EXEMPLARY BUILDING PRE-CONSTRUCTION ENERGY STUDY FOR HOBSON PLACE SOUTH

Respectfully submitted to
Seattle City Light
by

O'Brien360

7/12/2021

I. Summary and Project Description

Hobson Place South (HPS) is a new, permanent supportive housing (PSH) building project being developed by DESC in the Rainier Valley neighborhood of Seattle, WA. HPS is permitted as a 7-story addition to an existing building, Hobson Place North (HPN)[1]. HPS includes 92 small efficiency dwelling units (SEDUs), PSH resident services at level L1, medical clinic space on L1, L2 and L3, and one level (P1) of below-grade enclosed parking garage. The project is designed to comply with the 2015 Seattle Energy Code (SEC), Washington State Department of Commerce's Evergreen Sustainable Development Standards (ESDS), and PHIUS+ 2018 (a.k.a "Passive House") certification for the PSH portion of the building. Electricity is the only fuel source used for HPS, and the PSH portion of the project is master-metered separately from the HPS medical clinic and HPN.

As part of DESC's pursuit of the Housing Development Consortium's (HDC) Exemplary Building (EB) Program, O'Brien360 has completed this Pre-Construction Energy Study, as defined by Seattle City Light's (SCL) "Project-Specific Specifications for An Energy Analysis Assistance (EAA) Agreement". The purpose of this study is estimate site energy savings and costs for energy conservation measures (ECMs) included in the proposed design, as compared to a 2015 Seattle Energy Code (SEC) baseline design, as well as estimate to the annual energy use index (EUI), in kBtu/ft2/year. To qualify for SCL's EB incentives, the proposed design must be all-electric and comply with one of two criteria:

a) Annual site EUI, not including renewables, of 20 kBtu/ft2/year or less.
b) Annual site energy use is 40% less than the 2015 SEC baseline design, not including renewables.

The scope of the energy study is limited to the residential dwelling units on L4-L7 units and the associated residential circulation and support areas. Table 1 summarizes the floor areas of the project, and what areas are included in the model, while Appendix A has floor plan diagrams that highlight the extent of the model scope. Once HPS is built, there will be floor connections between it and HPN.

[1] The existing building, Hobson Place North, is constructed under permit #6617518-CN. Hobson Place South is constructed under permit #6707386-CN.

Table 1. Building Floor Areas

Space Type	Conditioned Area (ft^2)	Unconditioned Area (ft^2)	Notes
Residential Apartments	32,045	0	92 SEDUs on levels 4-7
Residential Corridors	7,490	0	Corridors on levels 4-7
Residential Stairwell	3,427	0	Includes stairwells from L7 down to L1, excludes extension to P1
Residential Laundries	760	0	Laundry rooms on level 4-7
Residential Storage	597	0	Storage rooms on level 4-7
Other Residential Area	2,213	1,498	Unconditioned includes trash and mechanical rooms on L1. Conditioned areas include shafts.
Supportive Housing Area (Level 1)	5,360	0	All area and energy excluded from this analysis
Health Clinic (Levels 1-3)	26,375	0	All area and energy excluded from this analysis
Parking Garage (Entire Level P1)	840	12,265	26 stalls for clinic staff use only. Bike storage for residents and staff. All area and energy excluded from this analysis
TOTAL Building Areas	**79,107**	**13,763**	
TOTAL Model Areas	**44,319** (Area Used to Calculate EUI)	**0**	Modeled areas only include apartments, corridors, stairwell, laundry and storage rooms.

An eQUEST (v3.65.7174) model was developed using the HPS 1/14/2020 Bid Set drawings and specification with the 2/6/2020 Addendum 1 updates. The principal proposed HVAC system design is electric resistance (cove) heaters in the apartments, along with three, rooftop dedicated outdoor air systems (DOAS) with energy recovery, which provide balanced ventilation for both the dwelling units and the corridors.

2015 SEC envelope compliance was demonstrated using the Component Approach method and complying prescriptively with C406.8 (enhanced thermal envelope), and C406.9 (reduced air infiltration) options which have been reflected in the baseline design model. See description of ECMs A1.0 and A2.0 for how these options were accounted for in the baseline design model.

Table 2 summarizes the modeled baseline and proposed end-use and total annual EUIs, including and excluding the estimated energy produced by photovoltaics (PV). Table 3 lists the title, non-interactive, and interactive (proportionate) energy impact of each of the modeled ECMs. The EUIs are modeled assuming typical meteorological year (TMY3) conditions for the Seattle-Boeing Field weather station, with wind speed adjustment for the local terrain. ECM assumptions and analysis method are described further in Section II. As indicated in Table 1 above, the floor area used all EUI calculations included in the tables below is 44,319 ft^2.

Table 2. Annual End-Use and Total EUI

Design (units = kBtu/ft2)	Interior Lights	Appl. + Misc.	Heating	Cooling	Pumps & Aux	Interior Fans	DHW	Total (Excl. PV)	PV	Total (Incl. PV)
Baseline	4.3	9.8	13.2	0.1	0.3	3.6	18.2	49.5	(0.3)	49.1
Proposed	3.1	9.0	0.4	0.1	0.7	3.5	3.2	20.0	(3.1)	16.9
Reduction	**27%**	**8%**	**97%**	**16%**	**-121%**	**3%**	**83%**	**60%**		**66%**

Table 3. ECM Summary Table

		Estimated Anuual Consumption					Estimated Anuual Savings							Incremental Costs		
ECM ID	ECM Description	Modeled Energy	Non-Modeled Energy	Total Energy		EUI	Non-Interactive Savings			Interactive Savings				First	Simple Payback	Annual O&M
		kWh	kWh	kWh	MBtu	*kBtu/ft2*	*MBtu*	*kWh*	*%*	*MBtu*	*kWh*	*$/year*	*%*	*$*	*years*	*$/year*
-	Baseline	372,537	269,785	642,322	2,192	49.5	-	-	0.0%	-	-	-	0.0%	$ -		
A1.0	Thermally Improved Windows	357,321	269,785	627,106	2,140	48.3	52	15,216	2.4%	51	15,039	$ 1,504	2.3%	$ 52,750	35	$ -
A2.0	Reduced Air Leakage	370,123	269,785	639,908	2,183	49.3	8	2,414	0.4%	8	2,386	$ 239	0.4%	$ 80,783	339	$ -
E1.0	Reduced Int. Lighting Power	368,410	269,785	638,195	2,178	49.1	14	4,127	0.6%	14	4,079	$ 408	0.6%	$ -	0.0	$ -
E2.0	Energy Star Refrigerators	371,203	269,785	640,988	2,187	49.3	5	1,334	0.2%	4	1,318	$ 132	0.2%	$ 6,900	52	$ -
E3.0	Energy Star Common Laundry	372,537	254,603	627,140	2,140	48.3	52	15,182	2.4%	51	15,005	$ 1,500	2.3%	$ -	0.0	$ -
M1.0	ERV System	252,594	269,785	522,379	1,782	40.2	409	119,943	18.7%	404	118,545	$ 11,854	18.5%	$ 577,879	49	$ 4,400
M2.0	Thermostat w/ Window Switch	357,742	269,785	627,527	2,141	48.3	51	14,795	2.3%	50	14,623	$ 1,462	2.3%	$ 12,200	8	$ -
P1.0	Efficient Plumbing Fixtures	372,537	232,672	605,209	2,065	46.6	127	37,113	5.8%	125	36,680	$ 3,668	5.7%	$ -	0.0	$ -
P2.0	Improved Plumbing Distribution	389,762	238,274	628,036	2,143	48.4	49	14,286	2.2%	48	14,119	$ 1,412	2.2%	$ 30,500	22	$ -
P3.0	Heat Pump Water Heater	372,537	106,963	479,500	1,636	36.9	556	162,822	25.3%	549	160,924	$ 16,092	25.1%	$ 73,000	5	$ 1,000
	Proposed (Not Incl. PV)	192,034	67,794	259,828	887	20.0	1,306	382,494	59.5%	1,306	382,718	$ 38,272	60%	$ 834,012	21.8	$ 5,400
	Proposed (Incl. PV)	192,034	27,794	219,828	750	16.9				1,442	422,494	$ 42,249	66%	$ 910,259	21.5	

II. Energy Conservation Measures

ECM Descriptions

The sub-sections below summarize the following information for each of the ECMs included in the proposed design:

- A description of the proposed design ECM, and the corresponding baseline design assumptions.
- A description of how the ECM was analyzed.
- The estimated (modeled) energy savings of the ECM (kWh/year), as well as the first-year energy cost savings, assuming a blended utility rate of $0.10/kWh. Energy and energy cost savings reported in these tables reflect the calculated proportionate accounting of interactive effects.
- The estimated incremental costs for the measure, as provided by the project general contractor, Walsh Construction Company (WCC), as well as the calculated simple payback in years. Also provided is the estimated incremental maintenance cost. Appendix C includes a table summarizing cost estimating notes and assumptions.
- A description of the ECMs influence on tenant satisfaction and building operations, such as indoor air quality, thermal comfort, usability, durability, reliability, ease of maintenance, and maintenance cost, as they compare to the baseline system. A qualitative assessment, on a scale of -5 to +5 for each attribute is provided, with 0 being neutral, -5 being a very negative impact, and +5 being a very positive impact.

ECM Results Summary

Table 4 at the end of this section summarizes the ECMs, including energy consumption and cost savings (both non-interactive and proportionate accounting of interactive effects), estimated incremental first cost/simple payback, and estimated incremental annual maintenance cost. For each run, the DOE-2.2 Building Energy Performance Summary (BEPS) report for each run has been included in Appendix C.

A1.0 – Thermally Improved Windows

	Proposed		Baseline
ECM Description	Triple-pane vinyl windows (U-0.18, SHGC-0.18). These windows, as well as other improvements to the thermal envelope, result in the proposed UA (per the SEC 'Component Approach') being 18% better than code. This exceeds the requirement for SEC C406.8.		Double-pane vinyl windows (U-0.26, SHGC-0.18). These windows, and assuming other components of the baseline envelope are modeled the same as the proposed, the baseline design UA is 15% better than code. This minimally satisfies the requirement for C406.8.
How Measure Was Analyzed	Constructions modeled using 'Layers' specification method, with mass assumed only for the interior and exterior sheathing. Windows modeled using 'Simplified' specification method. L4 floor is adiabatic since it is over conditioned space that is not modeled. Dwelling unit thermostat setpoint of 70F, assumed to be the same in both the proposed and baseline.		
Annual kWh/Cost Savings	15,039 kWh | $1,504/year		
Inc. First Cost / Simple Payback	$52,750 / 35 years		
Maintenance Cost	$0/year		
Operational Impacts	**Rating (-5 to +5)**	**Comments**	
Indoor Air Quality	0	No anticipated impact for this measure.	
Thermal Comfort	+5	The proposed envelope, in particular the windows, have low thermal transmittance. This is expected to increase the mean radiant temperature of the apartments, and therefore result in the space feeling "warmer". This should translate to lower thermostat setpoints needed to maintain the same comfort level, however, the proposed and baseline space temperature setpoints were assumed the same for this measure.	
Usability	0	No anticipated impact for this measure.	
Reliability	0	No anticipated impact for this measure.	
Ease of Maintenance	0	No anticipated impact for this measure.	
Maintenance Cost	0	No anticipated impact for this measure.	

A2.0 – Reduced Air Leakage

	Proposed	Baseline
ECM Description	Air leakage is 0.08 cfm/ft2 of envelope enclosure area @ 0.3 in. H2O. This satisfies PHIUS+ 2018 requirements, and substantially exceeds the requirement for SEC C406.8.	Air leakage is 0.25 cfm/ft2 of envelope enclosure area @ 0.3 in. H2O. This minimally satisfies the requirement for SEC C406.8.
How Measure Was Analyzed	The tested leakage rate was then converted to a "natural" infiltration rate at 10 mph by multiplying the test value by 0.115, per PNNL[2]. The natural infiltration rate was modeled using the 'AIR-CHANGE' method, with the infiltration only assumed to occur in apartments zones. In addition, to account for the observation that many occupants have the windows open throughout the year, both the proposed and baseline models include and an additional, constant 0.05 cfm/ft2 infiltration for each apartment. This estimate assumes roughly half the apartments have the awning apartment window opened 2" or more.	
Annual kWh/Cost Savings	2,386 kWh | $239/year	
Inc. First Cost / Simple Payback	$80,783 / 339 years	
Maintenance Cost	$0/year	

Operational Impacts	Rating (-5 to +5)	Comments
Indoor Air Quality	+3	This measure helps ensure the influence on building air leakage on mechanically balanced ventilation flows is decreased.
Thermal Comfort	+1	Reducing infiltration reduces heating loads and ensures balanced ventilation system works as intended.
Usability	0	No anticipated impact for this measure.
Reliability	0	No anticipated impact for this measure.
Ease of Maintenance	+5	Since the air and weather barrier for the exterior walls are the same layer, an air barrier that has better design details and field inspection and should translate to less water infiltration, which should increase the lifespan of the building envelope.
Maintenance Cost	0	No anticipated impact for this measure.

[2] PNNL Report 18898, Infiltration Modeling Guidelines for Commercial Building Energy Analysis (2009)

E1.0 – Reduced Interior Lighting Power

<table>
<tr><th></th><th>Proposed</th><th>Baseline</th></tr>
<tr><td>ECM Description</td><td>The average space lighting power is as designed, summarized below based on lighting fixture and area take-offs. The proposed is on average 37% less than the baseline.
<table><tr><th>Space Type</th><th>(W/ft²)</th></tr><tr><td>Corridor</td><td>0.263</td></tr><tr><td>Stairwell</td><td>0.398</td></tr><tr><td>Laundry room</td><td>0.349</td></tr><tr><td>Trash room</td><td>0.318</td></tr><tr><td>Storage room</td><td>0.349</td></tr><tr><td>Mechanical room</td><td>0.597</td></tr></table></td><td>The average space lighting power are the allowances defined by Table C405.4.2(2). Summarized in the table below.
<table><tr><th>Space Type</th><th>(W/ft²)</th></tr><tr><td>Corridor</td><td>0.480</td></tr><tr><td>Stairwell</td><td>0.500</td></tr><tr><td>Laundry room</td><td>0.430</td></tr><tr><td>Trash room</td><td>0.680</td></tr><tr><td>Storage room</td><td>0.450</td></tr><tr><td>Mechanical room</td><td>0.680</td></tr></table></td></tr>
<tr><td>How Measure Was Analyzed</td><td colspan="2">Lighting is defined as a sensible load in the space that it occurs. Lighting schedules for corridor, stairwells, and laundry room are 24/7, other spaces assumed to be 854 hrs per year. For both the proposed and baseline design, stairwell, laundry room, and storage room lighting power are reduced to account for code-required occupancy sensors (stairwells = 35% reduction, 10% for other spaces). Dwelling unit lighting power is assumed the same in the proposed and baseline design, 0.6 W/ft2, and on for 2.34 full load hours per day.</td></tr>
<tr><td>Annual kWh/Cost Savings</td><td colspan="2">4,079 kWh | $408/year</td></tr>
<tr><td>Inc. First Cost / Simple Payback</td><td colspan="2">$0</td></tr>
<tr><td>Maintenance Cost</td><td colspan="2">$0/year</td></tr>
</table>

Operational Impacts	Rating (-5 to +5)	Comments
Indoor Air Quality	0	No anticipated impact for this measure.
Thermal Comfort	0	No anticipated impact for this measure.
Usability	0	No anticipated impact for this measure.
Reliability	0	No anticipated impact for this measure.
Ease of Maintenance	0	No anticipated impact for this measure.
Maintenance Cost	+5	Fewer light fixtures translates to fewer fixtures that will need to be replaced in the future.

E2.0 – Energy Star Refrigerators

	Proposed	Baseline
ECM Description	The proposed refrigerator is Energy Star, GE model GPE12FGK, which has a rated energy use of 310 kWh/year	The baseline refrigerator is non-Energy Star and assumed to meet federal minimum requirement for the given size, 347 kWh/year.
How Measure Was Analyzed	Refrigerator energy use is converted to an average W/ft2 of apartment area, and modeled as 100% sensible load distribute evenly across all hours of the year,	
Annual kWh/Cost Savings	1,318 kWh | $132/year	
Inc. First Cost / Simple Payback	$6,900 / 52 years	
Maintenance Cost	$0/year	

Operational Impacts	Rating (-5 to +5)	Comments
Indoor Air Quality	0	No anticipated impact for this measure.
Thermal Comfort	+2	A more efficient refrigerator adds less heat to the space, which improves thermal comfort in the summer.
Usability	0	No anticipated impact for this measure.
Reliability	0	No anticipated impact for this measure.
Ease of Maintenance	+3	DESC has specified this same refrigerator for most of its other new properties, so using the same model makes it easier to maintain.
Maintenance Cost	0	No anticipated impact for this measure.

E3.0 – Energy Star Common Laundry

	Proposed		Baseline
ECM Description	The proposed common washer/dryer pairs (2 per residential floor) are Energy Star, and are estimated to use: Washer: 0.16 kWh/cycle, 2.7 gal HW/cycle Dryer: 3.0 kWh/cycle		The baseline washer/dryers are non-Energy Star, same quantity as the proposed, and are estimated to use: Washer: 0.15 kWh/cycle, 10.3 gal HW/cycle Dryer: 4.0 kWh/cycle
How Measure Was Analyzed	1.5 wash & dry cycles/apartment/week are assumed for both the proposed and baseline design, based on DESC laundry vendor data obtained for a previous project. Energy consumption and hot water consumption for the proposed and baseline design is based on ACEEE studies.[3,4] Washer/dryer energy use is assigned to laundry rooms, with 100% assumed to be exhausted from the building. Laundry hot water loads are added to the DHW plant load.		
Annual kWh/Cost Savings	15,005 kWh | $1,500/year		
Inc. First Cost / Simple Payback	$0		
Maintenance Cost	$0/year		
Operational Impacts	**Rating (-5 to +5)**	**Comments**	
Indoor Air Quality	0	No anticipated impact for this measure.	
Thermal Comfort	+1	A more efficient washing system results in less heat to the space, which improves thermal comfort in the summer.	
Usability	0	No anticipated impact for this measure.	
Reliability	0	No anticipated impact for this measure.	
Ease of Maintenance	0	No anticipated impact for this measure.	
Maintenance Cost	0	No anticipated impact for this measure.	

[3] High-Performance, Coin-Operated Clothes Washer Demonstration and Evaluation (2002)

[4] Are We Missing Energy Savings in Clothes Dryers? (2010)

M1.0 – Energy Recovery Ventilation (ERV) System

	Proposed	Baseline
ECM Description	Three rooftop ERVs (Swegon Gold RX) serving dwelling units, corridors and trash rooms. Design target is 50 cfm supply/60 cfm exhaust per apartment. Trash/janitor room exhaust = 700 cfm. Total supply/exhaust air flow = 6,620 cfm. (see mechanical schedules for individual unit ERV values). ERV has net sensible efficiency 85%; no preheat coil, MERV 13 supply filters, fan power = 0.78 W/cfm of both supply flow. Local kitchen exhaust by ERV and recirculating range hood.	Each apartment has a whole house exhaust fans, operating continuously at the same dwelling unit exhaust rate as the proposed (4,600 cfm), fan power = 0.71 W/cfm. Make-up air by via trickle vents. Corridor ventilated by rooftop air handler with electric heat, same supply flow as proposed (1,260 cfm), MERV 13 supply filters, fan power = 0.50 W/cfm of supply flow. Trash rooms have separate exhaust fan, 700 cfm, 0.30 W/cfm. Local kitchen exhaust by range hood ducted to exterior.
How Measure Was Analyzed	The proposed ERV is modeled as one multizone HVAC system with the specified fan power and heat recovery effectiveness, serving both the dwelling units and corridor. It operates continuously at the proposed design ventilation rate. Heating in dwelling units modeled as baseboard heats, with a constant setpoint of 70F. The baseline apartment ventilation is modeled as a continuously operated zone exhaust fan, with specified fan power and same outside air supply flow rate as the proposed. Make-up air calculated by the program as the quadratic sum with infiltration flow. The baseline corridor ventilation system is modeled as a 100% OA packaged single zone system with electric heat, operating continuously with the same supply ventilation as proposed. Heating in dwelling units modeled the same as the proposed. Intermittent range hood flow and fan power modeled the same in both the proposed and baseline model.	
Annual kWh/Cost Savings	118,545 kWh | $11,854/year	
Inc. First Cost / Simple Payback	$577,879 / 49 years	
Maintenance Cost	$4,400/year	

Operational Impacts	Rating (-5 to +5)	Comments
Indoor Air Quality	+5	Balanced ventilation provides better ventilation effectiveness, and supply air is filtered to MERV 13.
Thermal Comfort	+5	Reduced drafts at windows due to balanced pressurization.
Usability	0	No anticipated impact for this measure.
Reliability	+5	System is
Ease of Maintenance	+3	System is centralized, so simple to replace filters and ERVs can be integrated into control system to alert building operations if not working.
Maintenance Cost	-3	Maintenance costs include regular maintenance of central ERVs, and annual replacement of charcoal filters for recirculation hoods.

M2.0 – Thermostat with Window Switch

	Proposed	Baseline
ECM Description	Apartments have cove heaters controlled by a line voltage thermostat, King Window Watcher (WR230-B) or equivalent. This thermostat includes a dry contact that is connected to magnetic window switch, which when the contact is open (i.e. window is open), the thermostat automatically sets back the heat setpoint to 60F. This is anticipated to Proposed infiltration rate for this individual ECM is 0.25 cfm/ft2 @ 75Pa.	The baseline is the same as the proposed except windows do not have a magnetic switch installed and therefore the cove heater thermostat does not setback when the window is open. To account for the lack of heater setback it is assumed that roughly half the apartments have the awning apartment windows opened 2" or more.
How Measure Was Analyzed	For both the proposed and baseline, the thermostat setpoint is assumed to be constant, 70°F. For the baseline, To account for the lack of a window switch and open windows, the baseline includes an additional, constant 0.05 cfm/ft2 infiltration modeled for each apartment. The tested envelope air leakage rate is assumed to be the same for both the proposed and baseline designs.	
Annual kWh/Cost Savings	14,623 kWh | $1,462/year	
Inc. First Cost / Simple Payback	$12,200 / 8 years	
Maintenance Cost	$0/year	

Operational Impacts	Rating (-5 to +5)	Comments
Indoor Air Quality	0	No anticipated impact for this measure.
Thermal Comfort	-3	Apartments will be colder if the windows are left open. This measure is intended to encourage tenants to keep windows closed, but if they don't understand or agree, they may complain about poor thermal comfort.
Usability	0	The thermostat use by itself is operated by the tenant in a similar manner as a thermostat stat w/o a window switch.
Reliability	-3	This system has a magnetic switch and may need adjustment if windows/building frame shifts over time.
Ease of Maintenance	-3	The thermostat maintenance itself is similar to ones w/o switches, however, die to reliability and thermal comfort issues noted above, maintenance personnel should expect some questions/complaints until tenants understand why they can't keep the apartment warm and the windows are open.
Maintenance Cost	-3	Cost for replacing thermostat is higher than normal, and if switch is damaged by tenant, there are costs to replace it.

P1.0 – Efficient Plumbing Fixtures

	Proposed	Baseline
ECM Description	Plumbing fixture rated flow rates: Showerhead: 1.50 gal/min Lavatory faucet: 1.50 gal/min Kitchen faucet: 1.80 gal/min Total estimated hot water use: 23.6 gal/apt/day	Code-maximum fixture rated flow rates: Showerhead: 2.50 gal/min Lavatory faucet: 2.20 gal/min Kitchen faucet: 2.20 gal/min Total estimated hot water use: 31.1 gal/apt/day
How Measure Was Analyzed	The proposed daily DHW use is based on sub-meter data for another DESC project that uses low-flow fixtures. The baseline consumption was estimated using the same duration and number of fixtures uses as the proposed, but assuming standard flow plumbing fixtures. The baseline DHW demand was calculated using the formula from the Energy Star Multifamily Simulation Guidelines[5], using the proposed target flow from submetering data, and solving for the baseline: ProposedHWDemand = BaselineHWDemand*(0.36+0.54*LFS/2.5+0.1*LFF/2.2) Where: LFS(gpm) = rated flow rate of the low-flow showerheads specified on the drawings LFF(gpm) = rated flow rate of the low-flow faucets specified on the drawings The loads were then input into the model of the DHW plant (see ECM P3.0 description).	
Annual kWh/Cost Savings	36,680 kWh | $3,668/year	
Inc. First Cost / Simple Payback	$0	
Maintenance Cost	$0/year	

Operational Impacts	Rating (-5 to +5)	Comments
Indoor Air Quality	0	No anticipated impact for this measure.
Thermal Comfort	0	No anticipated impact for this measure.
Usability	0	No anticipated impact for this measure.
Reliability	0	No anticipated impact for this measure.
Ease of Maintenance	0	No anticipated impact for this measure.
Maintenance Cost	0	No anticipated impact for this measure.

[5] Energy Star Multifamily High Rise Program Simulation Guidelines, Version 1.0, Revision 03 January 2015

P2.0 – Improved Plumbing Distribution

	Proposed	Baseline
ECM Description	Proposed residential plumbing distribution design: - One DHW/DCW riser serving two apts where it is possible (17 total risers). - Additional pipe insulation: Hot water distribution on L4-7 (120F): 1" and smaller: 2.0" thick 1½" and larger: 2.5" thick Piping from DHW plant on P1 to L4 (140F): 1½ to 4: 3.0" thick	Typical residential plumbing distribution design: - One DHW/DCW riser serving every stack of apartments (24 total risers). - Code-minimum pipe insulation: Hot water distribution on L4-7 (120F): 1" and smaller: 1.0" thick 1½" and larger: 1.5" thick Piping from DHW plant on P1 to L4 (140F): 1½ to 4: 1.5" thick
How Measure Was Analyzed	The lengths of the HW piping system was measured from piping diagrams. Heat loss for the various lengths and diameters was estimated using the 3EPlus software[6]. The calculated heat loss was doubled to better align with expected value of 80 watts of heat loss/apt, as observed for a similar, recently built DESC PSH project. The heat loss was added as maintenance heater load (see ECM 3.0 description), and distributed as heat input in apartment spaces of the energy model. See Appendix B for calculations.	
Annual kWh/Cost Savings	14,119 kWh | $1,412 /year	
Inc. First Cost / Simple Payback	$30,500 / 22 years	
Maintenance Cost	$0/year	

Operational Impacts	Rating (-5 to +5)	Comments
Indoor Air Quality	0	No anticipated impact for this measure.
Thermal Comfort	+3	Reducing DHW distribution losses helps reduce over-heating in the summer.
Usability	0	No anticipated impact for this measure.
Reliability	0	No anticipated impact for this measure.
Ease of Maintenance	0	No anticipated impact for this measure.
Maintenance Cost	0	No anticipated impact for this measure.

[6] 3E Plus Software developed by the North American Insulation Manufacturers Association (NAIMA).

P3.0 – Heat Pump Water Heater

<table>
<tr><th></th><th>Proposed</th><th>Baseline</th></tr>
<tr><td>ECM Description</td><td>The proposed DHW plant is located on P1 and consists of:
- (10) Sanden CO2 heat pumps (HPs), located on the wall of the parking garage.
- (2) 504 gal storage tanks w/ R-16 insulation and a 27 kW electric resistance back-up heater, located in the P1 mechanical room.
- An 8 kW electric resistance temperature maintenance water heater and electronic TMV in a mechanical room on L4.
Hot water is generated and stored in the P1 tanks at 140F. The water is piped to a storage room on L4, and then mixed with cold/recirc water and supplied to building at 120F. Hot water is circulated through distribution on L4-7, but is not recirculated back to the plant on P1.</td><td>The baseline DHW plant is assumed to use the same design as the proposed with the following exceptions:
- Instead of CO2 HPs, the hot water is heated at the plant by electric resistance heaters, with an equivalent heating capacity as the (10) Sanden HPs (45 kW).
- Storage tank insulation is code-minimum R-12.5.</td></tr>
<tr><td>How Measure Was Analyzed</td><td colspan="2">An hourly simulation of the plant was developed using a spreadsheet. The model accounts for:
- Hot water loads, varying on a daily basis using the average load profile developed from how water sub-metering data from another DESC PSH project.
- Hourly environmental temperature for the HP evaporators and storage tanks. This is conservatively assumed to be the same as the ambient air temperature, as the parking garage should typically be warmer than the ambient air temperature.
- Efficiency as a function of environmental temperature for the Sanden heat pump.
- Monthly variation in temperature of municipal make-up water.
- Storage tank stratification and heat losses.
- Distribution losses from piping system, which adds to the total hot water heating energy load.
- Circulation pump input energy and pump heat gain to recirculation system.
- Defrost cycles of CO2 HPs (assumed to be every hour when environmental temp is <40F, and reducing hourly COP by 20%).
See Appendix B for a view copy of the model inputs and outputs for the first 4 days of 8760 simulation.</td></tr>
<tr><td>Annual kWh/Cost Savings</td><td colspan="2">160,924 kWh | $16,092 /year</td></tr>
<tr><td>Inc. First Cost / Simple Payback</td><td colspan="2">$73,000 / 5 years</td></tr>
<tr><td>Maintenance Cost</td><td colspan="2">$1000/year</td></tr>
</table>

Operational Impacts	Rating (-5 to +5)	Comments
Indoor Air Quality	0	No anticipated impact for this measure.
Thermal Comfort	0	No anticipated impact for this measure.
Usability	-3	The HPs
Reliability	-3	HPs have more moving parts than electric resistance water heaters. However, the refrigeration circuit of the Sanden HPs is not field serviceable, and is relatively easy to replace.
Ease of Maintenance	-3	There are 10 individual HPs, as well as one electric water heater that must be maintained.
Maintenance Cost	-3	Maintenance costs are anticipated to be higher than electric resistance water heaters.

Solar PV

	Proposed	Baseline
ECM Description	40.0 kW solar PV system, oriented south on the L7 roof.	C411.1 required PV system, 4.0 kW
How Measure Was Analyzed	The C411.1 required PV system is based on 70 W/ft2 for the five largest building levels (56,890 ft2). Electricity production was estimated assuming 1000 kWh/kW.	
Annual kWh/Cost Savings	36,000 kWh | $3,600 /year	
Inc. First Cost / Simple Payback	$76,274 / 21 years (No production degradation is assumed in the simple payback calculation)	
Maintenance Cost	$0/year	

Operational Impacts	Rating (-5 to +5)	Comments
Indoor Air Quality	0	No anticipated impact for this measure.
Thermal Comfort	0	No anticipated impact for this measure.
Usability	0	No anticipated impact for this measure.
Reliability	0	No anticipated impact for this measure.
Ease of Maintenance	0	No anticipated impact for this measure.
Maintenance Cost	0	No anticipated impact for this measure.

ECM Results Summary

Table 4. ECM Results Summary

		Estimated Anuual Consumption					Estimated Anuual Savings							Incremental Costs		
ECM ID	**ECM Description**	**Modeled Energy**	**Non-Modeled Energy**	**Total Energy**		**EUI**	**Non-Interactive Savings**			**Interactive Savings**				**First**	**Simple Payback**	**Annual O&M**
		kWh	**kWh**	**kWh**	**MBtu**	***kBtu/ft2***	***MBtu***	***kWh***	***%***	***MBtu***	***kWh***	***$/year***	***%***	***$***	***years***	***$/year***
-	Baseline	372,537	269,785	642,322	2,192	49.5	-	-	0.0%	-	-	-	0.0%	$ -		
A1.0	Thermally Improved Windows	357,321	269,785	627,106	2,140	48.3	52	15,216	2.4%	51	15,039	$ 1,504	2.3%	$ 52,750	35	$ -
A2.0	Reduced Air Leakage	370,123	269,785	639,908	2,183	49.3	8	2,414	0.4%	8	2,386	$ 239	0.4%	$ 80,783	339	$ -
E1.0	Reduced Int. Lighting Power	368,410	269,785	638,195	2,178	49.1	14	4,127	0.6%	14	4,079	$ 408	0.6%	$ -	0.0	$ -
E2.0	Energy Star Refrigerators	371,203	269,785	640,988	2,187	49.3	5	1,334	0.2%	4	1,318	$ 132	0.2%	$ 6,900	52	$ -
E3.0	Energy Star Common Laundry	372,537	254,603	627,140	2,140	48.3	52	15,182	2.4%	51	15,005	$ 1,500	2.3%	$ -	0.0	$ -
M1.0	ERV System	252,594	269,785	522,379	1,782	40.2	409	119,943	18.7%	404	118,545	$ 11,854	18.5%	$ 577,879	49	$ 4,400
M2.0	Thermostat w/ Window Switch	357,742	269,785	627,527	2,141	48.3	51	14,795	2.3%	50	14,623	$ 1,462	2.3%	$ 12,200	8	$ -
P1.0	Efficient Plumbing Fixtures	372,537	232,672	605,209	2,065	46.6	127	37,113	5.8%	125	36,680	$ 3,668	5.7%	$ -	0.0	$ -
P2.0	Improved Plumbing Distribution	389,762	238,274	628,036	2,143	48.4	49	14,286	2.2%	48	14,119	$ 1,412	2.2%	$ 30,500	22	$ -
P3.0	Heat Pump Water Heater	372,537	106,963	479,500	1,636	36.9	556	162,822	25.3%	549	160,924	$ 16,092	25.1%	$ 73,000	5	$ 1,000
	Proposed (Not Incl. PV)	192,034	67,794	259,828	887	20.0	1,306	382,494	59.5%	1,306	382,718	$ 38,272	60%	$ 834,012	21.8	$ 5,400
	Proposed (Incl. PV)	192,034	27,794	219,828	750	16.9				1,442	422,494	$ 42,249	66%	$ 910,259	21.5	

Table 5. ECM End Use Energy Summary

ECM ID	ECM Description	Interior Lights	Plug Loads	Space Heat	HP Aux	Space Cool	Heat Rej	Pumps & Aux	Interior Fans	Laundry	DHW	Exterior Lights	Total	EUI	Savings
		MBtu	MBtu	MBtu	MBtu	MBtu	MBtu	MBtu	MBtu	MBtu	MBtu	MBtu	MBtu	kbtu/ft2	Mbtu
	Baseline	189.9	333.1	584.8	-	3.7	-	13.3	159.9	101.9	805.5	-	2,192	49.5	-
A1.0	Thermally Improved Windows	189.9	333.1	533.3	-	3.7	-	13.3	159.5	101.9	805.5	-	2,140	48.3	52
A2.0	Reduced Air Leakage	189.9	333.1	576.6	-	3.7	-	13.3	159.8	101.9	805.5	-	2,184	49.3	8
E1.0	Reduced Int. Lighting Power	139.4	333.1	621.3	-	3.7	-	13.3	159.9	101.9	805.5	-	2,178	49.1	14
E2.0	Energy Star Refrigerators	189.9	321.5	591.8	-	3.7	-	13.3	160.0	101.9	805.5	-	2,188	49.4	5
E3.0	Energy Star Common Laundry	189.9	333.1	584.8	-	3.7	-	13.3	159.9	77.6	778.0	-	2,140	48.3	52
M1.0	ERV System	189.9	333.1	163.9	-	3.2	-	29.4	155.9	101.9	805.5	-	1,783	40.2	409
M2.0	Thermostat w/ Window Switch	189.9	333.1	534.9	-	3.7	-	13.3	159.4	101.9	805.5	-	2,142	48.3	50
P1.0	Efficient Plumbing Fixtures	189.9	333.1	584.8	-	3.7	-	13.3	159.9	101.9	678.9	-	2,066	46.6	127
P2.0	Improved Plumbing	189.9	333.1	643.0	-	3.7	-	13.3	160.5	101.9	698.0	-	2,143	48.4	49
P3.0	Heat Pump Water Heater	189.9	333.1	584.8	-	3.7	-	13.3	159.9	101.9	249.8	-	1,637	36.9	556
	Proposed (Not Incl. PV)	139.4	321.5	19.5	-	3.1	-	29.4	155.9	77.6	140.4	-	887	20.0	1,305

**values in blue are the results calculated outside of eQUEST.*

III. Analysis of Overall Project

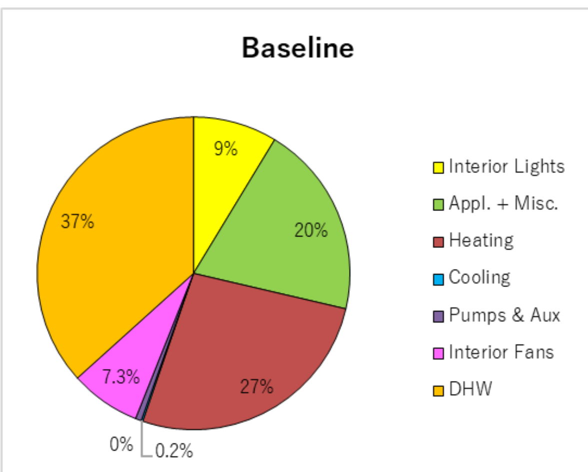
Results

Table 6 summarizes the end-use and total site EUIs for the project, as well as savings. The estimated annual EUI, before accounting for PV, is 19.1.

Table 6. Annual End-Use and Total EUI

Design (units = kBtu/ft2)	Interior Lights	Appl. + Misc.	Heating	Cooling	Pumps & Aux	Interior Fans	DHW	Total (Excl. PV)	PV	Total (Incl. PV)
Baseline	4.3	9.8	13.2	0.1	0.3	3.6	18.2	49.5	(0.3)	49.1
Proposed	3.1	9.0	0.4	0.1	0.7	3.5	3.2	20.0	(3.1)	16.9
Reduction	**27%**	**8%**	**97%**	**16%**	**-121%**	**3%**	**83%**	**60%**		**66%**

Figure 1 demonstrates the fraction of energy use by each end-use.



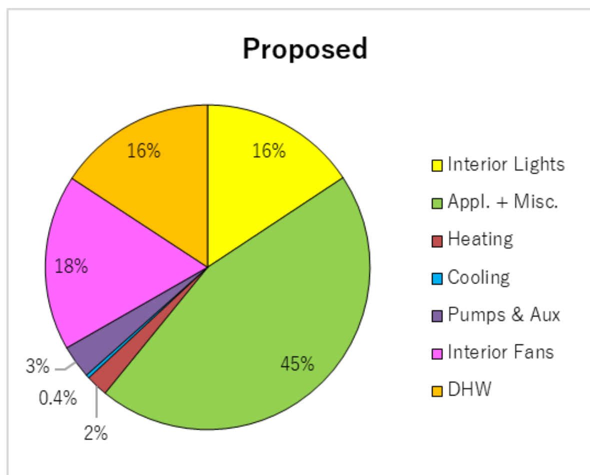


Figure 1. Annual Energy Fractions by End-use

Figure 2 plots the monthly electricity consumption by month.

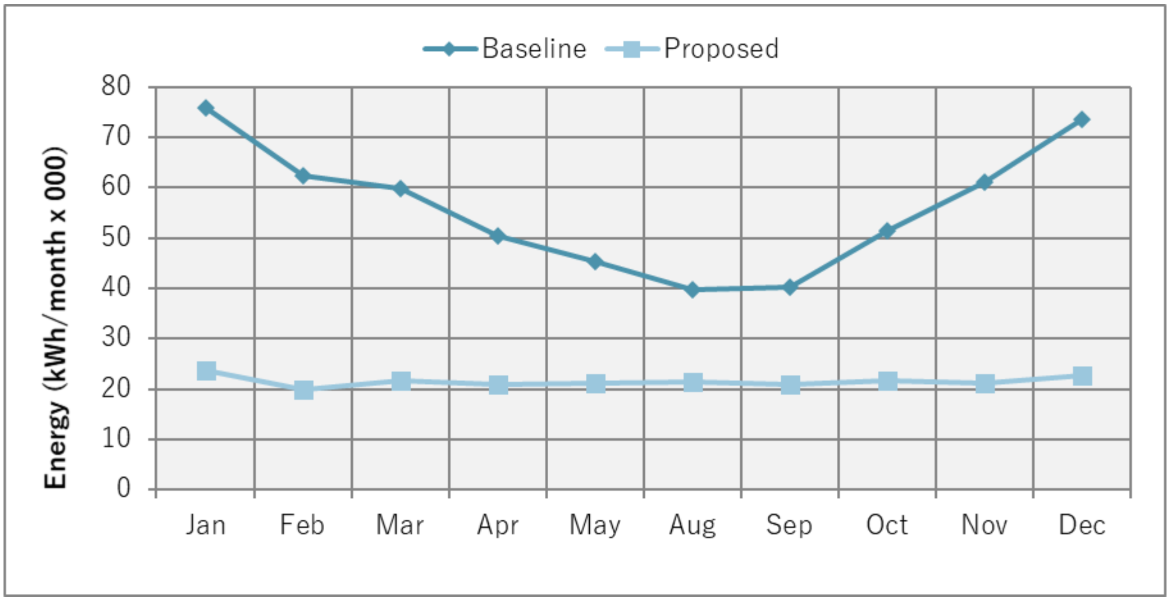


Figure 2. Monthly Energy Consumption

Discussion

The proposed design energy savings, with respect to the 2015 SEC baseline and before accounting for on-site PV, is **60%.** The estimated annual EUI is **20.0** kBtu/ft2/year, and therefore the HPS design complies with both criteria laid out in SCL's Exemplary Building incentive program. The largest reduction in energy use occurs in the space heating and DHW end-use categories. Space heating is reduced primarily by using energy recovery, but also by load reduction measures, such as triple-pane windows, reduced air leakage, and use of a window switch to help encourage tenants to keep windows closed when it is cold outside. DHW energy use is reduced primarily by using high-efficiency CO2 heat pumps, though load reduction measures such as low-flow fixtures and improved plumbing distribution reduce loads, and therefore reduce the capacity of heat pumps required.

There are several efficiency measures that, in recent years, have become low/no-cost measures to implement. These include reducing interior lighting power, Energy Star common laundry equipment, and low-flow plumbing fixtures. With the exception of laundry equipment, the 2018 SEC and Washington State appliance standards[7] largely codify these common measures by reducing lighting power allowances further and requiring all plumbing fixtures to be more efficient.

[7] Washington State Department of Commerce. [Appliance Standards]

Life Cycle Cost Analysis

A LCCA was prepared using the Washington State Office of Financial Management (OFM) tool[8]. The construction costs entered in the tool are based on estimates for the baseline and proposed designs prepared by the general contractor, Walsh Construction. In most cases, the LCCA includes a line item entry of sub-category costs when they differ between the proposed and base case designs. Where costs were assumed to be the same between the two designs, costs were rolled up and entered under the primary categories. In addition to differences in first cost, differences in expected useful life (EUL) and maintenance costs were estimated when possible.

Figure 3 presents the executive report from the LCCA tool for the following three cases:

1. Baseline: 2015 SEC Baseline described in this report, including C406.3, C406.8, and C411 minimum PV required
2. Alt. 1: Proposed Exemplary Building/PHIUS+ 2018 design, including as designed PV. Sales tax for additional energy efficiency measures and the projected minimum SCL rebate of $3,500/apartment has been included.
3. Alt. 2: Same as Alt 1., but adding additional soft costs anticipated for the proposed design.

The LCCA analysis indicates the proposed UHEE design has a positive net present savings (NPS) both before and after accounting for the social cost of carbon dioxide emission over the 50 year LCCA time horizon.

[8] LCCA tool Version 2019-A, provided to the Hobson Place project team for the 2019 Housing Trust Fund UHEE application

Office of Financial Management
Olympia, Washington - Version: 2019-A
Life Cycle Cost Analysis Tool

Executive Report

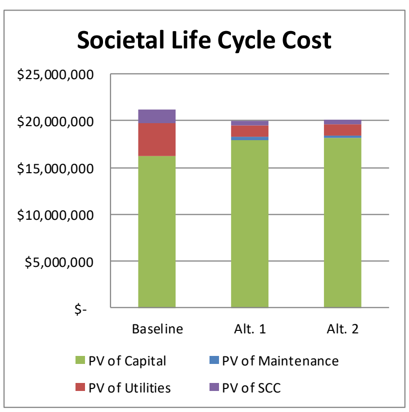
Project Information	
Project:	DESC Hobson Place - South
Address:	1911 22nd Ave S, Seattle, 98144
Company:	O'Brien360
Contact:	David Reddy
Contact Phone:	206-406-9856
Contact Email:	david@OBrien360.com

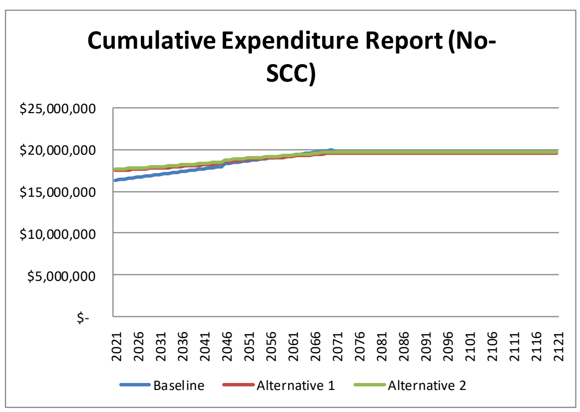
Key Analysis Variables		**Building Characteristics**	
Study Period (years)	50	Gross (Sq.Ft)	44,319
Nominal Discount Rate	3.11%	Useable (Sq.Ft)	44,319
Maintenance Escalation	1.00%	Space Efficiency	100.0%
Zero Year (Current Year)	2021	Project Phase	0
Construction Years	0	Building Type	0

Life Cycle Cost Analysis		**BEST**	
Alternative	Baseline	Alt. 1	Alt. 2
Energy Use Intenstity (kBtu/sq.ft)	49.1	16.9	16.9
1st Construction Costs	$ 16,299,771	$ 17,480,013	$ 17,634,805
PV of Capital Costs	$ 16,210,897	$ 17,961,630	$ 18,116,422
PV of Maintenance Costs	$ -	$ 344,656	$ 344,656
PV of Utility Costs	$ 3,502,973	$ 1,205,139	$ 1,205,139
Total Life Cycle Cost (LCC)	**$ 19,713,870**	**$ 19,511,425**	**$ 19,666,217**
Net Present Savings (NPS)	**N/A**	**$ 202,444**	**$ 47,652**

Societal LCC takes into consideration the social cost of carbon dioxide emissions caused by operational energy consumption

(GHG) Social Life Cycle Cost		**BEST**	
GHG Impact from Utility Consumption	Baseline	Alt. 1	Alt. 2
Tons of CO2e over Study Period	13,144	4,522	4,522
% CO2e Reduction vs. Baseline	N/A	66%	191%
Present Social Cost of Carbon (SCC)	$ 1,414,732	$ 486,715	$ 486,715
Total LCC with SCC	**$ 21,128,601**	**$ 19,998,140**	**$ 20,152,932**
NPS with SCC	**N/A**	**$ 1,130,461**	**$ 975,669**





Baseline Short Description
SCL EB 2015 SEC Baseline (including C406.3, C406.8, and C411 Minimum PV)
Alternative 1 Short Description
Proposed EB/UHEE design (including PV) + Alt 1 sales tax
Alternative 2 Short Description
Alt 1 + EB/UHEE soft costs

Figure 3. LCCA Executive Report

Parking Garage Energy

Table 7 summarizes the estimated parking garage ventilation and lighting energy for the project.

Table 7. Parking Garage Energy

Parking Garage Floor Area	10,996 ft2
Lighting	
Design Power Density	1.143 kW (~0.104 W/ft2)
Annual Operating Hours	8,760 hours
Controls	Occupancy sensor (OS) controls for 50% of the lighting, assume controlled lights are off for 50% of the time. 25% net reduction in lighting energy use.
Estimated Annual Energy Use	7,513 kWh
Ventilation	
Design Exhaust Flow Rate	8,300 cfm
Design Exhaust Fan Power	1.58 BHP (~0.16 W/cfm)
Annual Operating Hours	8,760 hours
Controls	Carbon monoxide (CO) controls for variable speed fans. 87.5% reduction in fan energy.
Estimated Annual Energy Use	1,454 kWh

IV. Post-Construction Monitoring Recommendations

Post-construction monitoring has been discussed throughout the project. One asset the HPS project has that most other multifamily projects do not is a central building automation system (BAS). That system will monitor and/or control the residential ERVs, the Sanden heat pump plant, and other equipment in the building outside the scope of this study. Additionally, separate energy and water metering systems are being installed, providing 15 minute or less interval measurement of residential apartment hot/cold water and electricity. There is currently no central monitoring capability associated with the residential apartment indoor air quality, temperature, or window switch operation, though there is a promising new product available from King Electric that would provide at minimum temperature and window switch operation. The following is a list recommended post-occupancy evaluations.

ERVs

The Swegon Gold RX ERV's used for this project are high-efficiency, Passive House certified units. Mechanical Sales, the local Swegon rep, and O'Brien360 have been facilitating a study of the ERVs and apartment indoor air quality as part of a larger study that compares the performance of the ERV systems used in HPS and Hobson Place North (HPN). HPN, the first phase of Hobson Place construction, with 85 apartments, also utilizes heat recovery for the apartment ventilation systems, but with the following principal differences:

a. HPN utilizes Greenheck ERVs that have lower design heat recovery effectiveness and higher fan power than the HPS Swegon Gold ERVs
b. HPN has trunk distribution ducts are located above the roof, outside the conditioned envelope, whereas HPS ductwork is completely within the conditioned space.
c. HPN corridors are served by a dedicated corridor ventilation unit, whereas HPS has the corridors ventilated by the Swegon ERVs.
d. HPN apartments have dedicated range hood exhaust, ducted to the exterior, whereas HPS has local kitchen exhaust via the ERV and recirculating range hoods.

The tentative scope of the NEEA study includes monitoring N phase in early 2021, and the S phase shortly after it is constructed in early 2022. The following summarizes the monitoring that will be performed to assess the energy and other performance differences between N and S phase ventilation systems:

- Real power or amperage of ERVs
- Real power or amperage, supply air, return air, and outside air temperature of N phase corridor RTU.

- Cove heater amperage and range hood energy on a sample of dwelling units (10% sample of units recommended)
- ERV supply, return, exhaust and outside air temperatures on (2) ERVs to determine typical ERV effectiveness (8 points)
- ERV supply temperature after entering the conditioned building space, and exhaust temperature leaving conditioned space, to determine the impact of roof ductwork heat loss (4 points)
- CO2, temperature, and relative humidity in a sample of dwelling units (same units where cove heaters are metered)

In addition, operational differences should be monitored between the two phases, such as how often filters need to be replaced, to better understand the long-term operating costs of centralized ERV systems, particularly as they compare to in-unit ERVs used in other Exemplary Building projects. NEEA has provided verbal commitment to cover the costs for monitoring and data analysis, as well as some level of energy model calibration, at least for the heating/ventilation systems.

CO2 HPWH Plant

The proposed design utilizes Sanden CO2 HPs in a central plant, “swing tank” configuration. There are 10 total HPs, with 5 units manifolded to supply hot water to a single 500-gallon tank, two tanks total, piped in parallel. HPs and primary storage tanks are located in the basement parking garage, and hot water is piped without recirc to the 4th floor swing tank, where it is circulated to apartments on the top four residential floors of the S phase project. Figure 4 provides a schematic diagram of the system. The current design utilizes an older approach for staging the HPs on/off, whereby each HP has its own temperature thermistor inserted into a well on the storage tank. The Sanden HP supplier is now offering a local controller that replaces the individual thermistor control with one thermistor that is used to more reliably and intelligently stage HPs on/off. We strongly recommend the design team adopt this new controller, and to have the controller integrated into the planned building wide BMS so it can be monitored, including alarms pushed though the interface that facility managers will use to manage other systems. Use of the Sanden controller should reduce the number of BMS points that need to be installed by the control contractor, and likely reduce first cost and improve long-term efficiency. At the time of this report publication, DESC has requested change order to include the Sanden controller.

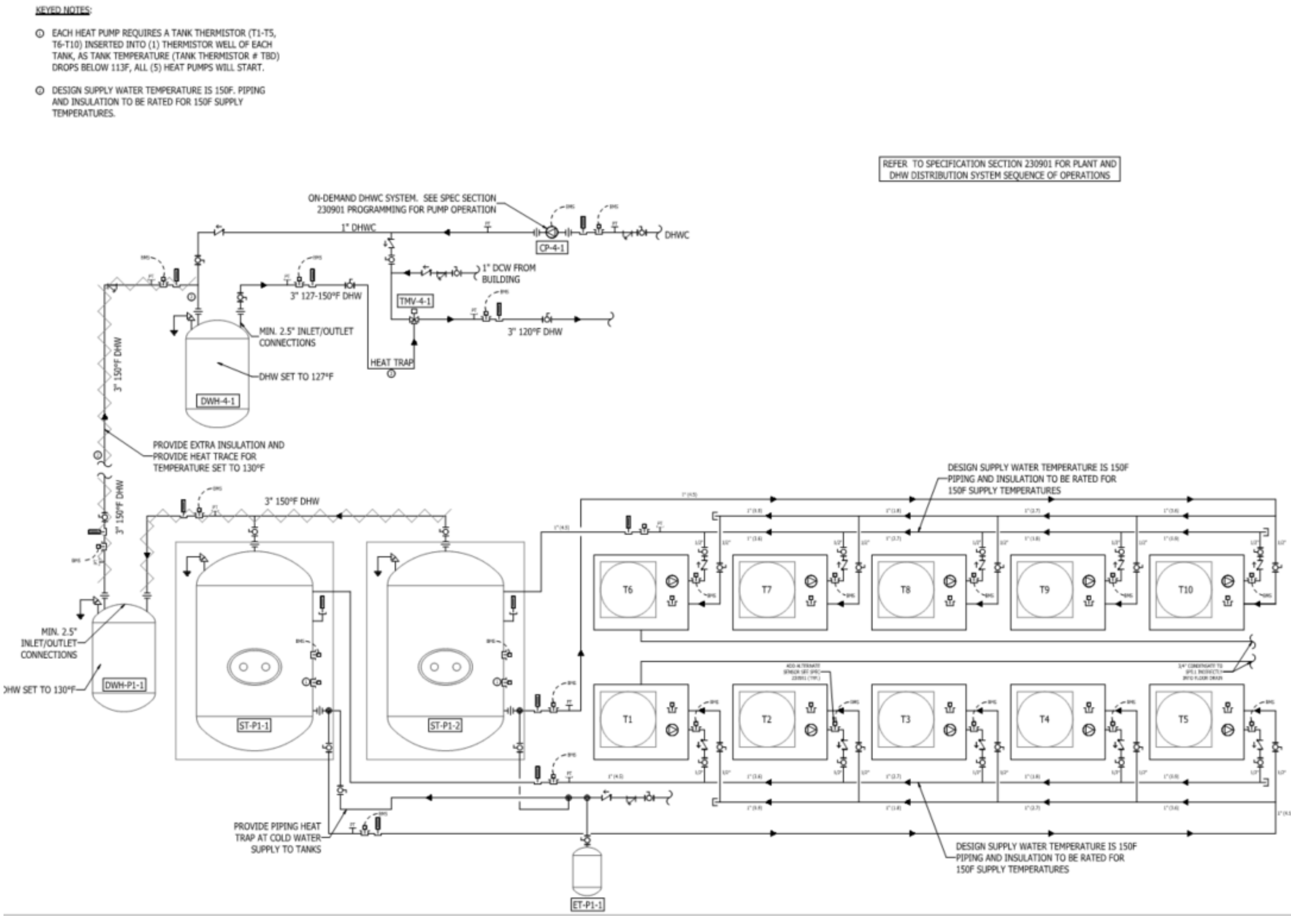


Figure 4. HPS HPWH Plant Diagram

The recommended points to monitor for a robust post-occupancy study include:

- Ambient air temperature in garage and outside.
- Temperature of entering municipal water supply.
- Hot water sub-metering metering for each apartment, which is already included in the design, as well as additional meters for laundry rooms and janitor sink to capture total demand. The next best option would be a make-up water sub-meter for the HW plant, located in the basement.
- Outlet and inlet temperature for each heat pump, or at minimum, the entering and leaving temperature of each of the two manifolds for the HPs.
- Current or power meter for each HP to confirm its status and measure system COP.
- Storage tank temperature, both temperature sensor used for HP control, as well as 3-4 other vertical points to monitor stratification.
- Temperature of hot water leaving the plant in the basement, as well as the temperature entering the swing tank on L4.

- Temperature leaving swing tank, as well as current or power for swing tank electric heating element(s).
- Temperature of supply to building after thermostatic mixing valve, and temperature of recirc return, prior to and after mixing with cold water from building, as well as make-up cold water at L4.
- Temperature of hot water at the top of each supply riser, adjacent to thermostatic balancing valve on L7.

In addition to monitoring performance, alarm criteria should be developed to notify DESC if a HP is not working or hot water supply from the plant drops below the target setpoint temperature. The added cost for all these metering points is hard to define since much of this is already included in the BMS scope already defined and/or available through the recommended Sanden HP controller. Further effort is needed to define the added equipment cost.

Thermostats

The thermostat planned for the S phase is the King WR230-B, which includes a terminal that that a magnetic window switch will be wired to. When the window is opened, the heater setpoint will be automatically setback to 60°F. With input from O'Brien360, King has also developed a prototype of a new thermostat, Model K-802, with similar capabilities as well as the ability to network and centrally monitor the space temperature, setpoint, heater status, and window status. Figure 5 illustrates the concept. This thermostat would provide a great deal of apartment specific data that is hard to capture, such as:

- Typical heating setpoints
- Temperature (at the thermostat) during the different seasons
- Heating energy consumption for all the units
- How often windows are open, particularly in the heating season

To install the system, the K-802 is anticipated to cost approximately $50-100 more per thermostat than the WRP, at least initially based on the volume needed for HPS. Additionally, low voltage data wiring among the units to the multiplexers and main gateway would need to be added, at an estimated cost of ~$250-300/unit. At the time of this report publication, DESC has evaluated and chosen not to pursue this thermostat alternative.

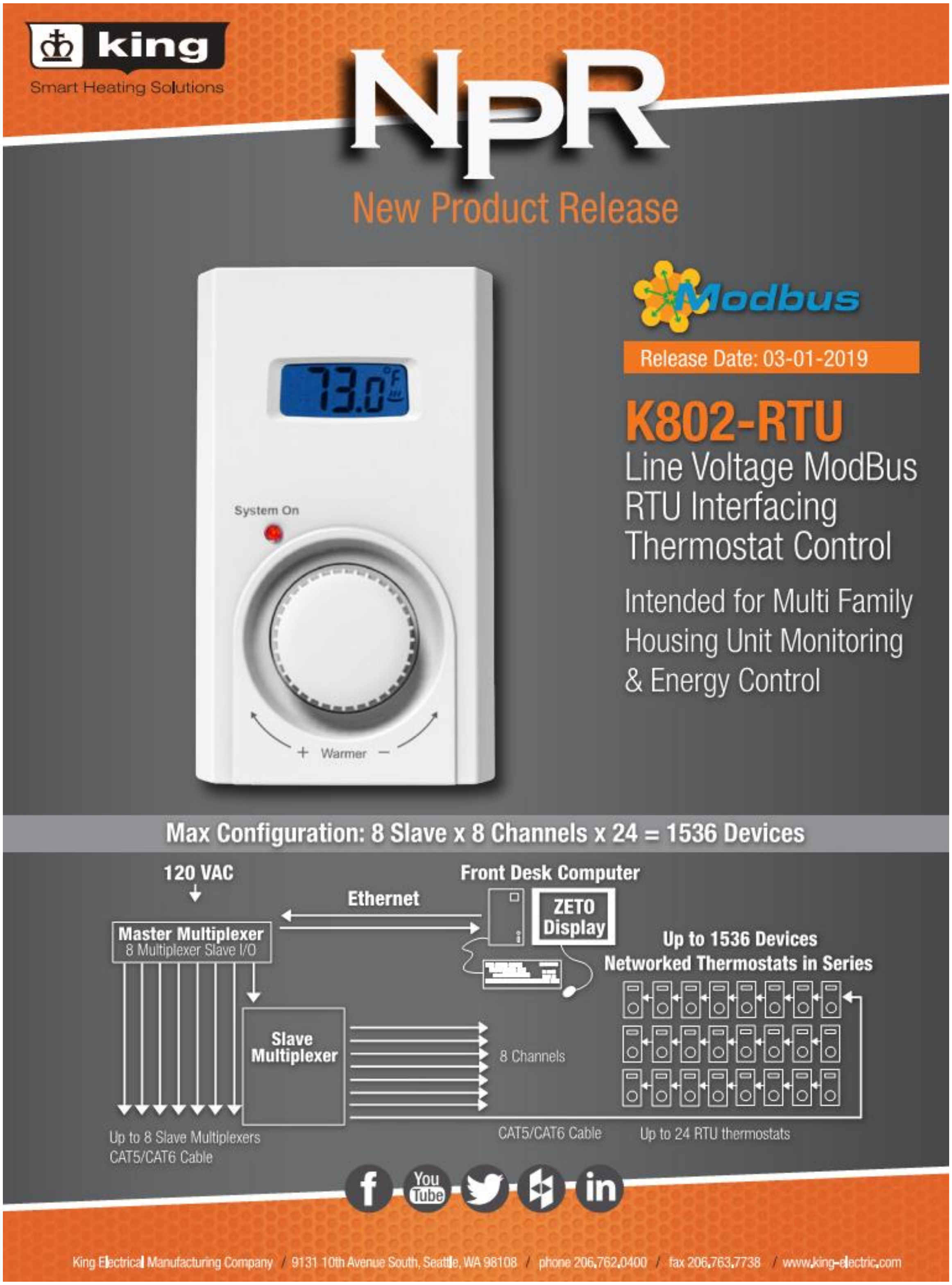


Figure 5. King K-802 Thermostat

Water and Electric Sub-Metering

A robust, apartment water submetering system has been planned for the Hobson Place project. Every unit will have hot and cold water submeters installed. These meters will report wirelessly to a central, Obvius Aquisuite A-8810 data acquisition server. O'Brien360 has proposed to DESC to utilize the CopperTree Analytics Kaizen FDD software to trend data from the Aquisuite on near real-time basis (15-minute intervals), and send alarms based on high water flow rate and/or daily consumption. This will allow DESC to intervene as soon as possible if a tenant uses a very large volume of water in a short-time period. Leak detection algorithms will also be evaluated.

As described in the HPWH monitoring recommendations, there are loads on the central hot water system that are not currently metered, primarily the laundry rooms and janitor sinks on L4-7. To add these meters to the current scope, the estimated cost is ~$2,000, there would be no additional costs for software to monitor these points.

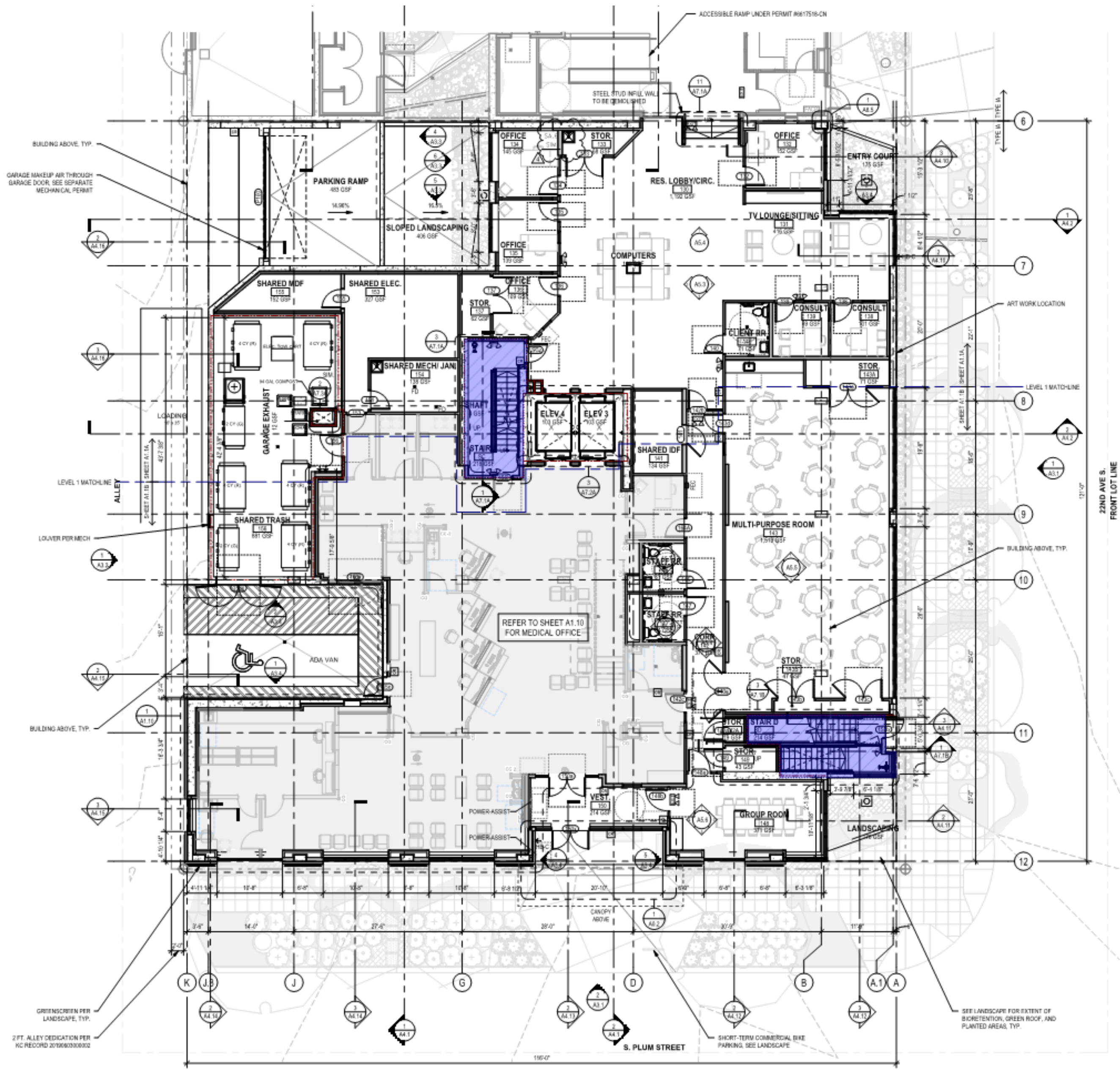
Additionally, an apartment electric sub-metering system is defined in the current scope since the project is master-metered. However, due to added cost, there is currently no plan to integrate the electric submeters into the Kaizen FDD platform that will be used for water metering. The estimated cost to implement the electric sub-metering trending and analytics is anticipated to be minimal. Having both electric and water sub metering would be very useful for calibrating the loads of the whole building energy model developed for this study.

Revision	Date	Originator	Description
01	7/12/2021	DR	First draft for SCL review. Models and results based on r56.
02	8/21/2020	DR	Second draft for SCL review. Models and results based on r62.
03	12/15/2020	DR	Final draft for DESC review. Models and results based on r66
04	2/19/2021	DR	Incorporate comments from JM, update results/LCCA to use final ERV cost estimate and also revise LCCA Alt 1 to include sales tax
05	6/18/2021	DR	Incorporate comments from PW. Remove L1 trash and mechanical rooms from the scope. Models and results based on r67.
06	7/12/2021	JP	Incorporate comments from PW. Remove shafts from the scope. Move recirculation pumping energy from modeled energy to non-modeled energy. Revise DHW table format.

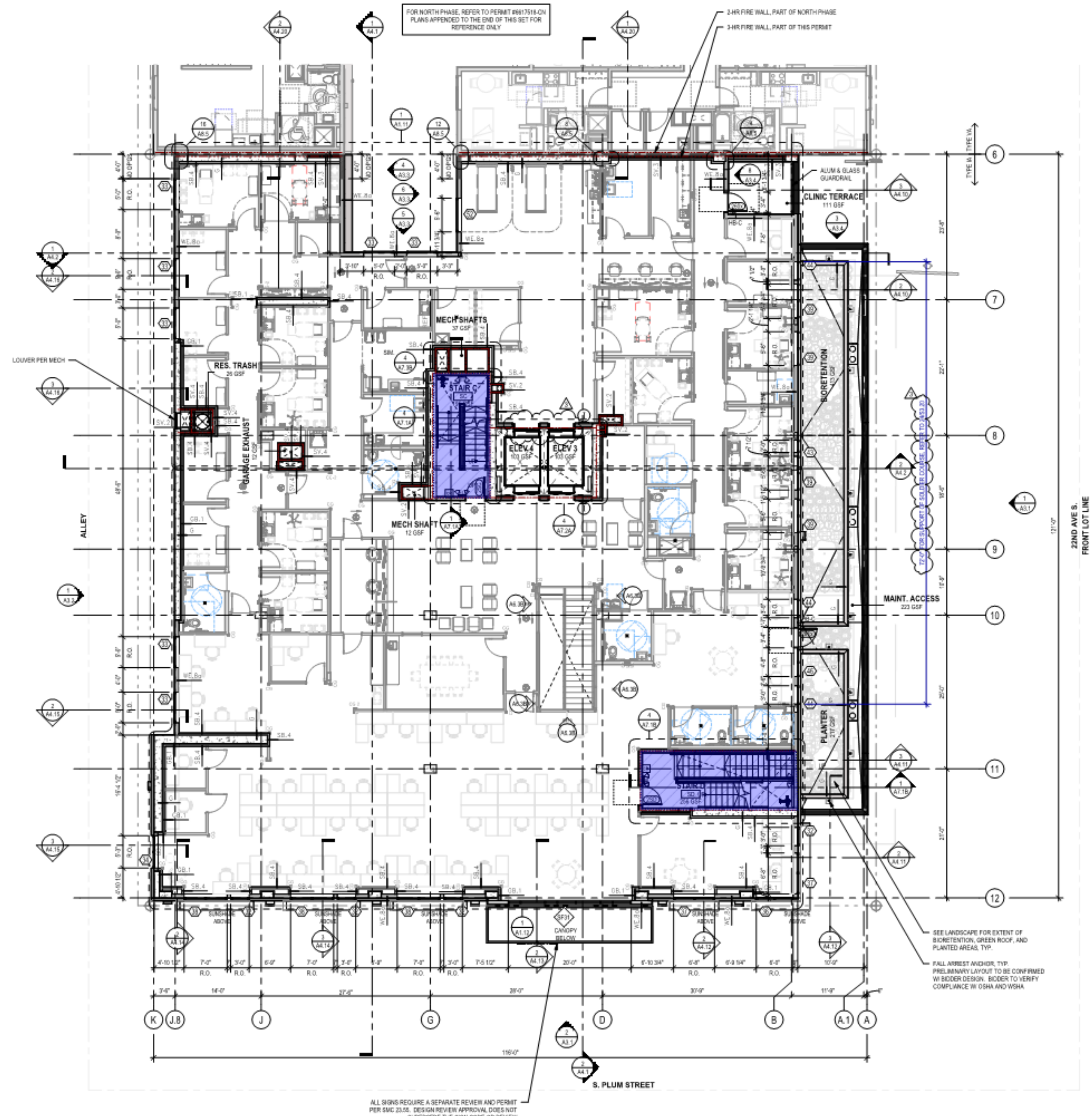
V. Appendices

Appendix A - Floor Plan Area Diagrams
Appendix B - Heat Pump Hot Water Model
Appendix C – Incremental Cost Estimate Detail
Appendix D - eQUEST BEPS Output For Each Run

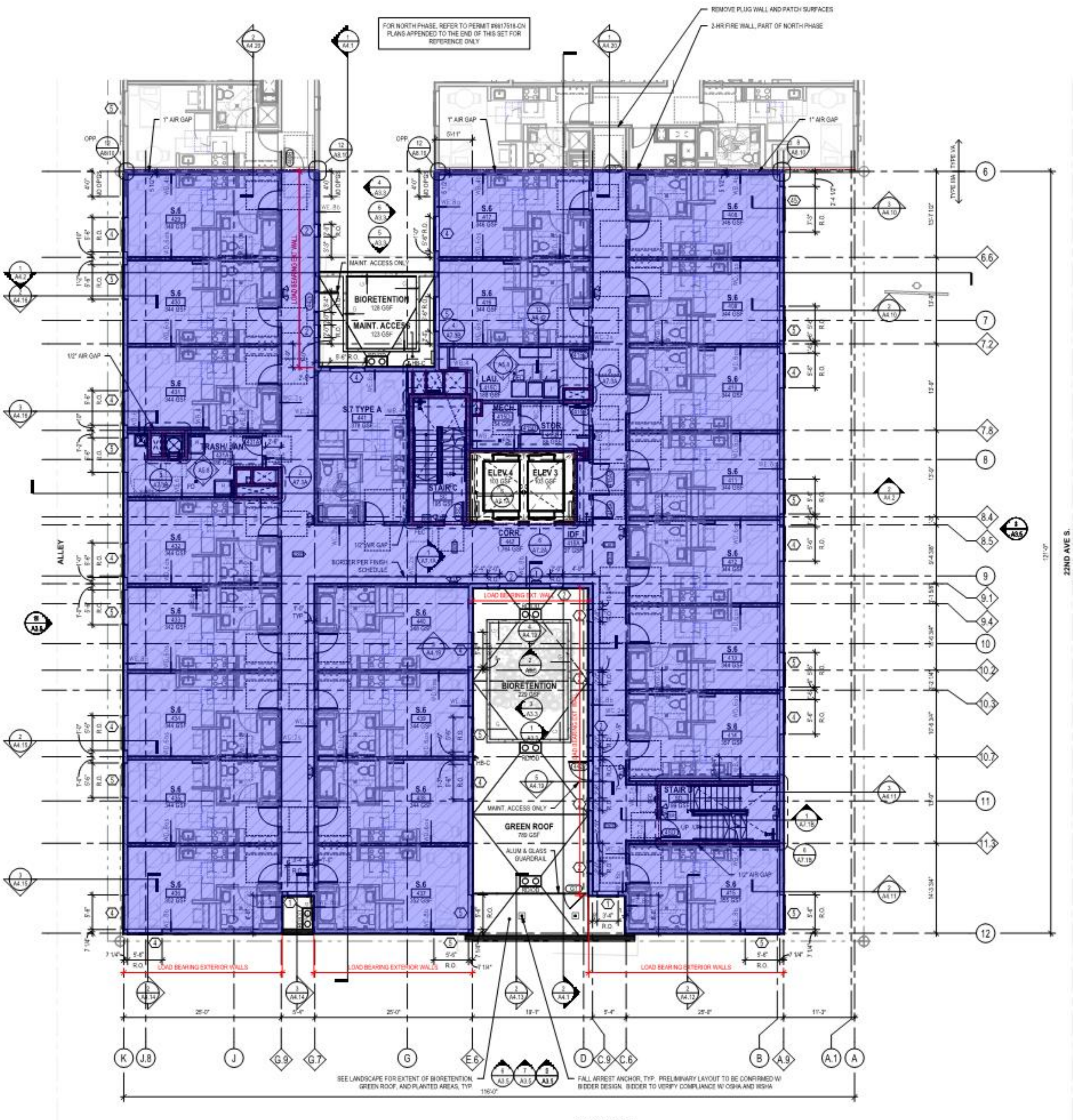
Appendix A - Floor Plan Area Diagrams



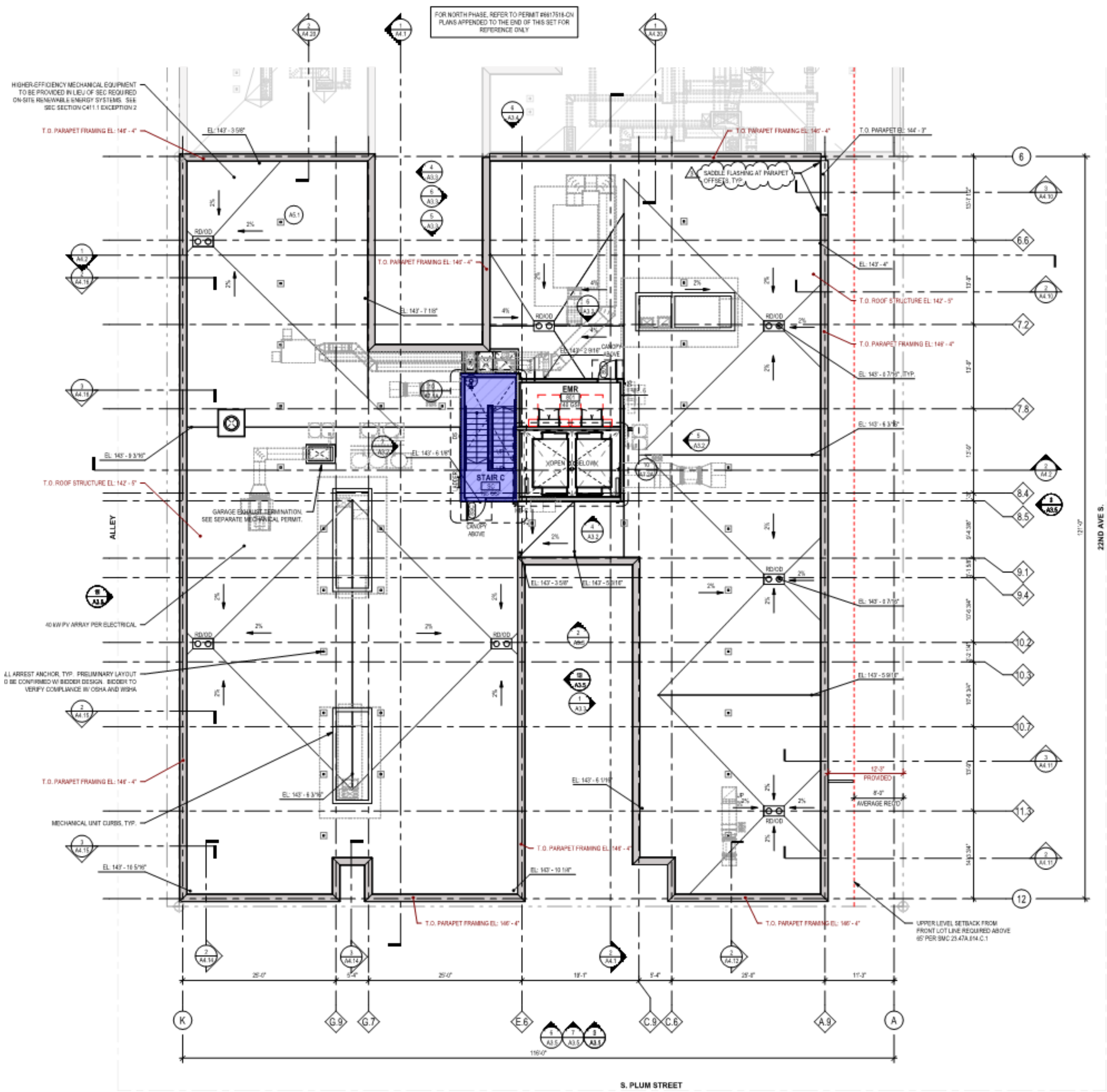
LEVEL 1 – FLOOR PLAN



LEVEL 2 & 3 – FLOOR PLAN



LEVEL 4~7 – FLOOR PLAN



ROOF PLAN

Appendix B - Heat Pump Hot Water Model

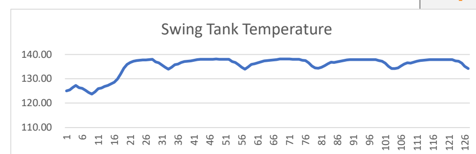
The following page provides a snapshot of the hourly model developed for the central electric (resistance and/or heat pump) hot water plant. The complete spreadsheet can be provided upon request. The primary output of the model is monthly/annual hot water heating electricity and recirculation pump energy.

INPUTS		
# Apartments	92	
# Occupants	92	people
Res. Unit Floor Area	25,380	ft2
Daily Apt DHW Use	20.3	gal/per/day
Annual Apt DHW Use	792,488	gal/yr
Annual Laundry DHW U	19,428	gal/yr
Total Annual DHW	811,916	gal/yr
Service Hot Water Temp	120.0	° F
Municipal Water Temps	BAHSP Pred Water Temp	
Average CW Temp	59.4	
Useful DHW Energy	408,607	kBtu/yr
Conversion	8.313	lbm/gal @ 85° F
Specific Heat	0.998	Btu/lbm-° F
Simulation Interval	60	minutes
Simulation Steps	8760	

Distribution System		
Distribution Option	Proposed	
Distribution Heat Loss	13,415	Btu/hr
Building Temp	70	° F
Circulation Rate	10	gpm
Normalized Heat Loss	42.72	W/unit
Heat Loss/SF For Model	0.15	Btu/ft2/hr
Annual Heat Lost	117,513	kBtu/yr
	34,441	kWh/yr

Circulation Pump		
Flow rate	10.5	gpm
Head rise	40	ft
Pump Input Power	446	W
Motor Efficiency	80%	
Pump Efficiency	66%	
Annual Pumping Energy	13,331	kBtu/yr
	3,907	kWh/yr

Swing Tank		
Tank Volume	320	gal
Tank UA	10	Btu/hr-F
Heater sizing ratio	1.5	
Heating Capacity	20.1	kBtu/h
Heating Efficiency	98%	
Setpoint Temp	120	° F
Deadband	8	° F
Start Temp	125	° F
Annual Heat Loss	5,856	kBtu/yr
Annual Backup Htg	-	kBtu/yr
	-	kWh/yr



Main Riser		
Distribution	Proposed	
Heat Loss	357	Btu/hr
Annual Heat Loss	3,130	kBtu/yr
Heat Trace		
Heat Trace Capacity	0	Btu/hr
Setpoint Temp	135	° F
Annual Heating Energy	-	kBtu/yr
	-	kWh/yr

Stratified Storage Tanks		
Tank Volume	500	gal
Tank Volume	66.8	ft3
Tank Diameter	3.50	ft
Tank Length	6.95	ft
Tank Area (axial)	9.6	ft2
Tank Area (side)	76.4	ft2
Tank Qty	2	
Tank Insulation Rval	16	hr-F/Btu-ft2
Tank UA (axial)	1.2	Btu/hr-F
Tank UA (lateral)	9.5	Btu/hr-F
Start Temperature	140	° F
Room Temp	50	° F
Annual Heat Loss	5,499	kBtu/yr

Heat Pump		
Type	Sanden	
Off Temp	122	° F
On Temp	113	° F
Off CW Level	38%	
On CW Level	50%	
HP Output Temp	140	° F
HP Heat Output	4000	W
Heat Pump Qty	10	
Defrost Cycle		
Cycle On Temp	40.0	° F
Reverse Cycle Time	-	mins/hr
COP Drop	20%	
Annual HP Energy	127,070	kBtu/yr
	37,242	kWh/yr

RESULTS		
Heat to Supply	408,701	kBtu
Heat Loss	131,998	kBtu
Heat Pump Output	533,662	kBtu
Heat Pump Input	37,242	kWh
Heat Pump COP	4.20	
Heat Pump Run Hours	3,906	FLH
Backup Heater Output	-	kBtu
Backup Heater Input	-	kWh
Swing T Heater Output	-	kBtu
Swing T Heater Input	-	kWh
System Output	533,662	kBtu
System Input	37,242	kWh
System COP	4.20	(incl. HPs and back-up, but excl other)
Pump Energy	3,907	kWh
Fan Power	-	kWh
Total Electric Energy	41,149	kWh
Total System COP	3.80	(incl. pumps, fans, etc)

Time				Environment		Demand (at delivered DHW temp)			Distribution System					
Month	Day	Hour	Day Type	Condenser Air Temp	MU H2O Temp	Total Demand Flow	Total Demand Volume	Useful DHW Energy	Swing Tank Temp	Building Supply Temp	Return H2O Temp	Circulation Heat Loss	Circulation Pump Energy	Circulation Pump Gains
				° F	° F	gpm	gal	kBtu	° F	° F	° F	Btu	kWh	Btu
1	1	1	8	37.4	54.3	1.45	86.78	47.29	125.00	120.0	117.5	13,415	0.446	803.5
1	1	2	8	35.6	54.3	1.68	100.72	54.88	125.33	120.0	117.5	13,415	0.446	803.5
1	1	3	8	35.6	54.3	1.57	94.16	51.31	126.49	120.0	117.5	13,415	0.446	803.5
1	1	4	8	33.8	54.3	1.16	69.32	37.77	127.19	120.0	117.5	13,415	0.446	803.5
1	1	5	8	33.8	54.3	1.30	78.05	42.53	126.36	120.0	117.5	13,415	0.446	803.5
1	1	6	8	33.8	54.3	1.19	71.22	38.81	126.06	120.0	117.5	13,415	0.446	803.5
1	1	7	8	35.6	54.3	1.14	68.59	37.38	125.32	120.0	117.5	13,415	0.446	803.5
1	1	8	8	35.6	54.3	1.21	72.84	39.69	124.40	120.0	117.5	13,415	0.446	803.5
1	1	9	8	35.6	54.3	1.65	99.22	54.07	123.70	120.0	117.5	13,415	0.446	803.5
1	1	10	8	35.6	54.3	1.74	104.29	56.83	124.64	120.0	117.5	13,415	0.446	803.5
1	1	11	8	37.4	54.3	1.50	90.13	49.11	125.88	120.0	117.5	13,415	0.446	803.5
1	1	12	8	39.2	54.3	1.59	95.33	51.95	126.24	120.0	117.5	13,415	0.446	803.5
1	1	13	8	41.0	54.3	1.53	91.71	49.97	126.88	120.0	117.5	13,415	0.446	803.5
1	1	14	8	39.2	54.3	1.59	95.65	52.12	127.25	120.0	117.5	13,415	0.446	803.5
1	1	15	8	37.4	54.3	1.57	94.16	51.31	127.92	120.0	117.5	13,415	0.446	803.5
1	1	16	8	33.8	54.3	1.77	106.10	57.81	128.53	120.0	117.5	13,415	0.446	803.5
1	1	17	8	33.8	54.3	1.99	119.22	64.96	129.84	120.0	117.5	13,415	0.446	803.5
1	1	18	8	33.8	54.3	2.11	126.78	69.08	131.89	120.0	117.5	13,415	0.446	803.5
1	1	19	8	33.8	54.3	2.08	124.51	67.85	134.32	120.0	117.5	13,415	0.446	803.5
1	1	20	8	33.8	54.3	1.77	106.05	57.79	135.84	120.0	117.5	13,415	0.446	803.5
1	1	21	8	33.8	54.3	1.69	101.39	55.25	136.63	120.0	117.5	13,415	0.446	803.5
1	1	22	8	33.8	54.3	1.63	97.82	53.30	137.14	120.0	117.5	13,415	0.446	803.5
1	1	23	8	33.8	54.3	1.76	105.74	57.62	137.45	120.0	117.5	13,415	0.446	803.5
1	1	24	8	33.8	54.3	1.77	106.01	57.77	137.66	120.0	117.5	13,415	0.446	803.5
1	2	1	6	33.8	54.3	1.45	86.78	47.29	137.75	120.0	117.5	13,415	0.446	803.5
1	2	2	6	33.8	54.3	1.68	100.72	54.88	137.79	120.0	117.5	13,415	0.446	803.5
1	2	3	6	33.8	54.3	1.57	94.16	51.31	137.91	120.0	117.5	13,415	0.446	803.5
1	2	4	6	33.8	54.3	1.16	69.32	37.77	137.95	120.0	117.5	13,415	0.446	803.5
1	2	5	6	33.8	54.3	1.30	78.05	42.53	136.99	120.0	117.5	13,415	0.446	803.5
1	2	6	6	33.8	54.3	1.19	71.22	38.81	136.52	120.0	117.5	13,415	0.446	803.5
1	2	7	6	33.8	54.3	1.14	68.59	37.38	135.68	120.0	117.5	13,415	0.446	803.5
1	2	8	6	33.8	54.3	1.21	72.84	39.69	134.69	120.0	117.5	13,415	0.446	803.5
1	2	9	6	32.0	54.3	1.65	99.22	54.07	133.95	120.0	117.5	13,415	0.446	803.5
1	2	10	6	33.8	54.3	1.74	104.29	56.83	134.76	120.0	117.5	13,415	0.446	803.5
1	2	11	6	35.6	54.3	1.50	90.13	49.11	135.76	120.0	117.5	13,415	0.446	803.5
1	2	12	6	39.2	54.3	1.59	95.33	51.95	136.04	120.0	117.5	13,415	0.446	803.5
1	2	13	6	38.5	54.3	1.53	91.71	49.97	136.64	120.0	117.5	13,415	0.446	803.5
1	2	14	6	37.4	54.3	1.59	95.65	52.12	137.02	120.0	117.5	13,415	0.446	803.5
1	2	15	6	37.4	54.3	1.57	94.16	51.31	137.27	120.0	117.5	13,415	0.446	803.5
1	2	16	6	37.4	54.3	1.77	106.10	57.81	137.39	120.0	117.5	13,415	0.446	803.5
1	2	17	6	37.4	54.3	1.99	119.22	64.96	137.60	120.0	117.5	13,415	0.446	803.5
1	2	18	6	37.4	54.3	2.11	126.78	69.08	137.83	120.0	117.5	13,415	0.446	803.5
1	2	19	6	37.4	54.3	2.08	124.51	67.85	138.01	120.0	117.5	13,415	0.446	803.5
1	2	20	6	35.6	54.3	1.77	106.05	57.79	138.05	120.0	117.5	13,415	0.446	803.5
1	2	21	6	37.4	54.3	1.69	101.39	55.25	137.98	120.0	117.5	13,415	0.446	803.5
1	2	22	6	37.4	54.3	1.63	97.82	53.30	137.99	120.0	117.5	13,415	0.446	803.5
1	2	23	6	35.6	54.3	1.76	105.74	57.62	138.03	120.0	117.5	13,415	0.446	803.5
1	2	24	6	37.4	54.3	1.77	106.01	57.77	138.09	120.0	117.5	13,415	0.446	803.5
1	3	1	7	35.6	54.3	1.45	86.78	47.29	138.12	120.0	117.5	13,415	0.446	803.5
1	3	2	7	37.4	54.3	1.68	100.72	54.88	138.03	120.0	117.5	13,415	0.446	803.5
1	3	3	7	37.4	54.3	1.57	94.16	51.31	137.97	120.0	117.5	13,415	0.446	803.5
1	3	4	7	37.4	54.3	1.16	69.32	37.77	137.97	120.0	117.5	13,415	0.446	803.5
1	3	5	7	37.4	54.3	1.30	78.05	42.53	137.03	120.0	117.5	13,415	0.446	803.5
1	3	6	7	35.6	54.3	1.19	71.22	38.81	136.62	120.0	117.5	13,415	0.446	803.5
1	3	7	7	33.8	54.3	1.14	68.59	37.38	135.76	120.0	117.5	13,415	0.446	803.5
1	3	8	7	33.8	54.3	1.21	72.84	39.69	134.72	120.0	117.5	13,415	0.446	803.5
1	3	9	7	32.0	54.3	1.65	99.22	54.07	133.98	120.0	117.5	13,415	0.446	803.5
1	3	10	7	30.2	54.3	1.74	104.29	56.83	134.83	120.0	117.5	13,415	0.446	803.5
1	3	11	7	30.2	54.3	1.50	90.13	49.11	135.89	120.0	117.5	13,415	0.446	803.5
1	3	12	7	30.2	54.3	1.59	95.33	51.95	136.14	120.0	117.5	13,415	0.446	803.5
1	3	13	7	30.2	54.3	1.53	91.71	49.97	136.59	120.0	117.5	13,415	0.446	803.5
1	3	14	7	30.2	54.3	1.59	95.65	52.12	136.96	120.0	117.5	13,415	0.446	803.5
1	3	15	7	30.2	54.3	1.57	94.16	51.31	137.28	120.0	117.5	13,415	0.446	803.5
1	3	16	7	28.4	54.3	1.77	106.10	57.81	137.48	120.0	117.5	13,415	0.446	803.5
1	3	17	7	28.4	54.3	1.99	119.22	64.96	137.64	120.0	117.5	13,415	0.446	803.5
1	3	18	7	28.4	54.3	2.11	126.78	69.08	137.73	120.0	117.5	13,415	0.446	803.5
1	3	19	7	26.6	54.3	2.08	124.51	67.85	137.91	120.0	117.5	13,415	0.446	803.5
1	3	20	7	26.6	54.3	1.77	106.05	57.79	138.06	120.0	117.5	13,415	0.446	803.5
1	3	21	7	26.6	54.3	1.69	101.39	55.25	138.11	120.0	117.5	13,415	0.446	803.5
1	3	22	7	26.6	54.3	1.63	97.82	53.30	138.11	120.0	117.5	13,415	0.446	803.5
1	3	23	7	26.6	54.3	1.76	105.74	57.62	138.06	120.0	117.5	13,415	0.446	803.5
1	3	24	7	26.6	54.3	1.77	106.01	57.77	138.00	120.0	117.5	13,415	0.446	803.5

		Distribution System							Main Riser			Stratified Storage Tank					
Day	Hour	Swing Tank Heat Loss	Swing tank Backup Heat	Return to Swing Tank Volume	Recirculate Volume	Swing Tank Draw Volume	Prim. Tank Draw Volume	MU H2O Volume	Pipe Loss	Heat Trace Energy	H2O Temp Through Main Riser	Storage Tank Cold H2O Temp	Storage Tank Cold H2O Temp	Storage Tank Heat Loss (Hot)	Storage Tank Heat Loss (Cold)	Storage Tank Cold H2O Level	Target Cold H2O Level
		Btu	Btu	gal	gal	gal	gal	gal	Btu	Btu	° F	° F	° F	Btu	Btu	%	%
1	1	550.0	-	144.1	455.9	230.9	86.8	-	357.35	-	139.5	140.0	54.3	641.1	21.0	38%	50%
1	2	553.3	-	124.9	475.1	225.6	100.7	0.0	357.35	-	139.4	139.9	54.3	569.4	24.4	46%	50%
1	3	564.9	-	100.7	499.3	194.8	94.2	0.0	357.35	-	139.2	139.7	54.3	486.5	28.3	56%	38%
1	4	571.9	-	105.0	495.0	174.3	69.3	(0.0)	357.35	-	139.1	139.7	54.3	566.1	24.4	47%	38%
1	5	563.6	-	115.1	484.9	193.1	78.0	-	357.35	-	139.1	139.7	54.3	635.0	21.0	38%	38%
1	6	560.6	-	126.7	473.3	197.9	71.2	-	357.35	-	139.0	139.6	54.3	637.9	20.8	38%	38%
1	7	553.2	-	147.0	453.0	215.6	68.6	-	357.35	-	138.8	139.4	54.3	579.2	23.6	45%	50%
1	8	544.0	-	173.0	427.0	245.8	72.8	0.0	357.35	-	138.7	139.3	54.3	522.7	26.3	51%	38%
1	9	537.0	-	184.7	415.3	284.0	99.2	-	357.35	-	139.0	139.4	54.3	620.0	21.6	40%	38%
1	10	546.4	-	144.4	455.6	248.7	104.3	-	357.35	-	139.0	139.4	54.3	636.0	20.8	38%	38%
1	11	558.8	-	117.7	482.3	207.9	90.1	-	357.35	-	138.9	139.4	54.3	636.7	20.7	38%	38%
1	12	562.4	-	105.4	494.6	200.7	95.3	-	357.35	-	138.8	139.2	54.3	562.7	24.2	47%	50%
1	13	568.8	-	94.4	505.6	186.1	91.7	-	357.35	-	138.6	139.1	54.3	484.8	28.0	56%	38%
1	14	572.5	-	84.4	515.6	180.1	95.6	-	357.35	-	138.9	139.3	54.3	567.2	24.0	46%	38%
1	15	579.2	-	74.0	526.0	168.2	94.2	-	357.35	-	138.9	139.4	54.3	633.2	20.8	38%	38%
1	16	585.3	-	55.6	544.4	161.7	106.1	0.0	357.35	-	139.0	139.4	54.3	636.4	20.7	38%	38%
1	17	598.4	-	28.0	572.0	147.2	119.2	-	357.35	-	138.9	139.2	54.3	549.5	24.8	48%	50%
1	18	618.9	-	0.8	599.2	127.6	126.8	-	357.35	-	138.7	139.0	54.3	452.3	29.5	59%	38%
1	19	643.2	-	-	600.0	121.2	121.2	3.3	357.35	-	139.0	139.3	54.3	506.5	26.9	53%	38%
1	20	658.4	-	-	600.0	104.1	104.1	2.0	357.35	-	139.0	139.4	54.3	564.6	24.1	46%	38%
1	21	666.3	-	-	600.0	99.4	99.4	2.0	357.35	-	139.1	139.5	54.3	633.9	20.8	38%	38%
1	22	671.4	-	-	600.0	95.9	95.9	1.9	357.35	-	139.0	139.5	54.3	637.1	20.6	38%	38%
1	23	674.5	-	-	600.0	101.8	101.8	3.9	357.35	-	138.9	139.3	54.3	558.4	24.4	47%	50%
1	24	676.6	-	-	600.0	101.8	101.8	4.2	357.35	-	138.7	139.2	54.3	475.1	28.4	57%	38%
2	1	677.5	-	-	600.0	86.5	86.5	0.2	357.35	-	138.9	139.4	54.3	549.3	24.8	48%	38%
2	2	677.9	-	-	600.0	97.5	97.5	3.3	357.35	-	139.0	139.4	54.3	632.7	20.8	39%	38%
2	3	679.1	-	-	600.0	92.2	92.2	2.0	357.35	-	138.9	139.4	54.3	636.7	20.6	38%	38%
2	4	679.5	-	13.4	586.6	82.8	69.3	-	357.35	-	138.7	139.3	54.3	561.1	24.2	47%	50%
2	5	669.9	-	9.9	590.1	88.0	78.0	-	357.35	-	138.6	139.1	54.3	504.2	26.9	53%	38%
2	6	665.2	-	18.0	582.0	89.2	71.2	-	357.35	-	138.7	139.3	54.3	597.5	22.5	43%	38%
2	7	656.8	-	24.4	575.6	93.0	68.6	(0.0)	357.35	-	138.7	139.3	54.3	634.3	20.7	38%	38%
2	8	646.9	-	26.1	573.9	98.9	72.8	0.0	357.35	-	138.7	139.3	54.3	635.8	20.5	38%	38%
2	9	639.5	-	8.2	591.8	107.4	99.2	-	357.35	-	138.7	139.1	54.3	576.0	23.4	45%	50%
2	10	647.6	-	-	600.0	104.0	104.0	0.2	357.35	-	138.6	139.0	54.3	495.0	27.3	54%	38%
2	11	657.6	-	5.4	594.6	95.6	90.1	-	357.35	-	138.8	139.2	54.3	567.5	23.8	46%	38%
2	12	660.4	-	-	600.0	95.2	95.2	0.1	357.35	-	138.9	139.3	54.3	632.9	20.7	38%	38%
2	13	666.4	-	-	600.0	91.6	91.6	0.1	357.35	-	138.8	139.3	54.2	636.0	20.5	38%	38%
2	14	670.2	-	-	600.0	94.3	94.3	1.3	357.35	-	138.7	139.2	54.3	560.9	24.1	47%	50%
2	15	672.7	-	-	600.0	92.9	92.9	1.3	357.35	-	138.6	139.0	54.3	483.9	27.8	56%	38%
2	16	673.9	-	-	600.0	102.2	102.2	3.9	357.35	-	138.8	139.3	54.3	565.4	24.0	46%	38%
2	17	676.0	-	-	600.0	112.3	112.3	6.9	357.35	-	139.0	139.4	54.3	633.0	20.7	38%	38%
2	18	678.3	-	-	600.0	117.9	117.9	8.9	357.35	-	139.0	139.4	54.2	636.4	20.5	38%	38%
2	19	680.1	-	-	600.0	115.9	115.9	8.6	357.35	-	138.8	139.2	54.3	539.9	25.2	49%	50%
2	20	680.5	-	-	600.0	101.3	101.3	4.7	357.35	-	138.6	139.0	54.3	445.4	29.7	60%	38%
2	21	679.8	-	-	600.0	97.8	97.8	3.6	357.35	-	138.9	139.3	54.3	520.2	26.2	52%	38%
2	22	679.9	-	-	600.0	94.9	94.9	2.9	357.35	-	139.0	139.4	54.3	597.3	22.5	43%	38%
2	23	680.3	-	-	600.0	101.1	101.1	4.6	357.35	-	139.0	139.4	54.3	635.1	20.6	38%	38%
2	24	680.9	-	-	600.0	101.3	101.3	4.7	357.35	-	139.0	139.4	54.2	636.8	20.5	38%	38%
3	1	681.2	-	-	600.0	86.2	86.2	0.6	357.35	-	138.8	139.3	54.3	553.8	24.5	48%	50%
3	2	680.3	-	-	600.0	97.2	97.2	3.5	357.35	-	138.7	139.1	54.3	483.3	27.9	56%	38%
3	3	679.7	-	-	600.0	92.1	92.1	2.1	357.35	-	138.9	139.3	54.3	561.2	24.2	47%	38%
3	4	679.7	-	13.4	586.6	82.7	69.3	-	357.35	-	138.8	139.4	54.3	633.1	20.7	38%	38%
3	5	670.3	-	9.7	590.3	87.8	78.0	-	357.35	-	138.8	139.4	54.2	636.3	20.5	38%	38%
3	6	666.2	-	17.5	582.5	88.8	71.2	-	357.35	-	138.6	139.2	54.3	572.2	23.6	45%	50%
3	7	657.6	-	24.0	576.0	92.6	68.6	-	357.35	-	138.4	139.1	54.3	513.8	26.4	52%	38%
3	8	647.2	-	25.9	574.1	98.8	72.8	-	357.35	-	138.7	139.3	54.3	614.8	21.6	40%	38%
3	9	639.8	-	8.0	592.0	107.3	99.2	-	357.35	-	138.8	139.3	54.2	634.8	20.6	38%	38%
3	10	648.3	-	-	600.0	104.0	104.0	0.3	357.35	-	138.8	139.3	54.2	635.7	20.5	38%	38%
3	11	658.9	-	4.8	595.2	94.9	90.1	-	357.35	-	138.6	139.1	54.3	550.7	24.6	48%	50%
3	12	661.4	-	-	600.0	95.1	95.1	0.2	357.35	-	138.5	139.0	54.3	477.1	28.1	56%	38%
3	13	665.9	-	-	600.0	91.7	91.7	0.0	357.35	-	138.8	139.2	54.3	556.9	24.3	47%	38%
3	14	669.6	-	-	600.0	94.4	94.4	1.2	357.35	-	138.9	139.3	54.3	632.4	20.7	38%	38%
3	15	672.8	-	-	600.0	92.9	92.9	1.3	357.35	-	138.9	139.3	54.2	636.1	20.5	38%	38%
3	16	674.8	-	-	600.0	102.1	102.1	4.0	357.35	-	138.8	139.2	54.3	560.0	24.2	47%	50%
3	17	676.4	-	-	600.0	112.2	112.2	7.0	357.35	-	138.6	139.0	54.3	476.6	28.2	57%	38%
3	18	677.3	-	-	600.0	118.0	118.0	8.7	357.35	-	138.9	139.3	54.3	542.6	25.0	49%	38%
3	19	679.1	-	-	600.0	116.0	116.0	8.5	357.35	-	139.0	139.4	54.3	603.3	22.1	42%	38%
3	20	680.6	-	-	600.0	101.3	101.3	4.7	357.35	-	139.0	139.4	54.2	635.4	20.6	38%	38%
3	21	681.1	-	-	600.0	97.6	97.6	3.8	357.35	-	139.0	139.4	54.2	636.8	20.5	38%	38%
3	22	681.1	-	-	600.0	94.8	94.8	3.0	357.35	-	138.8	139.3	54.3	556.7	24.3	47%	50%
3	23	680.6	-	-	600.0	101.1	101.1	4.7	357.35	-	138.7	139.1	54.3	479.2	28.0	56%	38%
3	24	680.0	-	-	600.0	101.4	101.4	4.6	357.35	-	138.9	139.3	54.3	554.0	24.5	48%	38%

		Stratified Storage Tank						Heat Pump						
Day	Hour	HP On?	MU H2O to Tank Volume	MU H2O to HP Volume	Tank Cold H2O to HP Volume	H2O to HP Temp	Hot H2O Needed to Target	HP Flow Capacity	Hot H2O from HP Volume	Heating Demand	Defrost Cycle On?	HP COP	HP Run Fraction	HP Power
		0/1	gal	gal	gal	° F	gal	gal	gal	kBtu	0/1		ratio	kWh
1	1	0	86.8	-	-	0.0	-	-	-	-	1	-	0%	-
1	2	0	100.7	-	-	0.0	-	-	-	-	1	-	0%	-
1	3	1	0.0	94.2	97.9	54.3	272.1	192.0	192.0	136.5	1	3.1	100%	12.9
1	4	1	0.0	69.3	85.1	54.3	154.4	192.0	154.4	109.8	1	3.1	80%	10.5
1	5	1	0.0	78.0	4.3	54.3	82.4	192.0	82.4	58.6	1	3.1	43%	5.6
1	6	0	71.2	-	-	0.0	-	-	-	-	1	-	0%	-
1	7	0	68.6	-	-	0.0	-	-	-	-	1	-	0%	-
1	8	1	0.0	72.8	119.2	54.3	205.8	192.0	192.0	136.6	1	3.1	100%	12.9
1	9	1	0.0	99.2	19.8	54.3	119.0	192.0	119.0	84.6	1	3.1	62%	8.0
1	10	1	0.0	104.3	1.0	54.3	105.3	192.0	105.3	74.9	1	3.1	55%	7.1
1	11	0	90.1	-	-	0.0	-	-	-	-	1	-	0%	-
1	12	0	95.3	-	-	0.0	-	-	-	-	1	-	0%	-
1	13	1	0.0	91.7	100.3	54.3	267.8	192.0	192.0	136.6	0	4.0	100%	9.9
1	14	1	0.0	95.6	80.9	54.3	176.5	192.0	176.5	125.5	1	3.2	92%	11.5
1	15	1	0.0	94.2	4.1	54.3	98.3	192.0	98.3	69.9	1	3.1	51%	6.5
1	16	0	106.1	-	-	0.0	-	-	-	-	1	-	0%	-
1	17	0	119.2	-	-	0.0	-	-	-	-	1	-	0%	-
1	18	1	0.0	126.8	65.3	54.3	340.9	192.0	192.0	136.5	1	3.1	100%	13.1
1	19	1	0.0	121.2	70.8	54.3	273.4	192.0	192.0	136.6	1	3.1	100%	13.1
1	20	1	0.0	104.1	84.9	54.3	189.0	192.0	189.0	134.4	1	3.1	98%	12.9
1	21	1	0.0	99.4	4.3	54.3	103.7	192.0	103.7	73.7	1	3.1	54%	7.1
1	22	0	95.9	-	-	0.0	-	-	-	-	1	-	0%	-
1	23	0	101.8	-	-	0.0	-	-	-	-	1	-	0%	-
1	24	1	0.0	101.8	90.3	54.3	289.7	192.0	192.0	136.6	1	3.1	100%	13.1
2	1	1	0.0	86.5	102.3	54.3	188.8	192.0	188.8	134.3	1	3.1	98%	12.9
2	2	1	0.0	97.5	5.2	54.3	102.6	192.0	102.6	73.0	1	3.1	53%	7.0
2	3	0	92.2	-	-	0.0	-	-	-	-	1	-	0%	-
2	4	0	69.3	-	-	0.0	-	-	-	-	1	-	0%	-
2	5	1	0.0	78.0	114.0	54.3	231.6	192.0	192.0	136.6	1	3.1	100%	13.1
2	6	1	0.0	71.2	45.3	54.3	116.6	192.0	116.6	82.9	1	3.1	61%	8.0
2	7	1	0.0	68.6	2.3	54.3	70.9	192.0	70.9	50.4	1	3.1	37%	4.8
2	8	0	72.8	-	-	0.0	-	-	-	-	1	-	0%	-
2	9	0	99.2	-	-	0.0	-	-	-	-	1	-	0%	-
2	10	1	0.0	104.0	88.0	54.3	267.5	192.0	192.0	136.6	1	3.1	100%	13.1
2	11	1	0.0	90.1	79.9	54.3	170.0	192.0	170.0	120.9	1	3.1	89%	11.4
2	12	1	0.0	95.2	4.1	54.3	99.3	192.0	99.3	70.6	1	3.2	52%	6.5
2	13	0	91.6	-	-	0.0	-	-	-	-	1	-	0%	-
2	14	0	94.3	-	-	0.0	-	-	-	-	1	-	0%	-
2	15	1	0.0	92.9	99.2	54.3	269.6	192.0	192.0	136.6	1	3.1	100%	12.7
2	16	1	0.0	102.2	82.6	54.3	184.8	192.0	184.8	131.4	1	3.1	96%	12.2
2	17	1	0.0	112.3	4.2	54.3	116.5	192.0	116.5	82.8	1	3.1	61%	7.7
2	18	0	117.9	-	-	0.0	-	-	-	-	1	-	0%	-
2	19	0	115.9	-	-	0.0	-	-	-	-	1	-	0%	-
2	20	1	0.0	101.3	90.7	54.3	323.5	192.0	192.0	136.6	1	3.1	100%	12.9
2	21	1	0.0	97.8	94.3	54.3	233.8	192.0	192.0	136.6	1	3.1	100%	12.7
2	22	1	0.0	94.9	46.5	54.3	141.5	192.0	141.5	100.6	1	3.1	74%	9.4
2	23	1	0.0	101.1	2.4	54.3	103.5	192.0	103.5	73.6	1	3.1	54%	6.9
2	24	0	101.3	-	-	0.0	-	-	-	-	1	-	0%	-
3	1	0	86.2	-	-	0.0	-	-	-	-	1	-	0%	-
3	2	1	0.0	97.2	94.9	54.3	275.2	192.0	192.0	136.6	1	3.1	100%	12.7
3	3	1	0.0	92.1	88.0	54.3	180.1	192.0	180.1	128.1	1	3.1	94%	11.9
3	4	1	0.0	69.3	4.5	54.3	73.8	192.0	73.8	52.5	1	3.1	38%	4.9
3	5	0	78.0	-	-	0.0	-	-	-	-	1	-	0%	-
3	6	0	71.2	-	-	0.0	-	-	-	-	1	-	0%	-
3	7	1	0.0	68.6	123.4	54.3	210.5	192.0	192.0	136.6	1	3.1	100%	13.1
3	8	1	0.0	72.8	24.7	54.3	97.6	192.0	97.6	69.4	1	3.1	51%	6.7
3	9	1	0.0	99.2	1.3	54.3	100.5	192.0	100.5	71.4	1	3.0	52%	7.0
3	10	0	104.0	-	-	0.0	-	-	-	-	1	-	0%	-
3	11	0	90.1	-	-	0.0	-	-	-	-	1	-	0%	-
3	12	1	0.0	95.1	96.9	54.3	279.4	192.0	192.0	136.6	1	3.0	100%	13.6
3	13	1	0.0	91.7	92.3	54.3	184.0	192.0	184.0	130.8	1	3.0	96%	13.0
3	14	1	0.0	94.4	4.7	54.3	99.1	192.0	99.1	70.4	1	3.0	52%	7.0
3	15	0	92.9	-	-	0.0	-	-	-	-	1	-	0%	-
3	16	0	102.1	-	-	0.0	-	-	-	-	1	-	0%	-
3	17	1	0.0	112.2	79.8	54.3	297.5	192.0	192.0	136.6	1	2.9	100%	13.8
3	18	1	0.0	118.0	74.0	54.3	227.5	192.0	192.0	136.6	1	2.9	100%	13.8
3	19	1	0.0	116.0	39.3	54.3	155.3	192.0	155.3	110.4	1	2.8	81%	11.4
3	20	1	0.0	101.3	2.0	54.3	103.3	192.0	103.3	73.4	1	2.8	54%	7.6
3	21	0	97.6	-	-	0.0	-	-	-	-	1	-	0%	-
3	22	0	94.8	-	-	0.0	-	-	-	-	1	-	0%	-
3	23	1	0.0	101.1	91.0	54.3	283.8	192.0	192.0	136.6	1	2.8	100%	14.1
3	24	1	0.0	101.4	90.7	54.3	197.8	192.0	192.0	136.6	1	2.8	100%	14.1

Appendix C - Laundry Energy Calculations

In the laundry energy calculations, 1.5 washer & dryer cycles/apartment/week are assumed for both the proposed and baseline design, based on DESC laundry vendor data obtained for a previous project. Energy consumption and hot water consumption for the proposed and baseline design is based on ACEEE studies.

	Baseline	Proposed
Total Dwelling Units	92	
Total Number of Occupants	92	
Laundry Cycles (cycle/unit/week)	1.5	
Clothes Washer Hot Water Consumption (gallon/cycle)	10.3	2.7
Clothes Washer Energy Consumption (kWh/cycle)	0.15	0.16
Clothes Dryer Energy Consumption (kWh/cycle)	4	3
Total Hot Water Consumption (gallon/year)	74,116	19,428
Total Laundry Energy Consumption (kWh/year)	29,862	22,738

Appendix D - Incremental Cost Estimate Detail

Hobson Place - S

SCL Energy Study Cost Estimating Summary

Date 7/12/2021

$/kWh	# Units	Area (ft2)
0.10	92	46,532

ECM ID	Proposed Case	Baseline Case	Walsh's Cost Estimating Approach Updated 3/19/20	Incremental First Cost Est. ($)	Energy Savings (kwh/year)	Energy Cost Savings ($/year)	Simple Payback (years)	Cost/Unit	Cost/SF	Incremental Maintenance Cost Est. ($/year	Maintenance Cost Notes
A1.0	2x8 wood walls w/ R-30 blow-in batt, as designed	2x6 wood walls w/ R-21 blow-in batt	WCC: Per Magellan Insulation. Value of R-30 as compared to R-21 OB360: This is included in baseline to achieve C406.8	-	-	-		$ -	$ -	$ -	No additional maintenace costs compared to baseline anticpated
	Wood joist roof with rigid insulation above deck, as designed (R-50 overall average)	Same roof structure with code-miniumum (R-38 overall average) rigid insulation above deck	WCC: Per Axiom D7. Value of increase from R-38 average to R-50 average. OB360: This is included in baseline to achieve C406.8	-	-	-		$ -	$ -	$ -	
	Triple-pane vinyl windows, as designed	Double-pane vinyl windows, U-0.24	WCC: Per VPI Windows. Pricing to go from 0.24 to 0.18, per Budget Control log 8-29-20 and DD phase estimate.	52,750	15,039	1,504	35	$ 573	$ 1.13	$ -	
A2.0	Passive House air leakage target (0.08 cfm/ft2 at 75 Pascals)	Building envelope air leakage = 0.25 cfm/ft2 at 75 Pascals*	WCC: Used WCC Passive House Sealant Upgrades, per analysis provided to owner 10-4-19.	80,783	2,386	239	339	$ 878	$ 1.74	$ -	No additional maintenace costs compared to baseline anticpated
E.1.0	All LED lighting fixtures, proposed design lighting power and controls	All LED lighting fixtures, 25% lower lighting power* than Table C405.4.2(2) and controls as required by code.	OB360: WCC indicates the cost for achieving the reduce lighting power targets in affordable housing projects is negligible.	-	4,152	415	-	$ -	$ -	$ -	No additional maintenace costs anticpated
E2.0	Energy Star refrigerators	Non-Energy Star refrigerators	OB360: At this given size, GE does not offer a non-Energy Star refrigerator. Whirlpool model WRT112CZJ has similar specifications and is not Energy Star, and the incremental cost in MSRP is $430. A comparable Energy Star Fridgedaire model FFET1222 has an incremental MSRP cost of $250 over the Whirlpool, so this incremental cost has been used assuming the cost for the GE refrigerator can be negotiated down with vendors.	6,900	1,317	132	52	$ 75	$ 0.15	$ -	No additional maintenace costs anticpated
E3.0	Energy Star commercial washers in common laundry rooms	Non-Energy Star commercial washers in common laundry rooms	OB360: DESC leases laundry equipment from an outside vendor, and it is our understanding non-Energy Star commercial laundry appliances are no longer available.	-	15,005	1,500	-	$ -	$ -	$ -	No additional maintenace costs compared to baseline anticpated
M1.0	Passive House ventilation system, as designed. - (3) Swegon rooftop energy recovery ventilators serving dwelling units and corridors. MERV 13 filters - Trunk ducting moved to inside the conditioned space, individual supply/exhaust duct drops to each unit. - Supply register in living area, exhaust register in bathroom and kitchen (grease filter behind kitchen grille) - Recirculating range hoods with carbon filter.	Code-minimum house/corridor ventilation: - AirKing AK-100D (or similar) two speed exhaust fan in each dwelling unit with two trickle vents in window. Venting of exhaust horizontally to exterior (same diameter as proposed exhaust ducts) - (2) Greenheck rooftop air handlers w/ electric heat for corridors. Same corridor supply/return flow rate as proposed, MERV 13 filters. - Kitchen exhaust hood vented horizontally to exterior (no carbon filter)	WCC: Used WCC costs for horizontal ductwork to in-unit bath fan and range hood fans at recent project. See supporting calculations below.	577,879	118,545	11,855	49	$ 6,281	$ 12.42	$ 4,417	See Horiz. Ductwork Analysis + $30/unit/year for recirculating hood filter
M2.0	Apartment heating system, as designed: - King thermostat for electric cove heaters that is wired to window switch that automatically sets back thermostat set point when window is open.	Line-voltage thermostat for electric cove heaters, no window switch.	WCC: $1600 for the switches (VPI). Assume $100/unit for low volt wiring, and $50/unit for upgraded t-stats.	12,200	14,623	1,462	8	$ 133	$ 0.26		No additional maintenace costs compared to baseline anticpated
P1.0	Low-flow plumbing fixtures, as specified	Code-maximum flow plumbing fixtures	OB360: WCC indicates the cost for low-flow fixtures used in most affordable housing is negligible.	-	36,680	3,668	-	$ -	$ -	$ -	No additional maintenace costs compared to baseline anticpated
P2.0	Current proposed DHW/DCW plumbing design: - One riser serving two apartments where it was possible. - Additional pipe insulation, as described by Add Alt in Spec 220700 3.5.A.1	"Typical" residential HW/CW plumbing design: - Same HW/CW distribution design except one HW/CW riser serving every stack of apartments. - Code minimum pipe insulation on HW supply and recirc.	WCC: Per Sunrise Plumbing: ROM for (7) additional stacks ($24,500), plus cost premium for Revised DHW Routing and Increased Insulation Thickness for DHW and DCW system ($55,000).	30,500	14,120	1,412	22	$ 332	$ 0.66	$ -	No additional maintenace costs compared to baseline anticpated
P3.0	DHW heating plant, as designed: - (10) Sanden CO2 heat pumps with 2 – 500 gal storage tanks w/ R-16 insulation - Electric resistance back-up and temperature maintenance tank water heaters.	Electric resistance water heater plant with 2 – 500 gal storage tanks w/ code-minimum (R-12.5) insulation. Assume total electric water heater capacity is the same as the total peak) output of Sanden HPs (45 kW).	WCC: Amount for hypothetical hot water plant with electric water heaters at same capacity as existing design (Sunrise Plumbing), plus $5000 electrical to wire, minus cost of Sanden Heat Pumps ($50,000, per EAI).	73,000	160,924	16,092	5	$ 793	$ 1.57	$ 1,000	Annual maintenance checks and fin cleaning
PV	Proposed PV system, as designed, 40.0 kW	C411.1 required PV system, 4.0 kW	Per NWWS. Cost of code-minimum 4kW system, $30000. Per WCC, proposed PV system is $106,247, including hoisting.	76,247	36,000	3,600	21	$ 829	$ 1.64	$ -	No additional maintenace costs anticpated
			Totals (Not Incl PV)	**$ 834,011**	**$ 382,791**	**$ 38,279**				**$ 5,417**	
			Total (Incl PV)	**$ 910,258**	**$ 418,791**	**$ 41,879**				**$ 5,417**	

Appendix E - eQUEST Output Reports For Each Run

The eQUEST BEPS and BEPU reports are provided for each simulation run except P1.0 and P2.0, which were simulated using a separate model of the central hot water plant. As such, DHW energy is not reported in any of the reports. See Appendix B for model of baseline/proposed DHW energy use.

Baseline

2033_MDL00 DOE-2.2-48z 6/04/2021 10:16:24 BDL RUN 1

REPORT- BEPS Building Energy Performance WEATHER FILE- SEATTLE BOEING FI WA

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
RESI ELECTRICITY MBTU	56.1	0.0	302.3	478.0	0.0	0.0	0.0	124.5	0.0	0.0	0.0	0.0	961.0
HOUS ELECTRICITY MBTU	133.8	0.0	30.8	106.8	3.7	0.0	0.0	35.4	0.0	0.0	0.0	0.0	310.5
EM1 ELECTRICITY MBTU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FM1 NATURAL-GAS MBTU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MBTU	189.9	0.0	333.1	584.8	3.7	0.0	0.0	159.9	0.0	0.0	0.0	0.0	1271.5

```
TOTAL SITE ENERGY      1271.46 MBTU     30.3 KBTU/SQFT-YR GROSS-AREA     30.3 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY    1271.46 MBTU     30.3 KBTU/SQFT-YR GROSS-AREA     30.3 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE =  0.11
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED                =  0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE                =     6
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE                =     4

NOTE:  ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.
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2033_MDL00 DOE-2.2-48z 6/04/2021 10:16:24 BDL RUN 1

REPORT- BEPU Building Utility Performance WEATHER FILE- SEATTLE BOEING FI WA

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
RESI ELECTRICITY KWH	16442.	0.	88565.	140062.	0.	0.	0.	36493.	0.	0.	0.	0.	281562.
HOUS ELECTRICITY KWH	39208.	0.	9032.	31283.	1087.	0.	0.	10365.	0.	0.	0.	0.	90975.
EM1 ELECTRICITY KWH	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
FM1 NATURAL-GAS THERM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

```
TOTAL ELECTRICITY    372537. KWH        8.867 KWH     /SQFT-YR GROSS-AREA    8.867 KWH     /SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE =  0.11
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED                =  0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE                =     6
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE                =     4

NOTE:  ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.
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A1.0 – Triple-pane Windows

2033_MDL00 DOE-2.2-48z 6/04/2021 10:17:05 BDL RUN 3

REPORT- BEPS Building Energy Performance WEATHER FILE- SEATTLE BOEING FI WA

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
RESI ELECTRICITY MBTU	56.1	0.0	302.3	436.6	0.0	0.0	0.0	124.1	0.0	0.0	0.0	0.0	919.1
HOUS ELECTRICITY MBTU	133.8	0.0	30.8	96.7	3.7	0.0	0.0	35.4	0.0	0.0	0.0	0.0	300.4
EM1 ELECTRICITY MBTU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FM1 NATURAL-GAS MBTU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MBTU	189.9	0.0	333.1	533.3	3.7	0.0	0.0	159.5	0.0	0.0	0.0	0.0	1219.5

TOTAL SITE ENERGY 1219.52 MBTU 29.0 KBTU/SQFT-YR GROSS-AREA 29.0 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 1219.52 MBTU 29.0 KBTU/SQFT-YR GROSS-AREA 29.0 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.23
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 8
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 12

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

2033_MDL00 DOE-2.2-48z 6/04/2021 10:17:05 BDL RUN 3

REPORT- BEPU Building Utility Performance WEATHER FILE- SEATTLE BOEING FI WA

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
RESI ELECTRICITY KWH	16442.	0.	88565.	127929.	0.	0.	0.	36365.	0.	0.	0.	0.	269301.
HOUS ELECTRICITY KWH	39208.	0.	9032.	28327.	1087.	0.	0.	10365.	0.	0.	0.	0.	88020.
EM1 ELECTRICITY KWH	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
FM1 NATURAL-GAS THERM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

TOTAL ELECTRICITY 357321. KWH 8.505 KWH /SQFT-YR GROSS-AREA 8.505 KWH /SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.23
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 8
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 12

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

A2.0 – Reduced Air Leakage

2033_MDL00 DOE-2.2-48z 6/04/2021 10:17:38 BDL RUN 4

REPORT- BEPS Building Energy Performance WEATHER FILE- SEATTLE BOEING FI WA

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
RESI ELECTRICITY MBTU	56.1	0.0	302.3	469.7	0.0	0.0	0.0	124.5	0.0	0.0	0.0	0.0	952.6
HOUS ELECTRICITY MBTU	133.8	0.0	30.8	106.9	3.7	0.0	0.0	35.4	0.0	0.0	0.0	0.0	310.6
EM1 ELECTRICITY MBTU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FM1 NATURAL-GAS MBTU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MBTU	189.9	0.0	333.1	576.6	3.7	0.0	0.0	159.8	0.0	0.0	0.0	0.0	1263.2

TOTAL SITE ENERGY 1263.22 MBTU 30.1 KBTU/SQFT-YR GROSS-AREA 30.1 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 1263.22 MBTU 30.1 KBTU/SQFT-YR GROSS-AREA 30.1 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.21
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 6
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 12

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

2033_MDL00 DOE-2.2-48z 6/04/2021 10:17:38 BDL RUN 4

REPORT- BEPU Building Utility Performance WEATHER FILE- SEATTLE BOEING FI WA

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
RESI ELECTRICITY KWH	16442.	0.	88565.	137630.	0.	0.	0.	36467.	0.	0.	0.	0.	279105.
HOUS ELECTRICITY KWH	39208.	0.	9032.	31325.	1087.	0.	0.	10365.	0.	0.	0.	0.	91018.
EM1 ELECTRICITY KWH	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
FM1 NATURAL-GAS THERM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

TOTAL ELECTRICITY 370122. KWH 8.810 KWH /SQFT-YR GROSS-AREA 8.810 KWH /SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.21
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 6
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 12

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

E1.0 – Reduced Interior Lighting Power

2033_MDL00 DOE-2.2-48z 6/04/2021 10:18:09 BDL RUN 5

REPORT- BEPS Building Energy Performance WEATHER FILE- SEATTLE BOEING FI WA

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
RESI ELECTRICITY MBTU	56.1	0.0	302.3	480.5	0.0	0.0	0.0	124.6	0.0	0.0	0.0	0.0	963.5
HOUS ELECTRICITY MBTU	83.3	0.0	30.8	140.8	3.7	0.0	0.0	35.4	0.0	0.0	0.0	0.0	293.9
EM1 ELECTRICITY MBTU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FM1 NATURAL-GAS MBTU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MBTU	139.4	0.0	333.1	621.3	3.7	0.0	0.0	159.9	0.0	0.0	0.0	0.0	1257.4

TOTAL SITE ENERGY 1257.37 MBTU 29.9 KBTU/SQFT-YR GROSS-AREA 29.9 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 1257.37 MBTU 29.9 KBTU/SQFT-YR GROSS-AREA 29.9 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.08
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 5
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 2

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

2033_MDL00 DOE-2.2-48z 6/04/2021 10:18:09 BDL RUN 5

REPORT- BEPU Building Utility Performance WEATHER FILE- SEATTLE BOEING FI WA

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
RESI ELECTRICITY KWH	16442.	0.	88565.	140797.	0.	0.	0.	36501.	0.	0.	0.	0.	282304.
HOUS ELECTRICITY KWH	24393.	0.	9032.	41240.	1077.	0.	0.	10364.	0.	0.	0.	0.	86106.
EM1 ELECTRICITY KWH	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
FM1 NATURAL-GAS THERM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

TOTAL ELECTRICITY 368410. KWH 8.769 KWH /SQFT-YR GROSS-AREA 8.769 KWH /SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.08
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 5
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 2

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

E2.0 – Energy Star Refrigerators

2033_MDL00 DOE-2.2-48z 6/04/2021 10:18:36 BDL RUN 6

REPORT- BEPS Building Energy Performance WEATHER FILE- SEATTLE BOEING FI WA

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
RESI ELECTRICITY MBTU	56.1	0.0	290.6	485.0	0.0	0.0	0.0	124.6	0.0	0.0	0.0	0.0	956.3
HOUS ELECTRICITY MBTU	133.8	0.0	30.8	106.8	3.7	0.0	0.0	35.4	0.0	0.0	0.0	0.0	310.6
EM1 ELECTRICITY MBTU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FM1 NATURAL-GAS MBTU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MBTU	189.9	0.0	321.5	591.8	3.7	0.0	0.0	160.0	0.0	0.0	0.0	0.0	1266.9

TOTAL SITE ENERGY 1266.91 MBTU 30.2 KBTU/SQFT-YR GROSS-AREA 30.2 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 1266.91 MBTU 30.2 KBTU/SQFT-YR GROSS-AREA 30.2 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.11
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 6
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 4

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

2033_MDL00 DOE-2.2-48z 6/04/2021 10:18:36 BDL RUN 6

REPORT- BEPU Building Utility Performance WEATHER FILE- SEATTLE BOEING FI WA

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
RESI ELECTRICITY KWH	16442.	0.	85156.	142093.	0.	0.	0.	36514.	0.	0.	0.	0.	280205.
HOUS ELECTRICITY KWH	39208.	0.	9032.	31307.	1087.	0.	0.	10365.	0.	0.	0.	0.	90999.
EM1 ELECTRICITY KWH	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
FM1 NATURAL-GAS THERM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

TOTAL ELECTRICITY 371204. KWH 8.836 KWH /SQFT-YR GROSS-AREA 8.836 KWH /SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.11
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 6
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 4

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

M1.0 – Energy Recovery Ventilation (ERV) System

2033_MDL00 DOE-2.2-48z 6/04/2021 10:52:20 BDL RUN 10

REPORT- BEPS Building Energy Performance WEATHER FILE- SEATTLE BOEING FI WA

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
RESI ELECTRICITY MBTU	56.1	0.0	302.3	163.4	0.0	0.0	16.1	155.3	0.0	0.0	0.0	0.0	693.2
HOUS ELECTRICITY MBTU	133.8	0.0	30.8	0.5	3.2	0.0	0.0	0.6	0.0	0.0	0.0	0.0	168.9
EM1 ELECTRICITY MBTU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FM1 NATURAL-GAS MBTU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MBTU	189.9	0.0	333.1	163.9	3.2	0.0	16.1	155.9	0.0	0.0	0.0	0.0	862.1

TOTAL SITE ENERGY 862.10 MBTU 20.5 KBTU/SQFT-YR GROSS-AREA 20.5 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 862.10 MBTU 20.5 KBTU/SQFT-YR GROSS-AREA 20.5 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 1.59
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 6
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 133

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

2033_MDL00 DOE-2.2-48z 6/04/2021 10:52:20 BDL RUN 10

REPORT- BEPU Building Utility Performance WEATHER FILE- SEATTLE BOEING FI WA

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
RESI ELECTRICITY KWH	16442.	0.	88565.	47889.	0.	0.	4715.	45498.	0.	0.	0.	0.	203110.
HOUS ELECTRICITY KWH	39208.	0.	9032.	146.	926.	0.	0.	172.	0.	0.	0.	0.	49484.
EM1 ELECTRICITY KWH	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
FM1 NATURAL-GAS THERM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

TOTAL ELECTRICITY 252594. KWH 6.012 KWH /SQFT-YR GROSS-AREA 6.012 KWH /SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 1.59
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 6
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 133

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

M2.0 – Thermostat with Window Switch

2033_MDL00 DOE-2.2-48z 6/04/2021 10:19:08 BDL RUN 7

REPORT- BEPS Building Energy Performance WEATHER FILE- SEATTLE BOEING FI WA

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
RESI ELECTRICITY MBTU	56.1	0.0	302.3	426.0	0.0	0.0	0.0	124.0	0.0	0.0	0.0	0.0	908.3
HOUS ELECTRICITY MBTU	133.8	0.0	30.8	108.9	3.7	0.0	0.0	35.4	0.0	0.0	0.0	0.0	312.6
EM1 ELECTRICITY MBTU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FM1 NATURAL-GAS MBTU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MBTU	189.9	0.0	333.1	534.8	3.7	0.0	0.0	159.4	0.0	0.0	0.0	0.0	1221.0

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TOTAL SITE ENERGY      1220.96 MBTU     29.1 KBTU/SQFT-YR GROSS-AREA     29.1 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY    1220.96 MBTU     29.1 KBTU/SQFT-YR GROSS-AREA     29.1 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE =  3.40
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED                =  0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE                =     6
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE                =   292

NOTE:  ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.
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2033_MDL00 DOE-2.2-48z 6/04/2021 10:19:08 BDL RUN 7

REPORT- BEPU Building Utility Performance WEATHER FILE- SEATTLE BOEING FI WA

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
RESI ELECTRICITY KWH	16442.	0.	88565.	124807.	0.	0.	0.	36333.	0.	0.	0.	0.	266146.
HOUS ELECTRICITY KWH	39208.	0.	9032.	31903.	1087.	0.	0.	10365.	0.	0.	0.	0.	91596.
EM1 ELECTRICITY KWH	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
FM1 NATURAL-GAS THERM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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TOTAL ELECTRICITY    357742. KWH        8.515 KWH     /SQFT-YR GROSS-AREA    8.515 KWH     /SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE =  3.40
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED                =  0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE                =     6
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE                =   292

NOTE:  ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.
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P2.0 – Improved Plumbing Distribution

2033_MDL00 DOE-2.2-48z 6/04/2021 10:19:39 BDL RUN 8

REPORT- BEPS Building Energy Performance WEATHER FILE- SEATTLE BOEING FI WA

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
RESI ELECTRICITY MBTU	56.1	0.0	302.3	535.8	0.0	0.0	0.0	125.2	0.0	0.0	0.0	0.0	1019.3
HOUS ELECTRICITY MBTU	133.8	0.0	30.8	107.2	3.7	0.0	0.0	35.4	0.0	0.0	0.0	0.0	310.9
EM1 ELECTRICITY MBTU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FM1 NATURAL-GAS MBTU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MBTU	189.9	0.0	333.1	643.0	3.7	0.0	0.0	160.5	0.0	0.0	0.0	0.0	1330.2

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TOTAL SITE ENERGY     1330.25 MBTU    31.7 KBTU/SQFT-YR GROSS-AREA    31.7 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY   1330.25 MBTU    31.7 KBTU/SQFT-YR GROSS-AREA    31.7 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE =  0.18
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED                =  0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE                =     6
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE                =    10

NOTE:  ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.
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2033_MDL00 DOE-2.2-48z 6/04/2021 10:19:39 BDL RUN 8

REPORT- BEPU Building Utility Performance WEATHER FILE- SEATTLE BOEING FI WA

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
RESI ELECTRICITY KWH	16442.	0.	88565.	156983.	0.	0.	0.	36671.	0.	0.	0.	0.	298661.
HOUS ELECTRICITY KWH	39208.	0.	9032.	31409.	1087.	0.	0.	10365.	0.	0.	0.	0.	91101.
EM1 ELECTRICITY KWH	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
FM1 NATURAL-GAS THERM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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TOTAL ELECTRICITY    389762. KWH       9.277 KWH    /SQFT-YR GROSS-AREA    9.277 KWH    /SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE =  0.18
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED                =  0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE                =     6
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE                =    10

NOTE:  ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.
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Proposed (All Measures Included)

2033_MDL00 DOE-2.2-48z 6/04/2021 10:52:15 BDL RUN 10

REPORT- BEPS Building Energy Performance WEATHER FILE- SEATTLE BOEING FI WA

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
RESI ELECTRICITY MBTU	56.1	0.0	290.6	19.1	0.0	0.0	16.1	155.3	0.0	0.0	0.0	0.0	537.2
HOUS ELECTRICITY MBTU	83.3	0.0	30.8	0.4	3.1	0.0	0.0	0.6	0.0	0.0	0.0	0.0	118.2
EM1 ELECTRICITY MBTU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FM1 NATURAL-GAS MBTU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MBTU	139.4	0.0	321.5	19.5	3.1	0.0	16.1	155.9	0.0	0.0	0.0	0.0	655.4

TOTAL SITE ENERGY 655.41 MBTU 15.6 KBTU/SQFT-YR GROSS-AREA 15.6 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 655.41 MBTU 15.6 KBTU/SQFT-YR GROSS-AREA 15.6 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 1.62
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 5
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 137

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

2033_MDL00 DOE-2.2-48z 6/04/2021 10:52:15 BDL RUN 10

REPORT- BEPU Building Utility Performance WEATHER FILE- SEATTLE BOEING FI WA

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
RESI ELECTRICITY KWH	16442.	0.	85156.	5585.	0.	0.	4715.	45498.	0.	0.	0.	0.	157396.
HOUS ELECTRICITY KWH	24393.	0.	9032.	126.	918.	0.	0.	170.	0.	0.	0.	0.	34639.
EM1 ELECTRICITY KWH	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
FM1 NATURAL-GAS THERM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

TOTAL ELECTRICITY 192035. KWH 4.571 KWH /SQFT-YR GROSS-AREA 4.571 KWH /SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 1.62
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 5
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 137

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.