serve the entry lobby. Both of these units are constant volume and include 80% efficient indirect gas furnaces. Outside air flow rates are set at roughly 0% and there is a 100% outside air economizer for free cooling. The controls also include demand control ventilation.
6. Unit Heaters: There are a total of 21 electric unit heaters serving the baggage handling areas and storage and mechanical rooms. Capacities range from 2kw-5kw. Supply fans cycle on with call from controlling thermostat that is linked to the BMS. During this tune-up cycle, CTA realized that the BMS was turning the units on when the roll-up doors were open. This was corrected by CTA and the controls vendor, Johnson Controls (JCI).
7. Radiant Heaters: There are a total of 18 electric radiant heaters on local thermostats that cycle on to maintain zone temperature. These serve restrooms, and the customs and border patrol areas.
8. Exhaust Fans: There are roughly 23 exhaust fans. Fans serving mechanical, electrical, and telecom rooms are controlled by t-stats. Fans serving restrooms are scheduled by the Building Management System.
9. Domestic Hot Water: 4 tank style 9kW 80 gallon electric hot water heaters serve the restrooms, janitor sinks, and breakrooms. There are four re-circulation pumps. Both the water heaters and the pumps are scheduled and controlled by the Building Management System. They are OFF during the winter. Three of the systems were newly replaced at the time of the tune-up review in January 2024. The fourth was also replaced in 2024.

Lighting Summary

With lighting upgrades in the baggage handling areas, Pier 91 has an approximate lighting power density (LPD) of 0.61 W/SF. By comparison, the current 2021 Seattle energy code requires transportation buildings to have an LPD not to exceed 0.50 W/SF. Lighting illuminance levels in the spaces are appropriate, no instances of over or underlit spaces were observed on the site walks.

High bay fixtures in the double height entrance area and upstairs arrivals lounge are the largest contributor to the high LPD. According to the design drawings, each fixture has a total installed wattage of 226 watts and there are 239 fixtures, so the installed load is 59 kW.

The baggage lay down and handling area is likewise lit with parabolic fixtures with three T5 tLED retrofit lamps per fixture. These spaces have long on times. Assuming that 25W high output T5 tLEDS were used, the wattage per fixture will be 75W per fixture, a greater than 50% reduction from the 180W total for the original T5 fluorescent lamps. Per drawings there are 195 of these fixtures, so the installed load is 14.6 kW.

Exterior lights located on the building are lamped with 175-watt metal halides, there are 44 of these. Staff note that they are seldom used during summer and locked out during winter when the facility is closed. These areas have the highest potential lighting energy consumption of the building, but low hours of use mean that exterior lighting is likely not a sizable energy use. The installed load is 7.7 kW.

Multiplying each installed load by the annual hours of on time will yield the kWh per year consumed. The end use estimate below estimates the lighting consumes 240,000 kWh per year.

Egress lighting (lights left on for navigation when the space lighting is turned off) is much improved since 2020 with zero lighting found to be on during the January walk-through.

Interior area lights are scheduled by a central building control system used to manage event lighting. The system allows two-step dimming of the high bay events hall fixtures. Occupancy sensors are present in private offices and the downstairs restrooms. Upstairs restrooms, mechanical spaces, and open work areas are not controlled by occupancy sensors.

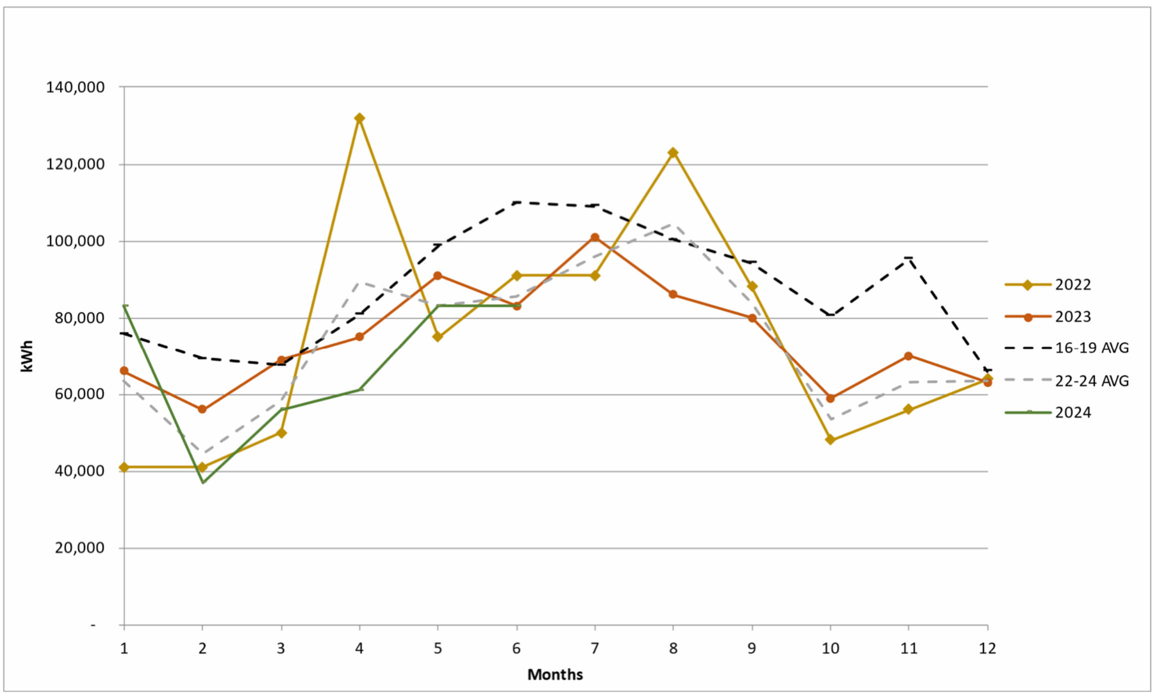
Billing Analysis

A billing analysis examined monthly electric, water, and gas bills from 2020 through 2024 (partial) and compared them with the pre-pandemic energy use. The utility bills show volatile energy use during 2020 and 2021, so this analysis is focused just on 2022 and 2023. Historically, the Energy Use Intensity (EUI) for the building from 2016-2019 is about 42 kBtu/sf/yr. Looking at 2022 and 2023, the electricity use decreased and the natural gas use increased compared with the years immediately prior to the pandemic.

April and May of 2022 included large spikes of electricity and natural gas use. May 2022 was the highest energy using month of all data Ecotope reviewed, going back to 2016. There was a similar reading in August 2021 that appears to be a "catch-up" reading from the pandemic months. Whatever the cause, it has not happened since.

Electricity Consumption

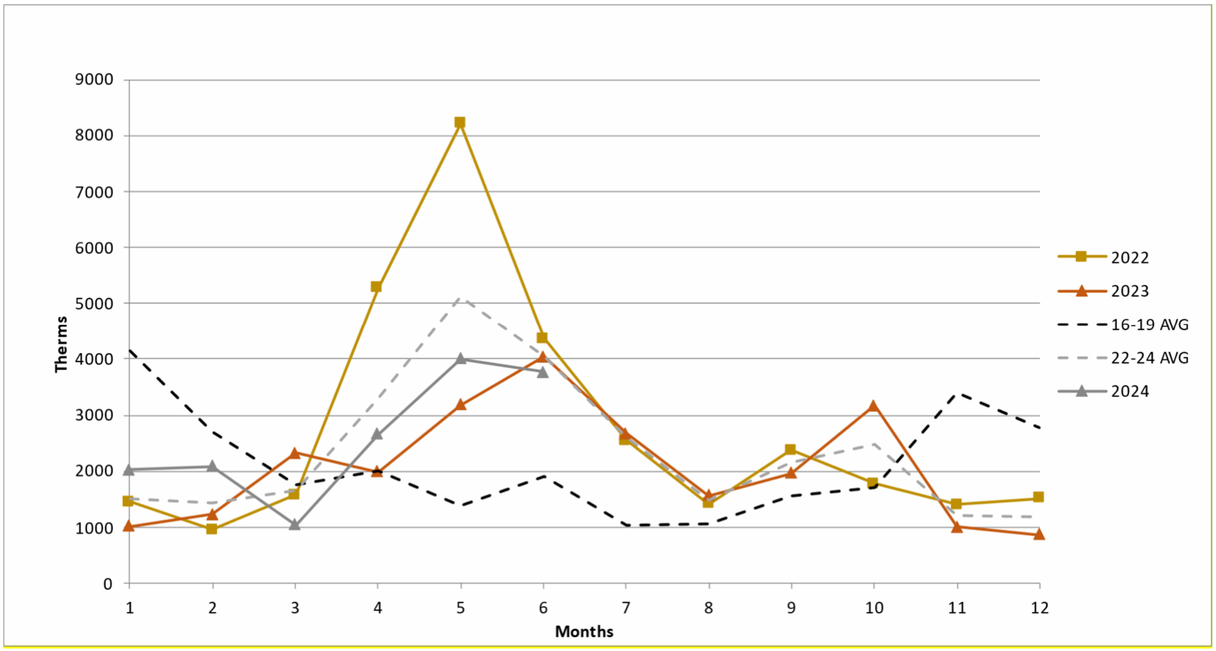
Figure 1: Average Monthly Electricity Use for Pier 91



The average electric EUI for the building is 24 kBtu/sf/yr which is lower than the first tune-up. As with our first tune-up, there is a significant summer energy peak, which would normally be attributed to cooling energy, but is due to very low occupancy during the winter (November-March). Also, we compared the winter consumption with the previous tune-up, shown in Figure 1 as "2016-2019 average". The recent winter consumption has been 30-35% lower in the off-season. It seems that the energy efficient lighting controls and space conditioning schedules have been very effective. We note that the consumption during December has been constant every year (except 2020 and 2021). This is likely due to holiday event rentals.

Natural Gas Consumption

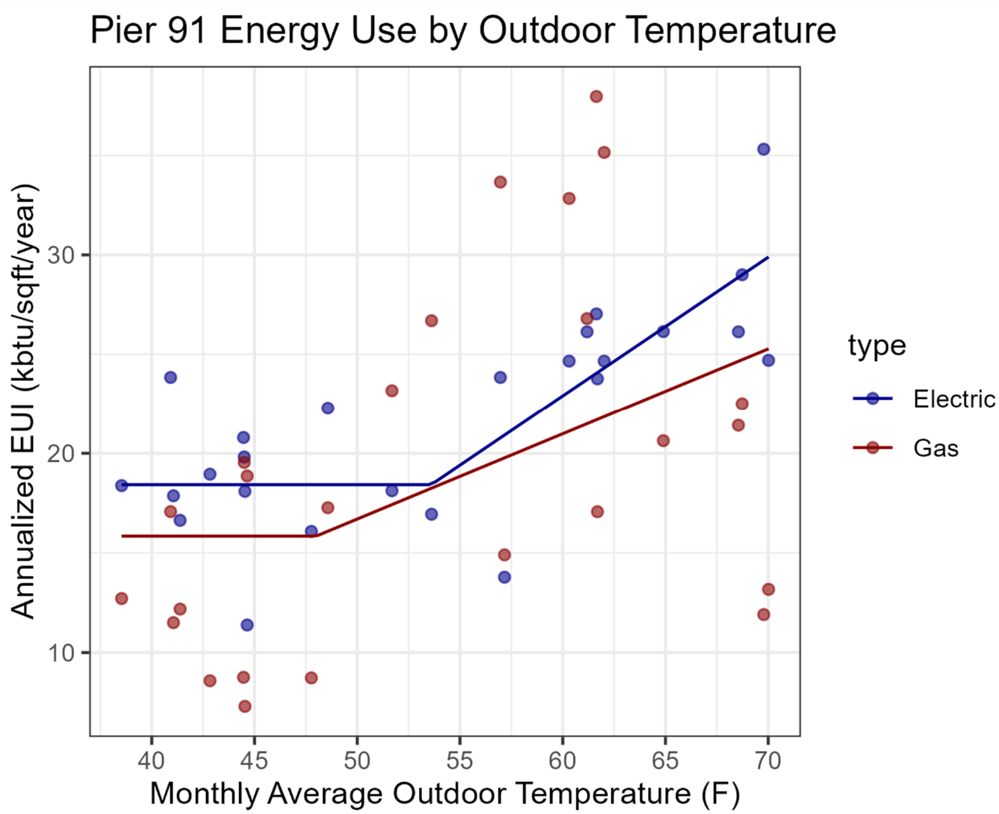
Figure 2: Average Monthly Gas Use for Pier 91



The 2023 natural gas EUI for the building is 20 kBtu/sf/yr which is higher than the first tune-up. Like the electricity, the gas energy during the off-season is lower than the first tune-up cycle, likely due to efficient HVAC schedules. However, there has been a dramatic increase in on-season gas use, with **recent use higher for every month of cruise operation** and particularly high in May, June, and July. Possible reasons why the cruise season natural gas use is high include:

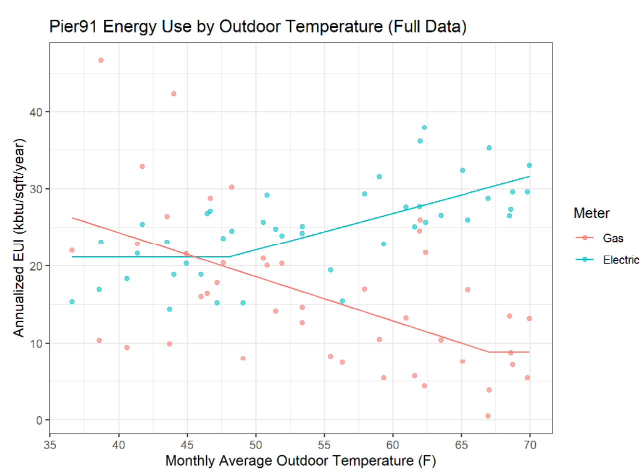
- How doors are managed during baggage handling and ship embarking/debarking, especially during early morning hours after the HVAC is turned on
- Heated air leaking out of the roof via skylights
- A control change that allows too much heating to occur during summer months. For example, this can happen when "optimum start" is enabled on a system or when the system is started in the early morning with normal occupied temperature setting but without an actual requirement for heating.
- Outside air control, where more airflow is processed now than it was during the first tune-up. This is unlikely because we reviewed the outdoor air controls during the tune-up and did not find an issue. Also, increased outdoor airflow would also show in the electricity data.

Figure 3: Electric and Gas Energy versus Temperature, June 2022 to June 2024



The EUI for the facility for 2023 is 43 kBtu/SF/yr. Billing regression analysis compares the average monthly temperature during each billing period to the bills to tease out the amount of temperature dependence in the utility energy consumption. For electricity & cooling energy, this chart tells a better story than the first tune-up. The electrical correlation with outdoor air temperature is stronger now than it was during the first tune-up with a confidence interval (R^2) of 0.6.

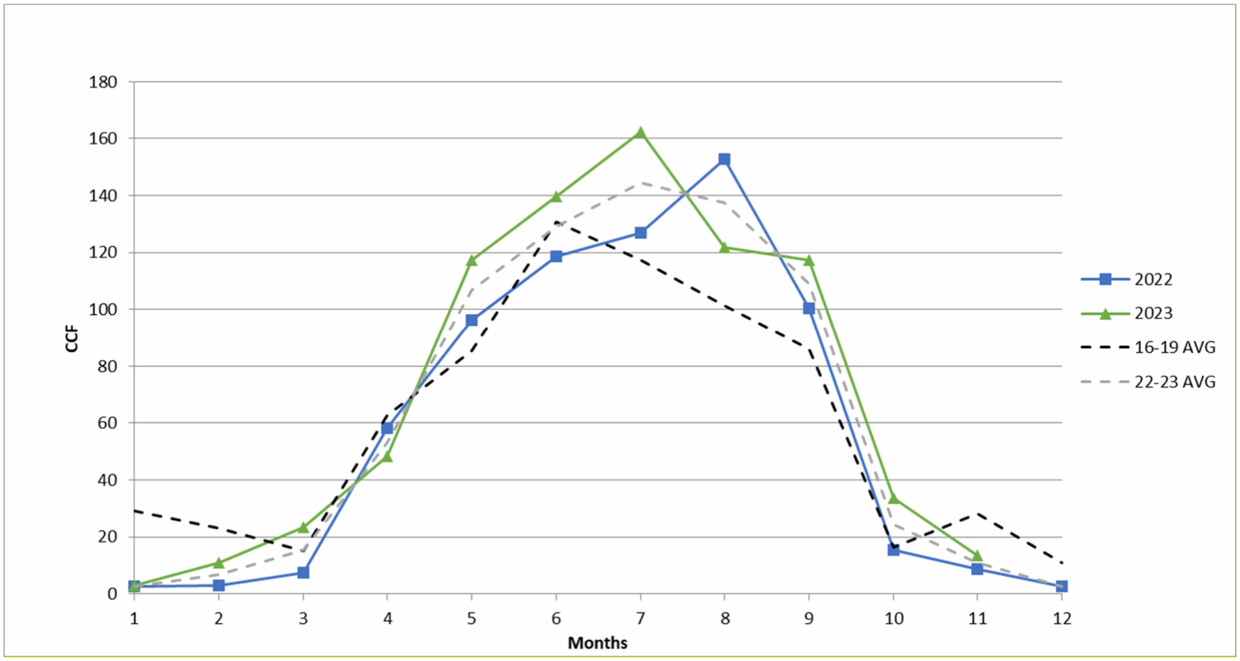
There is a much larger difference between the current chart, above, and the 2020 chart below: the natural gas curve is inverted. The older chart shows the correct correlation for heating (gas) where the gas decreases with increasing temperatures. The current chart shows the opposite – more gas is used during warm weather than during cold weather. The potential reasons for this are listed in the previous section. The confidence interval (R^2) value is very low 0.16 meaning that the gas use is not correlated with warmer monthly temperatures. It seems to be correlated with occupancy: summer cruise season.



Water Consumption

Water bills are shown in Figure 4. Water use has been largely consistent year after year, with an annual peak in July or August. Higher summertime use is predominantly due to cruise passenger consumption, as there is little to no landscaping on site. There are no cooling towers.

Figure 4: Monthly Water Use (CCF)



Billing Analysis Conclusions

1. Base-load:

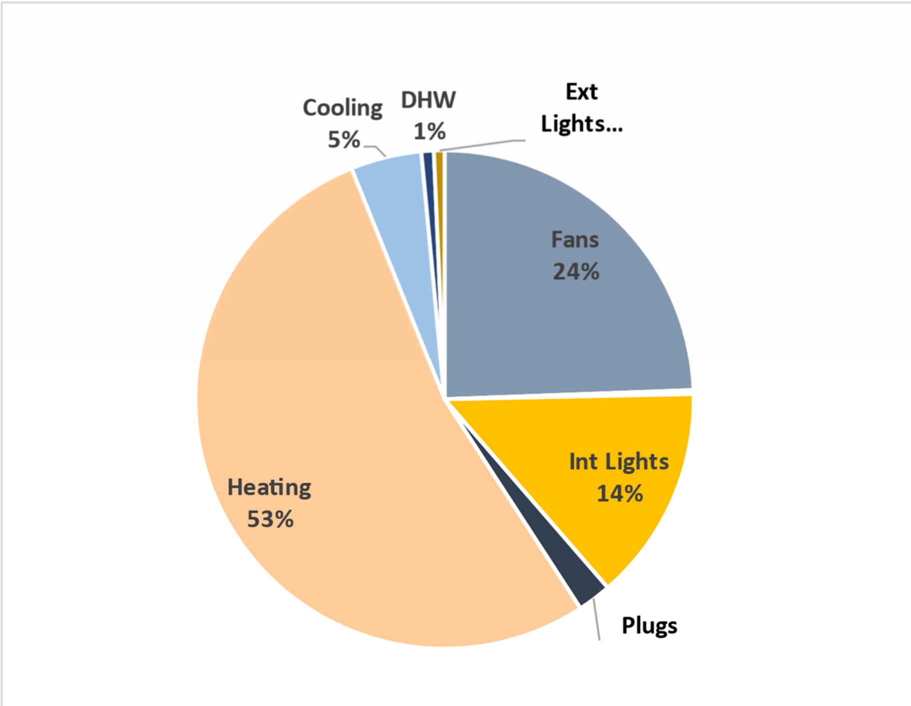
   Winter gas and electric consumption is higher than would be expected for an unoccupied building. The tune-up adjustments made to the outside air control settings should further reduce gas use during the winter. Additional recommendations are to repair air leaks in the building that are likely causing HVAC cycling during unoccupied times.

2. Natural Gas Use:

   Excessive heating is happening during the cruise season. Four potential causes of this are listed on page 6, above.

End Use Breakdown

Figure 5: Total Energy End Use Estimate



The end uses estimate is built up from site observations of equipment sizes, actual control logic, lighting power, actual operating schedules, actual base loads during non-cruise season, etc. The result is based on actual utility bills for 2023.

Heating dominates energy consumption. The heating end use include all the natural gas plus fifteen percent of the electricity use. Summertime natural gas use doubled from the previous tune-up cycle.

The second highest end use is HVAC fans. Fan usage appears to be large due to the large constant volume fans. Addressing the fan energy will be difficult without significant capital investment, as the schedules are already well managed.

Lighting accounts for about 14% of the total energy use at Pier 91, with a lighting EUI of roughly 6.7 kBtu/sf/year or 25% of the annual *electricity* consumption. The lighting power density with a tLED retrofit is approximately 0.61W/SF.

Electricity is also used to power cooling, plug loads, exterior lighting, and hot water. Based on our analysis of the utility bills, each of these end uses is less than 5%. The cooling temperatures are well managed as are the exterior lighting schedules and hot water heater operation. Plug loads are difficult to estimate in a building of this nature; we believe they are small, perhaps 4% of the power use.

Tune-up Requirements and Results

The items listed in this section were required to be addressed according to the Seattle Tune Up Ordinance. CTA worked with JCI to implement each item. Ecotope verified the implementation through a site visit and follow up trend data review. Because this is the second round of tune-ups the total savings this time for the required measures was much lower than the first round. We estimate savings of roughly 500 kWh and 2,450 Therms which is 8% of the gas use. Utility cost savings should be roughly $1,950.

- Baggage Handling Heaters: During the tune-up, CTA staff determined that the heaters were not interlocked with the rollup doors. During 2024, new controls were added to shut off the electric duct heaters when the roll-up doors are open. This efficiency measure was not identified by Ecotope during this tune-up; however, it will be intermixed with the consumption / savings from the tune-up so it is listed here for reference.

1. HVAC 1-1: The VAV box minimum and maximum schedule values were found not to match existing space occupancy requirements. CTA agreed to update the programming to match the intended design.
2. CO2 Sensor replacement & sequence update
    a. HVAC 2-2, HVAC 2-3, HVAC 2-4, HVAC 2-5: The CO2 sensors were found to be out of calibration. This is a similar finding to the last tune-up; however, a different batch of sensors were bad this time. JCI replaced 4 CO2 sensors.
    b. All HVAC and AHUs: The CO2 sensor programming from the last tune-up was overridden during the pandemic. It was reenabled and reverified as part of this tune-up. The new sequence keeps the outdoor air dampers closed until CO2 concentrations exceed 700 ppm. Then, the outdoor air dampers open slowly until they reach 100% open at 1800 ppm. If the CO2 sensor reaches 2000 ppm, an alarm will be initiated at the building management system.

Efficiency & Decarbonization Recommendations

In general, the true low-hanging fruit in this building is still tune-ups to the HVAC. Ecotope found significant summertime natural gas consumption after the tune-up measures were completed. We believe the HVAC units are operating incorrectly in heating mode throughout the summer. Also, the lighting equipment is due for an upgrade. Updating lamps, fixtures, and controls is a significant investment; however, it seems preferable to continuing with the expense of replacing CFLs. Seattle City Light offers rebates for lighting projects using approved fixtures based on estimated annual energy savings from the upgrades. Finally, there is some potential for cost-effective HVAC measures especially as the Port works to decarbonize. To maximize potential savings, plans should be made for HVAC replacement before equipment failure.

Reduce Summertime Natural Gas Heating

The amount of natural gas used May through July doubled since before the pandemic. This may be due to a setpoint change or, perhaps, it is a symptom of air leaks in the roof causing the heating to run more often. Another possibility is an incorrect "optimum start" control algorithm.

Our notes indicate that the heating occupied setpoint is 64F. If passengers tolerate cooler temperatures during spring and summer mornings, we suggest lowering the heating setpoint as low at 60F during cruise season, whenever the doors are open. Alternately, the natural gas can be locked out completely starting when outdoor temperatures are high enough for passengers to tolerate unheated spaces. Typically, heating is not needed once the outdoor temperature exceeds 65F.

Either implement a lockout or consider making a programming adjustment to reduce the following heating temperature setpoint:

- Heating Occupied Setpoint = 60F to 64F
- Heating Unoccupied Setpoint = 55F

Repair Roof Air Leaks

The air and water leaks at the skylights will reduce the building's energy efficiency and increase the natural gas use, especially during cold weather event rentals. Although the temporary measures around the skylights may prevent water from leaking into the building, it is likely that air is leaking out whenever the HVAC units are running. Especially in heating mode, the air near the ceiling is over 100F and the hot air will rise into the skylights and find small cracks to get out of the building. This sort of "chimney effect" will pull cold, unconditioned air from the out-of-doors through doorways or other openings which may cause drafts and complaints.

We strongly recommend permanent repair of the skylights, including an air-tight roof. The building's HVAC design relies on an airtight roof to provide high indoor air quality, cooling, and heating. Without this air barrier, it is difficult to implement other measures to increase efficiency and prevent cold complaints.

Upgrade AC Unit Controls

For two cycles, Ecotope has recommended setting the unit controls for the 10 AC units in the building to shut off the fan when the unit is in standby. The team has been unable to adjust the settings to accommodate this recommendation. However, Mitsubishi has published “Application Note: 3048” regarding how to turn on the indoor unit fan when the setpoint is met. Appendix A includes the technical instructions for making this change. With these instructions, we expect the implementation cost to be small.

Replace Lighting Fixtures

Plan to begin replacing fixtures with increasing maintenance issues very soon. Appendix C provides specific fixture and lighting control recommendations. Modern LED fixtures have continuous dimming, which is more versatile and less intrusive than the stepped dimming. New LED fixtures will be more efficient than re-lamped fixtures both due to reduced wattage and the option for more frequent fixture dimming. Ecotope typically finds that these changes are cost-effective; however, the low operating hours for this building mean that the simple payback for the two larger measures exceed the life of the measure. The three specific measures analyzed are:

1. Replace High Bay Fixtures:
    a. Upgrade 1st and 2nd floor lobby high bay fixtures with dimmable LED fixtures and dimming controls.
    b. Install occupancy sensors to dim the fixtures (reducing power draw) when spaces, or zones within them, are vacant. Networked lighting control or luminaire level lighting control (LLLC) systems can do this and accommodate rezoning or rescheduling as needed.
    c. On the 2nd floor, add automatic daylight dimming so the lighting can reduce when enough sun is shining through the skylights. LLLC systems would include this option on all fixtures.
    d. Consider installing network lighting controls and programming entrance hall fixtures to dim about 20% after sunset. Lower nighttime light both saves energy and assists in faster eye adaptation times as people enter the building.
2. Install lighting controls in rooms with intermittent occupancy: Install ceiling mounted “dual-technology” occupancy sensors in the spaces listed below. Dual technology sensors will be more accurate at detecting occupancy and better accepted in these spaces. In spaces with windows, vacancy function should be specified so that lights do not turn on automatically when daylight might be sufficient but do turn off automatically when the space is left vacant.
    a. 2nd floor public restrooms
    b. staff breakrooms
    c. mechanical and storage rooms with more than 2 fixtures

3. Replace exterior fixtures (year-around operation): Upgrade building-mounted metal halide area lights on the building meter to new LED fixtures with fixture-integrated occupancy sensors. Consider relocation of lights closer to the ground where practicable so that lower-wattage fixtures can illuminate the area. New generation wall packs reduce light pollution by dimming and will alert security and staff when someone is in the area by coming to full power when motion is detected. Installing dark sky compliant LED fixtures (like current fixtures) is also recommended to avoid light pollution, given the building's location adjacent to the waters of the Sound.

Install Destratification Fans

We recommend products manufactured by Big Ass Fans. The Port of Seattle has had a good experience with Aries turbine fans. JCI could add controls to these fans to adjust the speed. We recommend operating the destratification fans at 15-20 Hz in heating mode and 40 Hz in cooling mode. *If air is leaking out of the skylights, the destratification fans will be less effective in heating mode since hot air may be leaking directly out of the building.*

The cost estimate provided by the Port of Seattle (POS) includes line items more than $300,000 which far exceeds the modest project that Ecotope was envisioning. We have used a cost estimate for some of the POS items on the first floor (entrance hall); even so, the simple payback far exceeds the life of the measure.

Install VFDs on Rooftop Unit Fans

Like the last tune-up, Ecotope continues to recommend adding Variable Frequencey Drives (VFDs) to supply and exhaust fans on the rooftop units listed below. In addition, control the supply fan speed based off of zone temperature, as single zone variable volume units. Control the exhaust fans to maintain building static pressure so the fans would stay off unless the building were positively pressurized.

1. HVAC-2-1, HVAC-2-2, HVAC-2-3, HVAC-2-4, HVAC-2-5, AHU-1-1, AHU-1-5, AHU-1-6, AHU-1-7
2. Add VFD to control HVAC 1-1 exhaust fan motor, control exhaust fan speed based on building static pressure.

The Port of Seattle cost estimate is $37,000 per VFD which is far more than our experience. Our calculations assume $10,000 per VFD.

Important: We strongly recommend upgrading the equipment rather than adding VFDs; however, the simple payback the upgrade exceeds the measure life which means that it would not be required by the Clean Building Act. It seems clear that replacing the RTUs with new variable speed equipment is inevitable and it is hoped that CTA and POS can do this in an energy efficiency way rather than replacing the equipment "like for like".

Replace HVAC Equipment to Decarbonize

Nearly all the HVAC fans in the building are constant volume. If the building were designed today, the rooftop equipment would require variable flow and heat recovery due to outside air-flow rates. To achieve the Port of Seattle's carbon goals, the building should be electrified, and gas furnaces should be replaced with heat pump equipment. The obvious path for the next HVAC solution is a Dedicated Outdoor Air System (DOAS) with high-efficiency variable capacity rooftop heat pumps. The renovation project would include:

1. Add ~3 dedicated outside air units with high-performance energy recovery ventilators on the roof to provide ventilation air to occupied spaces. Route ducts from new DOAS systems to existing supply/return ductwork from packaged rooftop HVAC equipment.
2. Replace 9 packaged rooftop gas/dx equipment with ~6 variable capacity rooftop heat pumps. Operate only when spaces require heating and/or cooling. Use existing ductwork.

Make the next water heaters Heat Pumps

The water heaters were just replaced with like-for-like electric resistance water heaters. Next time, these should be heat pump water heaters. Add an equipment replacement standard that considers heat pump water heaters as the first choice for future replacements. Heat pump water heaters will operate especially well indoors during cruise season and will help keep the mechanical rooms cool. There is a minimum air volume required to operate these units which is approximately 300 cubic feet.

In a room with a 10' ceiling, 300 square feet of floor area is needed. Although these units make a heat pump sound when they operate, it is unlikely to be bothersome because we estimate that the amount of hot water consumed at the building is low so the water heater would not run often.

Note that the Port of Seattle cost estimate includes cost to remove the existing water heaters; however, this is not part of the energy efficiency work. Since we recommend waiting until the current heaters need replacement, the measure's cost is limited to the incremental change between a like-for-like units and the heat pump units. We estimate this difference to be $15,000 per unit.

Important: thermostats located in the same room as a heat pump water heater should either be re-located or set for cooling only. Otherwise, the thermostat might enable an HVAC unit in heating mode which defeats the purpose of the energy efficiency measure.

Savings Analysis Summary

Beyond the required tune-up measures, a suite of ten energy efficiency and decarbonization measures were analyzed using simplified hand calculations. Results of the analysis can be seen in Table 1. The required tune-up items are listed first followed by the recommendations described in the previous section. The required tune-up items have simple paybacks of less than 4 years. Since this is the second round of tune-ups, the anticipated savings is only about 8% of Pier 91’s current natural gas consumption.

According to our analysis, four measures have a payback within the expected measure life. These are indicated in the “meets LCA requirement” column of Table 1.

- Reduce summertime natural gas heating
- Upgrade AC unit controls
- Occupancy sensors in intermittently occupied spaces
- Install RTU VFDs

When combined with the measures already implemented during the tune-up, this work is estimated to save enough energy to meet the CBPS EUIt. See the next section for details.

Next, all measures were summed together. As described above, these measures would improve occupant experience and thermal comfort as well as save energy. This package would save 30% of the total annual energy use with an estimated payback of 25 years.

Finally, the last 3 measures on the list were analyzed together as a long-term renovation and net-zero option. This option was analyzed to estimate potential energy savings and the costs to decarbonize the fuel source of the building. In addition, calculations were made to identify the capacity and cost to install PV panels to get the building to net-zero after the high carbon footprint HVAC system is replaced. The three measures at the bottom of Table 2 have a payback of about 40 years.

Estimated energy savings from adding a Dedicated Outside Air System with Energy Recovery and Packaged Rooftop Heat Pumps, when combined with all other measures, would drop the EUI from the current 43 kBtu/sf/year, down to 19 kBtu/SF/year. Total energy and utility savings would be close to 40%. At that point, adding roughly 725 kW of photovoltaic panels to the roof would be sufficient to offset the entirety of the facility’s energy consumption on an annual basis.

Although these simple payback calculations omit the savings in maintenance costs such as replacing failing HVAC components and relamping fixtures, they also exclude costs associated with large renovation projects such as hiring firms to perform design, project management, and general contracting which includes overhead, mark-up, taxes, etc. A more thorough life-cycle cost analysis would be helpful to support long term planning for this facility.

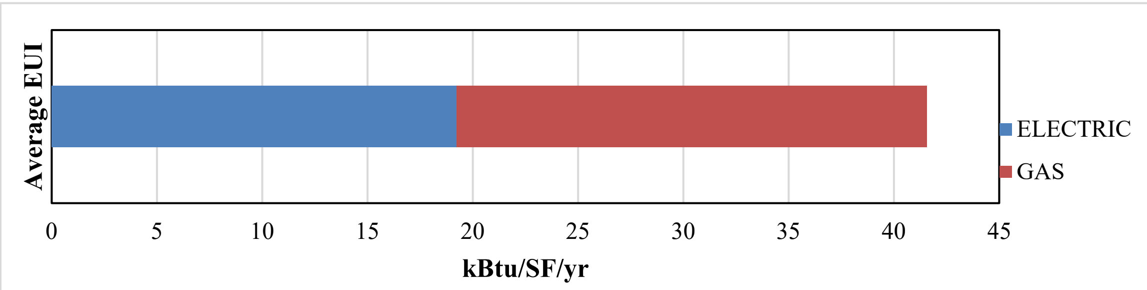
Table 2: Simple Payback Savings Summary

The predicated incentives in the chart below are limited to the typical Seattle City Light electricity custom incentive values. The City Light incentive has typically been 23 cents per kWh saved up to a maximum of 70% of the project's cost. Pursuing multiple projects together and/or upgrading the ventilation system to include dedicated outdoor air systems while leaving the RTUs in place may allow the utility companies to pay additional incentives above the values in this chart. Additionally, federal funding may be available for decarbonization measures.

Package	Measures	Savings (KWH)	Elec Savings ($)	Savings (therms)	Gas Savings ($)	Estimated Cost ($)	Predicted Incentive ($)	Simple Payback (yrs)	First Cost $$	Meets LCA requirement?
Tune-up	HVAC-1-1 Zone tune-up	417	$ 27	160	$ 128	$ 500	$ -	3.2	$ 500	No (complete)
Tune-up	CO2 Sensor Replacement and Sequence Update	0	$ -	2281	$ 1,825	$ 5,500	$ -	3.0	$ 5,500	No (complete)
HVAC controls	Correct summertime natural gas heating	5036	$ 320	5546	$ 4,437	$ 3,000	$ 1,158	0.4	$ 1,842	Yes
Envelope	Repair leaking skylights	7062	$ 449	2183	$ 1,746	$ 124,410	$ -	56.7	$ 124,410	No
HVAC controls	Upgrade AC unit controls	6570	$ 418	0	$ -	$ 1,500	$ -	3.6	$ 1,500	Yes
Lighting	Exterior Wallpack LED replacement	9700	$ 617	0	$ -	$ 22,000	$ 2,231	32.1	$ 19,769	No
Lighting	Occupancy sensors in intermittent occ. Space	3908	$ 248	0	$ -	$ 6,000	$ 899	20.5	$ 5,101	Yes
Lighting	Dimmable LED Lobby lighting	111889	$ 7,114	0	$ -	$ 258,998	$ 25,734	32.8	$ 233,263	No
HVAC	Install Destratification Fans: Entrance Hall Only	5446	$ 346	309	$ 247	$ 185,970	$ 1,253	311.3	$ 184,717	No
HVAC	RTU VFDs	176243	$ 11,205	0	$ -	$ 160,000	$ 40,536	10.7	$ 119,464	Yes
Renovation	DOAS + Heat Pump HVAC Retrofit	-12748	$ (811)	25022	$ 20,018	$ 1,001,100		52.1	$ 1,001,100	No
Renovation	Heat Pump Water Heaters	6570	$ 418	0	$ -	$ 60,000	$ 1,511	140.0	$ 58,489	No
Renovation	Net Zero	725000	$ 46,095	0	$ -	$ 1,450,000		31.5	$ 1,450,000	No

Washington Clean Buildings Performance Standard (CBPS) Compliance

CBPS mandates that each building covered by the law establish its EUI_t using a state-developed table of targets weighted by the square footage dedicated to each building use and its occupancy. **The calculated EUI_t for Smith Cove is 33.0 kBtu/ft^2/yr. Based on energy data from 2023, the weather adjusted EUI is 40.9 kBtu/ ft^2/yr, which is 30% above (worse than) its EUI_t.**



The site EUI of the facility is below the national median percentile for Transportation Terminal / Stations of 56.2 kBtu/ft^2/yr, mostly likely due to the seasonal nature of the cruise operations. About 45% of the facility's EUI is from on-site natural gas usage.

CBPS provides several compliance pathways. Ecotope recommends one of these:

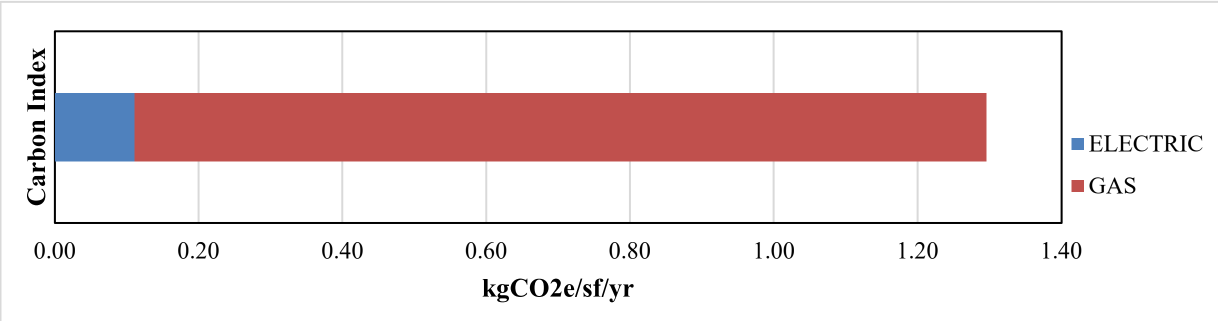
1) Make improvements to the building to meet the EUIt or
2) Follow the *Investment Criteria* pathway, requiring completion of all cost-effective energy efficiency measures.

Based on the analysis in this report, there is a package of energy efficiency measures that, taken together, should allow the building to meet the energy use target. We estimate that implementing these measures will reduce the buildings EUI to 32 kBtu/sf-year.

Seattle Building Emissions Performance Standard (BEPS)

In 2023, the Seattle City Council passed the Seattle Building Emissions Performance Standard (BEPS) establishing carbon emissions targets that buildings over 20,000 ft^2 must meet over the next two to three decades. BEPS compliance requires energy benchmarking data verification and GHG reporting starting in 2027 to count building emissions and encourage owners to prepare for emissions reductions, followed by requirements to meet emissions targets in five-year intervals with deadlines for compliance starting in 2031. Based on this building's total energy usage for 2022, the total carbon dioxide equivalents CO_2e produced by the building is high at 190,504 $kgCO_2e$/yr or 1.30 $kgCO_2e$/sf/yr. Onsite gas usage accounts for 91% of Smith Cove's GHGI. Measures reducing natural gas usage will have the greatest impact on the building's CO_2e production.

Using the BEPS proposed $GHGI_t$, the preliminary calculated $GHGI_t$ for Smith Cove is 1.18 $kgCO_2e$/sf/yr. For the year ending December 2022, Smith Cove's GHGI is 1.30 $kgCO_2e$/sf/yr., **which exceeds the 2032 target by 10%.**



The table below is updated from the memo we published earlier in 2024. It indicates the results of our energy savings calculations and suggests a timeline to implement measures to comply with each compliance cycle.

Table 3. BEPS Compliance Periods and Recommended Actions for Smith Cove

Compliance Period	$GHGI_t$ ($kgCO_2e$/SF/yr)[1]	Compliant based on 2022 energy[2]	Recommended Measures
2031 – 3035	1.18	No	Investigate and Correct summertime natural gas heating Alternate: use "renewable" nature gas emissions values, if the RNG emissions value is low enough for this building to comply without changes
2036 – 2040	0.69	No	-- Repair leaking skylights -- Replace the gas RTUs with DOAS and rooftop heat pumps.
2041 – 2045	0.0	No	
2046 - 2050	0.0	No	

[1] $GHGI_t$ targets by compliance interval for building activity type Other from the **Jan 2024 Seattle BEPS factsheet**.

[2] Compliance compared to baseline GHGI footprint (2024) of building.

Appendix A. Walk-through Conclusions from January 2024

1. The rooftop skylights have historical leaks and appear to continue to be leaking air. Air leaks should be repaired.
2. HVAC Equipment Condition

   Equipment has been well maintained but the cases are in deteriorating condition due the maritime location. Roof-top HVAC equipment is roughly 17 years old; it can be expected to last for up to 25 years. It was noted that some of the outdoor air dampers are starting to rust, most likely due to proximity to the Puget Sound.
3. Changes since 2020
   a. Limited LED lighting upgrades were made to the baggage handling area.
   b. JCI reports that the HVAC units continue to operate well. They have only replaced 1 compressor on any of the 10 units.
4. Persistence of 2020 tune-up measures
   a. The schedule measures from the first tune up are still being used including interlocks with exhaust fans, domestic hot water pumps, and domestic hot water tanks.
   b. The HVAC programming measures are partially complete. It appears that some of the programming was not originally implemented and should be updated now.
   c. Most of the CO2 sensors that were not replaced last time have now drifted far out of range and should be replaced.
   d. The AC unit fan program (not part of the BMS) is not capable of being operated in AUTO so the fans run all the time.
5. Base-load:
   a. Computing equipment is left on 24-7.
   b. AC units are all constant volume 24-7 equipment.
   c. Except for one unit, the air-handling equipment is constant volume. Both supply and power exhaust fan motors are rated for VFDs. Supply fans could be retro-fit with VFDs and controlled as single zone VAV units. Similarly, power exhaust fans could be retrofit with VFDs and controlled to maintain slightly positive building pressure. This report instead recommends replacing the units since they are nearing end of life.
6. Outside Air:
   a. Demand control ventilation logic should be corrected.
   b. CO2 sensors should be replaced.

7. Lighting is in good condition and provides appropriate illumination level for the spaces. Egress area lights are shut off during the off season, lowering the “base load” electricity.
    a. Original fixtures are still in use throughout the terminal, these fixtures are now 16 years old and can be expected to begin having electrical and mechanical problems which increase maintenance needs as they pass 15 years of age. Maintenance of the high bay fixtures is difficult; staff currently wait for lamps to be out in several fixtures before scheduling time and equipment to access the fixtures.
    b. Area lighting in the lobby/public spaces is the largest contributor to lighting energy use. LED fixtures can reduce this energy by approximately 50%, when paired with occupancy dimming controls this savings could increase to 65% to 70%.
    c. Additional occupancy controls in intermittently occupied spaces will help reduce energy use. Also, upgrading the entrance hall lighting controls to include dimmable fixtures that lower lighting based on occupancy and daylight will have the largest impact.
    d. Exterior building wallpacks are metal halide, the existing fixtures have full lighting cutoff to avoid light pollution given the building location adjacent to waters of the Sound. Replacing the metal halide with similarly shielded LEDs will reduce energy use, however staff note the lights have very little on time so these would not be a first priority

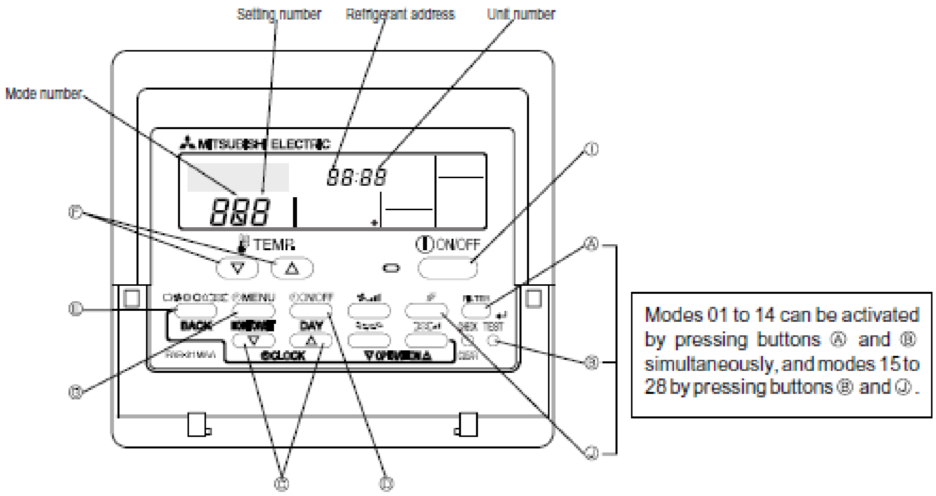
Appendix B. Instructions to turn off the AC unit fans when setpoint is met

The PKA AC units are controlled via PAR-21 thermostats. Although these thermostats are of an older vintage, they are still capable of having the fans turn off when the setpoint is met. Modes 25 and 27 should both be set to setting 2, "stop".

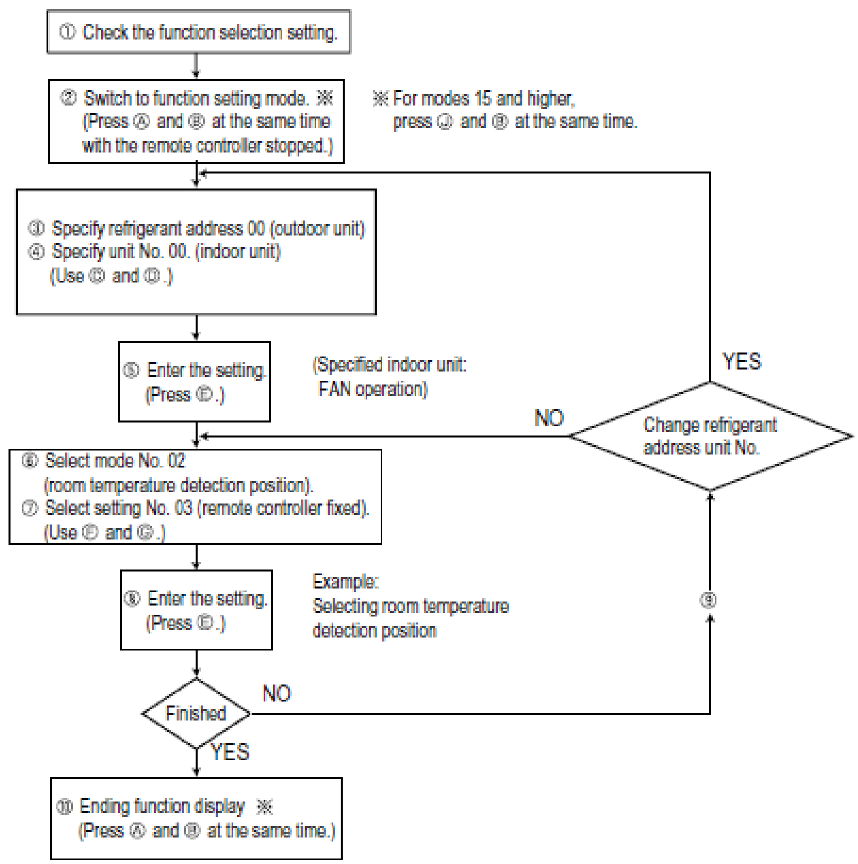
Mode #	Indoor Unit Compatibility	Function	Setting #	Settings
16	SVZ/PVA	Humidifier Control	1	With compressor only
			2	In Heat mode all the time
17	PLA PCA/PKA	Change of Defrosting Control	1	Standard
			2	High humidity
23 *D	PLA-BA	Vane Swing	1	Swing
			2	Wave air flow
23 *D	PCA/PKA	Vane Swing	1	Not available (OFF)
			2	Available (ON)
23 *D	SLZ SEZ	Heater Control *23-1	1	Set temp -4.5 °F ON
			2	Set temp -1.8 °F ON
23 *D	SVZ/PEAD/PVA	Heater Control *23-1	1	Disable heater during Defrost/Error
			2	Enable heater during defrost and error *23-2
24	SLZ/PLA SEZ/SVZ/PEAD PCA/PKA *24-1	Heating Height Offset 4	1	Available (ON) 4 °C (7.2 °F) up
			2	Not available (OFF)
25	SLZ/PLA SEZ/SVZ/PEAD/PVA PCA/PKA	Fan Speed Thermo-Off Heating	1	Extra low
			2	Stop
			3	RC setting
26 *D	SLZ-KF/PLA-A__EA7	3D i-See Sensor Height Offset Setting *12-1 *12-2	1	Low (less than 8.9 feet)
			2	Standard (8.9 to 11.5)
			3	High (11.5 to 14.8)
26 *D	SVZ	Erv Control	1	IDU STOP, fan speed STOP, and CN2C is OFF
			2	IDU STOP, fan speed is RC Setting, and CN2C is ON
27	SLZ/PLA SEZ/SVZ/PEAD PCA/PKA	Fan Speed Thermo-Off Cooling	1	RC setting
			2	Stop
			3	Extra Low *27-1
28	SLZ/PLA SEZ/SVZ/PEAD PCA/PKA	Detection of Abnormal of the Pipe Temperature (P8)	1	Available (ON)
			2	Not Available (OFF)

[Flow of function selection]

First, try to familiarize yourself with the flow of the function selection procedure. In this section, an example of setting the room temperature detection position is given.
For actual operations, refer to steps ① to ⑩.



Selecting functions using the wired remote controller



The above procedure must be carried out only if changes are necessary.

Appendix C. Recommendations for Lighting Renovation

This appendix provides a discussion of options for LED retrofit fixtures to replace the existing holophane type pendant fixtures installed in the entrance hall and second floor public spaces. The current fixtures are lamped with six (or eight in double height spaces) 42W pin base fluorescent and configured for dual switching: ½ lamps on or all lamps on. The fixtures are at end of life, having been installed in 2009, and staff note that re-lamping requires lift equipment and facilities scheduling which will increase in frequency as the components such as ballasts begin to fail. It is recommended that the fixtures be replaced rather than relamped.

Replacing these fixtures with new LED fixtures with dimming will improve the energy performance of the lighting be roughly 50%, if high efficiency fixtures are used. Implementing occupancy sensor dimming can recover up to an additional 10-15% of the energy of the existing lighting, and daylighting will recapture 5- 10% of the lighting energy. In total, an efficient LED installation with very good occupancy and daylighting control might save 70% over the current installed fixtures. Incorporating energy conscious scheduling and nighttime setbacks can further increase this savings.

LED Fixtures for high bay applications such as these are eligible for utility rebates from Seattle City Light, if the fixtures selected meet SCL's efficiency requirements:

Characteristic	**Requirement**
CRI:	>80
Lumens per watt:	>65
Warranty:	5 years or better
Power Factor:	>.90
Total Harmonic Distortion:	<20%
if not DLC or Energy Star:	Provide LM79 report for the fixture

It is recommended that in addition to the above, the fixtures specified have 3500K color temperature. This is like Halogen in color profile, while delivering better energy efficiency versus warmer color temperatures.

SCL offers increased incentives for retrofits which employ DLC Networked Lighting controls, and the incentives are increased again if the fixtures are DLC qualified LLLC, which incorporates controls on the fixtures and allows for networking and wireless configuration of the controls. Each of these options is discussed below. Examples from recent installations are pictured with each option.

Option 1. One for One fixture replacement

The most basic LED replacement would be a one for one replacement of the fixtures. This would require additional electrical work to introduce energy code compliant controls (daylight dimming) and occupancy sensors and dimming controls as desired. The current circuiting of the fixtures is likely not well aligned with daylight zones and areas where dimming on vacancy might be desired, so this path has potential for complexity, and gives up controllability and daylight/dimming savings if controls aren't implemented.

An example of a simple dimmable LED fixture which would meet SCL's requirements is the Lithonia JCBL, seen here installed in a vehicle repair shop. This fixture configuration has a similar clear prismatic lensing to the fixtures currently installed at Pier 91.

(Lithonia JCBL installed at Seattle Charles Street Tireshop, targeting 50FC, mount height 20 feet)

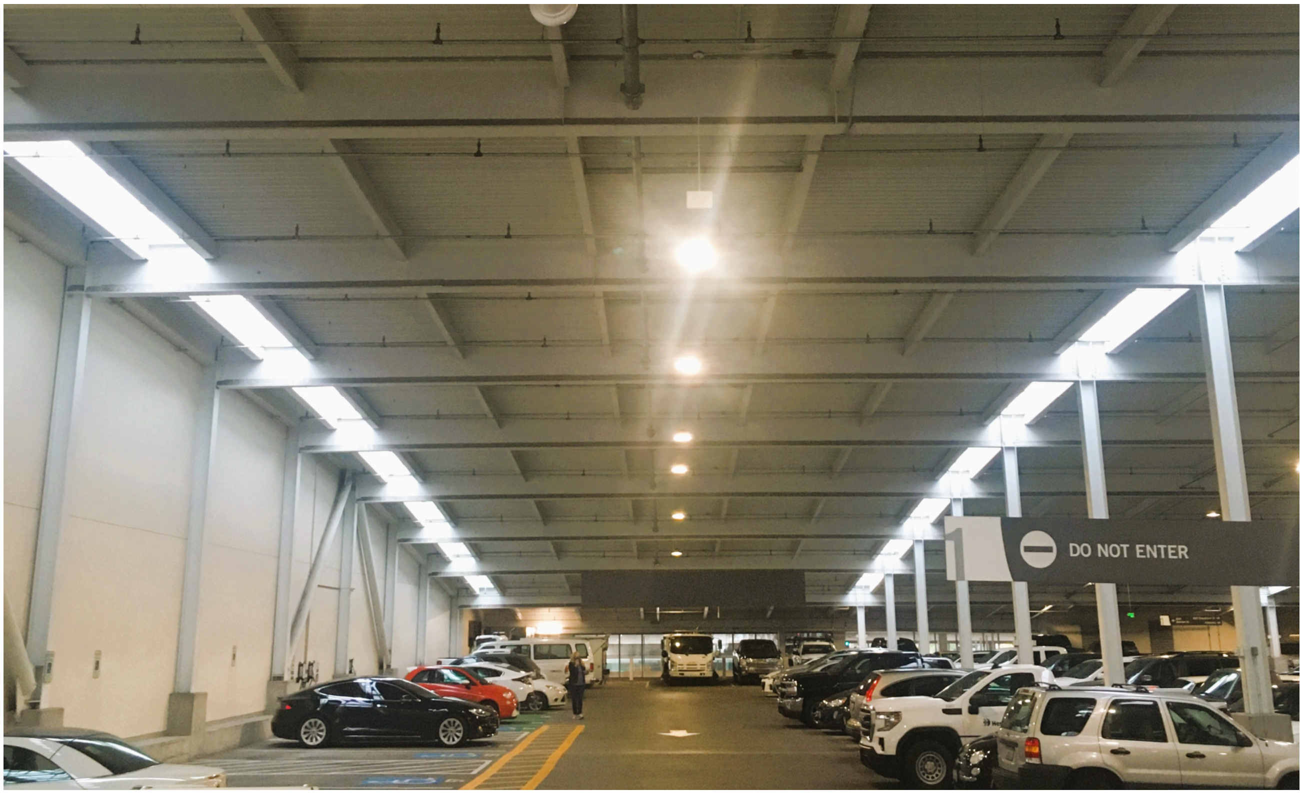
Option 2. Incorporate Networked Lighting Controls

A potentially more versatile or less disruptive installation would incorporate networked lighting controls. These systems can be a combination of wireless networked modules that control the existing circuits, smart fixtures that can be individually programmed, and wireless occupancy and daylight sensors that relay information to the modules to control the light levels of the fixtures. Installation will require some electrical work, but recircuiting fixtures can often be avoided, saving downtime. This level of control may be sufficient at Pier 91, if measurements confirm the upper floor is one daylight zone due to the skylights, and the entry and upper floor are served by separated circuits, and if limited control of zoning on each floor for vacancy dimming is acceptable. SCL provides a higher rebate level per fixture for installations with NLC. The systems often allow for app based scheduling and dimming, or a touch screen control panel can be installed to serve as a programming interface.

An example Networked Lighting Controls work with any compatible fixture. Manufacteres generally offer one or more NLC compatible options on a fixture, for example, the JCBL fixture above is compatible with the nLight AIR system. NLC systems are offered by Wattstopper, Wavelinx, nLight, and others.

Option 3. luminaire level lighting controls

The most versatile installation is an LLLC or luminaire level lighting control system. LLLC fixtures have onboard sensors and networking modules, and are generally controlled by an app that allows wireless setup and reconfigurations of zoning, schedules and light levels as space uses call for them. As each fixture is individually configurable, conflicts with wiring circuiting are eliminated, and rezoning or altering controls behavior can be done without an electrician or lighting expert. This level of control receives SCLs highest rebate per wattage saved, as the controls can recoup the highest energy savings. However, the higher price point for the fixtures may make first costs too high. Examples of LLLC fixtures are the Cooper MetaluxSSLED with Wavelinx controls (below) and the Kenall SSPG with Teklink controls (next page). Below, is a literature picture. This fixture with Wavelinx controls has been installed at Rainier Community Center gymnasium and can be viewed there.



Kenall SSPG installed at 5th Avenue Parking Garage, Gates foundation. Targeting 25FC, 35 foot mounting height, 20% uplight on ceiling)

- electronic copies of three options for replacement of the concourse area lights
- pics of installs of those options in some Seattle projects recently completed
- a short discussion of the retrofits and controls options, rebatable fixtures, etc.