Brookfield Properties Community Heat Pump Study: Chiller Plant Optimization

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Brookfield Properties Community Heat Pump Study: Chiller Plant Optimization

Final Report

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Abstract

This report presents the preliminary findings of a Smith Engineering study commissioned by Brookfield Properties and NYSERDA to perform a community heat pump feasibility study at the 250 Vesey St facility in New York, NY.

Keywords

thermal energy network, district energy, heat recovery, electrification, decarbonization, feasibility study, lifecycle cost analysis

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Acronyms and Abbreviations

ΔP	differential pressure
ΔT	differential temperature
$/klbs	dollars per kilo-pounds
%Sp	% speed
°C	degrees Celsius
°F	degrees Fahrenheit
A	amps/area
AAV	automatic air vent
ABV CLG	above finished ceiling
ACU	air conditioning unit
AFF	above finished floor
AHU	air handling unit
AP	access panel
BAS	building automation system
BD	balancing damper
BFF	below finished floor
BMS	burner management system
BTU	British thermal units
BTUH	BTU per hour
BYP	bypass
CAC	control air compressor
CD	ceiling diffuser
CF	cubic feet
CFH	cubic feet per hour
CFM	cubic feet per minute
CHW	chilled water
CHWP	chilled water pump
CHWR	chilled water return
CHWS	chilled water supply
CO_2	carbon dioxide
CO_2e	carbon dioxide emissions

COND	condensate
Cond	condenser
CR	cold room
CU	condensing unit; copper
CV	coefficient of valve
CW	condenser water
CWP	condenser water pump
CWR	condenser water return
CWS	condenser water supply
CWST	condenser water supply temperature
DAT	discharge air temperature
DB	dry-bulb
DDC	direct digital controls
DG	door grille
DIA	diameter
Dmd	demand
Dp	dew point
DP	differential pressure
Dpr	damper
DTW	dual temperature water
DTWR	dual temperature water return
DTWS	dual temperature water supply
EA	each
EAT	entering air temperature
EC	evaporative cooler
EDH	electric duct heater
EF	exhaust fan
Eff	efficiency
EG	exhaust grille
EH	exhaust hood
EMCS	energy management control system
ER	exhaust register
ESP	external static pressure
Evap	evaporator
EWT	entering water temperature
F	flow
FCU	fan coil unit
FD	fire damper
FG	fire grille

FL DR	floor drain
FPM	feet per minute
FT WG	feet of water, gauge
Ft	feet
FTU	fan terminal unit
FW	feed water
G	glycol
GA	gauge
GAL	gallons
GALV	galvanized
GPH	gallons per hour
GPM	gallons per minute
H	enthalpy
H2O	water
HG	hot gas
HHW	heating hot water
HHWP	heating hot water pump
HHWR	heating hot water return
HHWST	heating hot water supply temperature
HP	heat pump; horsepower
HR	hour
HVAC	heating, ventilation, and air conditioning
HW	hot water
HX	heat exchanger
I.D.	inside diameter
IN. WG	inches of water, gauge
In.	inches
klbs	kilo pounds
kW	kilowatt
kW/ton	kilowatt per ton
kWh	kilowatt hour
kWh/ton	kilowatt per ton
LAT	leaving air temperature
LB	pound
LD	linear diffuser
LPS	low-pressure steam
LWT	leaving water temperature
MA	mixed air
MAT	mixed air temperature

MBH	thousand BTUH
MCF	thousands of Cubic Feet
MD	motorized damper
MT	megatons
N.O.	normally open
NC	normally closed
NIC	not in contract
No.	number
NPLV	nominal part load value
NPSHa	net positive suction head available
NPSHr	net positive suction head required
NTS	not to scale
OA	outside air
OAL	outdoor air louver
OAT	outdoor air temperature
OC	on center
OD	outside diameter
PF	power factor
PG	process glycol
PH	phase
Po	position
Press	pressure
PSI	pounds per square inch
PSIG	pounds per square inch gauge
RA	return air
RAG	return air grille
RAR	return air register
RAT	return air temperature
RD	round diffuser
ReH	ReHeat
RH	relative humidity
RL	refrigerant liquid
RPM	revolutions per minute
RS	refrigerant suction
RV	roof vent
RW	river water
SA	supply air
SAR	supply air register
SAT	supply air temperature

SD	smoke damper
SF	supply fan; square feet
SG	soffit grille
SIM	similar
SP	static pressure
SPEC	specification
St	status
STD	standard
STL	steel
Stm	steam
TDH	total dynamic head
TEMP	temperature
TES	thermal energy storage
TG	transfer grille
TSP	total static pressure
TYP	typical
UC	undercut door
UH	unit heater
V	valve; volts
VAV	variable air volume
VFD	variable frequency drive
VFM	venturi flow meter
VVU	variable volume unit
WB	wet-bulb
WPD	water pressure drop

Executive Summary

ES.1 Subject and Purpose

This report presents the preliminary findings of a Smith Engineering study commissioned by Brookfield Properties and NYSERDA to perform a community heat pump feasibility study at the 250 Vesey St. facility in New York, NY. The purpose of the heat pump system is to reduce the on-site steam usage of the 250 Vesey St. property in conjunction with New York City's energy usage goals. The heat pump system is intended to reduce the amount of steam usage by using the internal and external heat gains of the building which are inherently transferred to the heating, ventilation, and air conditioning (HVAC) chilled water system. Along with the new heat pumps, a new heating hot water distribution system would be provided to direct the heat toward existing HVAC and plumbing heating systems. The energy for this heat pump system would come from the electrical grid of New York City, which is in the process of becoming a more green energy source. In the end, the heat pump system will allow an overall greenhouse gas emission reduction at the building as shown by the tables and data within this report.

ES.2 Conclusion

The complex has a large amount of simultaneous heating and cooling, creating an opportunity for a heat pump application. The central heat pump option initially looked attractive since it could effectively leverage the site's year-round cooling loads. The site's potential carbon reduction by using the internal and solar heat gain is substantial. As electricity carbon content drops, the measures will improve the annual reduction and result in a much higher percentage of reduction of the total site.

Smith Engineering recommends proceeding with the following task: determining the system costs and completing Task 3 as outlined in the project scope.

Table ES-1 presents a financial summary of the proposed modifications, highlighting the projected costs and benefits of the heat pump system.

Table ES-1. Financial Summary of Modifications

Breakdown of Modification Options														
Option	Description	Estimated Annual Steam Reduction	Estimated Annual Electric Reduction	2024 Estimated Annual CO2 Reduction			First Cost - Estimated			Estimated Annual Energy Cost Savings		With CO2 Tax (2024)		Net Present Value
		Energy	Energy	Steam	Electric	Total	First Cost	Rebate	Net Capex After Rebate	Measure Savings	SPB	CO2 Tax	SPB	20 Year NPV
		Mlbs	kWh	MT CO2e	MT CO2e	MT CO2e	$	$	$	$	Years	$	Years	$
M.1	Central Heat Pump	113,650	-4,739,842	4,800	-1,370	3,430	$ (35,657,579)	$ -	$ (35,657,579)	$ 2,971,526	12.0	$ 919,313	9.2	$ 39,892,695
M.2	Tower A Heat Pump	5,954	-271,945	251	-79	173	$ (3,741,971)	$ -	$ (3,741,971)	$ 118,944	31.5	$ 46,334	22.6	$ (532,686)
M.3	Tower B Heat Pump	11,324	-467,814	478	-135	343	$ (3,210,609)	$ -	$ (3,210,609)	$ 267,538	12.0	$ 91,940	8.9	$ 3,769,543
M.4	Tower C Heat Pump	2,974	-64,663	126	-19	107	$ (3,400,390)	$ -	$ (3,400,390)	$ 89,458	38.0	$ 28,659	28.7	-1,106,849.5
M.5	Tower D Heat Pump	4,578	-104,168	193	-30	163	$ (3,158,404)	$ -	$ (3,158,404)	$ 135,183	23.4	$ 43,750	17.6	316,027.0
Cost Estimates														
X	**Placeholder**	**Based on past experience on similar projects. This number could go down or up substantially based on further development.**												
	Estimates / Budgetary	Based on some contractor estimates and more refined scope												
	Investment Grade / Proposal	Fully developed scope, subcontractor pricing, ready for design build proposal and management approval												
Savings Calculations and Paybacks														
	Placeholder	Based on past experience on similar projects. This number could go down or up substantially based on further development.												
	Estimates / Budgetary	Energy model build based on final scope.												
X	**Investment Grade / Rebate Ready**	**Fully developed energy model calibrated with full QA/QC**												

1 Introduction

1.1 Subject and Purpose

Smith Engineering conducted a study that Brookfield Properties and the New York State Energy Research and Development Authority (NYSERDA) commissioned to evaluate the feasibility of heat pump systems at the 250 Vesey St. facility in New York, NY. The study examines two primary strategies for electrifying the heating system:

- Installing a centralized heat pump in the Central Plant
- Installing decentralized heat pumps in individual buildings

1.2 Scope of Work

The contracted scope of work includes the following tasks:

- Task 1: Survey the existing equipment and infrastructure
- Task 2: Energy model of proposed system operation
- Task 3: Economic model and summary
- Task 4: Schematic design
- Task 5: Prepare the final report

1.2.1 Task 1: Survey the Existing Equipment and Infrastructure

1. Collect equipment information
    - Gather available and relevant photos of equipment nameplates
    - Collect available and relevant equipment submittals and cut sheets
    - Assemble available and relevant drawing sheets with equipment schedules
    - Obtain available and relevant existing equipment performance test reports
2. Collect system information
    - Gather process and instrumentation drawings or one-line drawings
3. Collect controls data:
    - Capture photos/images of existing control system
    - Assemble existing sequence of operations
    - Gather available and relevant trend data
4. Collect utility information
    - Compile available and relevant utility bills and rate structure information
5. Develop an evaluation matrix of viable technology
6. Consolidate and present a summary of baseline energy use and life-cycle costs to NYSERDA, including the following deliverables

- Prepare the final report, including survey results within Task 5E, F, and G
- Produce an evaluation matrix summarizing four studied technologies, outlining positives, negatives, and scores for each technology; the matrix will determine which technology advances in the study

Table 1 lists the manufacturer and model numbers considered.

Table 1. List of Manufacturers and Models

Manufacturer	Model Name
JCI	OM
JCI	CYK
JCI	Frick
Vilter	—

1.2.2 Task 2: Energy Model of Proposed System Operation

1. Summarize analytical methods used for analysis
   - Describe the methods applied to model and compare system performance
2. Develop proposed model
   - Model each proposed system modification and compare the operation to the existing system operation model (base model)
   - Include the following system addition, with each measure requiring one model run and a result report) as defined below
     - Central heat pump
   - Perform model quality assurance and quality control
3. Submit the deliverables, which include the following
   - Weather-normalize 8,760 load profiles to TMY3 data
     - Chilled water load (heat pump evaporator load)
     - Heating hot water (HHW) load per building (heat pump condenser load)
   - Develop 8,760 temperature profiles
     - River water temperature profile (low temp for the heat pump lift)
     - Heating hot water temperature reset strategy for each building (high temp for the heat pump lift)
   - Calculate 8,760 system metrics
     - Steam reduction
     - Electrical energy consumption of the heat pump

- Perform cost analysis
    - Compare the cost of additional steam savings for the upper house with the cost of routing heating hot water piping to the upper house of each building
- Analyze heating hot water load distribution
    - Use available data to assess existing heating hot water load distribution between the upper house and lower house of the buildings

1.2.3 Task 3: Economic Model and Summary

1. Develop cost estimates for proposed system modification
    - Develop cost estimates using the following methodologies
        - Previous project data
        - Contractor quotes
        - Material quotes
2. Summarize the following per proposed modification; the total impact to the site may include:
    - Energy reduction per energy source
    - Demand reduction per energy source
    - Energy cost reduction per energy source
    - Demand cost reduction per energy source
    - Total energy and demand cost reduction
    - Demand response payment increase
    - Carbon reduction per energy source
    - Carbon tax reduction
    - Simple payback
3. Submit the deliverables, which include the following
    - Prepare cost-benefit analysis of the heat pump
        - This milestone will also include a deliverable of the cost-benefit analysis of smaller packaged heat pumps versus extending the large-scale heat pump distribution up the building to handle the upper house, including reasons why the chosen scale of technology is better for this application
    - As a part of this milestone, a first cost estimate will be generated for the project to move forward, and an energy calculation will be made for the energy savings and potential carbon emission reduction

1.2.4 Task 4: Schematic Design

1. Prepare schematic level mechanical and electrical drawing set for project concept
    - Scope: heat pump
        - Identifying existing/demolition plan views (major equipment only)

        - Create new work plan views (major equipment only)
        - Develop mechanical one-line drawings

    - Plant, piping distribution, and connection to the building

        - Develop electrical one-line drawings

2. Submit the deliverables, including

    - Analyze space requirements for each heat pump size and include findings in the Conclusions section of the report
    - Evaluate the existing underground tunnel network at the World Financial Center buildings that holds steam and chilled water (CHW) piping coming from the Central Plant

        - Assess requirements for adding additional heating hot water piping in these tunnels and determine how heating hot water will be pumped to each building

1.2.5 Task 5 Prepare the Final Report

1. Create a presentation, including:

    - Executive summary: Summarize options analyzed, economic analysis, and results
    - Purpose: Define the purpose of the report
    - Scope: Outline the scope of the project
    - Introduction: Provide an overview of the project
    - Existing facility description: Present detailed equipment information, system description, existing equipment curves, and operational data
    - Existing operation: Describe the existing load profile and existing equipment efficiency maps
    - Field observations: Document observations made during fieldwork
    - System modification options: Describe proposed modification description, economic analysis, feasibility
    - Conclusion and recommendations: Summarize conclusions and provide recommendations
    - Appendix: Include results impact and lessons learned

2. Submit the deliverables, including:

    - Provide the final step to proving the feasibility of this project before it moves forward
    - Submit a draft version of the Final Report to NYSERDA's Project Manager by the date specified in the Milestone Schedule of the NYSERDA Agreement for this step

        - NYSERDA will review the draft within 60 working days after receipt
        - Prepare and submit a final version of the report incorporating NYSERDA's comments within 30 working days after receiving feedback

2 Existing Infrastructure Summary

2.1 Building

This study focuses on the Brookfield Properties chilled water system, with a central chiller plant at 250 Vesey St., New York, NY. This analysis targets the chilled water system with an installed capacity of approximately 15,000 Tons. The central plant supplies chilled water to Tower A, Tower B, Tower C, Tower D, Winter Garden, and retail areas.

Figure 1. Site Image

2.2 Central Chilled Water Plant

The chilled water plant at 250 Vesey St. has 10 chillers, one chiller with 1,581 tons and the other 9 with 1,496 tons each, for a total plant capacity of 15,045 tons. The detailed existing system information is broken up into four sections: generating equipment, distribution equipment, utilization equipment, and system controls.

2.3 Chilled Water Generation

The chilled water generating equipment consists of water-cooled chillers and river water heat rejection. The chillers are tied to a closed loop condenser water system. This system is connected to 11 plate and frame heat exchangers that reject heat to the adjacent Hudson River.

Table 2 provides the water-cooled chiller specifications, including model numbers, nominal capacity, refrigerant type, year manufactured, efficiency metrics, and fluid operating conditions.

Table 2. Chiller Specifications

Water Cooled Chillers												
	Chiller ID		**CH-1**	**CH-2**	**CH-3**	**CH-4**	**CH-5**	**CH-6**	**CH-7**	**CH-8**	**CH-9**	**CH-10**
	Location		250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant
	Service		CHW	CHW	CHW	CHW	CHW	CHW	CHW	CHW	CHW	CHW
	Make		Carrier	Carrier	Carrier	Carrier	Carrier	Carrier	Carrier	Carrier	Carrier	Carrier
	Model Number		19FA583	19FA561-B-500-5929-L-EC	19XR-8987E65ENB64	19XR-8987E65ENB64	19XR-8987E65ENB64	19FA561-B-500-5929-L-EC	19XR-8987E65ENB64	19XR-8987E65ENB64	19XR-8987E65ENB64	19XR-8987E65ENB64
	Serial Number		34501	34502	-	-	-	35759	-	-	-	-
	Nominal Capacity	**Tons**	1,581	1,581	1,440	1,440	1,440	1,581	1,440	1,440	1,440	1,440
	Specified Net Capacity	**Tons**	1,572	1,581	1,435	1,435	1,435	1,581	1,435	1,435	1,435	1,435
	Original Refrigerant		R-500	R-500	R-500	R-500	R-500	R-500	R-500	R-500	R-500	R-500
	Current Refrigerant		R-134A	R-134A	R-134A	R-134A	R-134A	R-134A	R-134A	R-134A	R-134A	R-134A
	Year Manufactured		-	1984	2018	2018	2018	1984	2018	2018	2018	2018
Design	**Compressor**											
	Type		Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal
	Model		19FA583	19FA561BEC	19XR-E65	19XR-E65	19XR-E65	19FA561BEC	19XR-E65	19XR-E65	19XR-E65	19XR-E65
	Stages		2	2	2	2	2	2	2	2	2	2
	Driver - Electric Motor											
	Make		-	-	-	-	-	-	-	-	-	-
	Motor Control Type		Starter	Starter	VFD	VFD	VFD	Starter	VFD	VFD	VFD	VFD
	Input Power	**kW**	970	1,083	757	757	757	1,083	757	757	757	757
	Motor Nameplate Power	**HP**	-	-	-	-	-	-	-	-	-	-
	Voltage	**V**	460	460	460	460	460	460	460	460	460	460
	Speed	**RPM**	3,571	9,440	-	-	-	9,440	-	-	-	-
	Full Load Efficiency	**kW/Ton**	0.62	0.68	0.53	0.53	0.53	0.68	0.53	0.53	0.53	0.53
	Refrigerant Evaporator											
	Fluid		Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
	Fluid Flow	**GPM**	2,750	2,750	2,750	2,750	2,750	2,750	2,750	2,750	2,750	2,750
	Fluid Pressure Drop	**Ft of H2O**	18.8	18.6	20.5	20.5	20.5	18.6	20.5	20.5	20.5	20.5
	Entering Fluid Temp.	**°F**	52.72	55.80	54.52	54.52	54.52	55.80	54.52	54.52	54.52	54.52
	Leaving Fluid Temp.	**°F**	39.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00
	Fluid Passes	**No.**	2	2	2	2	2	2	2	2	2	2
	Approach	**°F**	-	-	-	-	-	-	-	-	-	-
	Design Working Pressure	**PSIG**	250	250	250	250	250	250	250	250	250	250
	Refrigerant Condenser											
	Fluid		Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
	Fluid Flow	**GPM**	4,285	4,285	5,035	5,035	5,035	4,285	5,035	5,035	5,035	5,035
	Fluid Pressure Drop	**Ft of H2O**	25.3	24.2	44.3	44.3	44.3	24.2	44.3	44.3	44.3	44.3
	Entering Fluid Temp.	**°F**	79.00	79.00	79.00	79.00	79.00	79.00	79.00	79.00	79.00	79.00
	Leaving Fluid Temp.	**°F**	89.44	89.60	86.89	86.89	86.89	89.60	86.89	86.89	86.89	86.89
	Fluid Passes	**No.**	2	2	2	2	2	2	2	2	2	2
	Approach	**°F**	-	-	-	-	-	-	-	-	-	-
	Design Working Pressure	**PSIG**	250	250	250	250	250	250	250	250	250	250

2.4 Thermal Energy Storage

The thermal energy storage (TES) includes thirteen tanks with a total storage capacity of 3.3 million gallons of chilled water. Four heat exchangers manage the charging and discharging the thermal energy storage tanks. Table 3 provides specifications for the thermal energy storage tanks. Table 4 provides specifications for the thermal storage tank pumps. Table 5 provides specifications for the heat exchangers serving the thermal storage tanks.

Table 3. Thermal Energy Storage Tank Specifications

		TES Tanks												
Fan ID		**Tank 1**	**Tank 2**	**Tank 3**	**Tank 4**	**Tank 5**	**Tank 6**	**Tank 7**	**Tank 8**	**Tank 9**	**Tank 10**	**Tank 11**	**Tank 12**	**Tank 13**
Location		250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant
Service		Thermal Storage	Thermal Storage	Thermal Storage	Thermal Storage	Thermal Storage	Thermal Storage	Thermal Storage	Thermal Storage	Thermal Storage	Thermal Storage	Thermal Storage	Thermal Storage	Thermal Storage
Capacity	**Gallons**	284,493	262,788	262,788	258,973	264,647	264,647	269,075	283,830	283,830	283,753	277,247	272,137	270,859

Table 4. Thermal Energy Storage Pump Specifications

Pumps									
Pump ID			**P-25P**	**P-26P**	**P-27P**	**P-38P**	**P-39P**	**P-40P**	**P-41P**
Location			250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant
Service			Open Loop TES CHW	Open Loop TES CHW	Open Loop TES CHW	Closed Loop TES CHW	Closed Loop TES CHW	Closed Loop TES CHW	Closed Loop TES CHW
Make			Armstrong	Armstrong	Armstrong	Armstrong	Armstrong	Armstrong	Armstrong
Model Number			10FN / 4310	10FN / 4310	10FN / 4310	10G / 4310	10G / 4310	10G / 4310	10G / 4310
Serial Number			113428	113429	-	113408	113409	113410	113411
Design	**Pump**								
	Type		Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal
	Style		Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line
	Fluid		Water	Water	Water	Water	Water	Water	Water
	Impeller Diameter	**Inches**	10.6	10.6	10.6	12.0	12.0	12.0	12.0
	Stages	**No.**	1	1	1	1	1	1	1
	Design Working Pressure	**PSIG**	175	175	175	175	175	175	175
	Fluid Flow	**GPM**	3,030	3,030	3,030	3,225	3,225	3,225	3,225
	Head (TDH)	**Ft of H2O**	80	80	80	45	45	45	45
	NPSHr	**Ft of H2O**	16.0	16.0	16.0	19.0	19.0	19.0	19.0
	Design Point Efficiency	**%**	82.0%	82.0%	82.0%	81.0%	81.0%	81.0%	81.0%
	Driver - Electric Motor								
	Make		Marathon	Marathon	Marathon	Marathon	Marathon	Marathon	Marathon
	Motor Control Type		VFD	VFD	VFD	Starter	Starter	Starter	Starter
	Motor Insulation Class		F	F	F	B	B	B	B
	Overloading	**Yes/No**	No	No	No	No	No	No	No
	Motor Nameplate Power	**HP**	100	100	100	50	50	50	50
	Voltage	**V**	460	460	460	460	460	460	460
	Speed	**RPM**	1,175	1,175	1,175	1,185	1,185	1,185	1,185
	Nominal Efficiency	**%**	93.0%	93.0%	93.0%	92.4%	92.4%	92.4%	92.4%

Table 5. Thermal Energy Storage Heat Exchanger Specifications

Plate and Frame Heat Exchanger						
Heat Exchanger ID			**PHX-11**	**PHX-12**	**PHX-13**	**PHX-14**
Location			250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant
Service			TES HX	TES HX	TES HX	TES HX
Make			Alfa Laval	Alfa Laval	Alfa Laval	Alfa Laval
Model Number			A20-BFG	A20-BFG	A20-BFG	A20-BFG
Serial Number			-	-	-	-
Specified Net Capacity		**Tons**	1,342	1,342	1,342	1,342
Specified Net Capacity		**MBH**	16,100	16,100	16,100	16,100
Design	**Plates**					
	Material		304 SS	304 SS	304 SS	304 SS
	Plate Thickness	**Inches**	0.02	0.02	0.02	0.02
	Installed Quantity	**No.**	684	684	684	684
	Maxiumum Quantity	**No.**	684	684	684	684
	Cold Side					
	Fluid		Water	Water	Water	Water
	Fluid Flow	**GPM**	2,300	2,300	2,300	2,300
	Fluid Pressure Drop	**Ft of H2O**	3.6	3.6	3.6	3.6
	Entering Fluid Temp.	**°F**	42.00	42.00	42.00	42.00
	Leaving Fluid Temp.	**°F**	56.00	56.00	56.00	56.00
	Approach	**°F**	7	7	7	7
	Design Working Pressure	**PSIG**	200	200	200	200
	Capacity	**MBH**	16,100	16,100	16,100	16,100
	Hot Side					
	Fluid		Water	Water	Water	Water
	Fluid Flow	**GPM**	3,230	3,230	3,230	3,230
	Fluid Pressure Drop	**Ft of H2O**	7.1	7.1	7.1	7.1
	Entering Fluid Temp.	**°F**	59.00	59.00	59.00	59.00
	Leaving Fluid Temp.	**°F**	49.00	49.00	49.00	49.00
	Design Working Pressure	**PSIG**	200	200	200	200
	Capacity	**MBH**	16,150	16,150	16,150	16,150
	Min. Flow	**GPM**	-	-	-	-
	Max. Flow	**GPM**	-	-	-	-

2.5 Cooling System Distribution

The distribution equipment consists of condenser water pumps, chilled water pumps, river water pumps, and thermal energy storage pumps.

2.5.1 Condenser Water

The condenser water is delivered to the chillers through heat exchangers by 10 condenser water pumps. Table 6 provides specifications on the condenser water pumps. Table 7 provides specifications on the river water pumps.

Table 6. Condenser Water Pump Specifications

			Pumps									
Pump ID			P-1P	P-2P	P-3P	P-4P	P-5P	P-6P	P-7P	P-7A	P-7B	P-7C
Location			250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant
Service			CW	CW	CW	CW	CW	CW	CW	CW	CW	CW
Make			Armstrong	Armstrong	Armstrong	Armstrong	Armstrong	Armstrong	Armstrong	Armstrong	Armstrong	Armstrong
Model Number			10G / 4310	10G / 4310	10G / 4310	10G / 4310	10G / 4310	10G / 4310	10G / 4310	4300 12x12x13	4300 12x12x13	4300 12x12x13
Serial Number			113417	113418	-	113420	113421	119319	119318	140892	140893	146972
Design	Pump											
	Type		Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal
	Style		Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line
	Fluid		Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
	Impeller Diameter	Inches	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.4	12.4	12.4
	Stages	No.	1	1	1	1	1	1	1	1	1	1
	Design Working Pressure	PSIG	175	175	175	175	175	175	175	-	-	-
	Fluid Flow	GPM	4,285	4,285	4,285	4,285	4,285	4,285	4,285	4,285	4,285	4,285
	Head (TDH)	Ft of H2O	120	120	120	120	120	120	120	125	125	125
	NPSHr	Ft of H2O	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0
	Design Point Efficiency	%	83.0%	83.0%	83.0%	83.0%	83.0%	83.0%	83.0%	83.5%	83.5%	83.5%
	Driver - Electric Motor											
	Make		Marathon	Marathon	Marathon	Marathon	Marathon	Marathon	Marathon	Marathon	Marathon	Marathon
	Motor Control Type		Starter	Starter	Starter	Starter	Starter	Starter	VFD	Starter	VFD	Starter
	Motor Insulation Class		F	F	F	B	B	B	B	B	F	B
	Overloading	Yes/No	No	No	No	No	No	No	No	No	No	No
	Motor Nameplate Power	HP	175	175	175	175	175	175	175	175	175	175
	Voltage	V	460	460	460	460	460	460	460	460	460	460
	Speed	RPM	1,775	1,775	1,780	1,780	-	1,775	1,780	1,780	1,780	1,775
	Nominal Efficiency	%	94.1%	94.1%	94.1%	91.4%	-	94.1%	91.4%	91.4%	94.1%	94.1%

Table 7. River Water Pump Specifications

			Pumps							
Pump ID			P-28P	P-29P	P-30P	P-31P	P-32P	P-33P	P-50P	P-51P
Location			250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant
Service			River Water	River Water	River Water	River Water	River Water	River Water	River Water	River Water
Make			Johnston	Johnston	Johnston	Johnston	Johnston	Johnston	Johnston	Johnston
Model Number			22NMC	22NMC	22NMC	22NMC	22NMC	22NMC	22NMC	22NMC
Serial Number			-	-	-	-	-	-	-	-
Design	Pump									
	Type		-	-	-	-	-	-	-	-
	Style		Vertical Turbine	Vertical Turbine	Vertical Turbine	Vertical Turbine	Vertical Turbine	Vertical Turbine	Vertical Turbine	Vertical Turbine
	Fluid		River Water	River Water	River Water	River Water	River Water	River Water	River Water	River Water
	Impeller Diameter	Inches	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
	Stages	No.	2	2	2	2	2	2	2	2
	Design Working Pressure	PSIG	-	-	-	-	-	-	-	-
	Fluid Flow	GPM	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
	Head (TDH)	Ft of H2O	100	100	100	100	100	100	100	100
	NPSHr	Ft of H2O	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0
	Design Point Efficiency	%	87.0%	87.0%	87.0%	87.0%	87.0%	87.0%	87.0%	87.0%
	Driver - Electric Motor									
	Make		U.S. Motor	U.S. Motor	U.S. Motor	U.S. Motor	U.S. Motor	U.S. Motor	U.S. Motor	U.S. Motor
	Motor Control Type		VFD	VFD	VFD	VFD	VFD	VFD	VFD	VFD
	Motor Insulation Class		F	F	F	F	F	F	F	F
	Overloading	Yes/No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Motor Nameplate Power	HP	155	155	155	155	150	155	155	155
	Voltage	V	460	460	460	460	460	460	460	460
	Speed	RPM	1,180	1,180	1,180	1,180	1,185	1,185	1,180	1,180
	Nominal Efficiency	%	93.0%	93.0%	93.0%	93.0%	93.0%	93.0%	93.0%	93.0%

2.5.2 Chilled Water

The chilled water is circulated via a primary loop for the chillers and a secondary loop that provides chilled water to Towers A, B, C, and D; the Winter Garden; and retail areas. Table 8 and Table 9 provide specifications for the chilled water pumps.

Table 8. Primary Chilled Water Pump Specifications

			Pumps									
	Pump ID		**P-8P**	**P-9P**	**P-10P**	**P-11P**	**P-12P**	**P-13P**	**P-14P**	**P-14A**	**P-14B**	**P-14C**
	Location		250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant
	Service		Primary CHW	Primary CHW	Primary CHW	Primary CHW	Primary CHW	Primary CHW	Primary CHW	Primary CHW	Primary CHW	Primary CHW
	Make		Armstrong	Armstrong	Armstrong	Armstrong	Armstrong	Armstrong	Armstrong	Armstrong	Armstrong	Armstrong
	Model Number		10FN / 4310	10FN / 4310	10FN / 4310	10FN / 4310	10FN / 4310	10FN / 4310	10FN / 4310	4300 12x12x13	4300 12x12x13	4300 12x12x13
	Serial Number		113412	113413	113414	-	113416	119320	119321	140894	140895	146973
Design			**Pump**									
	Type		Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal
	Style		Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line
	Fluid		Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
	Impeller Diameter	**Inches**	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.4	9.4	9.4
	Stages	**No.**	1	1	1	1	1	1	1	1	1	1
	Design Working Pressure	**PSIG**	175	175	175	175	175	175	175	-	-	-
	Fluid Flow	**GPM**	2,750	2,750	2,750	2,750	2,750	2,750	2,750	2,750	2,750	2,750
	Head (TDH)	**Ft of H2O**	65	65	65	65	65	65	65	65	65	65
	NPSHr	**Ft of H2O**	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	Design Point Efficiency	**%**	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%
			Driver - Electric Motor									
	Make		Marathon	Marathon	Marathon	-	Marathon	Marathon	Marathon	Marathon	Marathon	Marathon
	Motor Control Type		Starter	Starter	VFD	VFD	VFD	VFD	VFD	VFD	VFD	VFD
	Motor Insulation Class		B	B	B	-	B	B	B	B	B	B
	Overloading	**Yes/No**	No	No	No	No	No	No	No	No	No	No
	Motor Nameplate Power	**HP**	75	75	75	75	75	75	75	75	75	75
	Voltage	**V**	460	460	460	460	460	460	460	460	460	460
	Speed	**RPM**	1,775	1,775	1,775	-	1,775	1,775	1,775	1,775	1,775	1,775
	Nominal Efficiency	**%**	91.7%	91.7%	91.7%	-	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%

Table 9. Secondary Chilled Water Pump Specifications

Pumps												
Pump ID			**P-15P**	**P-16P**	**P-17P**	**P-18P**	**P-19P**	**P-20P**	**P-21P**	**P-22P**	**P-23P**	**P-24P**
Location			250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant	250 Vesey Central Plant
Service			Tower D CHW	Tower D CHW	Tower D CHW	Tower C CHW	Tower C CHW	Tower C CHW	Tower A & B CHW	Tower A & B CHW	Tower A & B CHW	Tower A & B CHW
Make			Armstrong	Armstrong	Armstrong	Armstrong	Armstrong	Armstrong	Armstrong	Armstrong	Armstrong	Armstrong
Model Number			8GN / 4300	8GN / 4300	8GN / 4300	10GN / 4310	10GN / 4310	10GN / 4310	10GN / 4310	10GN / 4310	10GN / 4310	10GN / 4310
Serial Number			119322	119323	-	113422	-	113424	119325	113425	113426	113427
Design	**Pump**											
	Type		Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal
	Style		Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line	Vertical In-Line
	Fluid		Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
	Impeller Diameter	**Inches**	11.5	11.5	11.5	10.8	10.8	10.8	12.3	11.8	11.8	11.8
	Stages	**No.**	1	1	1	1	1	1	1	1	1	1
	Design Working Pressure	**PSIG**	175	175	175	175	175	175	175	175	175	175
	Fluid Flow	**GPM**	1,935	1,935	1,935	3,100	3,100	3,100	3,675	3,675	3,675	3,675
	Head (TDH)	**Ft of H2O**	100	100	100	110	110	110	125	125	125	125
	NPSHr	**Ft of H2O**	17.5	17.5	17.5	18.0	18.0	18.0	20.0	20.0	20.0	20.0
	Design Point Efficiency	**%**	76.0%	76.0%	76.0%	81.0%	81.0%	81.0%	83.5%	83.5%	83.5%	83.5%
	Driver - Electric Motor											
	Make		Marathon	Marathon	Marathon	Marathon	Marathon	Marathon	Marathon	Marathon	Marathon	Marathon
	Motor Control Type		VFD	VFD	VFD	VFD	VFD	VFD	VFD	Starter	VFD	VFD
	Motor Insulation Class		B	B	B	B	B	B	B	B	B	B
	Overloading	**Yes/No**	No	No	No	No	No	No	No	No	No	No
	Motor Nameplate Power	**HP**	75	75	75	125	125	125	150	150	150	150
	Voltage	**V**	460	460	460	460	460	460	460	460	460	460
	Speed	**RPM**	1,775	1,775	1,775	1,780	1,780	1,780	1,780	1,780	1,780	1,780
	Nominal Efficiency	**%**	91.7%	91.7%	91.7%	93.6%	93.6%	93.6%	93.6%	93.6%	93.6%	93.6%

2.6 Chilled Water Use

The chilled water system serves Towers A, B, C, and D; the Winter Garden; and retail areas, primarily for space cooling through air handling units (AHUs) and each tower's heat exchangers. A network of piping delivers the chilled water to these towers, with access through an underground tunnel. Table 10 through Table 16 provide the specifications of the heat exchangers and air handling units for each tower, the Winter Garden, and the Central Plant.

2.6.1 Building Primary to Secondary Chilled Water Heat Exchangers

See Table 10 for the existing chilled water heat exchanger specifications.

Table 10. Towers A, B, C, and D, and Winter Garden: Heat Exchanger Specifications

Plate and Frame Heat Exchanger										
Heat Exchanger ID			PX-1A	PX-2A	PHX-1B	PHX-2B	PX-1C	PX-2C	PHX-1D	PHX-2D
Location			11th Flr MER	11th Flr MER	10th Flr MER	10th Flr MER	15th Flr MER	15th Flr MER	17th Floor MER	17th Floor MER
Service			Chilled Water	Chilled Water	Chilled Water	Chilled Water	SCHW	PCHW	Secondary CHW Loop	Secondary CHW Loop
Make			Alfa-Laval	Alfa-Laval	Alfa Laval	Alfa Laval	Alfa-Laval	Alfa-Laval	Alfa Laval	Alfa Laval
Model Number			A-20-BHA	A-20-BHA	AX30-FD	AX30-FD	A - 20 - BFD	A - 20 - BFD	A20-BFD	A20-BFD
Serial Number			-	-	3010067020	3010067021	3010065030	3010065029	30100-66339	30100-66881
Specified Net Capacity		Tons	1,714	1,714	2,124	2,124	2,188	2,188	1,503	1,503
Specified Net Capacity		MBH	20,570	20,570	25,484	25,484	26,256	26,256	18,038	18,038
Design Specifications	Plates									
	Material		-	-	AISI 304	AISI 304	-	-	304 SS	304 SS
	Plate Thickness	Inches	-	-	0.04	0.04	-	-	-	-
	Installed Quantity	No.	-	-	678	678	-	-	634	634
	Maxiumum Quantity	No.	-	-	-	-	-	-	634	634
	Cold Side									
	Fluid		Water	Water	Water	Water	Water	Water	Water	Water
	Fluid Flow	GPM	2,420	2,420	2,755	2,755	3,282	3,282	1,850	1,850
	Fluid Pressure Drop	Ft of H2O	9.0	9.0	9.1	9.1	24.0	24.0	29.6	29.6
	Entering Fluid Temp.	°F	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00
	Leaving Fluid Temp.	°F	59.00	59.00	60.50	60.50	58.00	58.00	61.50	61.50
	Approach	°F	3.6	3.6	3.0	3.0	3.0	3.0	3.0	3.0
	Design Working Pressure	PSIG	-	-	300	300	250	250	250	250
	Capacity	MBH	20,570	20,570	25,484	25,484	26,256	26,256	18,000	18,000
	Min. Flow	GPM	-	-	-	-	-	-	-	-
	Max. Flow	GPM	-	-	-	-	-	-	-	-
	Hot Side									
	Fluid		Water	Water	Water	Water	Water	Water	Water	Water
	Fluid Flow	GPM	2,110	2,110	2,755	2,755	3,282	3,282	1,900	1,900
	Fluid Pressure Drop	Ft of H2O	11.7	11.7	9.1	9.1	24.0	24.0	30.0	30.0
	Entering Fluid Temp.	°F	65.10	65.10	63.50	63.50	61.00	61.00	64.00	64.00
	Leaving Fluid Temp.	°F	45.60	45.60	45.00	45.00	45.00	45.00	45.00	45.00
	Design Working Pressure	PSIG	-	-	300	300	250	250	250	250
	Capacity	MBH	20,573	20,573	25,484	25,484	26,256	26,256	18,000	18,000
	Min. Flow	GPM	-	-	-	-	-	-	-	-
	Max. Flow	GPM	-	-	-	-	-	-	-	-

2.6.2 Tower A: Air Handling Units

Table 11. Towers A Chilled Water Air Handling Unit Specifications

Air Handling Unit				
AHU ID			**AC-1A**	**AC-2A**
Location			Street Lvl Fan Room	Street Lvl Fan Room
Service			Lobby	Retail Area
Make			Joy	Joy
Supply Air Flow		**CFM**	60,000	52,500
Design	**Supply Fan**			
	Type		Axial	Axial
	Maximum Fan Speed	**RPM**	1,770	1,770
	Air Flow	**CFM**	60,000	52,500
	Total Fan Static	**In of H2O**	5.5	6.3
	Fan Brake Horsepower	**BHP**	60	55
	Fan Efficiency	**%**	87%	94%
	Quantity	**No.**	1	1
	Supply Fan Driver - Electric Motor			
	Make		-	-
	Motor Control Type		VFD	VFD
	Motor Nameplate Power	**HP**	75	75
	Voltage	**V**	460	460
	Speed	**RPM**	1,770	1,770
	Nominal Efficiency	**%**	-	-
	Quantity	**No.**	1	1
	Cooling Coil			
	Total Capacity	**MBH**	3,500	2,610
	Total Capacity	**Tons**	292	218
	Sensible Capacity	**MBH**	1,938	1,695
	Fluid		Water	Water
	Fluid Flow	**GPM**	350	261
	Fluid Pressure Drop	**Ft of H2O**	10.6	13.1
	Entering Fluid Temp.	**°F**	42.00	42.00
	Leaving Fluid Temp.	**°F**	62.00	62.00
	Fluid Rows	**No.**	8	8
	Number of Coils	**No.**	-	-
	Air Flow	**CFM**	60,000	52,500
	Air Pressure Drop	**In of H2O**	0.7	1.1
	Entering Air Temp. - DB	**°F**	81.50	81.50
	Entering Air Temp. - WB	**°F**	68.00	68.00
	Leaving Air Temp. - DB	**°F**	51.60	51.60
	Leaving Air Temp. - WB	**°F**	51.50	51.50
	Approach	**°F**	10	10
	Design Working Pressure	**PSIG**	-	-

2.6.3 Tower B: Air Handling Units

Table 12. Towers B Chilled Water Air Handling Unit Specifications

	`		Air Handling Unit				
	AHU ID		**AC-1B**	**AC-2B**	**AC-45B**	**AC-47B**	**AC-48B**
	Location		Cellar MER Area "C"	Street Lvl MER	Street Lvl MER	3rd Sub-Cellar MER	1st Sub-Cellar MER
	Service		Lobby & Street Lvls	Liberty Street Bridge	Primary Air 3rd to 15th Flrs	2nd & 3rd Sub Cellar Tennant Supply	1st Sub Cellar & Cellar Core Supply
	Make		Trane	Trane	Fanwall	Trane	Trane
	Model Number		Climate Changer	Climate Changer	-	Climate Changer	Climate Changer
	Serial Number		-	-	-	-	-
	Supply Air Flow	**CFM**	65,000	7,200	-	84,000	30,400
	OA Airflow	**CFM**	-	-	-	-	-
	Total External Static	**In of H2O**	6.00	4.50	-	4.75	3.75
Design			**Supply Fan**				
	Type		-	-	-	-	-
	Model		-	-	-	-	-
	Air Flow	**CFM**	65,000	7,200	-	84,000	30,400
	Fan Static	**In of H2O**	6.00	4.50	-	4.75	3.75
	Fan Efficiency	**%**	-	-	-	-	-
	Quantity	**No.**	3	1	15	1	1
			Supply Fan Driver - Electric Motor				
	Make		-	-	Toshiba	-	-
	Motor Control Type		VFD	VFD	VFD	Starter	Starter
	Motor Nameplate Power	**HP**	100	10	15	50	30
	Voltage	**V**	480	480	460	480	480
	Speed	**RPM**	865	1,287	1,770	935	1,116
	Nominal Efficiency	**%**	-	-	92.4%	-	-
	Quantity	**No.**	3	1	15	1	1
			Cooling Coil				
	Total Capacity	**MBH**	3,261	407	8,398	2,989	1,080
	Total Capacity	**Tons**	-	-	-	-	-
	Sensible Capacity	**MBH**	2,099	247	-	2,159	781
	Fluid		Water	Water	Water	Water	Water
	Fluid Flow	**GPM**	255	32	700	250	90
	Fluid Pressure Drop	**Ft of H2O**	8.70	10.40	24.90	6.80	2.30
	Entering Fluid Temp.	**°F**	42.00	42.00	45.00	45.00	45.00
	Leaving Fluid Temp.	**°F**	67.60	67.60	69.00	69.00	69.00
	Fluid Rows	**No.**	-	-	-	-	-
	Air Flow	**CFM**	-	-	-	-	-
	Air Pressure Drop	**In of H2O**	1.34	1.24	1.23	0.89	0.87
	Entering Air Temp. - DB	**°F**	81.50	80.80	92.00	80.80	80.80
	Entering Air Temp. - WB	**°F**	-	-	-	-	-
	Leaving Air Temp. - DB	**°F**	51.60	49.00	55.00	57.00	57.00
	Leaving Air Temp. - WB	**°F**	-	-	-	-	-
	Approach	**°F**	10	7	10	12	12
	Design Working Pressure	**PSIG**	-	-	-	-	-

2.6.4 Tower C: Air Handling Units

Table 13. Tower C Chilled Water Air Handling Unit Specifications

Air Handling Unit						
AHU ID			AC-1C	AC-2C	AHU-301C	AHU-303C
Location			3rd Flr Fan Room	3rd Flr Fan Room	3rd Flr Fan Room	3rd Flr Fan Room
Service			Lobby Levels	Retail Areas	Kitchen	Kitchen
Make			Trane	Trane	-	-
Supply Air Flow		CFM	63,000	117,500	-	-
Design	Supply Fan					
	Type		Centrifugal	Centrifugal	-	-
	Maximum Fan Speed	RPM	844	834	-	-
	Air Flow	CFM	63,000	58,750	-	-
	Total Fan Static	In of H2O	6.0	6.0	-	-
	Fan Brake Horsepower	BHP	77	72	-	-
	Fan Efficiency	%	78%	77%	-	-
	Quantity	No.	1	2	1	1
	Supply Fan Driver - Electric Motor					
	Make		-	-	-	-
	Motor Control Type		VFD	VFD	Starter	Starter
	Motor Nameplate Power	HP	100	100	-	-
	Voltage	V	460	460	-	-
	Speed	RPM	1,750	1,750	-	-
	Nominal Efficiency	%	-	-	-	-
	Quantity	No.	1	2	1	1
	Cooling Coil					
	Total Capacity	MBH	3,160	5,910	-	-
	Total Capacity	Tons	263	493	-	-
	Sensible Capacity	MBH	2,034	1,897	-	-
	Fluid		Water	Water	Water	Water
	Fluid Flow	GPM	316	591	-	-
	Fluid Pressure Drop	Ft of H2O	15.2	26.7	-	-
	Entering Fluid Temp.	°F	42.00	42.00	-	-
	Leaving Fluid Temp.	°F	62.00	62.00	-	-
	Fluid Rows	No.	8	8	-	-
	Number of Coils	No.	-	-	-	-
	Air Flow	CFM	63,000	117,500	-	-
	Air Pressure Drop	In of H2O	0.8	1.1	-	-
	Entering Air Temp. - DB	°F	81.50	81.50	-	-
	Entering Air Temp. - WB	°F	68.00	68.00	-	-
	Leaving Air Temp. - DB	°F	51.60	51.60	-	-
	Leaving Air Temp. - WB	°F	51.50	51.50	-	-
	Approach	°F	10	10	-	-
	Design Working Pressure	PSIG	-	-	-	-

2.6.5 Tower D: Air Handling Units

Table 14. Towers D Chilled Water Air Handling Unit Specifications

Air Handling Unit					
AHU ID			**AC-1D**	**AC-2DN**	**AC-2DS**
Location			+0'-6" Lvl MER	3rd Flr MER North	3rd Flr MER South
Service			Lobby	Courtyard North & East Area	Courtyard South & West Area
Make			Trane	Trane	Trane
Supply Air Flow		**CFM**	33,300	51,600	65,600
Design Specifications	**Supply Fan**				
	Type		Centrifugal	-	-
	Model		40-AFSW-21-10-11	44 AFD	49 AFD
	Design Fan Speed	**RPM**	1,136	-	-
	Maximum Fan Speed	**RPM**	1,283	819	757
	Air Flow	**CFM**	33,300	51,600	65,600
	Fan Static	**In of H2O**	3.9	3.3	3.3
	Fan Brake Horsepower	**BHP**	-	46	61
	Fan Efficiency	**%**	-	58%	56%
	Quantity	**No.**	1	1	1
	Supply Fan Driver - Electric Motor				
	Make		-	Marathon	-
	Motor Control Type		VFD	VFD	-
	Motor Nameplate Power	**HP**	40	60	75
	Voltage	**V**	460	460	460
	Speed	**RPM**	1,725	1,785	1,750
	Nominal Efficiency	**%**	94.1%	95.0%	-
	Quantity	**No.**	1	1	1
	Chilled Water Coil				
	Total Capacity	**MBH**	-	1,881	2,850
	Total Capacity	**Tons**	-	157	238
	Sensible Capacity	**MBH**	-	1,594	2,026
	Fluid		Water	Water	Water
	Fluid Flow	**GPM**	-	198	300
	Fluid Pressure Drop	**Ft of H2O**	-	4.3	6.6
	Entering Fluid Temp.	**°F**	-	42.00	42.00
	Leaving Fluid Temp.	**°F**	-	61.00	61.00
	Fluid Rows	**No.**	-	8	8
	Number of Coils	**No.**	-	-	-
	Air Flow	**CFM**	-	51,600	65,600
	Air Pressure Drop	**In of H2O**	-	0.7	1.1
	Entering Air Temp. - DB	**°F**	-	78.60	78.60
	Entering Air Temp. - WB	**°F**	-	62.80	62.80
	Leaving Air Temp. - DB	**°F**	-	50.00	50.00
	Leaving Air Temp. - WB	**°F**	-	49.90	49.90
	Approach	**°F**	-	8	8
	Design Working Pressure	**PSIG**	-	-	-

2.6.6 Winter Garden: Air Handling Units

Table 15. Winter Garden Chilled Water Air Handling Unit Specifications

			Air Handling Unit							
AHU ID			**AC-1W**	**AC-2W**	**AC-5W**	**AC-7W**	**AC-8W**	**AC-9W**	**AC-10W**	**AC-11W**
Location			Penthouse MER	Penthouse MER	Penthouse MER	Penthouse MER	Penthouse MER	Penthouse MER	Service Lvl MER	Penthouse MER
Service			Winter Garden	Winter Garden	Winter Garden	Winter Garden	Winter Garden	Retail Area	Entrance Lobby East Side	Retail Area
Make			Trane	Trane	Trane	Trane	Trane	Trane	Trane	Trane
Model Number			-	-	-	-	-	-	-	-
Serial Number			-	-	-	-	-	-	-	-
Supply Air Flow		**CFM**	29,900	29,900	29,900	29,900	29,900	25,000	6,800	7,000
	Supply Fan									
Design	**Type**		-	-	-	-	-	-	-	-
	Maximum Fan Speed	**RPM**	912	921	1,078	921	912	1,129	1,114	1,375
	Air Flow	**CFM**	29,900	29,900	29,900	29,900	29,900	25,000	6,800	7,000
	Total Fan Static	**In of H2O**	4.0	4.1	4.1	4.1	4.0	5.1	3.5	4.8
	Fan Brake Horsepower	**BHP**	23	24	24	24	23	26	6	9
	Fan Efficiency	**%**	81%	81%	80%	81%	81%	77%	63%	57%
	Quantity	**No.**	1	1	1	1	1	1	1	1
	Supply Fan Driver - Electric Motor									
	Make		-	-	-	-	-	-	-	-
	Motor Control Type		VFD	VFD	VFD	VFD	VFD	VFD	VFD	VFD
	Motor Nameplate Power	**HP**	30	30	30	30	30	30	8	10
	Voltage	**V**	460	460	460	460	460	460	460	460
	Speed	**RPM**	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750
	Nominal Efficiency	**%**	-	-	-	-	-	-	-	-
	Quantity	**No.**	1	1	1	1	1	1	1	1
	Cooling Coil									
	Total Capacity	**MBH**	1,134	1,134	1,133	1,134	1,134	1,241	229	346
	Total Capacity	**Tons**	95	95	94	95	95	103	19	29
	Sensible Capacity	**MBH**	823	823	823	823	823	797	176	223
	Fluid		Water	Water	Water	Water	Water	Water	Water	Water
	Fluid Flow	**GPM**	113	113	118	113	113	124	23	43
	Fluid Pressure Drop	**Ft of H2O**	9.5	9.5	10.3	9.5	9.5	17.5	1.6	5.2
	Entering Fluid Temp.	**°F**	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00
	Leaving Fluid Temp.	**°F**	62.00	62.00	61.20	62.00	62.00	62.00	62.00	58.00
	Fluid Rows	**No.**	-	-	-	-	-	-	-	-
	Number of Coils	**No.**	-	-	-	-	-	-	-	-
	Air Flow	**CFM**	29,900	29,900	29,900	29,900	29,900	25,000	6,800	7,000
	Air Pressure Drop	**In of H2O**	0.8	0.8	0.8	0.8	0.8	1.1	0.9	1.1
	Entering Air Temp. - DB	**°F**	79.50	79.50	79.50	79.50	79.50	83.50	78.00	83.50
	Entering Air Temp. - WB	**°F**	66.20	66.20	66.20	66.20	66.20	69.50	65.00	69.50
	Leaving Air Temp. - DB	**°F**	54.00	54.00	54.00	54.00	54.00	54.00	54.00	54.00
	Leaving Air Temp. - WB	**°F**	53.70	53.70	53.70	53.70	53.70	53.80	53.80	53.80
	Approach	**°F**	12	12	12	12	12	12	12	12
	Design Working Pressure	**PSIG**	-	-	-	-	-	-	-	-

2.6.7 Central Plant: Air Handling Unit

Table 16. Central Plant Chilled Water Air Handling Unit Specifications

Air Handling Unit			
AHU ID			**AC-5P**
Location			1st Sub-Cellar
Service			1st Sub-Cellar Offices
Make			Trane
Supply Air Flow		**CFM**	1,915
Design	**Supply Fan**		
	Design Fan Speed	**RPM**	-
	Maximum Fan Speed	**RPM**	1,372
	Air Flow	**CFM**	1,915
	Total Fan Static	**In of H2O**	2.3
	Fan Brake Horsepower	**BHP**	1
	Fan Efficiency	**%**	48%
	Quantity	**No.**	1
	Supply Fan Driver - Electric Motor		
	Make		-
	Motor Control Type		-
	Motor Nameplate Power	**HP**	2
	Voltage	**V**	460
	Speed	**RPM**	1,750
	Nominal Efficiency	**%**	-
	Quantity	**No.**	1
	Cooling Coil		
	Total Capacity	**MBH**	25
	Total Capacity	**Tons**	2
	Sensible Capacity	**MBH**	25
	Fluid		Water
	Fluid Flow	**GPM**	7
	Fluid Pressure Drop	**Ft of H2O**	-
	Entering Fluid Temp.	**°F**	45.00
	Leaving Fluid Temp.	**°F**	52.00
	Fluid Rows	**No.**	6
	Number of Coils	**No.**	-
	Air Flow	**CFM**	1,915
	Air Pressure Drop	**In of H2O**	0.6
	Entering Air Temp. - DB	**°F**	80.00
	Entering Air Temp. - WB	**°F**	67.00
	Leaving Air Temp. - DB	**°F**	68.00
	Leaving Air Temp. - WB	**°F**	57.00
	Approach	**°F**	23
	Design Working Pressure	**PSIG**	-

2.7 Decentralized Steam and Heating Hot Water Use

Steam enters the site through 250 Vesey St. and is distributed through tunnels to the four towers, Central Plant, and the Winter Garden. The steam is used in air handling units, steam-to-hot water heat exchangers, heating and ventilation units, cabinet unit heaters, unit heaters, and steam-to-domestic hot water heaters. Table 17 through Table 50 provide detailed specifications for these systems, for both steam and heating hot water components. These systems are essential for maintaining optimal environmental conditions within the four towers, Winter Garden, and Central Plant. The tables cover a range of equipment designed to efficiently manage heating, cooling, and ventilation requirements across the facility, ensuring reliable operation and comfort.

2.7.1 Tower A

Table 11 through Table 23 provide detailed specifications for the systems within Tower A for both steam and heating hot water systems. These include steam-to-heating hot water heat exchangers, air handling units, heating and ventilating units, and unit heaters.

2.7.1.1 *Steam-to-Heating Hot Water Heat Exchangers*

Table 17. Tower A Steam-to-Hot Water Heat Exchanger Specifications

Shell and Tube Heat Exchanger								
Heat Exchanger ID		**HX-1A**	**HX-2A**	**HX-3A**	**HX-4A**	**HX-5A**	**HX-6A**	**HX-7A**
Location		Tower A	Tower A	Tower A	Tower A	Tower A	Tower A	Tower A
Service		HW Heater 22nd-40th Flrs	HW AC-41A	HW Heater 3rd-21st Flrs	HW Heater Service, Street, 2nd Flr	HW HV-1A & HV-2A	Condensate Recovery System	HW Heater Standby HX-3A & HX-4A
Make		ITT	ITT	ITT	ITT	ITT	Yula	ITT
Model Number		SU 144-2	SU 125-2	SU 144-2	SU 124-2	SU 144-2	HIVC-4J-156B	SU 144-2
Serial Number		-	-	-	-	-	-	-
Nominal Capacity	**MBH**	4,400	7,200	3,900	3,000	4,440	1,430	3,900
Specified Net Capacity	**MBH**	4,400	7,260	3,900	3,000	4,400	1,430	3,900
Design Specifications								
Shell Side - Steam								
Fluid		Steam	Steam	Steam	Steam	Steam	Steam	Steam
Fluid Mass Flow	**LBs/Hr**	4,400	7,200	3,900	3,000	4,440	1,430	3,900
Entering Fluid Temp.	**°F**	302.10	302.10	302.10	302.10	302.10	302.10	302.10
Entering Fluid Pressure	**PSIG**	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Entering Fluid Enthalpy	**Btu/(Lbm-F)**	1193.30	1193.30	1193.30	1193.30	1193.30	1193.30	1193.30
Entering Fluid Deg Superheat	**°F**	83.60	83.60	83.60	83.60	83.60	83.60	83.60
Leaving Fluid Temp.	**°F**	218.50	218.50	218.50	218.50	218.50	218.50	218.50
Leaving Fluid Pressure	**PSIG**	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Leaving Fluid Enthalpy	**Btu/(Lbm-F)**	186.70	186.70	186.70	186.70	186.70	186.70	186.70
Fluid Passes	**No.**	2	2	2	2	2	-	2
Design Working Pressure	**PSIG**	-	-	-	-	-	-	-
Tube Side - Water								
Fluid		Water	Water	Water	Water	Water	Water	Water
Fluid Flow	**GPM**	440	440	390	300	440	220	390
Fluid Pressure Drop	**Ft of H2O**	1.6	3.3	1.0	1.3	1.6	4.0	1.0
Entering Fluid Temp.	**°F**	140.00	65.00	140.00	140.00	140.00	80.00	140.00
Leaving Fluid Temp.	**°F**	160.00	98.00	160.00	160.00	160.00	93.00	160.00
Fluid Passes	**No.**	2	2	2	2	2	4	2
Approach	**°F**	-	-	-	-	-	-	-
Design Working Pressure	**PSIG**	125	125	175	125	125	250	175
Min. Flow	**GPM**	-	-	-	-	-	-	-
Max. Flow	**GPM**	-	-	-	-	-	-	-

2.7.1.2 Tower A, Steam: Air Handling Units

Table 18. Tower A Steam Air Handling Unit Specifications

Air Handling Unit				
AHU ID			**AC-1A**	**AC-2A**
Location			Street Lvl Fan Room	Street Lvl Fan Room
Service			Lobby	Retail Area
Make			Joy	Joy
Supply Air Flow		**CFM**	60,000	52,500
Design	**Supply Fan**			
	Type		Axial	Axial
	Maximum Fan Speed	**RPM**	1,770	1,770
	Air Flow	**CFM**	60,000	52,500
	Total Fan Static	**In of H2O**	5.5	6.3
	Fan Brake Horsepower	**BHP**	60	55
	Fan Efficiency	**%**	87%	94%
	Quantity	**No.**	1	1
	Supply Fan Driver - Electric Motor			
	Make		-	-
	Motor Control Type		VFD	VFD
	Motor Nameplate Power	**HP**	75	75
	Voltage	**V**	460	460
	Speed	**RPM**	1,770	1,770
	Nominal Efficiency	**%**	-	-
	Quantity	**No.**	1	1
	Pre-Heat Coil			
	Capacity	**MBH**	3,078	2,805
	Fluid		Steam	Steam
	Steam Flow	**Lbs/Hr**	3,240	2,953
	Steam Inlet Pressure	**PSIG**	-	-
	Steam Temperture	**°F**	-	-
	Fluid Rows	**No.**	1	1
	Number of Coils	**No.**	-	-
	Air Flow	**CFM**	60,000	52,500
	Air Pressure Drop	**In of H2O**	0.2	-
	Entering Air Temp. - DB	**°F**	5.00	5.00
	Leaving Air Temp. - DB	**°F**	55.00	55.00
	Approach	**°F**	-	-
	Design Working Pressure	**PSIG**	-	-

2.7.1.3 Tower A, Steam: Unit Heaters and Cabinet Unit Heaters

Table 19. Tower A Steam Unit Heater and Cabinet Unit Heater Specifications

Unit Heaters

	Unit Heater ID		UH-1A & 2A	UH-3A & 4A	UH-13A
	Location		Street Lvl	Street Lvl	Street Lvl
	Service		Loading Dock	Loading Dock	Street Lvl MER
	Make		Trane	Trane	Trane
	Model Number		60S	336P	60S
	Serial Number		-	-	-
	Quantity of Units		2	2	1
	Unit Heater Capacity	**MBH**	49	328	51
Design	**Air Flow Data**				
	Supply Air Flow	**CFM**	597	5,210	597
	Discharge Air Temp	**°F**	139.00	119.00	139.00
	Motor Data				
	Make		-	-	-
	Motor Control Type		Starter	Starter	Starter
	Motor Nameplate Power	**HP**	1/20	3/4	1/20
	Voltage	**V**	115	460	115
	Speed	**RPM**	1,100	1,120	1,100
	Nominal Efficiency	**%**	-	-	-
	Quantity	**No.**	1	1	1
	Heating Coil				
	Capacity	**MBH**	49	328	49
	Fluid		Steam	Steam	Steam
	Steam Flow	**Lbs/Hr**	52	345	52
	Steam Inlet Pressure	**PSIG**	-	-	-
	Steam Temperture	**°F**	-	-	-
	Fluid Rows	**No.**	-	-	-
	Number of Coils	**No.**	-	-	-
	Air Flow	**CFM**	597	5,210	597
	Air Pressure Drop	**In of H2O**	-	-	-
	Entering Air Temp. - DB	**°F**	-	-	-
	Leaving Air Temp. - DB	**°F**	139.00	119.00	139.00
	Approach	**°F**	-	-	-
	Design Working Pressure	**PSIG**	-	-	-

2.7.1.4 Tower A, Heating Hot Water: Air Handling Unit

Table 20. Tower A Heating Hot Water Air Handling Unit Specifications

Air Handling Unit			
AHU ID			**AC-41A**
Location			Penthouse MER
Service			OA to CUs
Make			Trane
Supply Air Flow		**CFM**	145,000
Design Specifications	**Supply Fan**		
	Type		Centrifugal
	Maximum Fan Speed	**RPM**	516
	Air Flow	**CFM**	145,000
	Fan Static	**In of H2O**	4.5
	Fan Brake Horsepower	**BHP**	134
	Fan Efficiency	**%**	77%
	Quantity	**No.**	-
	Supply Fan Driver - Electric Motor		
	Make		Lincoln
	Motor Control Type		-
	Motor Nameplate Power	**HP**	150
	Voltage	**V**	460
	Speed	**RPM**	1,785
	Nominal Efficiency	**%**	-
	Quantity	**No.**	-
	Reclaim Coil		
	Capacity	**MBH**	6,539
	Fluid		Water
	Fluid Flow	**GPM**	4,087
	Fluid Pressure Drop	**Ft of H2O**	27.3
	Entering Fluid Temp.	**°F**	61.00
	Leaving Fluid Temp.	**°F**	64.20
	Fluid Rows	**No.**	6
	Number of Coils	**No.**	-
	Air Flow	**CFM**	145,000
	Air Pressure Drop	**In of H2O**	0.8
	Entering Air Temp. - DB	**°F**	92.00 / 5.00
	Entering Air Temp. - WB	**°F**	76.00 / -
	Leaving Air Temp. - DB	**°F**	66.50 / 50.00
	Leaving Air Temp. - WB	**°F**	65.80 / -
	Approach	**°F**	-
	Design Working Pressure	**PSIG**	-

2.7.1.5 Tower A, Heating Hot Water: Heating and Ventilating Units

Table 21. Tower A Heating Hot Water Heating and Ventilating Unit Specifications

Heating and Ventilation Air Handling Unit				
H&V ID			**HV-1A**	**HV-2A**
Location			Service Level MER	Service Level Fan Room
Service			Garage Ventilation	Service Level Ventilation
Make			Trane	Trane
Supply Air Flow		**CFM**	67,200	3,300
Design	**Supply Fan**			
	Type		-	-
	Maximum Fan Speed	**RPM**	461	1,150
	Air Flow	**CFM**	67,200	3,300
	Total Fan Static	**In of H2O**	2.0	2.0
	Fan Brake Horsepower	**BHP**	31	2
	Fan Efficiency	**%**	68%	58%
	Quantity	**No.**	1	1
	Supply Fan Driver - Electric Motor			
	Make		-	-
	Motor Control Type		Starter	Starter
	Motor Nameplate Power	**HP**	40	3
	Voltage	**V**	460	460
	Speed	**RPM**	1,750	1,750
	Nominal Efficiency	**%**	-	-
	Quantity	**No.**	1	1
	Pre-Heat Coil			
	Capacity	**MBH**	1,300	190
	Fluid		Water	Water
	Fluid Flow	**GPM**	200	19
	Fluid Pressure Drop	**Ft of H2O**	3.0	0.4
	Entering Fluid Temp.	**°F**	93.00	160.00
	Leaving Fluid Temp.	**°F**	80.00	140.00
	Fluid Rows	**No.**	4	2
	Number of Coils	**No.**	-	-
	Air Flow	**CFM**	67,200	3,300
	Air Pressure Drop	**In of H2O**	0.2	0.2
	Entering Air Temp. - DB	**°F**	5.00	10.00
	Leaving Air Temp. - DB	**°F**	70.00	60.00
	Approach	**°F**	-	-
	Design Working Pressure	**PSIG**	-	-

2.7.1.6 Tower A, Heating Hot Water: Unit Heaters and Cabinet Unit Heaters

Table 22. Tower A Heating Hot Water Unit Heater and Cabinet Unit Heater Specifications

Unit Heaters							
	Unit Heater ID		**UH-5A to 12A**	**CUH-1A to 4A**	**CUH-5A & 6A**	**UH-14A to 16A**	**UH-18A to 25A**
	Location		Penthouse Lvl	Street Lvl	Street Lvl	Garage	Gatehouse Penthouse
	Service		Penthouse MER	Secondary Entrance Htg	Exit Corridor Service Area	Garage	Gatehouse Penthouse
	Make		Trane	Trane	Trane	Trane	Trane
	Model Number		90S	04	02	90S	80P
	Serial Number		-	-	-	-	-
	Quantity of Units		8	4	2	3	8
	Unit Heater Capacity	**MBH**	40	22	14	40	30
Design	**Air Flow Data**						
	Supply Air Flow	**CFM**	1,214	370	145	1,214	858
	Discharge Air Temp	**°F**	102.30	145.60	141.50	102.30	100.00
	Motor Data						
	Make		-	-	-	-	-
	Motor Control Type		Starter	Starter	Starter	Starter	Starter
	Motor Nameplate Power	**HP**	1/8	1/30	1/60	1/8	1/20
	Voltage	**V**	115	115	115	115	115
	Speed	**RPM**	1,550	700	700	1,550	1,550
	Nominal Efficiency	**%**	-	-	-	-	-
	Quantity	**No.**	1	1	1	1	1
	Heating Coil						
	Capacity	**MBH**	40	22	14	40	30
	Fluid		Water	Water	Water	Water	Water
	Fluid Flow	**GPM**	4	2	1	4	3
	Fluid Pressure Drop	**Ft of H2O**	0.8	2.2	0.5	0.8	0.2
	Entering Fluid Temp.	**°F**	160.00	160.00	160.00	160.00	160.00
	Leaving Fluid Temp.	**°F**	140.00	140.00	140.00	140.00	140.00
	Number of Coils	**No.**	-	-	-	-	-
	Air Flow	**CFM**	1,214	370	145	1,214	858
	Leaving Air Temp. - DB	**°F**	102.30	145.60	141.50	102.30	100.00
	Approach	**°F**	-	-	-	-	-
	Design Working Pressure	**PSIG**	-	-	-	-	-

2.7.2 Tower B

The following tables present detailed specifications for various systems and equipment in Tower B, including both steam and heating hot water-based components. These systems are integral to the heating and ventilation infrastructure of the tower. The tables include specifications for the steam-to-heating hot water heat exchangers, steam-to-domestic hot water heaters, air handling units, heating and ventilating units, unit heaters, and cabinet unit heaters, as well as the corresponding heating hot water systems. Each table outlines the technical details and configurations of these components, providing a comprehensive overview of the Heating, Ventilation, and Air Conditioning (HVAC) systems in Tower B.

2.7.2.1 *Tower B, Steam: Steam-to-Heating Hot Water Heat Exchangers*

Table 23. Tower B Steam-to-Heating Hot Water Heat Exchanger Specifications

Shell and Tube Heat Exchanger									
Heat Exchanger ID			**HX-1B**	**HX-2B**	**HX-3B**	**HX-4B**	**HX-5B**	**HX-6B**	**HX-7B**
Location			Penthouse MER	Penthouse MER	Street Lvl MER	Street Lvl MER	Street Lvl MER	Street Lvl MER	Cellar 1 MER
Service			HW AC-46B	HW Heater 26th-44th Flrs	HW Heater 3rd-25th Flrs	HW Heater 3rd-25th Flrs	HW FCU Street/Lobby	HW A-B Bridge	HW HV-1B
Make			B&G	B&G	B&G	B&G	B&G	B&G	B&G
Model Number			SU 184-2	SU 184-2	SU 204-2	SU 204-2	SU 144-2	SU 46-2	SU 147-2
Serial Number			Q-59636	-	-	-	Q-59716	-	-
Nominal Capacity		**MBH**	-	-	-	-	-	-	-
Specified Net Capacity		**MBH**	5,500	5,500	6,800	6,800	3,800	80	5,400
Design Specifications	**Shell Side - Steam**								
	Fluid		Steam	Steam	Steam	Steam	Steam	Steam	Steam
	Fluid Mass Flow	**LBs/Hr**	5,670	5,670	7,010	7,010	3,920	8	5,570
	Entering Fluid Temp.	**°F**	302.10	302.10	302.10	302.10	302.10	302.10	302.10
	Entering Fluid Pressure	**PSIG**	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	Entering Fluid Enthalpy	**Btu/(Lbm-F)**	1193.30	1193.30	1193.30	1193.30	1193.30	1193.30	1193.30
	Entering Fluid Deg Superheat	**°F**	83.60	83.60	83.60	83.60	83.60	83.60	83.60
	Leaving Fluid Temp.	**°F**	218.50	218.50	218.50	218.50	218.50	218.50	218.50
	Leaving Fluid Pressure	**PSIG**	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	Leaving Fluid Enthalpy	**Btu/(Lbm-F)**	186.70	186.70	186.70	186.70	186.70	186.70	186.70
	Fluid Passes	**No.**	1	1	1	1	1	1	1
	Design Working Pressure	**PSIG**	150	150	150	150	150	150	150
	Tube Side - Water								
	Fluid		Water	Water	Water	Water	Water	Water	Water
	Fluid Flow	**GPM**	550	550	680	680	380	8	270
	Fluid Pressure Drop	**Ft of H2O**	1.0	1.0	1.0	1.0	1.0	1.0	1.7
	Entering Fluid Temp.	**°F**	61.00	140.00	140.00	140.00	140.00	180.00	80.00
	Leaving Fluid Temp.	**°F**	81.00	160.00	160.00	160.00	160.00	200.00	120.00
	Fluid Passes	**No.**	2	2	2	2	2	2	2
	Approach	**°F**	-	-	-	-	-	-	-
	Design Working Pressure	**PSIG**	125	125	125	125	125	125	125

2.7.2.2 *Tower B, Heating Hot Water: Steam-to-Domestic Hot Water Heaters*

Table 24. Tower B Steam-to-Domestic Hot Water Heater Specifications

Hot Water Heaters											
	Hot Water Heater ID		**H-1**	**H-2**	**H-3**	**H-4**	**H-5**	**H-6**	**H-7**	**H-8**	**H-9**
	Location		Cellar Level MER	Cellar Level MER	Cellar Level MER	Cellar Level MER	Cellar Level MER	Cellar Level MER	Cellar Level MER	Cellar Level MER	Cellar Level MER
	Service		Dining Terrace Bathrooms	Dining Terrace Bathrooms	Tenant Dining Terrace	Tenant Dining Terrace	Scullery Room	Scullery Room	Precipitators	Precipitators	Precipitators
	Make		AERCO	AERCO	AERCO	AERCO	AERCO	AERCO	AERCO	AERCO	AERCO
	Model Number		B+ 04EC	B+ 04EC	B+ 11EC	B+ 11EC	B+ 07EC	B+ 07EC	B+ 09EC	B+ 09EC	B+ 09EC
	Serial Number		H-12-391	H-12-390	H-12-393	H-12-392	H-12-395	H-12-394	H-12-388	H-12-389	H-12-387
	Nominal Capacity	**MBH**	-	-	-	-	-	-	-	-	-
	Specified Net Capacity	**MBH**	800	800	2,500	2,500	1,500	1,500	2,000	2,000	2,000
	Year Manufactured		2012	2012	2012	2012	2012	2012	2012	2012	2,012
Design Specifications	**Shell Side - Steam**										
	Fluid		Steam	Steam	Steam	Steam	Steam	Steam	Steam	Steam	Steam
	Fluid Mass Flow	**LBs/Hr**	802	802	2,506	2,506	1,504	1,504	2,005	2,005	2,005
	Entering Fluid Temp.	**°F**	303.50	303.50	303.50	303.50	303.50	303.50	303.50	303.50	303.50
	Entering Fluid Pressure	**PSIG**	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	Entering Fluid Enthalpy	**Btu/(Lbm-F)**	1,193.00	1,193.00	1,193.00	1,193.00	1,193.00	1,193.00	1,193.00	1,193.00	1,193.00
	Entering Fluid Deg Superheat	**°F**	76.40	76.40	76.40	76.40	76.40	76.40	76.40	76.40	76.40
	Leaving Fluid Temp.	**°F**	227.10	227.10	227.10	227.10	227.10	227.10	227.10	227.10	227.10
	Leaving Fluid Pressure	**PSIG**	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	Leaving Fluid Enthalpy	**Btu/(Lbm-F)**	195.40	195.40	195.40	195.40	195.40	195.40	195.40	195.40	195.40
	Fluid Passes	**No.**	-	-	-	-	-	-	-	-	-
	Design Working Pressure	**PSIG**	-	-	-	-	-	-	-	-	-
	Tube Side - Water										
	Fluid		Water	Water	Water	Water	Water	Water	Water	Water	Water
	Fluid Flow	**GPM**	20	20	50	50	30	30	40	40	40
	Fluid Pressure Drop	**Ft of H2O**	-	-	-	1.0	1.0	1.0	1.0	1.0	1.7
	Entering Fluid Temp.	**°F**	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
	Leaving Fluid Temp.	**°F**	120.00	120.00	140.00	140.00	140.00	140.00	140.00	140.00	140.00
	Fluid Passes	**No.**	1	1	1	1	1	1	1	1	1
	Min. Flow	**GPM**	-	-	-	-	-	-	-	-	-
	Max. Flow	**GPM**	-	-	-	-	-	-	-	-	-

2.7.2.3 *Tower B, Steam: Air Handling Units*

Table 25. Tower B Steam Air Handling Unit Specifications

Air Handling Unit							
AHU ID			AC-1B	AC-2B	AC-45B	AC-47B	AC-48B
Location			Cellar MER Area C	Street Lvl MER	Street Lvl MER	2nd Sub-Cellar MER	1st Sub-Cellar MER
Service			Lobby & Street Lvls	Liberty Street Bridge	OA 3rd to 15th Flrs	Cellar Lvl Tenant Storage	Cellar Lvls Core Areas
Make			Trane	Trane	Nortek	Trane	Trane
Supply Air Flow		CFM	65,000	7,200	130,000	84,000	30,400
OA Airflow		CFM	-	-	130,000	-	-
External Static		In of H2O	-	-	6.5	-	-
Design	Supply Fan						
	Type		-	-	Centrifugal	-	-
	Model		-	-	FW-45-1	-	-
	Design Fan Speed	RPM	-	-	2,381	-	-
	Maximum Fan Speed	RPM	865	1,287	-	621	1,116
	Air Flow	CFM	65,000	7,200	8,667	42,000	30,400
	Total Fan Static	In of H2O	6.0	4.5	-	4.8	3.8
	Fan Brake Horsepower	BHP	86	8	-	39	25
	Fan Efficiency	%	71%	61%	-	81%	72%
	Quantity	No.	1	1	15	2	1
	Supply Fan Driver - Electric Motor						
	Make		-	-	Toshiba	-	-
	Motor Control Type		VFD	VFD	VFD	Starter	Starter
	Motor Nameplate Power	HP	100	10	15	50	30
	Voltage	V	460	460	460	460	460
	Speed	RPM	1,750	1,750	1,770	1,750	1,750
	Nominal Efficiency	%	-	-	92.4%	-	-
	Quantity	No.	1	1	15	2	1
	Pre-Heat Coil						
	Capacity	MBH	3,481	236	-	2,508	1,712
	Fluid		Steam	Steam	Steam	Steam	Steam
	Steam Flow	Lbs/Hr	3,664	248	-	2,640	1,802
	Fluid Rows	No.	1	1	-	1	1
	Number of Coils	No.	-	-	-	-	-
	Air Flow	CFM	65,000	7,200	-	84,000	30,400
	Air Pressure Drop	In of H2O	0.2	0.2	-	0.1	0.1
	Entering Air Temp. - DB	°F	5.00	57.00	-	57.00	57.00
	Leaving Air Temp. - DB	°F	55.00	88.00	-	80.00	80.00
	Approach	°F	-	-	-	-	-
	Design Working Pressure	PSIG	-	-	-	-	-

2.7.2.4 *Tower B, Steam: Heating and Ventilating Units*

Table 26. Tower B Steam Heating and Ventilating Unit Specifications

Heating and Ventilation Air Handling Unit				
H&V ID			**HV-3B**	**HV-4B**
Location			Cellar MER	Cellar Storage Adj. Transformer Vaults
Service			Fresh Air/Smoke Retail Area	Storage/Mech. Space Ventilation
Make			Trane	Trane
Model Number			CAHB44C21CA2ESSSC10F0I0	-
Serial Number			K86G05323	-
Supply Air Flow		**CFM**	121,200	3,420
Design	**Supply Fan**			
	Type		Centrifugal	-
	Model		Master OL3109-0032-44	-
	Design Fan Speed	**RPM**	-	-
	Maximum Fan Speed	**RPM**	986	1,156
	Air Flow	**CFM**	60,600	3,420
	Total Fan Static	**In of H2O**	5.5	2.0
	Fan Brake Horsepower	**BHP**	-	2
	Fan Efficiency	**%**	-	57%
	Quantity	**No.**	2	1
	Supply Fan Driver - Electric Motor			
	Make		Marathon	-
	Motor Control Type		VFD	Starter
	Motor Nameplate Power	**HP**	50	3
	Voltage	**V**	460	460
	Speed	**RPM**	1,775	1,750
	Nominal Efficiency	**%**	93.0%	-
	Quantity	**No.**	2	1
	Pre-Heat Coil			
	Capacity	**MBH**	6,476	95
	Fluid		Steam	Steam
	Steam Flow	**Lbs/Hr**	6,817	100
	Steam Inlet Pressure	**PSIG**	-	-
	Steam Temperture	**°F**	-	-
	Fluid Rows	**No.**	1	1
	Number of Coils	**No.**	-	-
	Air Flow	**CFM**	121,200	3,420
	Air Pressure Drop	**In of H2O**	0.2	0.1
	Entering Air Temp. - DB	**°F**	5.00	62.20
	Leaving Air Temp. - DB	**°F**	55.00	88.30
	Approach	**°F**	-	-
	Design Working Pressure	**PSIG**	-	-

2.7.2.5 *Tower B, Steam: Unit Heaters and Cabinet Unit Heaters*

Table 27. Tower B Steam Unit Heater and Cabinet Unit Heater Specifications

	Unit Heaters					
	Unit Heater ID		**GEH-1B to 4B**	**UH-13B to 20B**	**UH-27B & 28B**	**UH-29B**
	Location		Car Ramps	Gatehouse Penthouse	Link MER	Gatehouse Penthouse
	Service		Car Ramp Entr. Heating	Gatehouse Penthouse	Link MER Heating	Emerg. Gen. Rm. Htg. Gatehouse
	Make		DynaForce	Trane	Trane	Trane
	Model Number		96-L/1	42P	42S	42S
	Serial Number		-	-	-	-
	Quantity of Units		4	8	2	1
	Unit Heater Capacity	**MBH**	447	41		51
Design	**Air Flow Data**					
	Supply Air Flow	**CFM**	7,580	660	660	660
	Discharge Air Temp	**°F**	-	124.00	124.00	124.00
	Motor Data					
	Make		-	-	-	-
	Motor Control Type		Starter	Starter	Starter	Starter
	Motor Nameplate Power	**HP**	1 1/ 2	1/25	1/25	1/25
	Voltage	**V**	460	115	115	115
	Speed	**RPM**	900	1550	1550	1550
	Nominal Efficiency	**%**	-	-		-
	Quantity	**No.**	2	1	1	1
	Heating Coil					
	Capacity	**MBH**	447	41	41	41
	Fluid		Steam	Steam	Steam	Steam
	Steam Flow	**Lbs/Hr**	470	43	43	43
	Steam Inlet Pressure	**PSIG**	-	-	-	-
	Steam Temperture	**°F**	-	-	-	-
	Fluid Rows	**No.**	-	-	-	-
	Number of Coils	**No.**	-	-	-	-
	Air Flow	**CFM**	7,580	660	660	660
	Air Pressure Drop	**In of H2O**	-	-	-	-
	Entering Air Temp. - DB	**°F**	-	-	-	-
	Leaving Air Temp. - DB	**°F**	-	124.00	124.00	124.00
	Approach	**°F**	-	-		-
	Design Working Pressure	**PSIG**	-	-		-

2.7.2.6 *Tower B, Heating Hot Water: Air Handling Unit*

Table 28. Tower B Heating Hot Water Air Handling Unit Specifications

Air Handling Unit			
AHU ID			**AC-46B**
Location			Penthouse MER
Service			OA 16th to 44th Flrs
Make			Trane
Model Number			CAFB49C12CC
Serial Number			K86J13488/9
Supply Air Flow		**CFM**	135,000
OA Airflow		**CFM**	135,000
External Static		**In of H2O**	6.50
Design	**Supply Fan**		
	Type		Centrifugal
	Model		490 BAE-DW
	Design Fan Speed	**RPM**	961
	Maximum Fan Speed	**RPM**	-
	Air Flow	**CFM**	67,500
	Fan Efficiency	**%**	-
	Quantity	**No.**	2
	Supply Fan Driver - Electric Motor		
	Make		Marathon
	Motor Control Type		VFD
	Motor Nameplate Power	**HP**	100
	Voltage	**V**	460
	Speed	**RPM**	1,788
	Nominal Efficiency	**%**	95.4%
	Quantity	**No.**	2
	Reclaim Coil		
	Capacity	**MBH**	-
	Fluid		Water
	Fluid Flow	**GPM**	2,313
	Fluid Pressure Drop	**Ft of H2O**	-
	Entering Fluid Temp.	**°F**	-
	Leaving Fluid Temp.	**°F**	-
	Fluid Rows	**No.**	-
	Number of Coils	**No.**	3
	Air Flow	**CFM**	135,000
	Air Pressure Drop	**In of H2O**	-
	Entering Air Temp. - DB	**°F**	-
	Leaving Air Temp. - DB	**°F**	-
	Approach	**°F**	-
	Design Working Pressure	**PSIG**	-

2.7.2.7 Tower B, Heating Hot Water: Heating and Ventilating Unit

Table 29. Tower B Heating Hot Water Heating and Ventilating Unit Specifications

Heating and Ventilation Air Handling Unit				
H&V ID			**HV-1B**	**HV-2B**
Location			1st Sub-Cellar MER	Cellar MER
Service			Garage Ventilation	Cellar Core Ventilation
Make			Trane	Trane
Supply Air Flow		**CFM**	42,500	2,600
Design	**Supply Fan**			
	Type		-	-
	Maximum Fan Speed	**RPM**	1,176	1,344
	Air Flow	**CFM**	42,500	2,600
	Total Fan Static	**In of H2O**	4.8	2.5
	Fan Brake Horsepower	**BHP**	48	2
	Fan Efficiency	**%**	66%	57%
	Quantity	**No.**	1	1
	Supply Fan Driver - Electric Motor			
	Make		Marathon	-
	Motor Control Type		Starter	Starter
	Motor Nameplate Power	**HP**	60	2
	Voltage	**V**	460	460
	Speed	**RPM**	1,782	1,750
	Nominal Efficiency	**%**	95.0%	-
	Quantity	**No.**	1	1
	Pre-Heat Coil			
	Capacity	**MBH**	5,400	169
	Fluid		Water	Water
	Fluid Flow	**GPM**	270	176
	Fluid Pressure Drop	**Ft of H2O**	4.0	-
	Entering Fluid Temp.	**°F**	120.00	-
	Leaving Fluid Temp.	**°F**	80.00	-
	Fluid Rows	**No.**	-	1
	Number of Coils	**No.**	-	-
	Air Flow	**CFM**	42,500	2,600
	Air Pressure Drop	**In of H2O**	0.5	0.1
	Entering Air Temp. - DB	**°F**	5.00	5.00
	Leaving Air Temp. - DB	**°F**	65.00	65.00
	Approach	**°F**	-	-
	Design Working Pressure	**PSIG**	-	

2.7.2.8 Tower B, Heating Hot Water: Unit Heaters and Cabinet Unit Heaters

Table 30. Tower B Heating Hot Water Unit Heater and Cabinet Unit Heater Specifications

Unit Heaters						
	Unit Heater ID		**CUH-1B & 2B**	**CUH-3B to 5B**	**CUH-6B & 7B**	**UH-7B to 12B**
	Location		Street Lvl	Street Lvl	Street Lvl	Penthouse
	Service		Exit Heating	Exit Heating	Exit Heating	Penthouse MER Heating
	Make		Trane	Trane	Trane	Trane
	Model Number		N-AO-04	N-AO-03	N-AO-04	90S
	Serial Number		-	-	-	-
	Quantity of Units		2	3	2	6
	Unit Heater Capacity	**MBH**	38	29	38	40
Design	**Air Flow Data**					
	Supply Air Flow	**CFM**	400	300	400	1,214
	Discharge Air Temp	**°F**	136.90	136.80	136.90	102.50
	Motor Data					
	Make		-	-	-	-
	Motor Control Type		Starter	Starter	Starter	Starter
	Motor Nameplate Power	**HP**	1/30	1/30	1/30	1/8
	Voltage	**V**	115	115	115	115
	Speed	**RPM**	1100	1100	1100	1550
	Nominal Efficiency	**%**	-	-	-	-
	Quantity	**No.**	1	1	1	1
	Heating Coil					
	Capacity	**MBH**	38	29	38	40
	Fluid		Water	Water	Water	Water
	Fluid Flow	**GPM**	4	3	4	4
	Fluid Pressure Drop	**Ft of H2O**	3.9	1.8	3.9	0.8
	Entering Fluid Temp.	**°F**	160.00	160.00	160.00	160.00
	Leaving Fluid Temp.	**°F**	140.00	140.00	140.00	140.00
	Fluid Rows	**No.**	-	-	-	-
	Number of Coils	**No.**	-	-	-	-
	Air Flow	**CFM**	400	300	400	1,214
	Air Pressure Drop	**In of H2O**	-	-	-	-
	Entering Air Temp. - DB	**°F**	-	-	-	-
	Leaving Air Temp. - DB	**°F**	136.90	136.80	136.90	102.50
	Approach	**°F**	-	-	-	-
	Design Working Pressure	**PSIG**	-	-	-	-

2.7.3 Tower C

The following tables present detailed specifications for various systems and equipment in Tower C, including both steam and heating hot water-based components. These systems are integral to the heating and ventilation infrastructure of the tower. The tables include specifications for the steam-to-heating hot water heat exchangers, steam-to-domestic hot water heaters, air handling units, heating and ventilating units, unit heaters, and cabinet unit heaters, as well as the corresponding heating hot water systems. Each table outlines the technical details and configurations of these components, providing a comprehensive overview of the HVAC systems in Tower C.

2.7.3.1 *Tower C, Steam: Steam-to-Heating Hot Water Heat Exchangers*

Table 31. Tower C Steam-to-Heating Hot Water Heat Exchanger Specifications

Shell and Tube Heat Exchanger								
Heat Exchanger ID		**HX-1C**	**HX-2C**	**HX-3C**	**HX-4C**	**HX-5C**	**HX-6C**	**HX-7C**
Location		Tower C	Tower C	Tower C	Tower C	Tower C	Tower C	Tower C
Service		HHW 3rd - 27th Flrs	HHW Service, Street & 2nd Flrs	Condensate Heat Recovery	Aux. Heating AC-52C	HHW 28th - 51st Flrs	HHW HV-1C & 2C	Stdby. for HX-1C & 2C
Make		ITT	ITT	Yula	ITT	ITT	ITT	ITT
Model Number		SU 184-2	SU 184-2	HWC-4J-156B	SU 164-2	SU 184-2	SU 104-2	SU 184-2
Serial Number		-	-	-	-	-	-	-
Nominal Capacity	**MBH**	6,000	7,000	1,430	5,000	6,500	1,750	6,000
Specified Net Capacity	**MBH**	6,000	7,000	1,430	5,000	6,500	1,750	6,000
Design Specifications								
Shell Side - Steam								
Fluid		Steam	Steam	Steam	Steam	Steam	Steam	Steam
Fluid Mass Flow	**LBs/Hr**	6,000	7,000	1,430	5,000	6,500	1,750	6,000
Entering Fluid Temp.	**°F**	302.10	302.10	302.10	302.10	302.10	302.10	302.10
Entering Fluid Pressure	**PSIG**	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Entering Fluid Enthalpy	**Btu/(Lbm-F)**	1193.30	1193.30	1193.30	1193.30	1193.30	1193.30	1193.30
Entering Fluid Deg Superheat	**°F**	83.60	83.60	83.60	83.60	83.60	83.60	83.60
Leaving Fluid Temp.	**°F**	218.50	218.50	218.50	218.50	218.50	218.50	218.50
Leaving Fluid Pressure	**PSIG**	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Leaving Fluid Enthalpy	**Btu/(Lbm-F)**	186.70	186.70	186.70	186.70	186.70	186.70	186.70
Tube Side - Water								
Fluid		Water	Water	Water	Water	Water	Water	Water
Fluid Flow	**GPM**	600	700	220	500	650	175	600
Fluid Pressure Drop	**Ft of H2O**	1.1	1.5	4.0	1.2	1.2	1.1	1.1
Entering Fluid Temp.	**°F**	140.00	140.00	80.00	140.00	140.00	140.00	140.00
Leaving Fluid Temp.	**°F**	160.00	160.00	93.00	160.00	160.00	160.00	160.00
Fluid Passes	**No.**	2	2	4	2	2	2	2
Approach	**°F**	-	-	-	-	-	-	-
Design Working Pressure	**PSIG**	175	125	250	125	125	125	175
Min. Flow	**GPM**	-	-	-	-	-	-	-
Max. Flow	**GPM**	-	-	-	-	-	-	-

2.7.3.2 Tower C, Steam-to-Domestic Hot Water Heaters

Table 32. Tower C Steam-to-Domestic Hot Water Heater Specifications

Hot Water Heaters									
Hot Water Heater ID			**H-1**	**H-2**	**H-3**	**H-4**	**H-5**	**H-6**	**H-7**
Location			-	-	-	-	-	P-62 Room	P-62 Room
Service			-	-	-	-	-	Kitchen	Kitchen
Make			Patterson-Kelley	Patterson-Kelley	Patterson-Kelley	Patterson-Kelley	Patterson-Kelley	Patterson-Kelley	Patterson-Kelley
Model Number			-	-	-	-	-	-	-
Serial Number			270622	270623	270624	270625	270626	270914	270915
Nominal Capacity		**MBH**	1,000	1,000	1,000	1,000	1,000	2,000	2,000
Specified Net Capacity		**MBH**	1,000	1,000	1,000	1,000	1,000	2,000	2,000
Year Manufactured			1984	1984	1984	1984	1984	1984	1984
Design Specifications	**Shell Side - Steam**								
	Fluid		Steam	Steam	Steam	Steam	Steam	Steam	Steam
	Fluid Mass Flow	**LBs/Hr**	1,029	1,029	1,029	1,029	1,029	2,077	2,077
	Entering Fluid Temp.	**°F**	303.50	303.50	303.50	303.50	303.50	305.80	305.80
	Entering Fluid Pressure	**PSIG**	5.0	5.0	5.0	5.0	5.0	10.0	10.0
	Entering Fluid Enthalpy	**Btu/(Lbm-F)**	1,193.00	1,193.00	1,193.00	1,193.00	1,193.00	1,193.30	1,193.30
	Entering Fluid Deg Superheat	**°F**	76.40	76.40	76.40	76.40	76.40	66.40	66.40
	Leaving Fluid Temp.	**°F**	227.10	227.10	227.10	227.10	227.10	239.40	239.40
	Leaving Fluid Pressure	**PSIG**	5.0	5.0	5.0	5.0	5.0	10.0	10.0
	Leaving Fluid Enthalpy	**Btu/(Lbm-F)**	195.40	195.40	195.40	195.40	195.40	207.80	207.80
	Fluid Passes	**No.**	-	-	-	-	-	-	-
	Design Working Pressure	**PSIG**	150	150	150	150	150	150	150
	Tube Side - Water								
	Fluid		Water	Water	Water	Water	Water	Water	Water
	Fluid Flow	**GPM**	25	25	25	25	25	40	40
	Fluid Pressure Drop	**Ft of H2O**	150.0	150.0	150.0	-	-	150.0	150.0
	Entering Fluid Temp.	**°F**	40.0	40.0	40.0	40.0	40.0	40.0	40.0
	Leaving Fluid Temp.	**°F**	120.00	120.00	120.00	120.00	120.00	140.00	140.00
	Fluid Passes	**No.**	-	-	-	-	-	-	-
	Approach	**°F**	-	-	-	-	-	-	-
	Design Working Pressure	**PSIG**	150	150	150	150	150	150	150
	Min. Flow	**GPM**	-	-	-	-	-	-	-
	Max. Flow	**GPM**	-	-	-	-	-	-	-

2.7.3.3 *Tower C, Steam: Air Handling Units*

Table 33. Tower C Steam Air Handling Unit Specifications

Air Handling Unit						
	AHU ID		**AC-1C**	**AC-2C**	**AHU-301C**	**AHU-303C**
	Location		3rd Flr Fan Room	3rd Flr Fan Room	3rd Flr Fan Room	3rd Flr Fan Room
	Service		Lobby Levels	Retail Areas	Kitchen	Kitchen
	Make		Trane	Trane	-	-
	Supply Air Flow	**CFM**	63,000	117,500	-	-
Design	**Supply Fan**					
	Type		Centrifugal	Centrifugal	-	-
	Maximum Fan Speed	**RPM**	844	834	-	-
	Air Flow	**CFM**	63,000	58,750	-	-
	Total Fan Static	**In of H2O**	6.0	6.0	-	-
	Fan Brake Horsepower	**BHP**	77	72	-	-
	Fan Efficiency	**%**	78%	77%	-	-
	Quantity	**No.**	1	2	1	1
	Supply Fan Driver - Electric Motor					
	Make		-	-	-	-
	Motor Control Type		VFD	VFD	Starter	Starter
	Motor Nameplate Power	**HP**	100	100	-	-
	Voltage	**V**	460	460	-	-
	Speed	**RPM**	1,750	1,750	-	-
	Nominal Efficiency	**%**	-	-	-	-
	Quantity	**No.**	1	2	1	1
	Pre-Heat Coil					
	Capacity	**MBH**	1,615	1,520	-	-
	Fluid		Steam	Steam	Steam	Steam
	Steam Flow	**Lbs/Hr**	1,700	1,600	-	-
	Steam Inlet Pressure	**PSIG**	-	-	-	-
	Steam Temperture	**°F**	-	-	-	-
	Fluid Rows	**No.**	1	1	-	-
	Number of Coils	**No.**	-	-	-	-
	Air Flow	**CFM**	63,000	117,500	-	-
	Air Pressure Drop	**In of H2O**	0.2	0.2	-	-
	Entering Air Temp. - DB	**°F**	5.00	5.00	-	-
	Leaving Air Temp. - DB	**°F**	55.00	55.00	-	-
	Approach	**°F**	-	-	-	-
	Design Working Pressure	**PSIG**	-	-	-	-

2.7.3.4 *Tower C, Heating Hot Water: Heating and Ventilating Units*

Table 34. Tower C Heating Hot Water Heating and Ventilating Unit Specifications

Heating and Ventilation Air Handling Unit				
H&V ID			**HV-1C**	**HV-2C**
Location			Service Level	Service Level
Service			Garage Vent	MER Ventilation
Make			Trane	Trane
Supply Air Flow		**CFM**	25,000	5,410
Design	**Supply Fan**			
	Type		-	-
	Maximum Fan Speed	**RPM**	1,083	1,060
	Air Flow	**CFM**	25,000	5,410
	Total Fan Static	**In of H2O**	2.0	2.5
	Fan Brake Horsepower	**BHP**	15	4
	Fan Efficiency	**%**	53%	59%
	Quantity	**No.**	1	1
	Supply Fan Driver - Electric Motor			
	Make		-	-
	Motor Control Type		Starter	Starter
	Motor Nameplate Power	**HP**	20	5
	Voltage	**V**	460	460
	Quantity	**No.**	1	1
	Pre-Heat Coil			
	Capacity	**MBH**	1,660	360
	Fluid		Water	Water
	Fluid Flow	**GPM**	166	36
	Fluid Pressure Drop	**Ft of H2O**	10.1	1.0
	Entering Fluid Temp.	**°F**	160.00	160.00
	Leaving Fluid Temp.	**°F**	140.00	140.00
	Fluid Rows	**No.**	1	1
	Number of Coils	**No.**	-	-
	Air Flow	**CFM**	25,000	5,410
	Air Pressure Drop	**In of H2O**	0.3	0.3
	Entering Air Temp. - DB	**°F**	5.00	5.00
	Leaving Air Temp. - DB	**°F**	65.00	65.00
	Approach	**°F**	-	-
	Design Working Pressure	**PSIG**	-	-

2.7.3.5 Tower C, Heating Hot Water: Unit Heaters and Cabinet Unit Heaters

Table 35. Tower C Heating Hot Water Unit Heaters and Cabinet Unit Heaters Specifications

Unit Heaters			
Unit Heater ID			**UH-1C to 7C**
Location			Penthouse MER
Service			Penthouse MER
Make			Trane
Model Number			90S
Serial Number			-
Quantity of Units			7
Unit Heater Capacity		**MBH**	40
Design	**Air Flow Data**		
	Supply Air Flow	**CFM**	1,214
	Discharge Air Temp	**°F**	102.30
	Motor Data		
	Make		-
	Motor Control Type		Starter
	Motor Nameplate Power	**HP**	1/8
	Voltage	**V**	115
	Speed	**RPM**	1550
	Nominal Efficiency	**%**	-
	Quantity	**No.**	1
	Heating Coil		
	Capacity	**MBH**	40
	Fluid		Water
	Fluid Flow	**GPM**	4
	Fluid Pressure Drop	**Ft of H2O**	0.8
	Entering Fluid Temp.	**°F**	160.00
	Leaving Fluid Temp.	**°F**	140.00
	Number of Coils	**No.**	-
	Air Flow	**CFM**	1,214
	Air Pressure Drop	**In of H2O**	-
	Entering Air Temp. - DB	**°F**	-
	Leaving Air Temp. - DB	**°F**	102.30
	Approach	**°F**	-
	Design Working Pressure	**PSIG**	-

2.7.4 Tower D

The following tables present detailed specifications for various systems and equipment in Tower D, including both steam and heating hot water-based components. These systems are integral to the heating and ventilation infrastructure of the tower. The tables include specifications for the steam-to-heating hot water heat exchangers, steam-to-domestic hot water heaters, air handling units, heating and ventilating units, unit heaters, and cabinet unit heaters, as well as the corresponding heating hot water systems. Each table outlines the technical details and configurations of these components, providing a comprehensive overview of the HVAC systems in Tower D.

2.7.4.1 Tower D, Steam: Steam-to-Heating Hot Water Heat Exchangers

Table 36. Tower D Steam-to-Heating Hot Water Heat Exchanger Specifications

Shell and Tube Heat Exchanger									
Heat Exchanger ID			**HX-1D**	**HX-2D**	**HX-3D**	**HX-4D**	**HX-5D**	**HX-6D**	**HX-7D**
Location			Penthouse MER	2nd Floor MER	2nd Floor MER	2nd Floor MER	Penthouse MER	4th Floor MER	4th Floor MER
Service			HHW High Rise	HHW Mid Rise	HHW Trench System	HHW Trench System	HHW AC-35D	HHW Low Rise	HHW Low Rise
Make			Yula	Yula	Yula	Yula	Yula	B&G	B&G
Model Number			CV-2E-78B	CV-2C-108B	CV-2E-66B	CV-2E-66B	CV-2F-66B	SU-124-2	SU-124-2
Serial Number			11934	11937	11936	11935	11938	-	-
Nominal Capacity		**MBH**	4,350	2,000	3,500	3,500	8,010	3,800	3,800
Specified Net Capacity		**MBH**	4,350	2,000	3,500	3,500	8,010	3,800	3,800
Design Specifications	**Shell Side - Steam**								
	Fluid		Steam	Steam	Steam	Steam	Steam	Steam	Steam
	Fluid Mass Flow	**LBs/Hr**	4,570	2,070	3,625	3,625	8,260	3,934	3,934
	Entering Fluid Temp.	**°F**	302.10	302.10	302.10	302.10	302.10	302.10	302.10
	Entering Fluid Pressure	**PSIG**	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	Entering Fluid Enthalpy	**Btu/(Lbm-F)**	1193.30	1193.30	1193.30	1193.30	1193.30	1193.30	1193.30
	Entering Fluid Deg Superheat	**°F**	83.60	83.60	83.60	83.60	83.60	83.60	83.60
	Leaving Fluid Temp.	**°F**	218.50	218.50	218.50	218.50	218.50	218.50	218.50
	Leaving Fluid Pressure	**PSIG**	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	Leaving Fluid Enthalpy	**Btu/(Lbm-F)**	186.70	186.70	186.70	186.70	186.70	186.70	186.70
	Fluid Passes	**No.**	2	2	2	2	2	1	1
	Design Working Pressure	**PSIG**	150	150	150	150	150	150	150
	Tube Side								
	Fluid		Water	Water	Water	Water	Water	Water	Water
	Fluid Flow	**GPM**	435	200	350	350	450	380	380
	Fluid Pressure Drop	**Ft of H2O**	1.6	1.0	1.0	1.0	1.6	1.7	1.7
	Entering Fluid Temp.	**°F**	140.00	140.00	140.00	140.00	65.00	140.00	140.00
	Leaving Fluid Temp.	**°F**	160.00	160.00	160.00	160.00	100.60	160.00	160.00
	Fluid Passes	**No.**	2	2	2	2	2	2	2
	Approach	**°F**	-	-	-	-	-	-	-
	Design Working Pressure	**PSIG**	175	175	175	175	175	-	-
	Min. Flow	**GPM**	-	-	-	-	-	-	-
	Max. Flow	**GPM**	-	-	-	-	-	-	-

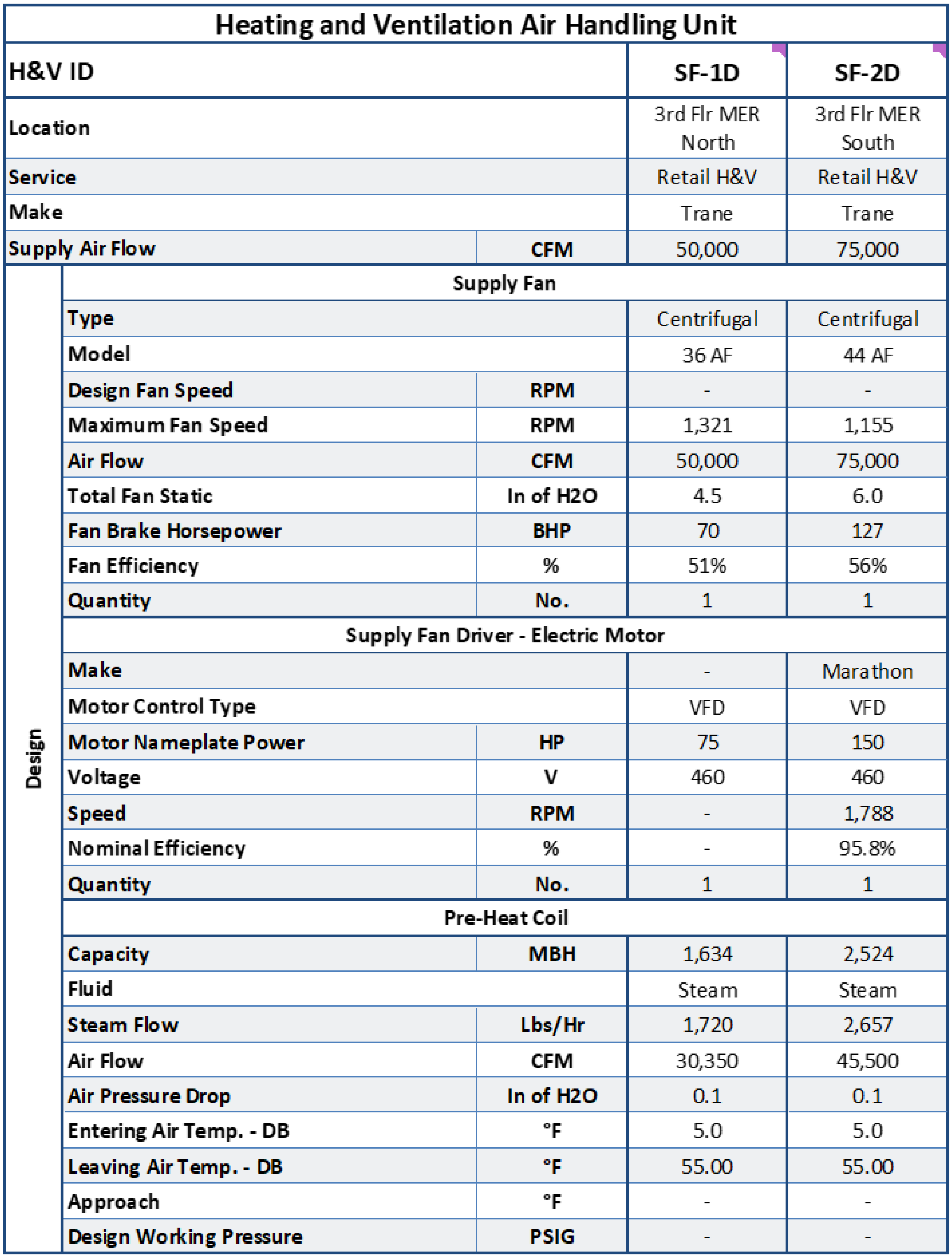
2.7.4.2 Tower D, Steam: Air Handling Units

Table 37. Tower D Steam Air Handling Unit Specifications

Air Handling Unit					
AHU ID			**AC-1D**	**AC-2DN**	**AC-2DS**
Location			+0'-6" Lvl MER	3rd Flr MER North	3rd Flr MER South
Service			Lobby	Courtyard North & East Area	Courtyard South & West Area
Make			Trane	Trane	Trane
Supply Air Flow		**CFM**	33,300	51,600	65,600
Design Specifications	**Supply Fan**				
	Type		Centrifugal	-	-
	Model		40-AFSW-21-10-11	44 AFD	49 AFD
	Design Fan Speed	**RPM**	1,136	-	-
	Maximum Fan Speed	**RPM**	1,283	819	757
	Air Flow	**CFM**	33,300	51,600	65,600
	Fan Static	**In of H2O**	3.9	3.3	3.3
	Fan Brake Horsepower	**BHP**	-	46	61
	Fan Efficiency	**%**	-	58%	56%
	Quantity	**No.**	1	1	1
	Supply Fan Driver - Electric Motor				
	Make		-	Marathon	-
	Motor Control Type		VFD	VFD	-
	Motor Nameplate Power	**HP**	40	60	75
	Voltage	**V**	460	460	460
	Speed	**RPM**	1,725	1,785	1,750
	Nominal Efficiency	**%**	94.1%	95.0%	-
	Quantity	**No.**	1	1	1
	Pre-Heat Coil				
	Capacity	**MBH**	-	2,762	3,510
	Fluid		Steam	Steam	Steam
	Steam Flow	**Lbs/Hr**	-	2,907	3,695
	Fluid Rows	**No.**	-	1	1
	Number of Coils	**No.**	-	-	-
	Air Flow	**CFM**	-	51,600	65,600
	Air Pressure Drop	**In of H2O**	-	0.2	0.2
	Entering Air Temp. - DB	**°F**	-	5.0	5.0
	Leaving Air Temp. - DB	**°F**	-	55.0	55.0
	Approach	**°F**	-	-	-
	Design Working Pressure	**PSIG**	-	-	-

2.7.4.3 *Tower D, Steam: Heating and Ventilating Units*

Table 38. Tower D Steam Heating and Ventilating Unit Information Specifications



Heating and Ventilation Air Handling Unit				
	H&V ID		**SF-1D**	**SF-2D**
	Location		3rd Flr MER North	3rd Flr MER South
	Service		Retail H&V	Retail H&V
	Make		Trane	Trane
	Supply Air Flow	**CFM**	50,000	75,000
Design	**Supply Fan**			
	Type		Centrifugal	Centrifugal
	Model		36 AF	44 AF
	Design Fan Speed	**RPM**	-	-
	Maximum Fan Speed	**RPM**	1,321	1,155
	Air Flow	**CFM**	50,000	75,000
	Total Fan Static	**In of H2O**	4.5	6.0
	Fan Brake Horsepower	**BHP**	70	127
	Fan Efficiency	**%**	51%	56%
	Quantity	**No.**	1	1
	Supply Fan Driver - Electric Motor			
	Make		-	Marathon
	Motor Control Type		VFD	VFD
	Motor Nameplate Power	**HP**	75	150
	Voltage	**V**	460	460
	Speed	**RPM**	-	1,788
	Nominal Efficiency	**%**	-	95.8%
	Quantity	**No.**	1	1
	Pre-Heat Coil			
	Capacity	**MBH**	1,634	2,524
	Fluid		Steam	Steam
	Steam Flow	**Lbs/Hr**	1,720	2,657
	Air Flow	**CFM**	30,350	45,500
	Air Pressure Drop	**In of H2O**	0.1	0.1
	Entering Air Temp. - DB	**°F**	5.0	5.0
	Leaving Air Temp. - DB	**°F**	55.00	55.00
	Approach	**°F**	-	-
	Design Working Pressure	**PSIG**	-	-

2.7.4.4 Tower D, Steam: Unit Heaters and Cabinet Unit Heaters

Table 39. Tower D Steam Unit Heater and Cabinet Unit Heater Specifications

Unit Heaters			
Unit Heater ID			**UH-44D**
Location			+0'-6" MER
Service			+0'-6" MER Smoke Exh Make Up
Make			Trane
Model Number			UHS-090-S
Serial Number			-
Quantity of Units			1
Unit Heater Capacity		**MBH**	93
Design	**Air Flow Data**		
	Supply Air Flow	**CFM**	1,214
	Discharge Air Temp	**°F**	127.00
	Motor Data		
	Make		-
	Motor Control Type		Starter
	Motor Nameplate Power	**HP**	1/8
	Voltage	**V**	115
	Speed	**RPM**	1550
	Nominal Efficiency	**%**	-
	Quantity	**No.**	1
	Heating Coil		
	Capacity	**MBH**	93
	Fluid		Steam
	Steam Flow	**Lbs/Hr**	98
	Steam Inlet Pressure	**PSIG**	5.0
	Steam Temperture	**°F**	-
	Fluid Rows	**No.**	-
	Number of Coils	**No.**	-
	Air Flow	**CFM**	1,214
	Air Pressure Drop	**In of H2O**	-
	Entering Air Temp. - DB	**°F**	-
	Leaving Air Temp. - DB	**°F**	127.00
	Approach	**°F**	-
	Design Working Pressure	**PSIG**	-

2.7.4.5 *Tower D, Heating Hot Water: Air Handling Unit*

Table 40. Tower D Heating Hot Water Air Handling Unit Specifications

Air Handling Unit			
AHU ID			**AC-35D**
Location			Penthouse MER
Service			OA to CUs
Make			Trane
Model Number			-
Serial Number			-
Supply Air Flow		**CFM**	-
OA Airflow		**CFM**	-
Total External Static		**In of H2O**	-
Design Specifications	**Supply Fan**		
	Type		Centrifugal
	Model		542 VCR AF
	Design Fan Speed	**RPM**	-
	Maximum Fan Speed	**RPM**	-
	Air Flow	**CFM**	-
	Fan Static	**In of H2O**	-
	Fan Brake Horsepower	**BHP**	-
	Fan Efficiency	**%**	-
	Quantity	**No.**	2
	Supply Fan Driver - Electric Motor		
	Make		Teco
	Motor Control Type		VFD
	Motor Nameplate Power	**HP**	200
	Voltage	**V**	460
	Speed	**RPM**	1,780
	Nominal Efficiency	**%**	95.0%
	Quantity	**No.**	2
	Reclaim Coil		
	Capacity	**MBH**	-
	Fluid		Water
	Fluid Flow	**GPM**	-
	Fluid Pressure Drop	**Ft of H2O**	-
	Entering Fluid Temp.	**°F**	-
	Leaving Fluid Temp.	**°F**	-
	Fluid Rows	**No.**	-
	Number of Coils	**No.**	-
	Air Flow	**CFM**	-
	Air Pressure Drop	**In of H2O**	-
	Entering Air Temp. - DB	**°F**	-
	Leaving Air Temp. - DB	**°F**	-
	Approach	**°F**	-
	Design Working Pressure	**PSIG**	-

2.7.4.6 *Tower D, Heating Hot Water: Unit Heaters and Cabinet Unit Heaters*

Table 41. Tower D Heating Hot Water Unit Heater and Cabinet Unit Heater Specifications

Shell and Tube Heat Exchanger			
Heat Exchanger ID		**HX-1W**	**HX-W2**
Location		Winter Garden	Winter Garden
Service		Secondary HW System	Secondary HW System
Make		B&G	B&G
Model Number		SU-125-2	SU-125-2
Serial Number		-	-
Nominal Capacity	**MBH**	1,080	1,080
Specified Net Capacity	**MBH**	1,078	1,078
Shell Side - Steam			
Fluid		Steam	Steam
Fluid Mass Flow	**LBs/Hr**	1,115	1,115
Entering Fluid Temp.	**°F**	302.10	302.10
Entering Fluid Pressure	**PSIG**	2.00	2.00
Entering Fluid Enthalpy	**Btu/(Lbm-F)**	1193.30	1193.30
Entering Fluid Deg Superheat	**F**	83.60	83.60
Leaving Fluid Temp.	**°F**	218.50	218.50
Leaving Fluid Pressure	**PSIG**	2.0	2.0
Leaving Fluid Enthalpy	**Btu/(Lbm-F)**	186.70	186.70
Fluid Passes	**No.**	-	-
Design Working Pressure	**PSIG**	-	-
Tube Side			
Fluid		Water	Water
Fluid Flow	**GPM**	98	98
Fluid Pressure Drop	**Ft of H2O**	1.0	1.0
Entering Fluid Temp.	**°F**	178.00	178.00
Leaving Fluid Temp.	**°F**	200.00	200.00
Fluid Passes	**No.**	2	2
Approach	**°F**	-	-
Design Working Pressure	**PSIG**	125	125
Min. Flow	**GPM**	-	-
Max. Flow	**GPM**	-	-

2.7.5 Winter Garden

The following tables present detailed specifications for various systems and equipment in Winter Garden, including both steam and heating hot water-based components. These systems are integral to the heating and ventilation infrastructure of the tower. The tables include specifications for the steam-to-heating hot water heat exchangers, steam-to-domestic hot water heaters, air handling units, heating and ventilating units, unit heaters, and cabinet unit heaters, as well as the corresponding heating hot water systems. Each table outlines the technical details and configurations of these components, providing a comprehensive overview of the HVAC systems in Winter Garden.

2.7.5.1 *Winter Garden, Steam: Steam-to-Heating Hot Water Heat Exchangers*

Table 42. Winter Garden Steam-to-Heating Hot Water Heat Exchanger Specifications

Shell and Tube Heat Exchanger			
Heat Exchanger ID		**HX-1W**	**HX-W2**
Location		Winter Garden	Winter Garden
Service		Secondary HW System	Secondary HW System
Make		B&G	B&G
Model Number		SU-125-2	SU-125-2
Serial Number		-	-
Nominal Capacity	**MBH**	1,080	1,080
Specified Net Capacity	**MBH**	1,078	1,078
Shell Side - Steam			
Fluid		Steam	Steam
Fluid Mass Flow	**LBs/Hr**	1,115	1,115
Entering Fluid Temp.	**°F**	302.10	302.10
Entering Fluid Pressure	**PSIG**	2.00	2.00
Entering Fluid Enthalpy	**Btu/(Lbm-F)**	1193.30	1193.30
Entering Fluid Deg Superheat	**F**	83.60	83.60
Leaving Fluid Temp.	**°F**	218.50	218.50
Leaving Fluid Pressure	**PSIG**	2.0	2.0
Leaving Fluid Enthalpy	**Btu/(Lbm-F)**	186.70	186.70
Fluid Passes	**No.**	-	-
Design Working Pressure	**PSIG**	-	-
Tube Side			
Fluid		Water	Water
Fluid Flow	**GPM**	98	98
Fluid Pressure Drop	**Ft of H2O**	1.0	1.0
Entering Fluid Temp.	**°F**	178.00	178.00
Leaving Fluid Temp.	**°F**	200.00	200.00
Fluid Passes	**No.**	2	2
Approach	**°F**	-	-
Design Working Pressure	**PSIG**	125	125
Min. Flow	**GPM**	-	-
Max. Flow	**GPM**	-	-

2.7.5.2 Winter Garden, Steam: Air Handling Units

Table 43. Winter Garden Steam Air Handling Unit Specifications

Air Handling Unit										
AHU ID			**AC-1W**	**AC-2W**	**AC-5W**	**AC-7W**	**AC-8W**	**AC-9W**	**AC-10W**	**AC-11W**
Location			Penthouse MER	Penthouse MER	Penthouse MER	Penthouse MER	Penthouse MER	Penthouse MER	Service Lvl MER	Penthouse MER
Service			Winter Garden	Winter Garden	Winter Garden	Winter Garden	Winter Garden	Retail Area	Entrance Lobby East Side	Retail Area
Make			Trane	Trane	Trane	Trane	Trane	Trane	Trane	Trane
Model Number			-	-	-	-	-	-	-	-
Serial Number			-	-	-	-	-	-	-	-
Supply Air Flow		**CFM**	29,900	29,900	29,900	29,900	29,900	25,000	6,800	7,000
Design	**Supply Fan**									
	Type		-	-	-	-	-	-	-	-
	Maximum Fan Speed	**RPM**	912	921	1,078	921	912	1,129	1,114	1,375
	Air Flow	**CFM**	29,900	29,900	29,900	29,900	29,900	25,000	6,800	7,000
	Total Fan Static	**In of H2O**	4.0	4.1	4.1	4.1	4.0	5.1	3.5	4.8
	Fan Brake Horsepower	**BHP**	23	24	24	24	23	26	6	9
	Fan Efficiency	**%**	81%	81%	80%	81%	81%	77%	63%	57%
	Quantity	**No.**	1	1	1	1	1	1	1	1
	Supply Fan Driver - Electric Motor									
	Make		-	-	-	-	-	-	-	-
	Motor Control Type		VFD	VFD	VFD	VFD	VFD	VFD	VFD	VFD
	Motor Nameplate Power	**HP**	30	30	30	30	30	30	8	10
	Voltage	**V**	460	460	460	460	460	460	460	460
	Speed	**RPM**	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750
	Nominal Efficiency	**%**	-	-	-	-	-	-	-	-
	Quantity	**No.**	1	1	1	1	1	1	1	1
	Pre-Heat Coil									
	Capacity	**MBH**	2,240	2,240	2,431	2,240	2,240	1,872	364	524
	Fluid		Steam	Steam	Steam	Steam	Steam	Steam	Steam	Steam
	Steam Flow	**Lbs/Hr**	2,358	2,358	2,559	2,358	2,358	1,971	384	552
	Fluid Rows	**No.**	1	1	1	1	1	1	1	1
	Number of Coils	**No.**	-	-	-	-	-	-	-	-
	Air Flow	**CFM**	29,900	29,900	29,900	29,900	29,900	25,000	6,800	7,000
	Air Pressure Drop	**In of H2O**	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
	Entering Air Temp. - DB	**°F**	5.00	5.00	5.00	5.00	5.00	5.00	70.00	5.00
	Leaving Air Temp. - DB	**°F**	75.00	75.00	81.00	75.00	75.00	75.00	120.00	75.00
	Approach	**°F**	-	-	-	-	-	-	-	-
	Design Working Pressure	**PSIG**	-	-	-	-	-	-	-	-

2.7.5.3 *Winter Garden, Steam: Heating and Ventilating Units*

Table 44. Winter Garden Steam Heating and Ventilating Unit Specifications

Heating and Ventilation Air Handling Unit				
H&V ID			**HV-1W**	**HV-2W**
Location			PRV Room	PRV Room
Service			Pipe Tunnel	PRV Room & Storage
Make			Trane	Trane
Model Number			-	-
Serial Number			-	-
Supply Air Flow		**CFM**	2,800	2,800
Design	**Supply Fan**			
	Type		-	-
	Model		-	-
	Design Fan Speed	**RPM**	-	-
	Maximum Fan Speed	**RPM**	1,136	1,136
	Air Flow	**CFM**	2,800	2,800
	Total Fan Static	**In of H2O**	2.0	2.0
	Fan Brake Horsepower	**BHP**	1	1
	Fan Efficiency	**%**	63%	63%
	Quantity	**No.**	1	1
	Supply Fan Driver - Electric Motor			
	Make		-	-
	Motor Control Type		Starter	Starter
	Motor Nameplate Power	**HP**	2	2
	Voltage	**V**	460	460
	Speed	**RPM**	1,750	1,750
	Nominal Efficiency	**%**	-	-
	Quantity	**No.**	1	1
	Pre-Heat Coil			
	Capacity	**MBH**	178	178
	Fluid		Steam	Steam
	Steam Flow	**Lbs/Hr**	187	187
	Air Flow	**CFM**	2,800	2,800
	Air Pressure Drop	**In of H2O**	-	-
	Entering Air Temp. - DB	**°F**	5.00	5.00
	Leaving Air Temp. - DB	**°F**	65.00	65.00
	Approach	**°F**	-	-
	Design Working Pressure	**PSIG**	-	-

2.7.5.4 *Winter Garden, Heating Hot Water: Air Handling Units*

Table 45. Winter Garden Heating Hot Water Air Handling Unit Specifications

Air Handling Unit			
AHU ID			**AC-12W & 13W**
Location			Entrance Vestibule Ceilings
Service			Entrance Vestibule West Side
Make			Trane
Model Number			-
Serial Number			-
Supply Air Flow		**CFM**	2,500
Design	**Supply Fan**		
	Type		-
	Maximum Fan Speed	**RPM**	1,031
	Air Flow	**CFM**	2,500
	Total Fan Static	**In of H2O**	1.8
	Fan Brake Horsepower	**BHP**	1
	Fan Efficiency	**%**	69%
	Quantity	**No.**	1
	Supply Fan Driver - Electric Motor		
	Make		-
	Motor Control Type		Starter
	Motor Nameplate Power	**HP**	2
	Voltage	**V**	460
	Speed	**RPM**	1,750
	Nominal Efficiency	**%**	-
	Quantity	**No.**	1
	Dual-Temp Coil (1 Coil on this AHU) - Heating Design Conditions		
	Capacity	**MBH**	136
	Fluid		Water
	Fluid Flow	**GPM**	-
	Air Flow	**CFM**	2,500
	Air Pressure Drop	**In of H2O**	-
	Entering Air Temp. - DB	**°F**	70.00
	Leaving Air Temp. - DB	**°F**	120.00
	Approach	**°F**	-
	Design Working Pressure	**PSIG**	-

2.7.6 Central Plant

The following tables present detailed specifications for various systems and equipment in the Central Plant, including both steam and heating hot water-based components. These systems are integral to the heating and ventilation infrastructure of the tower. The tables include specifications for the steam-to-heating hot water heat exchangers, steam-to-domestic hot water heaters, air handling units, heating and ventilating units, unit heaters, and cabinet unit heaters, as well as the corresponding heating hot water systems. Each table outlines the technical details and configurations of these components, providing a comprehensive overview of the HVAC systems in the Central Plant.

2.7.6.1 Central Plant, Steam: Steam-to-Heating Hot Water Heat Exchanger

Table 46. Central Plant Steam-to-Heating Hot Water Heat Exchanger Specifications

Shell and Tube Heat Exchanger		
Heat Exchanger ID		**HX-1P**
Location		MER No.1 +19 Level
Service		Glycol Heating
Make		Yula
Model Number		CB-2C-90B
Serial Number		-
Nominal Capacity	**MBH**	3,250
Specified Net Capacity	**MBH**	3,250
Shell Side - Steam		
Fluid		Steam
Fluid Mass Flow	**LBs/Hr**	3,000
Entering Fluid Temp.	**°F**	305.80
Entering Fluid Pressure	**PSIG**	10.00
Entering Fluid Enthalpy	**Btu/(Lbm-F)**	1193.30
Entering Fluid Deg Superheat	**F**	66.40
Leaving Fluid Temp.	**°F**	239.40
Leaving Fluid Pressure	**PSIG**	10.0
Leaving Fluid Enthalpy	**Btu/(Lbm-F)**	207.80
Fluid Passes	**No.**	1
Design Working Pressure	**PSIG**	-
Tube Side		
Fluid		Water
Fluid Flow	**GPM**	130
Fluid Pressure Drop	**Ft of H2O**	5.0
Entering Fluid Temp.	**°F**	90.00
Leaving Fluid Temp.	**°F**	140.00
Design Working Pressure	**PSIG**	125
Min. Flow	**GPM**	-
Max. Flow	**GPM**	-

2.7.6.2 *Central Plant, Steam: Air Handling Unit*

Table 47. Central Plant Steam Air Handling Unit Specifications

Air Handling Unit			
AHU ID			**AC-5P**
Location			1st Sub-Cellar
Service			1st Sub-Cellar Offices
Make			Trane
Supply Air Flow		**CFM**	1,915
Design	**Supply Fan**		
	Design Fan Speed	**RPM**	-
	Maximum Fan Speed	**RPM**	1,372
	Air Flow	**CFM**	1,915
	Total Fan Static	**In of H2O**	2.3
	Fan Brake Horsepower	**BHP**	1
	Fan Efficiency	**%**	48%
	Quantity	**No.**	1
	Supply Fan Driver - Electric Motor		
	Make		-
	Motor Control Type		-
	Motor Nameplate Power	**HP**	2
	Voltage	**V**	460
	Speed	**RPM**	1,750
	Nominal Efficiency	**%**	-
	Quantity	**No.**	1
	Pre-Heat Coil		
	Capacity	**MBH**	61
	Fluid		Steam
	Steam Flow	**Lbs/Hr**	64
	Steam Inlet Pressure	**PSIG**	-
	Steam Temperture	**°F**	-
	Air Flow	**CFM**	1,915
	Air Pressure Drop	**In of H2O**	0.2
	Entering Air Temp. - DB	**°F**	50.00
	Leaving Air Temp. - DB	**°F**	80.00
	Approach	**°F**	-
	Design Working Pressure	**PSIG**	-

2.7.6.3 *Central Plant, Steam: Heating and Ventilating Unit*

Table 48. Central Plant Steam Heating and Ventilating Unit Specifications

Heating and Ventilation Air Handling Unit												
H&V ID			**HV-1P**	**HV-2P**	**HV-3P**	**HV-4P**	**HV-5P**	**HV-6P**	**HV-7P**	**HV-8P**	**HV-10P**	**HV-11P**
Location			-7'-9" MER #3	-7'-9" MER #3	-7'-9" MER #3	+19 MER #2	+19 MER #2	+19 MER #1	-7'-9" MER #3	-7'-9" MER #3	+19 MER #2	Cellar Level
Service			Garage Ventilation 2nd, 3rd, & 4th Sub-Cellar	Garage Ventilation 2nd, 3rd, & 4th Sub-Cellar	Garage Ventilation Cellar & 1st Sub-Cellar	Central Plant Ventilation	5th Sub-Cellar Electric Rooms	Core Supply	Steam MER	Truck Dock Supply	5th Sub-Cellar Electric Room	Gas & Water Meter Room
Make			Joy	Joy	Joy	Joy	Joy	Joy	Joy	Joy	Joy	Trane
Supply Air Flow		**CFM**	99,700	99,700	46,800	48,000	59,000	68,355	38,000	43,400	40,500	2,500
Design	**Supply Fan**											
	Type		-	-	-	-	-	-	-	-	-	-
	Model		-	-	-	-	-	-	-	-	-	-
	Air Flow	**CFM**	99,700	99,700	46,800	48,000	59,000	68,355	38,000	43,400	40,500	2,500
	Total Fan Static	**In of H2O**	3.0	3.0	3.3	3.3	3.0	3.5	3.0	2.5	3.0	0.8
	Fan Brake Horsepower	**BHP**	75	75	38	38	40	65	27	27	29	1
	Fan Efficiency	**%**	63%	63%	63%	65%	70%	58%	66%	63%	66%	31%
	Quantity	**No.**	1	1	1	1	1	1	1	1	1	1
	Supply Fan Driver - Electric Motor											
	Make		-	-	-	-	-	-	-	-	-	-
	Motor Control Type	**RPM**	VFD	VFD	VFD	VFD	-	-	VFD	VFD	-	-
	Motor Nameplate Power	**HP**	75	75	40	40	50	75	40	30	40	2
	Voltage	**V**	460	460	460	460	460	460	460	460	460	460
	Speed	**RPM**	1,170	1,170	-	-	1,170	1,770	1,770	1,770	1,770	1,770
	Nominal Efficiency	**%**	-	-	-	-	-	-	-	-	-	-
	Quantity	**No.**	1	1	1	1	1	1	1	1	1	1
	Pre-Heat Coil											
	Capacity	**MBH**	5,707	5,707	2,678	2,886	-	3,945	2,153	2,471	-	-
	Fluid		Steam	Steam	Steam	Steam	Steam	Steam	Steam	Steam	Steam	Steam
	Steam Flow	**Lbs/Hr**	-	-	-	3,038	-	4,153	2,266	2,601	-	-
	Fluid Rows	**No.**	1	1	1	1	-	1	1	1	-	-
	Number of Coils	**No.**	-	-	-	-	-	-	-	-	-	-
	Air Flow	**CFM**	99,700	99,700	46,800	48,000	59,000	68,355	38,000	43,400	40,500	2,500
	Air Pressure Drop	**In of H2O**	0.3	0.3	0.3	0.3	-	0.3	0.3	0.3	-	-
	Entering Air Temp. - DB	**°F**	10.00	10.00	10.00	10.00	-	10.00	10.00	10.00	-	-
	Leaving Air Temp. - DB	**°F**	63.00	63.00	63.00	62.00	-	64.00	63.00	63.00	-	-
	Approach	**°F**	-	-	-	-	-	-	-	-	-	-
	Design Working Pressure	**PSIG**	-	-	-	-	-	-	-	-	-	-

2.7.6.4 Central Plant, Heating Hot Water: Air Handling Unit

Table 49. Central Plant Heating Hot Water Air Handling Unit Specifications

Heating and Ventilation Air Handling Unit			
H&V ID			**HV-9P**
Location			River Water Pump Room
Service			River Water Pump Room
Make			Joy
Supply Air Flow		**CFM**	43,600
Design	**Supply Fan**		
	Air Flow	**CFM**	43,600
	Total Fan Static	**In of H2O**	1.8
	Fan Brake Horsepower	**BHP**	24
	Fan Efficiency	**%**	50%
	Quantity	**No.**	1
	Supply Fan Driver - Electric Motor		
	Motor Nameplate Power	**HP**	30
	Voltage	**V**	460
	Speed	**RPM**	1,770
	Nominal Efficiency	**%**	-
	Quantity	**No.**	1
	Pre-Heat Coil		
	Capacity	**MBH**	1,649
	Fluid		40% EG
	Fluid Flow	**GPM**	106
	Fluid Pressure Drop	**Ft of H2O**	2.9
	Entering Fluid Temp.	**°F**	130.00
	Leaving Fluid Temp.	**°F**	93.00
	Fluid Rows	**No.**	4
	Number of Coils	**No.**	-
	Air Flow	**CFM**	43,600
	Air Pressure Drop	**In of H2O**	0.8
	Entering Air Temp. - DB	**°F**	10.00
	Leaving Air Temp. - DB	**°F**	49.00
	Approach	**°F**	-
	Design Working Pressure	**PSIG**	-

2.7.6.5 *Central Plant, Steam: Unit Heaters and Cabinet Unit Heaters*

Table 50. Central Plant Steam Unit Heater and Cabinet Unit Heater Specifications

Unit Heaters							
Unit Heater ID			**UH-3P to 5P**	**EH-1P**	**EH-2P & 3P**	**EH-4P**	**EH-5P**
Location			+19 MER	Entrance at Car Ramps	Car Ramp	Car Ramp	Truck Ramp
Service			Space Heater	Entrance Heater	Car Ramp Entrance	Car Ramp & Service Entrance	Truck Ramp Entrance
Make			Trane	Trane	DynaForce	DynaForce	DynaForce
Model Number			UHSA 91-S8	N46	96 L/1	144 L/1	168-H
Serial Number			-	-	-	-	-
Quantity of Units			3	1	2	1	1
Unit Heater Capacity		**MBH**	89	48	447	670	1216
Design	**Air Flow Data**						
	Supply Air Flow	**CFM**	1,740	600	7,580	11,375	31,500
	Discharge Air Temp	**°F**	108.00	138.00	-	-	-
	Motor Data						
	Motor Nameplate Power	**HP**	1/6	1/8	1.5	1.5	5
	Voltage	**V**	120	120	460	460	460
	Speed	**RPM**	1100	1200	900	900	1200
	Nominal Efficiency	**%**	-			-	-
	Quantity	**No.**	1	1	2	3	3
	Heating Coil						
	Capacity	**MBH**	89	48	447	670	1,216
	Fluid		Steam	Steam	Steam	Steam	Steam
	Steam Flow	**Lbs/Hr**	94	50	470	705	1,280
	Steam Inlet Pressure	**PSIG**	5.0	5.0	5.0	5.0	5.0
	Steam Temperture	**°F**	-	-	-	-	-
	Air Flow	**CFM**	1,740	600	7,580	11,375	31,500
	Leaving Air Temp. - DB	**°F**	108.00	138.00	-	-	-
	Approach	**°F**	-	-	-	-	-
	Design Working Pressure	**PSIG**	-	-	-	-	-

3 Existing System Sequences

3.1 Cooling System Controls

The chilled water system is designed to efficiently manage cooling for building comfort loads year-round while also optimizing energy usage during off-peak hours by charging thermal storage tanks. The following components work together to maintain desired temperatures and reduce energy consumption:

3.1.1 Chillers

The chillers are primarily used to supply the building comfort cooling loads 24/7/365, as well as to feed the thermal storage tanks during off-peak hours. When staging the plant, the newer VFD chiller is prioritized. The chillers maintain a chilled water supply temperature set-point of 41°F.

3.1.2 Chilled Water Pumps

3.1.2.1 Primary Chilled Water Pumps

The 10 primary chilled water pumps are equipped with VFDs. The plant operates one primary chilled water pump at a reduced speed per chiller.

3.1.2.2 Secondary Chilled Water Pumps

Of the 10 secondary chilled water pumps, 9 are equipped with VFDs. These pumps are staged so that at least one pump from each group is running to supply a tower when the connecting tower requires chilled water. The pumps modulate based on a remote differential pressure (ΔP) set-point. The set-points resets based on the tower heat exchanger valve position.

3.1.3 Thermal Storage Pumps and Storage Tanks

3.1.3.1 Primary Thermal Energy Storage Pumps

The primary thermal energy storage pumps are staged manually based on dispatching the thermal energy storage system.

3.1.3.2 Secondary Thermal Energy Storage Pumps

The secondary thermal energy storage pumps are also staged manually based on dispatching the thermal energy storage system.

3.1.3.3 Thermal Energy Storage Tanks

The thermal energy storage tanks are arranged in a pump-in, pump-out configuration and are used during summer to reduce total plant chilled water and power demand

3.1.4 Heat Rejection System Controls

3.1.4.1 River Water Heat Exchangers

The river water heat exchangers are staged based on load and heat exchanger approach to maintain condenser water supply temperature (CWST) to the chiller or used for free cooling if the river water temperature permits.

3.1.4.2 River Water Pumps

The river water pumps are staged based on condenser water demand and operate using VFDs.

3.1.4.3 Condenser Water Pumps

The condenser water pumps are staged one per chiller. Two pumps are equipped with VFDs and used for free cooling.

3.2 Heating System Controls

The complex's Heating system controls are described in Section 3.2.

3.2.1 Tower A, Lower House: Heating Hot Water Generation

The lower house of Tower A is provided with heating hot water with the source energy being the steam service. The following shell and tube heat exchangers have a modulating control valve that control the steam flow at to meet the heating hot water supply temperature setpoint. The setpoint rests from 100°F to 200°F with outdoor air temperature varying from 50°F to 0°F.

- HX-3A through HX-7A, serves levels 3 through 21

- HX-4A, which serves the service level, street level, and 2nd floor
- HX-5A, this provides hot water for the garage ventilation units (HV-1A and HV-2A)

3.2.2 Tower A, Upper House: Heating Hot Water Generation

The upper house of Tower A is provided with heating hot water for its space heating; the source energy for the heating hot water being the site's steam service. Heat is exchanged through a shell and tube heat exchangers. The shell and tube heat exchanger have a modulating control valve which controls the steam flow to meet the heating hot water supply temperature setpoint. The setpoint rests from 100°F to 200°F with outdoor air temperature. The heat exchanger tags and their services are listed below.

- HX-1A, which serves levels 22 through 40
- HX-2A, which provides auxiliary heating for AC-41A by heating the chilled water entering the reclaim coil for freeze protection. AC-41A provides ventilation air for the upper house office floors. The steam valve on the heat exchanger opens to 100%, and P26B activates if the average post-reclaim temperature falls below 48°F.

The Penthouse Mechanical Equipment Room unit heaters have UH-5A through UH-12A which use standalone controls to maintain the locally set space temperature set-point.

3.2.3 Tower A, Lower House: Steam Use

The following air handling systems use a steam heating coil for tempering of air during the heating season. The equipment name, its service and the control strategy are listed below:

- AC-1A, which serves the lobby
- AC-2A, which serves the retail areas
    - The heating mode controls for AC-1A and AC-2A is such that in heating mode, the steam valve controls to maintain the supply air temperature set-point. The set-point is adjustable, with the unoccupied minimum and maximum range being 60°F to 74°F and the occupied minimum and maximum range being 65°F to 75°F. The supply air temperature set-point resets based on the space temperature set-point.
    - The unit heaters which serve the loading dock have standalone controls which modulate the steam coil control valve to meet the space temperature setpoint. The unit heater tags are UH-1A, UH-2A, UH-3A, and UH-4A.

3.2.4 Tower A, Lower House: Heating Hot Water Use

The following unit heaters and cabinet unit heaters have standalone controls which are used to maintain the space temperature for which they serve. The standalone controls modulate the hot water control valve. The tag and service for the heaters include:

- UH-14A, UH-15A, UH-16A, serving Garage Unit Heaters
- UH-18A through UH-25A, serving Gatehouse Penthouse
- CUH-1A through CUH-4A, serving Street Level Entrance
- CUH-5A through CUH-6A, serving Street Level Service Area

The following heating and ventilation units (HV) have a modulating heating hot water valve to maintain a discharge air temperature set-point of 70°F. The units activate when the outdoor air temperature falls below 50°F.

- HV-1A, which provides Garage Ventilation
- HV-2A, which serves the Service Level

3.2.5 Tower B, Lower House: Heating Hot Water Generation

The lower house of Tower B is provided with heating hot water for its space heating; the source energy for the heating hot water being the site's steam service. Heat is exchanged through a shell and tube heat exchangers. The shell and tube heat exchangers have a modulating control valve which controls the steam flow at to meet the heating hot water supply temperature setpoint. The setpoint rests from 110°F to 160°F with outdoor air temperature.

- HX-3B and HX-4B, which serve levels 3 through 25
- HX-5B, which serves the street level and the lobby
- HX-6B, which serves the bridge that connects Building A to Building B
- HX-7B and HX-8B, which provide hot water for the garage ventilation unit (HV-1B)

3.2.6 Tower B, Upper House: Heating Hot Water Generation

The steam control valve for the shell and tube heat exchanger (HX-2B) modulates to maintain the heating hot water supply temperature set-point. The set-point adjusts between 110°F and 160°F depending on the outdoor air temperature, which ranges from 0°F to 60°F. This unit serves floors 26 through 44.

To prevent freezing, heat exchanger HX-1B heats the chilled water entering the reclaim coil on AC-46B. The steam valve on the heat exchanger opens to 100%, and P26B activates if the average post-reclaim temperature falls below 48°F. AC-46B provides ventilation to the upper house office floors.

3.2.7 Tower B, Lower House: Steam Use

In heating mode, the preheat steam control valve within air handling systems AC-1B and AC-2B modulates to maintain the supply air temperature set-point. The set-point adjusts between 55°F and 80°F depending on the return air temperature, which ranges from 78°F to 68°F. The south lobby reheat steam coil control valve in AC-1B modulates to maintain the lobby set-point of 68°F. AC-1B serves the lobby and street level spaces. AC-2B service the Liberty Street bridge.

In heating mode, the preheat steam control valve AC-45B, a 100% outdoor air unit, modulates to maintain a heating set-point of 65°F. This unit provides outside air for levels 3 through 15.

In winter mode, the preheat steam control valve AC-47B modulates to maintain the supply air temperature set-point. The set-point adjusts between 55°F and 80°F depending on the return air temperature, which ranges from 78°F to 66°F. This unit serves the tenant storage spaces in the cellar level.

In heating mode, the preheat steam control valve AC-48B modulates to maintain the supply air temperature set-point. The set-point adjusts between 55°F and 80°F depending on the return air temperature, which ranges from 78°F to 66°F. This unit serves the basement level core spaces.

The steam coil modulating valve for the unit HV-3B, modulates to maintain the space temperature set-point of 55°F. This unit provides outside air for the retail spaces.

The following unit heaters have steam coils and use standalone controls to maintain their local space temperature setpoints. The unit heater names and service are listed below:

- UH-13B through UH-20B ; Gatehouse Penthouse
- UH-27B and UH-28B ; The Link Mechanical Equipment Room
- UH-29B ; The East Generator Room of the Gatehouse

3.2.8 Tower B, Lower House: Heating Hot Water Use

The street-level exit unit heaters (CUH-1B through CUH-7B) use standalone controls to maintain the locally set space temperature set-point.

The heating and ventilation units (HV-1B and HV-2B) have a modulating hot water coil control valve which maintains a discharge air setpoint of 65°F. The unit HV-1B serves the garage. The unit HV-2B serves the core spaces in the cellar.

3.2.9 Tower B, Upper House: Heating Hot Water Use

The Penthouse Mechanical Equipment Room unit heaters in UH-7B through UH-12B use standalone controls to maintain the locally set space temperature set-point.

3.2.10 Tower C, Lower House: Heating Hot Water Generation

The steam control valve in the shell and tube heat exchangers (HX-1C, HX-2C, and HX-6C) modulates to maintain the heating hot water supply temperature set-point. The set-point adjusts between 120°F and 200°F depending on the outdoor air temperature. The heat exchangers serve the items listed below:

- HX-1C; 3rd floor through 27th floor
- HX-2C; Street level, lobby and 2nd floor
- HX-6C; provides hot water for heating and ventilation units (HV-1C and HV-2C). These HV units serve the garage and mechanical room respectively. The heat exchanger HX-7C serves as a backup for HX-6C.

3.2.11 Tower C, Upper House: Heating Hot Water Generation

In Tower C’s Upper House, the heat exchanger in HX-4C provides auxiliary heating for AC-52C by heating the chilled water entering the reclaim coil to prevent freeze damage. The heat exchanger pump activates when required, and the steam valve modulates to maintain a temperature of 55°F if the average post-reclaim temperature drops below 45°F. Additionally, the steam control valve in HX-5C modulates to maintain the heating hot water supply temperature set-point, which adjusts between 120°F and 200°F depending on the outdoor air temperature, which ranges from 60°F to 10°F. The system activates when the outdoor air temperature falls below 50°F and deactivates when the temperature rises above 60°F.

The heat exchanger in HX-4C provides auxiliary heating for AC-52C by heating the chilled water entering the reclaim coil for freeze protection. The heat exchanger pump activates when necessary, and the steam valve modulates to maintain a temperature of 55°F if the average postreclaim temperature drops below 45°F.

The steam control valve in HX-5C modulates to maintain the heating hot water supply temperature set-point. The set-point adjusts between 120°F and 200°F based on outdoor air temperature.

3.2.12 Tower C, Lower House: Steam Use

In heating mode, the preheat steam control valve in AC-1C modulates to maintain the supply air temperature set-point. The set-point adjusts between 50°F and 65°F based on the lobby temperature set-point of 70°F.

In heating mode, the heating hot water valve in AC-2C modulates to maintain the supply air temperature set-point of 55°F.

In heating mode, the heating hot water valve in AC-303C and AC-301C controls to maintain the supply air temperature set-point. The set-point is adjustable, with the unoccupied minimum and maximum range between 60°F to 74°F and the occupied minimum and maximum between 65°F and 75°F. The supply air temperature set-point adjusts based on the space temperature set-point.

3.2.13 Tower C, Lower House: Heating Hot Water Use

The heating hot water valve in HV-1C modulates to maintain discharge air temperature set-point of 70°F. The unit activates when the outdoor air temperature drops below setpoint. This unit serves the garage.

The heating hot water valve in HV-2C modulates to maintain the space temperature set-point of 70°F. The unit activates when the outdoor air temperature falls below 60°F. This unit serves a mechanical equipment room.

3.2.14 Tower D, Lower House: Heating Hot Water Generation

The steam control valve in shell and tube heat exchangers (HX-2D, HX-3D, HX-4D, HX-6D, HX-7D) modulates to maintain the heating hot water supply temperature set-point. The set-point adjusts between 120°F to 200°F depending on the outdoor air temperature, which ranges from 60°F to 10°F. The system activates below 55°F and deactivates above 60°F outdoor air temperature. The heat exchangers serve the items listed below.

- HX-2D; Heating Hot Water for Mid-Rise Office Floors
- HX-3D and HX-4D; Heating Hot Water for the trench fan-coil units serving the lobby
- HX-6D and HX-7D; Heating Hot Water for Low-Rise office floors

3.2.15 Tower D, Upper House: Heating Hot Water Generation

The steam control valve in HX-1D modulates to maintain the heating hot water supply temperature set-point. The set-point adjusts between 120°F to 200°F depending on the outdoor air temperature, which ranges from 60°F to 10°F. The system activates below 50°F and deactivates above 60°F outdoor air temperature.

The heat exchanger in HX-5D heats the chilled water entering the reclaim coil on AC-35C for freeze protection. The heat exchanger pump starts when necessary, and the steam valve modulates to maintain a temperature of 55°F if the average post-reclaim temperature drops below 45°F.

3.2.16 Tower D, Lower House: Steam Use

In heating mode, the preheat steam control valve in AC-1D modulates to maintain the supply air temperature set-point. The set-point adjusts between 50°F to 65°F depending on the lobby temperature set-point of 70°F.

In heating mode, the heating hot water valve in AC-2DN modulates to maintain the supply air temperature set-point, which is fixed at 55°F.

In heating mode, the heating hot water valve in AC-2DS controls to maintain the air temperature set-point. The set-point is adjustable, with the unoccupied minimum and maximum range being 60°F to 74°F and the occupied minimum and maximum range being 65°F to 75°F. The supply air temperature set-point resets based on the space temperature set-point.

In heating mode, the steam preheat valves in SF-1D and SF-1D modulate to maintain the supply air temperature set-point of 50°F.

The unit heater (UH-44D) located in the +0'-6" Mechanical Equipment Room, uses standalone controls to maintain the locally set space temperature set-point.

3.2.17 Tower D, Lower House: Heating Hot Water Use

The unit heaters (UH-42D and UH-43D) located in the 3rd floor penthouse, use standalone controls to maintain the locally set space temperature set-point.

The cabinet unit heaters (CUH-1D and CUH-2D) located in stairwells 6, 9, and 10, use standalone controls to maintain the locally set space temperature set-point.

3.2.18 Tower D, Upper House: Heating Hot Water Use

The unit heaters (UH-36D through UH-40D) located in the Penthouse Mechanical Equipment Room, use standalone controls to maintain the locally set space temperature set-point.

3.2.19 Winter Garden: Heating Hot Water Generation

The steam control valve in HX-1W and HX-2W modulates to maintain the heating hot water supply temperature set-point. The set-point adjusts between 120°F and 200°F based on the outdoor air temperature. These heat exchangers provide Heating Hot Water for the Winter Garden.

3.2.20 Winter Garden: Steam Use

In heating mode, the preheat steam control valve in the following air handling systems (AC-1W, AC-2W, AC-5W, AC-6W, AC-7W, AC-8W, AC-9W, AC-10W, andAC-11W) modulates to maintain the supply air temperature set-point. The set-point adjusts between 50°F to 75°F based on outdoor air temperature, ranging from 60°F and 10°F. The units AC-1W through AC-8W serve the atrium space. The units AC-9W and AC-11W serve retail spaces. AC-10W serves the east side lobby entrance.

In heating mode, the preheat steam control valve in the heating and ventilation units (HV-1W and HV-2W) modulate to maintain the supply air temperature set-point. The set-point adjusts between 50°F to 75°F based on outdoor air temperature. The unit HV-1W serves the Pipe Tunnel. The unit HV-2W serves the PRV room and storage space.

3.2.21 Central Plant, Heating Hot Water Generation

The steam control valve in the shell and tube heat exchangers (HX-1P) modulates to maintain the heating hot water supply temperature set-point. The set-point adjusts between 100°F and 140°F based on outdoor air temperature.

3.2.22 Central Plant: Steam Use

In heating mode, the preheat steam control valve in the heating and ventilation units (HV-1P, HV-2P, HV-3P, HV-4P, HV-5P, HV-6P, HV-7P, HV-8P, HV-9P, HV-10P, HV-11P,) modulate to maintain the supply air temperature set-point. The set-point adjusts between 50°F to 65°F based on outdoor air temperature. The unit HV-1P through HV-3P serve the garage. HV-4P, HV-5P, HV-7P, HV-9P, HV-10P and HV-11P serve mechanical or electrical rooms. The unit HV-6P serves the core. The unit HV-8P serves the Truck Dock.

4 Utility Data Analysis

Utility bill information is provided in Figure 2 and Figure 3 and Table 51. Figure 2 illustrates the monthly electrical consumption from 2015 to 2022, while Figure 3 shows the average monthly electrical demand for the same period. Additionally, Table 51 displays the monthly steam consumption and associated costs for 2021.

Figure 2. Monthly Electric Energy Consumption (2015–2022)

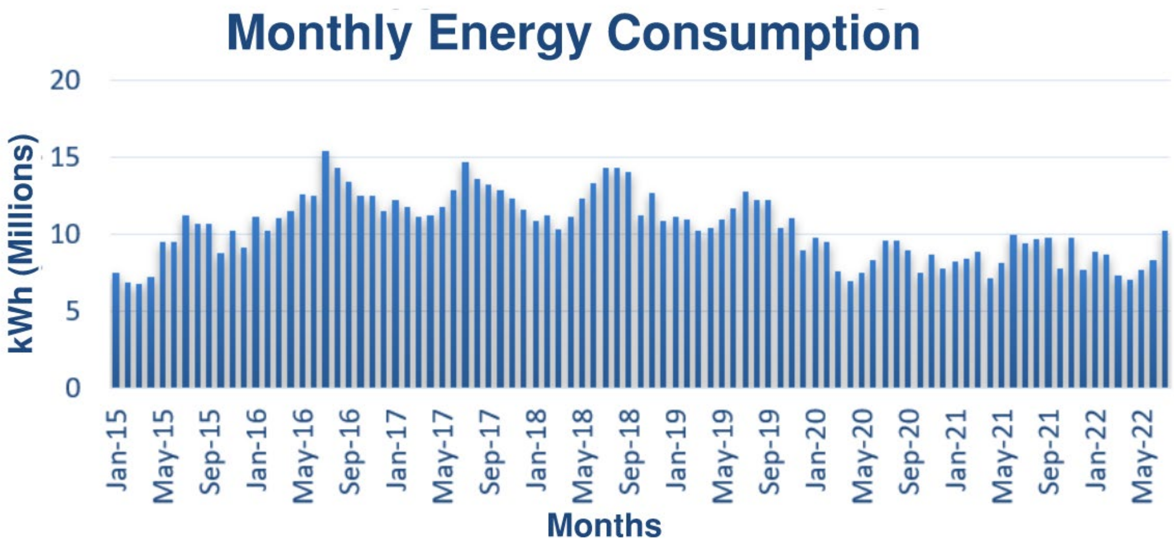


Figure 3. Monthly Electric Demand (2015–2022)

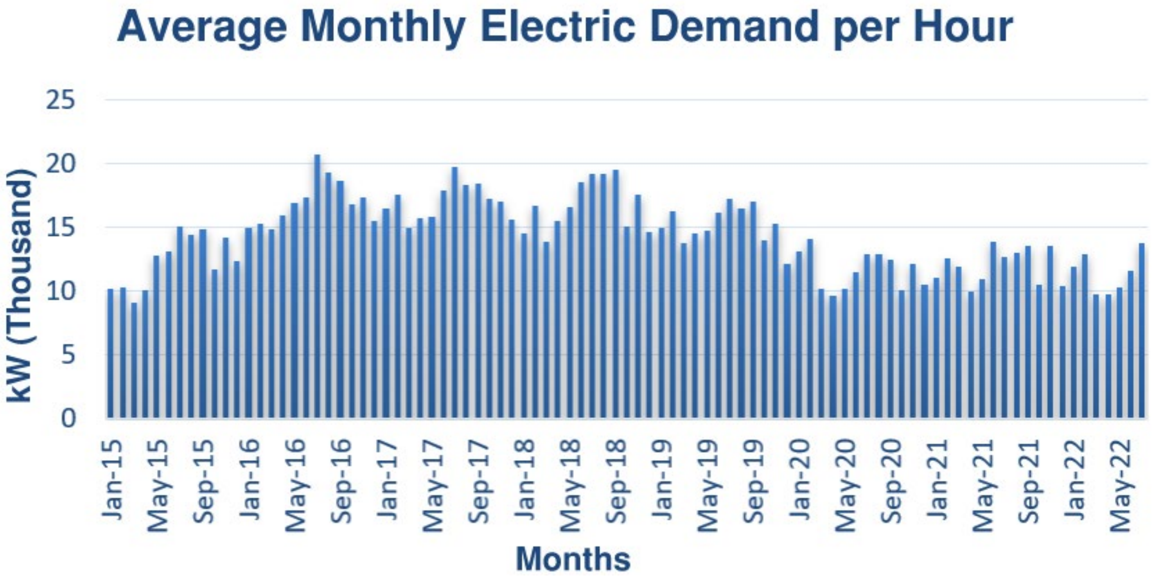
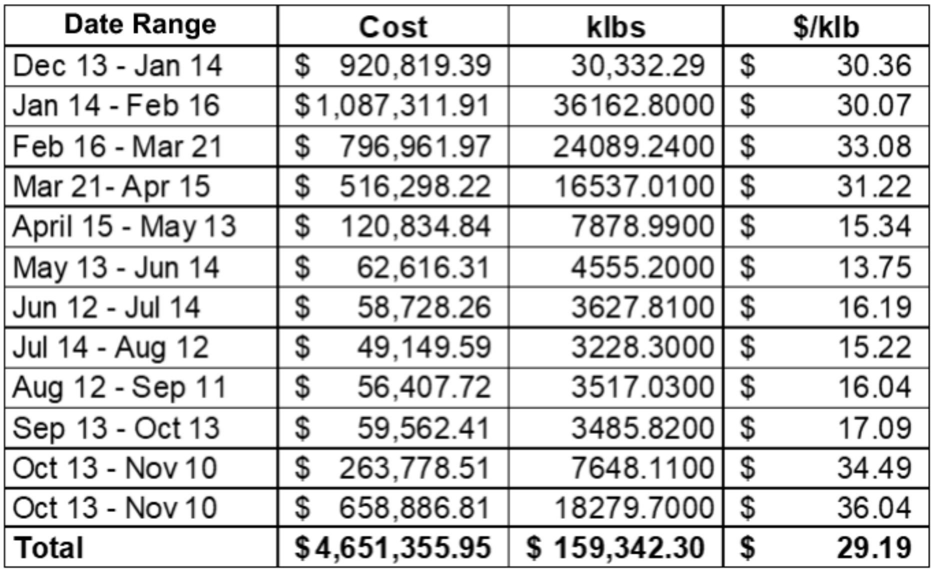


Table 51. Monthly Steam Consumption and Cost (2021)

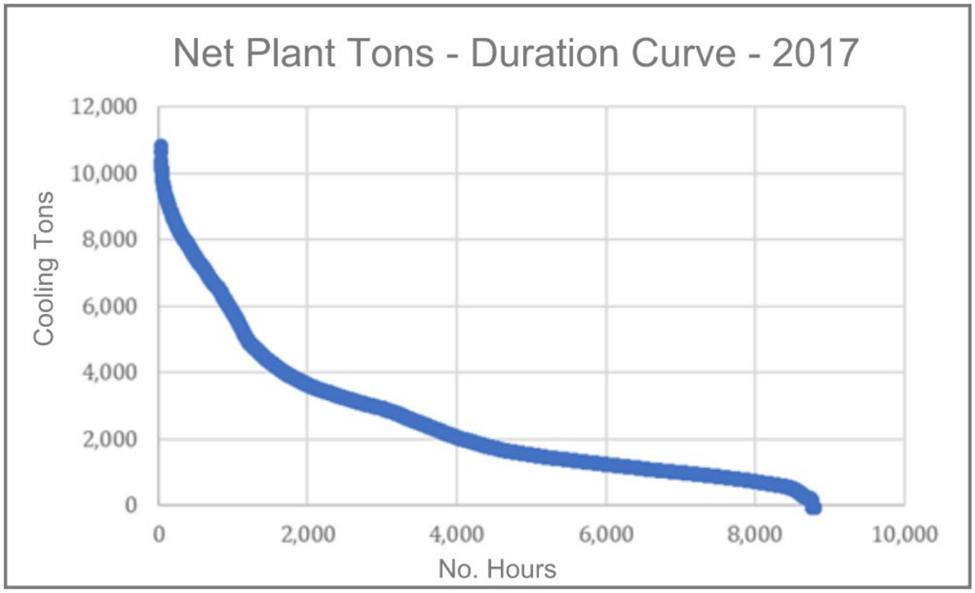


Date Range	Cost	klbs	$/klb
Dec 13 - Jan 14	$ 920,819.39	30,332.29	$ 30.36
Jan 14 - Feb 16	$1,087,311.91	36162.8000	$ 30.07
Feb 16 - Mar 21	$ 796,961.97	24089.2400	$ 33.08
Mar 21- Apr 15	$ 516,298.22	16537.0100	$ 31.22
April 15 - May 13	$ 120,834.84	7878.9900	$ 15.34
May 13 - Jun 14	$ 62,616.31	4555.2000	$ 13.75
Jun 12 - Jul 14	$ 58,728.26	3627.8100	$ 16.19
Jul 14 - Aug 12	$ 49,149.59	3228.3000	$ 15.22
Aug 12 - Sep 11	$ 56,407.72	3517.0300	$ 16.04
Sep 13 - Oct 13	$ 59,562.41	3485.8200	$ 17.09
Oct 13 - Nov 10	$ 263,778.51	7648.1100	$ 34.49
Oct 13 - Nov 10	$ 658,886.81	18279.7000	$ 36.04
Total	**$4,651,355.95**	**$ 159,342.30**	**$ 29.19**

5 Cooling Load Analysis

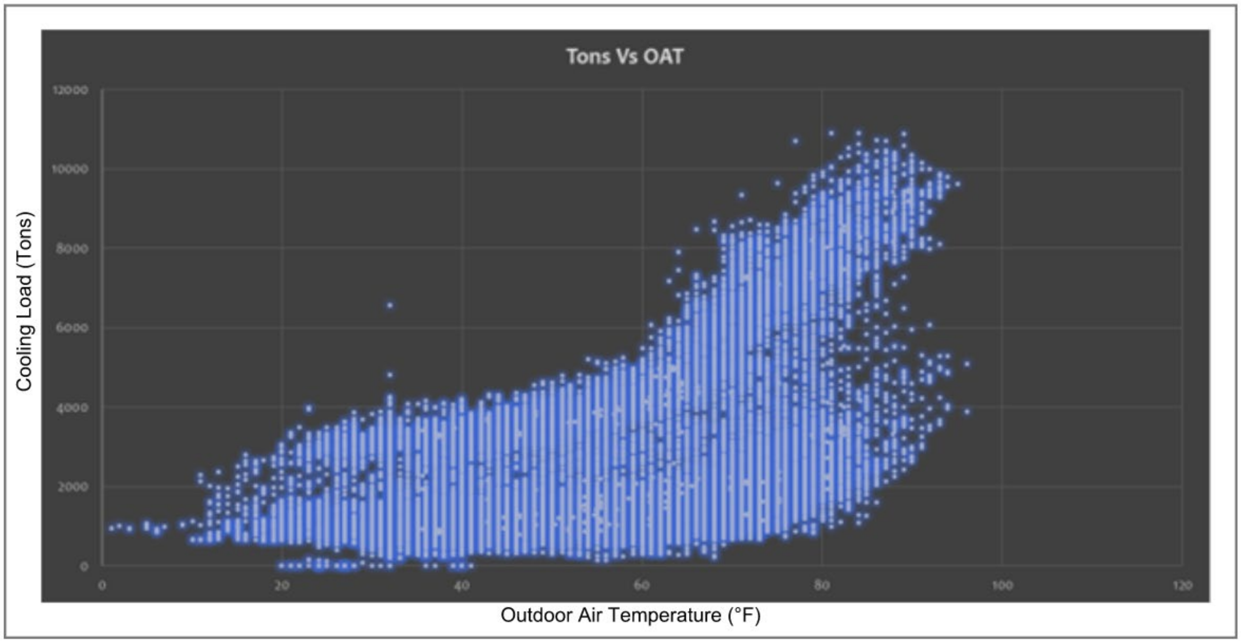
The team calculated the existing load for the central chiller plant using data obtained from site. Figure 4 presents the cooling load duration curve for the 2017 year, based on measured building chilled water flow rates and differential temperature (ΔT).

Figure 4. Net Plant Tons, Duration Curve (2017)



The graph shows that the peak cooling load for the facility is approximately 11,363 tons. This load aligns with the building's square footage and usage.

Figure 5. Cooling Tons versus Outdoor Air Temperature



6 Heating Load Analysis

The heat load was generated using an 8,760-energy model, which calculates steam usage for each piece of equipment in the six subdivided areas of the complex, each equipped with a submeter. Table 52 through Table 58 compare the modeled heating load to the past five years of submeter steam data for various areas within the building complex, including Towers A, B, C, D, the Winter Garden, Central Plant, and Coned Meter, serving as a validation exercise.

Table 52. Tower A Modeled Heating Load versus Past Five-Year Submeter Steam Data

Tower A						
	2018	2019	2020	2021	2022	Model TMY3
	Total klbs	Total klbs	Total klbs	Total klbs	Total klbs	Total klbs
Jan	7,163	4,917	4,771	4,512	3,958	4,143
Feb	6,109	6,123	5,005	5,648	6,221	3,341
Mar	3,924	5,382	3,809	3,674	3,748	3,789
Apr	3,704	3,107	2,729	2,465	2,082	1,469
May	1,971	1,740	1,801	1,346	1,352	1,114
Jun	1,414	944	648	960	716	898
July	1,072	740	417	920	618	924
Aug	989	813	616	997	723	927
Sep	1,042	603	902	864	839	915
Oct	1,069	719	860	717	1,040	1,408
Nov	2,195	2,220	4,588	1,286	1,236	2,914
Dec	5,052	4,310	3,357	3,225	0	4,525
Total	**35,704**	**31,618**	**29,503**	**26,614**	**22,533**	**26,366**

Table 53. Tower B Modeled Heating Load versus Past Five-Year Submeter Steam Data

Tower B						
	2018	**2019**	**2020**	**2021**	**2022**	**Model TMY3**
	Total klbs	**Total klbs**	**Total klbs**	**Total klbs**	**Total klbs**	**Total klbs**
Jan	10,582	7,485	7,278	7,119	6,642	7,231
Feb	9,772	10,171	6,834	9,301	8,943	5,431
Mar	8,024	8,489	5,160	6,191	5,924	6,563
Apr	7,475	5,485	2,630	4,177	4,008	1,509
May	3,409	2,614	1,624	1,976	2,508	1,141
Jun	1,851	1,868	1,323	1,636	1,591	811
July	1,746	1,821	1,228	1,580	1,484	800
Aug	1,718	1,719	1,166	1,636	1,329	805
Sep	1,618	1,510	1,325	1,418	1,498	832
Oct	1,624	1,778	1,463	1,495	1,568	1,332
Nov	3,305	3,528	2,145	2,190	1,993	4,092
Dec	7,474	6,625	4,097	5,599	0	8,665
Total	**58,598**	**53,093**	**36,273**	**44,319**	**37,489**	**39,212**

Table 54. Tower C Modeled Heating Load versus Past Five-Year Submeter Steam Data

Tower C						
	2018	**2019**	**2020**	**2021**	**2022**	**Model TMY3**
	Total klbs	**Total klbs**	**Total klbs**	**Total klbs**	**Total klbs**	**Total klbs**
Jan	6,182	5,077	5,021	4,865	4,910	5,956
Feb	5,190	5,791	4,773	5,764	6,513	4,639
Mar	4,077	5,120	4,194	3,726	4,728	5,358
Apr	3,742	3,905	2,595	3,067	3,436	2,316
May	2,768	2,789	1,851	2,021	2,624	2,015
Jun	1,722	2,034	1,650	1,588	1,503	1,585
July	1,586	1,822	1,521	1,521	1,420	1,584
Aug	1,587	1,606	1,435	1,491	1,310	1,591
Sep	1,724	1,530	1,557	1,530	1,492	1,610
Oct	1,699	1,634	1,975	1,604	1,681	2,143
Nov	3,042	3,548	2,785	2,179	2,044	4,089
Dec	5,240	4,591	3,577	4,386	0	6,591
Total	**38,559**	**39,447**	**32,934**	**33,742**	**31,662**	**39,478**

Table 55. Tower D Modeled Heating Load versus Past Five-Year Submeter Steam Data

Tower D						
	2018	2019	2020	2021	2022	Model TMY3
	Total klbs	Total klbs	Total klbs	Total klbs	Total klbs	Total klbs
Jan	13,527	6,708	6,136	5,881	5,178	7,139
Feb	8,382	7,326	5,896	7,273	7,324	5,496
Mar	4,841	5,626	5,326	5,145	5,084	6,498
Apr	4,668	4,105	4,165	5,055	3,358	2,721
May	2,653	1,925	2,838	2,245	1,662	2,186
Jun	1,468	1,669	1,406	1,651	1,482	1,282
July	1,426	1,753	1,471	1,518	1,435	1,187
Aug	1,592	1,584	1,571	1,655	1,337	1,200
Sep	1,715	1,566	1,675	1,443	1,530	1,344
Oct	1,698	1,633	1,723	1,397	1,664	2,297
Nov	3,266	2,969	3,044	1,965	2,117	5,019
Dec	6,688	5,156	3,993	4,543	0	7,877
Total	**51,924**	**42,020**	**39,245**	**39,772**	**32,171**	**44,246**

Table 56. Winter Garden Modeled Heating Load versus Past Five-Year Submeter Steam Data

Winter Garden						
	2018	2019	2020	2021	2022	Model TMY3
	Total klbs	Total klbs	Total klbs	Total klbs	Total klbs	Total klbs
Jan	1,903	924	778	947	613	1,239
Feb	1,552	1,314	719	1,175	1,059	890
Mar	932	1,160	596	740	739	1,051
Apr	1,042	1,036	508	616	562	170
May	748	10	6	207	12	79
Jun	1	0	0	0	0	5
July	2	0	0	0	0	0
Aug	0	0	0	0	0	0
Sep	0	0	0	0	0	8
Oct	0	0	0	1	0	119
Nov	1,155	809	457	505	599	685
Dec	1,385	902	683	711	0	1,431
Total	**8,720**	**6,155**	**3,747**	**4,901**	**3,583**	**5,678**

Table 57. Central Plant Modeled Heating Load versus Past Five-Year Submeter Steam Data

Central Plant						
	2018	2019	2020	2021	2022	Model TMY3
	Total klbs	Total klbs	Total klbs	Total klbs	Total klbs	Total klbs
Jan	1,458	1,600	1,934	2,143	868	2,711
Feb	1,859	2,074	1,928	2,202	1,686	1,940
Mar	1,786	1,606	1,496	1,866	1,076	2,297
Apr	1,188	516	802	1,157	342	350
May	499	72	314	205	152	155
Jun	370	14	285	5	125	9
July	367	16	29	1	113	0
Aug	225	15	32	1	110	0
Sep	0	14	27	1	136	14
Oct	15	17	21	104	151	245
Nov	248	277	22	164	130	1,474
Dec	1,777	1,329	511	520	0	3,146
Total	**9,792**	**7,549**	**7,401**	**8,368**	**4,889**	**12,339**

Table 58. Coned Meter Modeled Heating Load versus Past Five-Year Submeter Steam Data

Main Coned Meter						
	2018	2019	2020	2021	2022	Model TMY3
	Total klbs	Total klbs	Total klbs	Total klbs	Total klbs	Total klbs
Jan	28,000*	26,935	26,317	30,332	22,609	35,163
Feb	34,179	33,712	33,000*	36,163	31,444	26,890
Mar	27,000*	28,525	20,453	24,089	22,951	31,683
Apr	22,241	17,403	11,073	11,000*	11,000*	10,877
May	10,826	7,841	6,516	7,879	7,037	8,510
Jun	4,856	4,906	3,203	4,555	3,958	5,519
July	4,500*	4,389	4,500*	3,628	3,589	5,301
Aug	4,472	3,741	3,300*	3,228	3,341	5,362
Sep	4,487	3,842	3,517	3,517	3,637	5,714
Oct	4,428	4,310	3,867	3,486	4,663	9,456
Nov	11,783	10,504	8,277	7,648	6,930	22,932
Dec	27,131	23,998	19,053	18,280	19,000*	39,717
Total	**183,902**	**170,105**	**143,075**	**153,805**	**140,157**	**207,124**

*Denotes an estimated value in absence of an actual bill for this month.

7 Carbon Analysis

Figure 6 through Figure 8 show the historical carbon production from the site.

Figure 6. Monthly Carbon Production, Electric

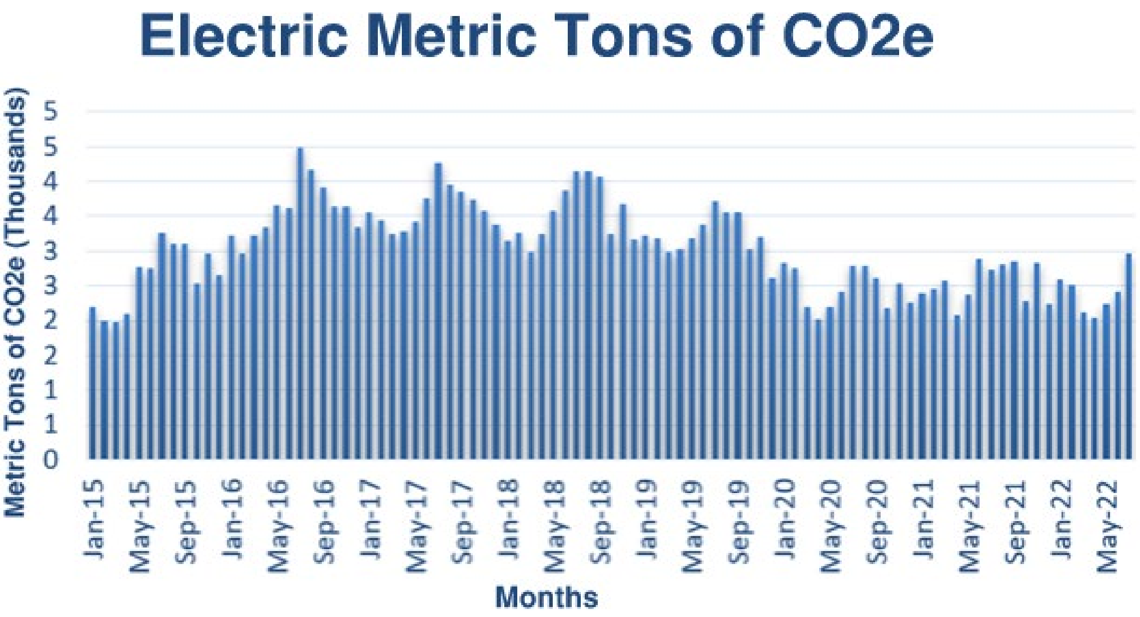


Figure 7. Monthly Carbon Production, Steam

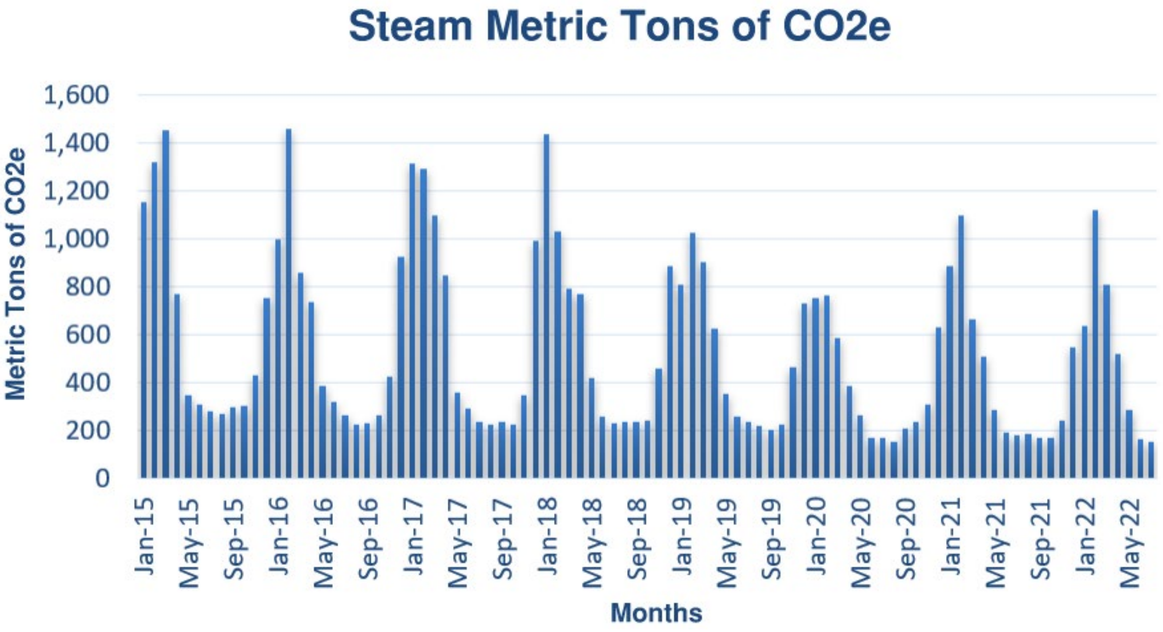
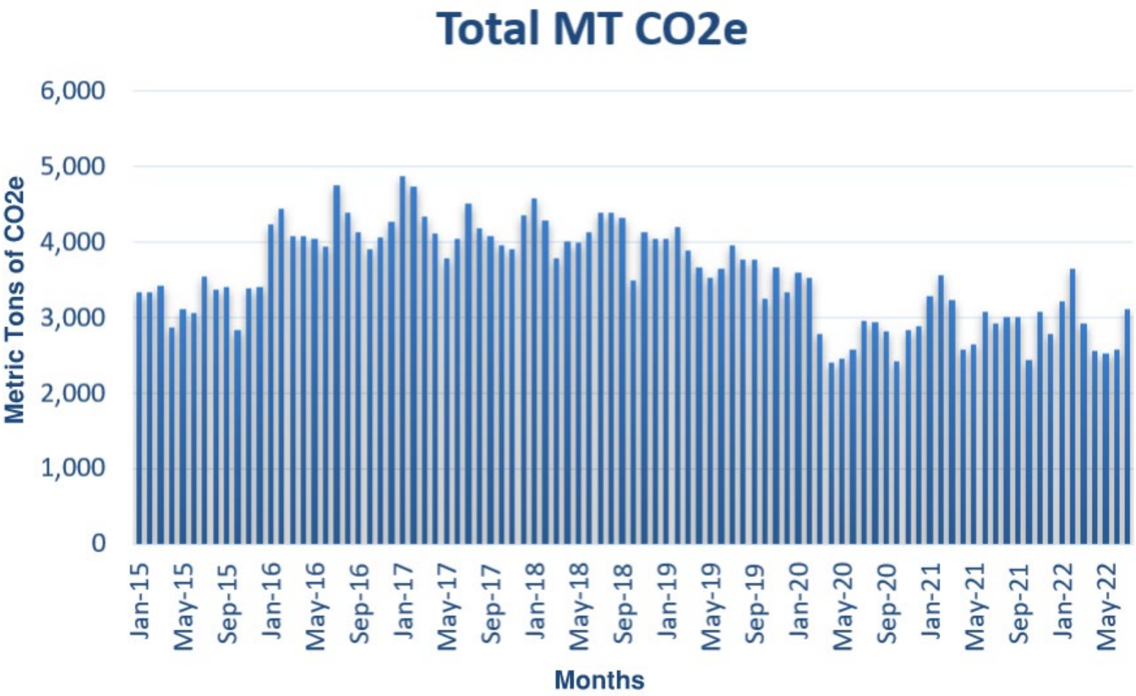


Figure 8. Monthly Carbon Production, Steam and Electric Combined



8 Heat Pump Technology Analysis

The contract requires an evaluation of four technologies, and the team assessed 15 commercially available heat pump models.

Table 59. Net Plant Tons, Duration Curve

Water Source Heat Pump Chillers / Heat Recovery Chillers																	
Chiller ID			JCI/York					Carrier					Trane				
Make			JCI/York	JCI/York	JCI/York	JCI/York	JCI/York	Carrier	Carrier	Carrier	Carrier	Carrier	Trane	Trane	Trane	Trane	Trane
Model Number			CYK	YVWA	YMC2	OM Titan	Frick	30MP	30HXC	30HXA	30XW	19DV	RTWD	RTHD	HDW	CTV	CVHH/CDHH
Max Capacity		**Tons**	2,500	300	1,000	5,500	1,200	71	265	265	400	1,000	250	430	450	2,000	2,000
Min Capacity		**Tons**	300	125	165	3,000	74	50	75	75	325	500	80	125	150	125	900
Score			1	2	4	3	5	6	4	4	2	4	5	2	2	4	4
Refrigerant			R-134a	R-134a	R-134a	R-134a	Ammonia	R-410A	R-134a	R-134a	R-134a	R-1233zd	R-134a or R-513A	R-134a or R-513A	R-134a or R-513A	R-514A	R-1233zd
Capacity Control			Independent IGVs and HGBP	VFD	VFD / IGV / HGBP	VFD / IGV / HGBP	Slide Valve	Compressor Staging with HGBP	Compressor Staging and Two unloaders per compressor	Compressor Staging and Two unloaders per compressor	Compressor Staging on the dual compressor machines, Slide Valve, and HGBP	VFD / IGV / HGBP	VFD, Compressor Staging, Slide Valve, and HGBP	VFD, Compressor Staging, Slide Valve, and HGBP	Compressor Staging on the dual compressor machines, Slide Valve, and HGBP	VFD / IGV / HGBP	VFD / IGV / HGBP
Capacity Control Process Variable			Leaving Evap Temp and Leaving Cond Temp	Leaving Evap Temp and Leaving Cond Temp	Leaving Evap Temp	Leaving Evap Temp and Leaving Cond Temp	Leaving Evap Temp and Leaving Cond Temp	Leaving Evap Temp	Leaving Evap Temp and Leaving Cond Temp	Leaving Evap Temp and Leaving Cond Temp	Leaving Evap Temp and Leaving Cond Temp	Leaving Evap Temp	Leaving Evap Temp and Leaving Cond Temp	Leaving Evap Temp and Leaving Cond Temp	Leaving Evap Temp and Leaving Cond Temp	Leaving Evap Temp	Leaving Evap Temp
Design	**Compressor**																
	Type		Centrifugal	Screw	Centrifugal	Centrifugal	Screw	Scroll	Screw	Screw	Screw	Centrifugal	Screw	Screw	Screw	Centrifugal	Centrifugal
	Model		YK	YVWA	YMC2	OM	Frick	30MP	30HXC	30HXA	30XW	19DV	CHHP	CHHC	HDMA	CVH/CDH	
	Stages		Dual Series Single Stage	Dual Parallel Screw	Single Single Stage	Single Two Stage or Single Three Stage	Single Compressor Single Stage Screw	Dual Parallel Single Stage Scroll	Dual or Triple Parallel Screw	Dual or Triple Parallel Screw	Single or Dual Parallel Screw	Dual Series Single Stage	Dual Parallel Screw	Dual Parallel Screw	Two Stage Centrifugal	Single or Dual parallel Two or Three Stage Centrifugal	Single or Dual parallel Two or Three Stage Centrifugal
	Driver - Electric Motor																
	Motor Control Type		Starter	VFD	VFD	Starter or VFD	Starter	Starter	Starter	Starter	Starter	VFD	Starter or VFD	Starter or VFD	VFD	Starter or VFD	Starter of VFD
	Full Load Efficiency	**kW/Ton**															
	Refrigerant Evaporator																
	Minimum Leaving Fluid Temp. Water	**°F**	20.00	38.00	42.00	36.00		40.00	40.00	40.00	40.00	38.00	?	?	?	34.00	?
	Minimum Leaving Fluid Temp. Glycol	**°F**	20.00	8.00	42.00	3.00		15.00	14.00	14.00	15.00	42.00	?	?	?	20.00	?
	Refrigerant Condenser																
	Max Leaving Fluid Temp.	**°F**	155.00	160.00	120.00	170.00	140.00	140.00	120.00	135.00	140.00	120.00	?	?	?	105.00	?

Based on our assessment, we identified the following viable options for specific locations:

- **The plant:**
  - York CYK
  - Potentially 19XR, YK, or CTV in series counterflow (This option will require further engagement with the manufacturer.)
- **The buildings:**
  - York YVWA
  - Carrier 30XW

9 Proposed System Modifications

9.1 M.1, Central Plant: Heat Pump

This section outlines the proposed modification and system descriptions, controls strategy, analysis of the proposed modifications, and first cost analysis for the energy conservation measure for the Central Plant heat pump. The team proposes the following system modifications across the Central Plant, various towers, and Winter Garden.

- Central Plant heat pump: The proposal includes replacing Chiller 2 and Chiller 6 with two York CYK heat pumps, each with a capacity of 1,250 tons.
- Tower A modifications: Due to the distance and complexity involved in extending piping to Tower A, no heating piping is included in this proposal for Tower A.
- Tower B modifications: The team proposes the following modifications for Tower B units and systems.
- For these units, replace the steam preheat coil with a heating hot water coil: AC-1B, AC-2B, AC-47B, and AC-48B.
- For the following heat exchangers, tap into the heating hot water distribution from the Central Plant using the existing heating hot water return piping to preheat the water before it enters the heat exchanger: HV-3B, HX-3B/4B, HX-5B, HX-6B, and HX-7B.
- For the following units, install duplex heating hot water-to-domestic hot water heat exchangers to preheat the domestic hot water before it enters the steam-to-hot-water heat exchangers: H-1, H-2, H-3, H-4, H-5, H-6, and H-7.
- Tower C modifications: The team proposes the following modifications for Tower C units and systems.
- For the following units, replace the steam preheat coil with a heating hot water coil: AC-1C, AC-2C, AC-301C, and AC-303C.
- For the following heat exchangers, tap into the heating hot water distribution from the Central Plant using the existing heating hot water return piping to preheat the water before it enters the heat exchanger: HV-3B, HX-1C, HX-2C, HX-6C, and HX-7C.
- For the following units, install duplex heating hot water-to-domestic hot water heat exchangers to preheat the domestic hot water before it enters the steam-to-hot-water heat exchangers: H-1, H-2, H-3, H-4, H-5, H-6, and H-7.
- Tower D modifications: The team proposes the following modifications for Tower D units and systems.
- For the following units, replace the steam preheat coil with a heating hot water coil: AC-1D, AC-2DN, AC-2DS, SF-1D, and SF-2D.
- For the following heat exchangers, tap into the heating hot water distribution from the Central Plant using the existing heating hot water return piping to preheat the water before it enters the heat exchanger: HX-2D, HX-3D/4D, and HX-6D/7D.

- For the following units, install duplex heating hot water-to-domestic hot water heat exchangers to preheat the domestic hot water before it enters the steam-to-hot-water heat exchangers: H-1, H-2, H-3, H-4, H-5, H-6, and H-7.
- Winter Garden modifications: The team proposes the following modifications for the Winter Garden units and systems.
- For the following units, replace the steam preheat coil with a heating hot water coil: AC-1W, AC-2W, AC-7W, AC-8W, AC-9W, AC-10W, AC-11W, HV-1W, and HV-2W.
- For the following heat exchangers, tap into the heating hot water distribution from the Central Plant using the existing heating hot water return piping to preheat the water before it enters the heat exchanger: HX-1W and HX-2W.
- Central Plant heating modifications: The team proposes the following heating modifications for the Central Plant units and systems.
- For the following units, replace the steam preheat coil with a heating hot water coil: HV-1P, HV-2P, HV-3P, HV-4P, HV-5P, HV-6P, HV-7P, HV-8P, HV-10P, HV-11P, and AC-5P.
- For the following heat exchangers, tap into the heating hot water distribution from the Central Plant using the existing heating hot water return piping to preheat the water before it enters the heat exchanger: HX-1P.

9.1.1 Proposed Controls Strategy

The team proposes the following controls strategy and adjustments to optimize the system’s performance:

- **Central Plant heat pump:** Replace Chiller-2 and Chiller-6 with a York CYK heat pump. The heat pump will operate to maintain heating hot water distribution set-point, which will adjust based on outdoor air temperature. All building equipment must coordinate with this set-point.
- **Air handling units and heating and ventilation units:** Provide new hot water unit heaters in the mixed air plenum of AC and HV units. The unit heaters will take load off of the steam coil and will satisfy set-point under most conditions. The steam coil will only need to be used under extreme conditions
- **Heating hot water:** The heat pump generated hot water will preheat the local heating hot water systems. If the heat pump generated water cannot satisfy the system setpoint then the existing steam-to-hot-water heat exchanger will add the remaining degrees of heat to meet setpoint.
- **Domestic hot water:** Use the heat pump generated heating hot water to heat the domestic cold water. New domestic water heaters will be provided in order to use heating hot water as the source energy. A local steam-to-hot water heat exchanger will be provided as a means of backup for the domestic water heat source.

9.1.2 Analysis of Proposed Modification: Base Case and Energy Conservation Measure Analysis

The team proposes the following modeling process for this energy conservation measure (ECM):

- **Base case**
    - Model the base case using an 8760 Excel model built solely for each heating load.
    - Implement the schedules and controls strategy for each unit.
- **Energy conservation measure analysis**
    - Incorporate a switch into the base model to toggle the heat pump on and off, with an adjustable heating hot water supply temperature. This hourly supply temperature dictates how much heating can transfer from steam to the heat pump. The model calculates the heating hot water flow profile based on the calculated load and differential temperature.
    - Use this flow to calculate the energy consumption of the new heating hot water pump (HHWP).
    - Use the model to calculate the pump energy power draw using factory equipment data. The existing plant chiller's 8,760-kilowatt per ton (kW/ton) profile calculates the reduction in power consumption for the existing plant.

9.1.3 First Cost Analysis

Smith Engineering produced the first cost estimate for this option. The estimate for the proposed modifications is $35,657,579, which is detailed in Table 60 through Table 65.

Table 60. M.1 Energy Model Heat Pump Cost Summary

Opinion of Probable Construction Cost		Date:	Wednesday, March 1, 2023
		Client:	Brookfield
For	M.1 - Summary	Project:	BFPL Community Heat Pump Stg A

Basis of Estimate ☐ No Design ☑ Conceptual Design ☐ Final Design ☐ Actual Cost

Item #	Description	Quantity	Units	Material Cost per Unit	Total Material Cost	Labor Hour	Labor Cost per Hour	Total Labor Cost	Total Cost
	Division 01000 - General								
1	Tower B				$ 510,000			$ 670,000	$ 1,180,000
2	Tower C				$ 345,000			$ 563,125	$ 908,125
3	Tower D				$ 425,000			$ 611,875	$ 1,036,875
4	Winter Garden				$ 420,000			$ 674,875	$ 1,094,875
5	Central Plant				$ 460,000			$ 845,875	$ 1,305,875
	Subtotal				**$ 2,160,000**			**$ 3,365,750**	**$ 5,525,750**
	Division 23000 - Mechanical								
1	Tower B				$ 1,420,000			$ 1,112,500	$ 2,532,500
2	Tower C				$ 1,060,000			$ 800,000	$ 1,860,000
3	Tower D				$ 790,000			$ 627,500	$ 1,417,500
4	Winter Garden				$ 950,000			$ 662,500	$ 1,612,500
5	Central Plant				$ 4,368,000			$ 1,112,500	$ 5,480,500
	Subtotal				**$ 8,588,000**			**$ 4,315,000**	**$ 12,903,000**
	Division 25000 - Controls								
1	Tower B				$ 175,000			$ 300,000	$ 475,000
2	Tower C				$ 141,000			$ 255,000	$ 396,000
3	Tower D				$ 100,000			$ 255,000	$ 355,000
4	Winter Garden				$ 110,000			$ 300,000	$ 410,000
5	Central Plant				$ 100,000			$ 360,000	$ 460,000
	Subtotal				**$ 626,000**			**$ 1,470,000**	**$ 2,096,000**
	Division 26000 - Electrical								
1	Tower B				$ 170,000			$ 247,500	$ 417,500
2	Tower C				$ 93,000			$ 206,250	$ 299,250
3	Tower D				$ 77,000			$ 220,000	$ 297,000
4	Winter Garden				$ 110,000			$ 225,500	$ 335,500
5	Central Plant				$ 270,000			$ 412,500	$ 682,500
	Subtotal				**$ 720,000**			**$ 1,311,750**	**$ 2,031,750**
	Subtotal			Multiplier	**$ 12,094,000**	Multiplier		**$10,462,500**	**$ 22,556,500**
	Contingency			10%	$ 1,209,400	10%		$ 1,046,250	$ 2,255,650
	Subtotal				**$ 13,303,400**			**$11,508,750**	**$ 24,812,150**
	Construction Management Overhead			10%	$ 1,330,340	10%		$ 1,150,875	$ 2,481,215
	Profit			10%	$ 1,330,340	10%		$ 1,150,875	$ 2,481,215
	Subtotal Construction				**$ 15,964,080**			**$13,810,500**	**$ 29,774,580**
	Tax			8.875%	$ 1,416,812	0%		$ -	$ 1,416,812
	Design Engineering							$ 2,381,966	$ 2,381,966
	Construction Administration							$ 1,190,983	$ 1,190,983
	Commissioning							$ 893,237	$ 893,237
	Total Estimated Cost	**$**							**35,657,579**

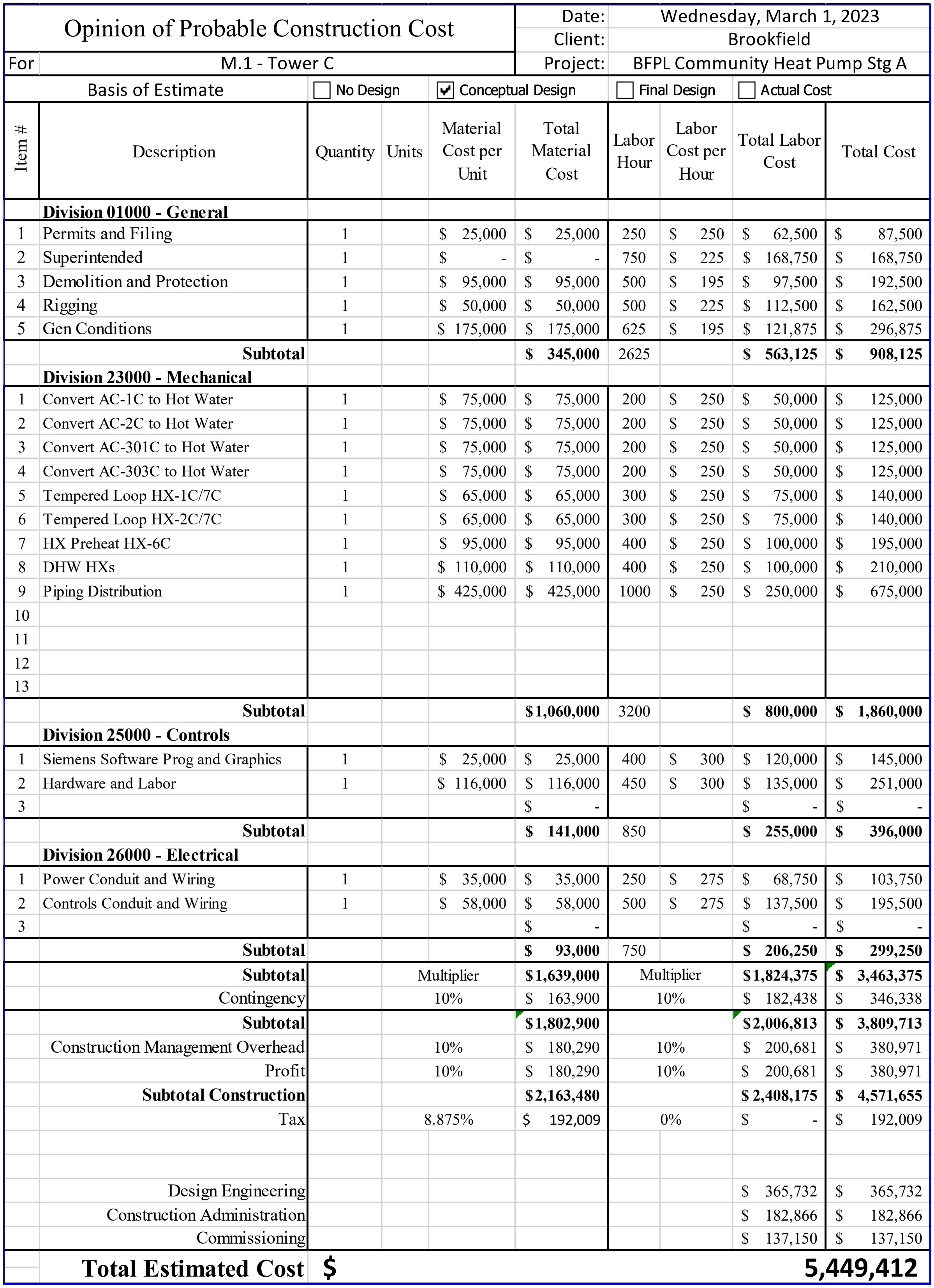
Table 61. M.1 Energy Model Tower B Estimated Heat Pump Cost

Opinion of Probable Construction Cost		Date:	Wednesday, March 1, 2023
		Client:	Brookfield
For	M.1 - Tower B	Project:	BFPL Community Heat Pump Stg A

Basis of Estimate ☐ No Design ☑ Conceptual Design ☐ Final Design ☐ Actual Cost

Item #	Description	Quantity	Units	Material Cost per Unit	Total Material Cost	Labor Hour	Labor Cost per Hour	Total Labor Cost	Total Cost
	Division 01000 - General								
1	Permits and Filing	1		$ 35,000	$ 35,000	250	$ 250	$ 62,500	$ 97,500
2	Superintended	1		$ -	$ -	900	$ 225	$ 202,500	$ 202,500
3	Demolition and Protection	1		$ 175,000	$ 175,000	750	$ 195	$ 146,250	$ 321,250
4	Rigging	1		$ 50,000	$ 50,000	500	$ 225	$ 112,500	$ 162,500
5	Gen Conditions	1		$ 250,000	$ 250,000	750	$ 195	$ 146,250	$ 396,250
	Subtotal				**$ 510,000**	3150		**$ 670,000**	**$ 1,180,000**
	Division 23000 - Mechanical								
1	Convert AC-1B to Hot Water	1		$ 75,000	$ 75,000	200	$ 250	$ 50,000	$ 125,000
2	Convert AC-2B to Hot Water	1		$ 75,000	$ 75,000	200	$ 250	$ 50,000	$ 125,000
3	Convert AC-45B to Hot Water	1		$ 75,000	$ 75,000	200	$ 250	$ 50,000	$ 125,000
4	Convert AC-47B to Hot Water	1		$ 75,000	$ 75,000	200	$ 250	$ 50,000	$ 125,000
5	Convert AC-48B to Hot Water	1		$ 75,000	$ 75,000	200	$ 250	$ 50,000	$ 125,000
6	HV-3B Glycol Loop with HX	1		$ 125,000	$ 125,000	400	$ 250	$ 100,000	$ 225,000
7	Tempered Loop HX-1B	1		$ 65,000	$ 65,000	300	$ 250	$ 75,000	$ 140,000
8	Tempered Loop HX-5B	1		$ 65,000	$ 65,000	300	$ 250	$ 75,000	$ 140,000
9	Tempered Loop HX-3B/4B	1		$ 65,000	$ 65,000	300	$ 250	$ 75,000	$ 140,000
10	HX Preheat HX-6B	1		$ 95,000	$ 95,000	400	$ 250	$ 100,000	$ 195,000
11	HX Preheat HX-7B/8B	1		$ 95,000	$ 95,000	400	$ 250	$ 100,000	$ 195,000
12	DHW HXs	1		$ 110,000	$ 110,000	400	$ 250	$ 100,000	$ 210,000
13	Piping Distribution	1		$ 425,000	$ 425,000	950	$ 250	$ 237,500	$ 662,500
	Subtotal				**$1,420,000**	4450		**$1,112,500**	**$ 2,532,500**
	Division 25000 - Controls								
1	Schneider Software Prog and Graphics	1		$ 25,000	$ 25,000	400	$ 300	$ 120,000	$ 145,000
2	Hardware and Labor	1		$ 150,000	$ 150,000	600	$ 300	$ 180,000	$ 330,000
3					$ -			$ -	$ -
	Subtotal				**$ 175,000**	1000		**$ 300,000**	**$ 475,000**
	Division 26000 - Electrical								
1	Power Conduit and Wiring	1		$ 95,000	$ 95,000	400	$ 275	$ 110,000	$ 205,000
2	Controls Conduit and Wiring	1		$ 75,000	$ 75,000	500	$ 275	$ 137,500	$ 212,500
3					$ -			$ -	$ -
	Subtotal				**$ 170,000**	900		**$ 247,500**	**$ 417,500**
	Subtotal		Multiplier		**$2,275,000**	Multiplier		**$2,330,000**	**$ 4,605,000**
	Contingency		10%		$ 227,500	10%		$ 233,000	$ 460,500
	Subtotal				**$2,502,500**			**$2,563,000**	**$ 5,065,500**
	Construction Management Overhead		10%		$ 250,250	10%		$ 256,300	$ 506,550
	Profit		10%		$ 250,250	10%		$ 256,300	$ 506,550
	Subtotal Construction				**$3,003,000**			**$3,075,600**	**$ 6,078,600**
	Tax		8.875%		$ 266,516	0%		$ -	$ 266,516
	Design Engineering							$ 486,288	$ 486,288
	Construction Administration							$ 243,144	$ 243,144
	Commissioning							$ 182,358	$ 182,358
	Total Estimated Cost	**$**							**7,256,906**

Table 62. M.1 Energy Model Tower C Estimated Heat Pump Cost



Opinion of Probable Construction Cost

Date: Wednesday, March 1, 2023
Client: Brookfield
For M.1 - Tower C
Project: BFPL Community Heat Pump Stg A

Basis of Estimate ☐ No Design ☑ Conceptual Design ☐ Final Design ☐ Actual Cost

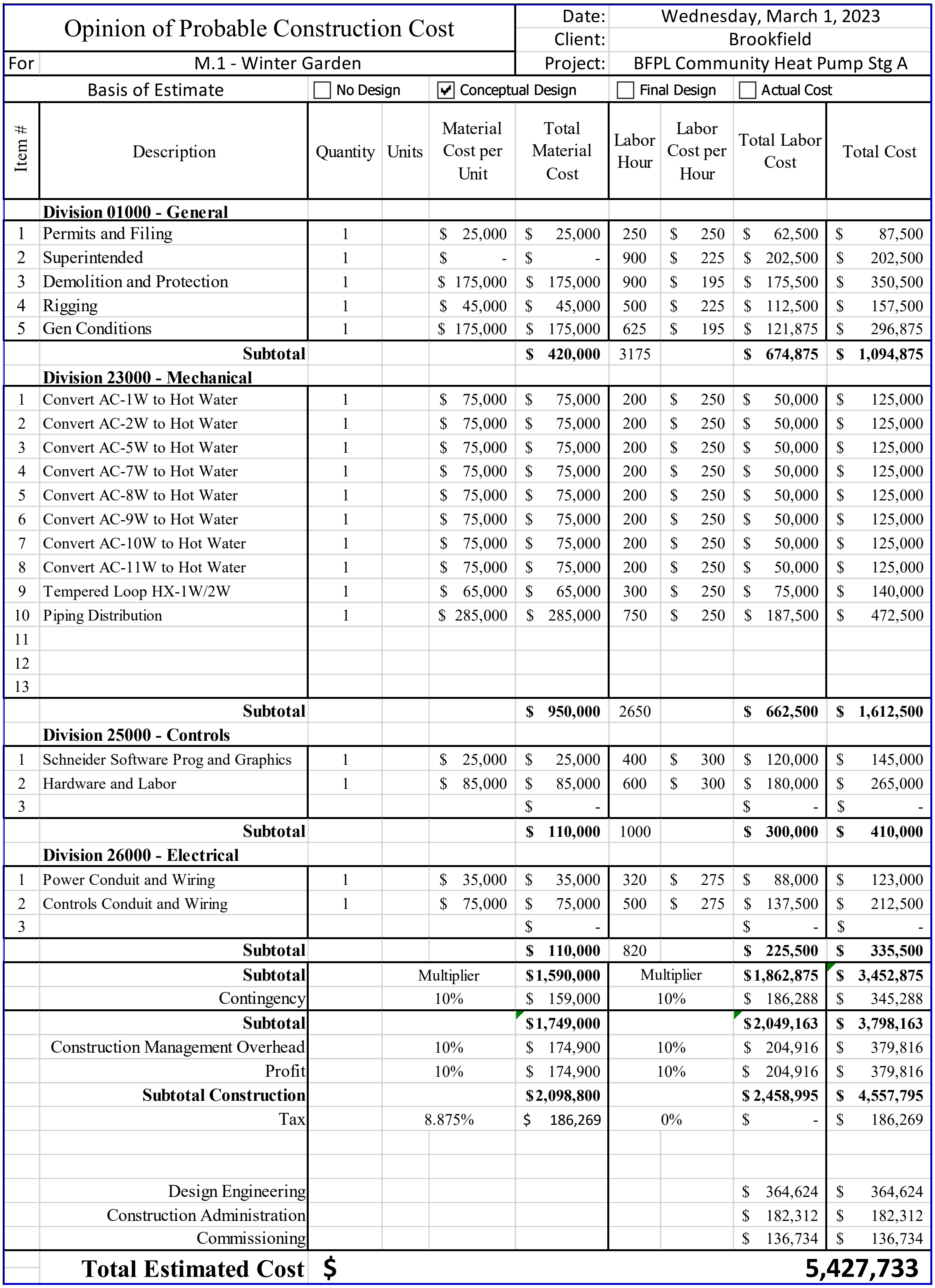
Item #	Description	Quantity	Units	Material Cost per Unit	Total Material Cost	Labor Hour	Labor Cost per Hour	Total Labor Cost	Total Cost
	Division 01000 - General								
1	Permits and Filing	1		$ 25,000	$ 25,000	250	$ 250	$ 62,500	$ 87,500
2	Superintended	1		$ -	$ -	750	$ 225	$ 168,750	$ 168,750
3	Demolition and Protection	1		$ 95,000	$ 95,000	500	$ 195	$ 97,500	$ 192,500
4	Rigging	1		$ 50,000	$ 50,000	500	$ 225	$ 112,500	$ 162,500
5	Gen Conditions	1		$ 175,000	$ 175,000	625	$ 195	$ 121,875	$ 296,875
	Subtotal				**$ 345,000**	2625		**$ 563,125**	**$ 908,125**
	Division 23000 - Mechanical								
1	Convert AC-1C to Hot Water	1		$ 75,000	$ 75,000	200	$ 250	$ 50,000	$ 125,000
2	Convert AC-2C to Hot Water	1		$ 75,000	$ 75,000	200	$ 250	$ 50,000	$ 125,000
3	Convert AC-301C to Hot Water	1		$ 75,000	$ 75,000	200	$ 250	$ 50,000	$ 125,000
4	Convert AC-303C to Hot Water	1		$ 75,000	$ 75,000	200	$ 250	$ 50,000	$ 125,000
5	Tempered Loop HX-1C/7C	1		$ 65,000	$ 65,000	300	$ 250	$ 75,000	$ 140,000
6	Tempered Loop HX-2C/7C	1		$ 65,000	$ 65,000	300	$ 250	$ 75,000	$ 140,000
7	HX Preheat HX-6C	1		$ 95,000	$ 95,000	400	$ 250	$ 100,000	$ 195,000
8	DHW HXs	1		$ 110,000	$ 110,000	400	$ 250	$ 100,000	$ 210,000
9	Piping Distribution	1		$ 425,000	$ 425,000	1000	$ 250	$ 250,000	$ 675,000
10									
11									
12									
13									
	Subtotal				**$1,060,000**	3200		**$ 800,000**	**$ 1,860,000**
	Division 25000 - Controls								
1	Siemens Software Prog and Graphics	1		$ 25,000	$ 25,000	400	$ 300	$ 120,000	$ 145,000
2	Hardware and Labor	1		$ 116,000	$ 116,000	450	$ 300	$ 135,000	$ 251,000
3					$ -			$ -	$ -
	Subtotal				**$ 141,000**	850		**$ 255,000**	**$ 396,000**
	Division 26000 - Electrical								
1	Power Conduit and Wiring	1		$ 35,000	$ 35,000	250	$ 275	$ 68,750	$ 103,750
2	Controls Conduit and Wiring	1		$ 58,000	$ 58,000	500	$ 275	$ 137,500	$ 195,500
3					$ -			$ -	$ -
	Subtotal				**$ 93,000**	750		**$ 206,250**	**$ 299,250**
	Subtotal			Multiplier	**$1,639,000**		Multiplier	**$1,824,375**	**$ 3,463,375**
	Contingency			10%	$ 163,900		10%	$ 182,438	$ 346,338
	Subtotal				**$1,802,900**			**$2,006,813**	**$ 3,809,713**
	Construction Management Overhead			10%	$ 180,290		10%	$ 200,681	$ 380,971
	Profit			10%	$ 180,290		10%	$ 200,681	$ 380,971
	Subtotal Construction				**$2,163,480**			**$ 2,408,175**	**$ 4,571,655**
	Tax			8.875%	$ 192,009		0%	$ -	$ 192,009
	Design Engineering							$ 365,732	$ 365,732
	Construction Administration							$ 182,866	$ 182,866
	Commissioning							$ 137,150	$ 137,150
	Total Estimated Cost	**$**							**5,449,412**

Table 63. M.1 Energy Model Tower D Estimated Heat Pump Cost

Opinion of Probable Construction Cost		Date:	Wednesday, March 1, 2023
		Client:	Brookfield
For	M.1 - Tower D	Project:	BFPL Community Heat Pump Stg A
Basis of Estimate	☐ No Design ☑ Conceptual Design	☐ Final Design	☐ Actual Cost

Item #	Description	Quantity	Units	Material Cost per Unit	Total Material Cost	Labor Hour	Labor Cost per Hour	Total Labor Cost	Total Cost
	Division 01000 - General								
1	Permits and Filing	1		$ 25,000	$ 25,000	250	$ 250	$ 62,500	$ 87,500
2	Superintended	1		$ -	$ -	750	$ 225	$ 168,750	$ 168,750
3	Demolition and Protection	1		$ 175,000	$ 175,000	750	$ 195	$ 146,250	$ 321,250
4	Rigging	1		$ 50,000	$ 50,000	500	$ 225	$ 112,500	$ 162,500
5	Gen Conditions	1		$ 175,000	$ 175,000	625	$ 195	$ 121,875	$ 296,875
	Subtotal				**$ 425,000**	2875		**$ 611,875**	**$ 1,036,875**
	Division 23000 - Mechanical								
1	Convert AC-1D to Hot Water	1		$ 75,000	$ 75,000	160	$ 250	$ 40,000	$ 115,000
2	Convert SF-3-1D to Hot Water	1		$ 75,000	$ 75,000	200	$ 250	$ 50,000	$ 125,000
3	Convert SC-SF-2D to Hot Water	1		$ 75,000	$ 75,000	200	$ 250	$ 50,000	$ 125,000
4	Tempered Loop HX-2D	1		$ 65,000	$ 65,000	300	$ 250	$ 75,000	$ 140,000
5	Tempered Loop HX-4D	1		$ 65,000	$ 65,000	300	$ 250	$ 75,000	$ 140,000
6	DHW HXs	1		$ 110,000	$ 110,000	400	$ 250	$ 100,000	$ 210,000
7	Piping Distribution	1		$ 325,000	$ 325,000	950	$ 250	$ 237,500	$ 562,500
8									
9									
10									
11									
12									
13									
	Subtotal				**$ 790,000**	2510		**$ 627,500**	**$ 1,417,500**
	Division 25000 - Controls								
1	TEC Software Prog and Graphics	1		$ 25,000	$ 25,000	400	$ 300	$ 120,000	$ 145,000
2	Hardware and Labor	1		$ 75,000	$ 75,000	450	$ 300	$ 135,000	$ 210,000
3					$ -			$ -	$ -
	Subtotal				**$ 100,000**	850		**$ 255,000**	**$ 355,000**
	Division 26000 - Electrical								
1	Power Conduit and Wiring	1		$ 35,000	$ 35,000	300	$ 275	$ 82,500	$ 117,500
2	Controls Conduit and Wiring	1		$ 42,000	$ 42,000	500	$ 275	$ 137,500	$ 179,500
3					$ -			$ -	$ -
	Subtotal				**$ 77,000**	800		**$ 220,000**	**$ 297,000**
	Subtotal			Multiplier	**$ 1,392,000**	Multiplier		**$ 1,714,375**	**$ 3,106,375**
	Contingency			10%	$ 139,200	10%		$ 171,438	$ 310,638
	Subtotal				**$ 1,531,200**			**$ 1,885,813**	**$ 3,417,013**
	Construction Management Overhead			10%	$ 153,120	10%		$ 188,581	$ 341,701
	Profit			10%	$ 153,120	10%		$ 188,581	$ 341,701
	Subtotal Construction				**$ 1,837,440**			**$ 2,262,975**	**$ 4,100,415**
	Tax			8.875%	$ 163,073	0%		$ -	$ 163,073
	Design Engineering							$ 328,033	$ 328,033
	Construction Administration							$ 164,017	$ 164,017
	Commissioning							$ 123,012	$ 123,012
	Total Estimated Cost	**$**							**4,878,550**

Table 64. M.1 Energy Model Winter Garden Estimated Heat Pump Cost



Opinion of Probable Construction Cost

Date: Wednesday, March 1, 2023
Client: Brookfield
For M.1 - Winter Garden
Project: BFPL Community Heat Pump Stg A

Basis of Estimate ☐ No Design ☑ Conceptual Design ☐ Final Design ☐ Actual Cost

Item #	Description	Quantity	Units	Material Cost per Unit	Total Material Cost	Labor Hour	Labor Cost per Hour	Total Labor Cost	Total Cost
	Division 01000 - General								
1	Permits and Filing	1		$ 25,000	$ 25,000	250	$ 250	$ 62,500	$ 87,500
2	Superintended	1		$ -	$ -	900	$ 225	$ 202,500	$ 202,500
3	Demolition and Protection	1		$ 175,000	$ 175,000	900	$ 195	$ 175,500	$ 350,500
4	Rigging	1		$ 45,000	$ 45,000	500	$ 225	$ 112,500	$ 157,500
5	Gen Conditions	1		$ 175,000	$ 175,000	625	$ 195	$ 121,875	$ 296,875
	Subtotal				**$ 420,000**	3175		**$ 674,875**	**$ 1,094,875**
	Division 23000 - Mechanical								
1	Convert AC-1W to Hot Water	1		$ 75,000	$ 75,000	200	$ 250	$ 50,000	$ 125,000
2	Convert AC-2W to Hot Water	1		$ 75,000	$ 75,000	200	$ 250	$ 50,000	$ 125,000
3	Convert AC-5W to Hot Water	1		$ 75,000	$ 75,000	200	$ 250	$ 50,000	$ 125,000
4	Convert AC-7W to Hot Water	1		$ 75,000	$ 75,000	200	$ 250	$ 50,000	$ 125,000
5	Convert AC-8W to Hot Water	1		$ 75,000	$ 75,000	200	$ 250	$ 50,000	$ 125,000
6	Convert AC-9W to Hot Water	1		$ 75,000	$ 75,000	200	$ 250	$ 50,000	$ 125,000
7	Convert AC-10W to Hot Water	1		$ 75,000	$ 75,000	200	$ 250	$ 50,000	$ 125,000
8	Convert AC-11W to Hot Water	1		$ 75,000	$ 75,000	200	$ 250	$ 50,000	$ 125,000
9	Tempered Loop HX-1W/2W	1		$ 65,000	$ 65,000	300	$ 250	$ 75,000	$ 140,000
10	Piping Distribution	1		$ 285,000	$ 285,000	750	$ 250	$ 187,500	$ 472,500
11									
12									
13									
	Subtotal				**$ 950,000**	2650		**$ 662,500**	**$ 1,612,500**
	Division 25000 - Controls								
1	Schneider Software Prog and Graphics	1		$ 25,000	$ 25,000	400	$ 300	$ 120,000	$ 145,000
2	Hardware and Labor	1		$ 85,000	$ 85,000	600	$ 300	$ 180,000	$ 265,000
3					$ -			$ -	$ -
	Subtotal				**$ 110,000**	1000		**$ 300,000**	**$ 410,000**
	Division 26000 - Electrical								
1	Power Conduit and Wiring	1		$ 35,000	$ 35,000	320	$ 275	$ 88,000	$ 123,000
2	Controls Conduit and Wiring	1		$ 75,000	$ 75,000	500	$ 275	$ 137,500	$ 212,500
3					$ -			$ -	$ -
	Subtotal				**$ 110,000**	820		**$ 225,500**	**$ 335,500**
	Subtotal			Multiplier	**$1,590,000**		Multiplier	**$1,862,875**	**$ 3,452,875**
	Contingency			10%	$ 159,000		10%	$ 186,288	$ 345,288
	Subtotal				**$1,749,000**			**$2,049,163**	**$ 3,798,163**
	Construction Management Overhead			10%	$ 174,900		10%	$ 204,916	$ 379,816
	Profit			10%	$ 174,900		10%	$ 204,916	$ 379,816
	Subtotal Construction				**$2,098,800**			**$ 2,458,995**	**$ 4,557,795**
	Tax			8.875%	$ 186,269		0%	$ -	$ 186,269
	Design Engineering							$ 364,624	$ 364,624
	Construction Administration							$ 182,312	$ 182,312
	Commissioning							$ 136,734	$ 136,734
	Total Estimated Cost	**$**							**5,427,733**

Table 65. M.1 Energy Model Central Plant Estimated Heat Pump Cost

Opinion of Probable Construction Cost
Date: Wednesday, March 1, 2023
Client: Brookfield
For M.1 - Central Plant
Project: BFPL Community Heat Pump Stg A
Basis of Estimate ☐ No Design ☑ Conceptual Design ☐ Final Design ☐ Actual Cost

Item #	Description	Quantity	Units	Material Cost per Unit	Total Material Cost	Labor Hour	Labor Cost per Hour	Total Labor Cost	Total Cost
	Division 01000 - General								
1	Permits and Filing	1		$ 50,000	$ 50,000	250	$ 250	$ 62,500	$ 112,500
2	Superintended	1		$ -	$ -	1400	$ 225	$ 315,000	$ 315,000
3	Demolition and Protection	1		$ 75,000	$ 75,000	1200	$ 195	$ 234,000	$ 309,000
4	Rigging	1		$ 250,000	$ 250,000	500	$ 225	$ 112,500	$ 362,500
5	Gen Conditions	1		$ 85,000	$ 85,000	625	$ 195	$ 121,875	$ 206,875
	Subtotal				**$ 460,000**	3975		**$ 845,875**	**$ 1,305,875**
	Division 23000 - Mechanical								
1	Heat Pump	2		$ 850,000	$ 1,700,000	500	$ 250	$ 125,000	$ 1,825,000
2	Convert HV-1P/2P/3P to Glycol	1		$ 225,000	$ 225,000	200	$ 250	$ 50,000	$ 275,000
3	Convert HV-4P/5P to Glycol	1		$ 145,000	$ 145,000	200	$ 250	$ 50,000	$ 195,000
4	Convert HV-6P to Glycol	1		$ 145,000	$ 145,000	200	$ 250	$ 50,000	$ 195,000
5	Convert HV-7P to Glycol	1		$ 145,000	$ 145,000	200	$ 250	$ 50,000	$ 195,000
6	Convert HV-8P to Glycol	1		$ 145,000	$ 145,000	200	$ 250	$ 50,000	$ 195,000
7	HHW Pumps	3		$ 76,000	$ 228,000	400	$ 250	$ 100,000	$ 328,000
8	Plant Piping	1		$ 110,000	$ 110,000	400	$ 250	$ 100,000	$ 210,000
9	Piping Distribution	1		$ 325,000	$ 325,000	650	$ 250	$ 162,500	$ 487,500
10	Tunnel Piping	1		$ 1,200,000	$ 1,200,000	1500	$ 250	$ 375,000	$ 1,575,000
11									
12									
13									
	Subtotal				**$ 4,368,000**	4450		**$ 1,112,500**	**$ 5,480,500**
	Division 25000 - Controls								
1	Schneider Software Prog and Graphics	1		$ 25,000	$ 25,000	600	$ 300	$ 180,000	$ 205,000
2	Hardware and Labor	1		$ 75,000	$ 75,000	600	$ 300	$ 180,000	$ 255,000
3					$ -			$ -	$ -
	Subtotal				**$ 100,000**	1200		**$ 360,000**	**$ 460,000**
	Division 26000 - Electrical								
1	Power Conduit and Wiring	1		$ 195,000	$ 195,000	1000	$ 275	$ 275,000	$ 470,000
2	Controls Conduit and Wiring	1		$ 75,000	$ 75,000	500	$ 275	$ 137,500	$ 212,500
3					$ -			$ -	$ -
	Subtotal				**$ 270,000**	1500		**$ 412,500**	**$ 682,500**
	Subtotal			Multiplier	**$ 5,198,000**		Multiplier	**$ 2,730,875**	**$ 7,928,875**
	Contingency			10%	$ 519,800		10%	$ 273,088	$ 792,888
	Subtotal				**$ 5,717,800**			**$ 3,003,963**	**$ 8,721,763**
	Construction Management Overhead			10%	$ 571,780		10%	$ 300,396	$ 872,176
	Profit			10%	$ 571,780		10%	$ 300,396	$ 872,176
	Subtotal Construction				**$ 6,861,360**			**$ 3,604,755**	**$ 10,466,115**
	Tax			8.875%	$ 608,946		0%	$ -	$ 608,946
	Design Engineering							$ 837,289	$ 837,289
	Construction Administration							$ 418,645	$ 418,645
	Commissioning							$ 313,983	$ 313,983
	Total Estimated Cost	**$**							**12,644,978**

9.1.4 Operational and Economic Analysis

Table 66 through Table 72 summarize the energy and financial results for this option.

Table 66. M.1 Energy Model Tower A Heating Summary

Tower A Heating

Measure: M.1 - Central Plant Heat Pump - Tower A

Date: 11/14/2022 **Client:** Brookfield
Project: **Community Heat Pump**

Calculation Method: 8,760

Basis: ☐ Installed ☑ Conceptual Design ☐ Final Design

Equipment Efficiency: ☐ Actual Dynamic ☑ Manufacturer Dynamic

Utility Rate Data

Utility		Blend Rate	
Winter Steam	$	36.000	$/klb
Summer Steam	$	18.000	$/klb
	$	-	$/klb
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Design / Existing Operation

Tag	Heat Pump Summary				Tower A LH HHW Gen			Tower A UH HHW Gen			Tower A LH Steam Utilization			Tower A UH Steam Utilization			Tower A LH HHW Utilization			ower A UH HHW Utilizatio					
	LH HP		UH HP																						
	HP MBH	Max HP HHW Flow	HP MBH	Max HP HHW Flow	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Total MBH	Total klbs	Sum Cost
Jan	0	0	0	0.00	364	1,713,087	1793.81	364	886,663	928.44	325	980,524	1026.73	0	0	0.00							3,580,274	3,749	$ 134,963
Feb	0	0	0	0.00	336	1,382,642	1447.79	336	712,250	745.81	257	768,416	804.62	0	0	0.00							2,863,308	2,998	$ 107,936
Mar	0	0	0	0.00	378	1,567,456	1641.32	378	832,618	871.85	287	863,537	904.23	0	0	0.00							3,263,611	3,417	$ 123,026
Apr	0	0	0	0.00	350	535,729	560.97	350	322,580	337.78	75	183,567	192.22	0	0	0.00							1,041,876	1,091	$ 19,637
May	0	0	0	0.00	378	361,045	378.06	378	295,133	309.04	31	58,630	61.39	0	0	0.00							714,808	748	$ 13,473
Jun	0	0	0	0.00	364	260,244	272.51	364	260,244	272.51	0	0	0.00	0	0	0.00							520,488	545	$ 9,810
July	0	0	0	0.00	364	259,176	271.39	364	259,176	271.39	0	0	0.00	0	0	0.00							518,352	543	$ 9,770
Aug	0	0	0	0.00	378	270,037	282.76	378	270,037	282.76	0	0	0.00	0	0	0.00							540,074	566	$ 10,179
Sep	0	0	0	0.00	364	268,701	281.36	364	262,525	274.89	2	4,679	4.90	0	0	0.00							535,905	561	$ 10,101
Oct	0	0	0	0.00	364	498,042	521.51	364	322,360	337.55	66	155,501	162.83	0	0	0.00							975,904	1,022	$ 36,788
Nov	0	0	0	0.00	364	1,203,098	1259.79	364	588,911	616.66	238	646,353	676.81	0	0	0.00							2,438,362	2,553	$ 91,917
Dec	0	0	0	0.00	364	1,859,547	1947.17	364	1,030,450	1079.00	337	1,054,141	1103.81	0	0	0.00							3,944,137	4,130	$ 148,680
Total	0	0	0	0.00	4,368	10,178,803	10,658	4,368	6,042,946	6,328	1,618	4,715,349	4,938	0	0	0	0	0	0	0	0	0	**20,937,098**	**21,924**	**$ 716,281**
Total Cost	$ -				$ **346,857**			$ **135,463**			$ **173,098**			$ -											

M.1 - Central Plant Heat Pump - Tower A

Utility Rate Data

Utility		Blend Rate	
Winter Steam	$	36.000	$/klb
Summer Steam	$	18.000	$/klb
0	$	-	$/klb
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Modified Operation

Tag	Heat Pump Summary				Tower A LH HHW Gen			Tower A UH HHW Gen			Tower A LH Steam Utilization			Tower A UH Steam Utilization			Tower A LH HHW Utilization			ower A UH HHW Utilizatio					
	LH HP		UH HP																						
	HP MBH	Max HP HHW Flow	HP MBH	Max HP HHW Flow	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Total MBH	Total klbs	Sum Cost
Jan	0	887	0	0.00	364	1,713,087	1793.81	364	886,663	928.44	325	980,524	1026.73	0	0	0.00							3,580,274	3,749	$ 134,963
Feb	0	855	0	0.00	336	1,382,642	1447.79	336	712,250	745.81	257	768,416	804.62	0	0	0.00							2,863,308	2,998	$ 107,936
Mar	0	846	0	0.00	378	1,567,456	1641.32	378	832,618	871.85	287	863,537	904.23	0	0	0.00							3,263,611	3,417	$ 123,026
Apr	0	372	0	0.00	350	535,729	560.97	350	322,580	337.78	75	183,567	192.22	0	0	0.00							1,041,876	1,091	$ 19,637
May	0	249	0	0.00	378	361,045	378.06	378	295,133	309.04	31	58,630	61.39	0	0	0.00							714,808	748	$ 13,473
Jun	0	14	0	0.00	364	260,244	272.51	364	260,244	272.51	0	0	0.00	0	0	0.00							520,488	545	$ 9,810
July	0	13	0	0.00	364	259,176	271.39	364	259,176	271.39	0	0	0.00	0	0	0.00							518,352	543	$ 9,770
Aug	0	13	0	0.00	378	270,037	282.76	378	270,037	282.76	0	0	0.00	0	0	0.00							540,074	566	$ 10,179
Sep	0	161	0	0.00	364	268,701	281.36	364	262,525	274.89	2	4,679	4.90	0	0	0.00							535,905	561	$ 10,101
Oct	0	304	0	0.00	364	498,042	521.51	364	322,360	337.55	66	155,501	162.83	0	0	0.00							975,904	1,022	$ 36,788
Nov	0	846	0	0.00	364	1,203,098	1259.79	364	588,911	616.66	238	646,353	676.81	0	0	0.00							2,438,362	2,553	$ 91,917
Dec	0	884	0	0.00	364	1,859,547	1947.17	364	1,030,450	1079.00	337	1,054,141	1103.81	0	0	0.00							3,944,137	4,130	$ 148,680
Total	0	5,444	0	0.00	4,368	10,178,803	888.20	4,368	6,042,946	6,328	1,618	4,715,349	4,938	0	0	0							**20,937,098**	**21,924**	**$ 716,281**
Total Cost	$ -				$ **346,857**			$ **135,463**			$ **173,098**			$ -											

Summary

Tag	Heat Pump Summary	Tower A LH HHW Gen	Tower A UH HHW Gen	Tower A LH Steam Utilization	Tower A UH Steam Utilization	Tower A LH HHW Utilization	ower A UH HHW Utilizatio	Total Saving	
Change Hrs	0	0	0	0	0			**0**	**MBH**
Energy Savings	0	0	0	0	0			**0**	**klbs**
Reduction in Cost	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**			**$ -**	

Table 67. M.1 Energy Model Tower B Heating Summary

Tower B Heating	**Measure:**	**M.1 - Central Plant Heat Pump - Tower B**	**Date:** 11/14/2022 **Project:**	**Client:** Brookfield **Community Heat Pump**

Calculation Method: 8,760

Basis: ☐ Installed ☑ Conceptual Design ☐ Final Design **Equipment Efficiency:** ☐ Actual Dynamic ☑ Manufacturer Dynamic

Design

Utility Rate Data

Utility		Blend Rate	
Winter Steam	$	36.000	$/klb
Summer Steam	$	18.000	$/klb
	$	-	$/klb
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Existing Operation

Tag	Heat Pump Summary				Tower B LH HHW Gen			Tower B UH HHW Gen			Tower B LH Steam Utilization			Tower B UH Steam Utilization			Tower B LH HHW Utilization			Tower B UH HHW Utilization					
	LH HP		UH HP																						
	HP MBH	Max HP HHW Flow	HP MBH	Max HP HHW Flow	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Total MBH	Total klbs	Sum Cost
Jan	0	0	0	0.00	646	2,013,514	2,108	320	1,247,602	1,306	459	3,644,082	3,816	0	0	0.00							6,905,199	7,231	$ 260,301
Feb	0	0	0	0.00	504	1,620,557	1,697	278	769,253	806	373	2,796,646	2,928	0	0	0.00							5,186,456	5,431	$ 195,510
Mar	0	0	0	0.00	558	1,823,227	1,909	307	1,213,777	1,271	426	3,230,191	3,382	0	0	0.00							6,267,195	6,563	$ 236,250
Apr	0	0	0	0.00	540	854,291	895	5	9,183	10	313	577,173	604	0	0	0.00							1,440,647	1,509	$ 27,154
May	0	0	0	0.00	558	797,245	835	0	0	0	302	292,331	306	0	0	0.00							1,089,576	1,141	$ 20,537
Jun	0	0	0	0.00	540	740,963	776	0	0	0	103	34,017	36	0	0	0.00							774,980	811	$ 14,607
July	0	0	0	0.00	558	763,578	800	0	0	0	13	536	1	0	0	0.00							764,114	800	$ 14,402
Aug	0	0	0	0.00	558	765,526	802	0	0	0	93	3,568	4	0	0	0.00							769,094	805	$ 14,496
Sep	0	0	0	0.00	540	742,680	778	0	0	0	165	52,284	55	0	0	0.00							794,964	832	$ 14,984
Oct	0	0	0	0.00	558	836,007	875	2	3,520	4	247	432,704	453	0	0	0.00							1,272,231	1,332	$ 47,958
Nov	0	0	0	0.00	540	1,417,509	1,484	141	353,280	370	401	2,137,358	2,238	0	0	0.00							3,908,146	4,092	$ 147,323
Dec	0	0	0	0.00	650	2,202,534	2,306	444	1,916,515	2,007	460	4,155,904	4,352	0	0	0.00							8,274,953	8,665	$ 311,935
Total	0	0	0	0.00	6,750	14,577,630	15,265	1,497	5,513,132	5,773	3,355	17,356,794	18,175	0	0	0	0	0	0	0	0	0	**37,447,556**	**39,212**	**$ 1,305,457**
Total Cost	$ -				$ **461,610**			$ **207,652**			$ **636,195**			$ -											

M.1 - Central Plant Heat Pump - Tower B

Utility Rate Data

Utility		Blend Rate	
Winter Steam	$	36.000	$/klb
Summer Steam	$	18.000	$/klb
0	$	-	$/klb
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Modified Operation

Tag	Heat Pump Summary				Tower B LH HHW Gen			Tower B UH HHW Gen			Tower B LH Steam Utilization			Tower B UH Steam Utilization			Tower B LH HHW Utilization			Tower B UH HHW Utilization					
	LH HP		UH HP																						
	HP MBH	Max HP HHW Flow	HP MBH	Max HP HHW Flow	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Total MBH	Total klbs	Sum Cost
Jan	5,634,623	2,389	0	0.00	646	22,973	24	320	1,247,602	1,306	459	0	0	0	0	0.00							1,270,576	1,330	$ 47,896
Feb	4,417,203	1,709	0	0.00	504	0	0	278	769,253	806	373	0	0	0	0	0.00							769,253	806	$ 28,998
Mar	5,053,418	1,750	0	0.00	558	0	0	307	1,213,777	1,271	426	0	0	0	0	0.00							1,213,777	1,271	$ 45,755
Apr	1,431,464	744	0	0.00	540	0	0	5	9,183	10	313	0	0	0	0	0.00							9,183	10	$ 173
May	1,089,576	631	0	0.00	558	0	0	0	0	0	302	0	0	0	0	0.00							0	0	$ -
Jun	774,980	135	0	0.00	540	0	0	0	0	0	103	0	0	0	0	0.00							0	0	$ -
July	764,114	40	0	0.00	558	0	0	0	0	0	13	0	0	0	0	0.00							0	0	$ -
Aug	769,094	54	0	0.00	558	0	0	0	0	0	93	0	0	0	0	0.00							0	0	$ -
Sep	794,964	219	0	0.00	540	0	0	0	0	0	165	0	0	0	0	0.00							0	0	$ -
Oct	1,268,710	687	0	0.00	558	0	0	2	3,520	4	247	0	0	0	0	0.00							3,520	4	$ 133
Nov	3,554,867	1,493	0	0.00	540	0	0	141	353,280	370	401	0	0	0	0	0.00							353,280	370	$ 13,317
Dec	6,334,782	2,372	0	0.00	650	23,656	25	444	1,916,515	2,007	460	0	0	0	0	0.00							1,940,171	2,032	$ 73,137
Total	31,887,795	12,222	0	0.00	6,750	46,629	4.07	1,497	5,513,132	5,773	3,355	0	0	0	0	0							**5,559,761**	**5,822**	**$ 209,410**
Total Cost	$ -				$ **1,758**			$ **207,652**			$ -			$ -											

Summary

Tag	Heat Pump Summary	Tower B LH HHW Gen	Tower B UH HHW Gen	Tower B LH Steam Utilization	Tower B UH Steam Utilization	Tower B LH HHW Utilization	Tower B UH HHW Utilization	Total Saving	
Change Hrs		0	0	0	0			**31,887,795**	**MBH**
Energy Reduction		14,531,001	0	17,356,794	0			**33,390**	**klbs**
Reduction in Cost	$ -	$ **459,852**	$ -	$ **636,195**	$ -			$ **1,096,047**	

Table 68. M.1 Energy Model Tower C Heating Summary

Tower C Heating

Measure: M.1 - Central Plant Heat Pump - Tower C

Date: 11/14/2022 **Client:** Brookfield
Project: Community Heat Pump

Calculation Method: 8,760

Basis: ☐ Installed ☑ Conceptual Design ☐ Final Design

Equipment Efficiency: ☐ Actual Dynamic ☑ Manufacturer Dynamic

Utility Rate Data

Utility	Blend Rate		
Winter Steam	$	34.000	$/klb
Summer Steam	$	13.880	$/klb
	$	-	$/klb
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Design

Existing Operation

Tag	Heat Pump Summary				Tower C LH HHW Gen			Tower C UH HHW Gen			Tower C LH Steam Utilization			Tower C UH Steam Utilization			Tower C LH HHW Utilization			Tower C UH HHW Utilization					
	LH HP		UH HP																						
	HP MBH	Max HP HHW Flow	HP MBH	Max HP HHW Flow	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Total MBH	Total klbs	Sum Cost
Jan	0	0	0	0.00	731	3,355,515	3,514	731	881,465	923	459	1,450,658	1,519	0	0	0.00							5,687,638	5,956	$ 202,492
Feb	0	0	0	0.00	610	2,720,925	2,849	610	599,259	627	373	1,110,049	1,162	0	0	0.00							4,430,233	4,639	$ 157,726
Mar	0	0	0	0.00	680	3,100,273	3,246	680	736,317	771	426	1,280,651	1,341	0	0	0.00							5,117,242	5,358	$ 182,185
Apr	0	0	0	0.00	540	1,845,934	1,933	422	160,950	169	282	205,220	215	0	0	0.00							2,212,104	2,316	$ 32,151
May	0	0	0	0.00	558	1,735,615	1,817	313	91,888	96	276	96,767	101	0	0	0.00							1,924,270	2,015	$ 27,967
Jun	0	0	0	0.00	540	1,494,308	1,565	59	11,796	12	79	7,684	8	0	0	0.00							1,513,788	1,585	$ 22,001
July	0	0	0	0.00	558	1,512,764	1,584	2	141	0	9	0	0	0	0	0.00							1,512,905	1,584	$ 21,989
Aug	0	0	0	0.00	558	1,518,322	1,590	10	937	1	46	0	0	0	0	0.00							1,519,259	1,591	$ 22,081
Sep	0	0	0	0.00	540	1,507,634	1,579	84	16,211	17	113	13,527	14	0	0	0.00							1,537,373	1,610	$ 22,344
Oct	0	0	0	0.00	558	1,771,157	1,855	278	107,822	113	223	167,374	175	0	0	0.00							2,046,352	2,143	$ 72,854
Nov	0	0	0	0.00	640	2,575,590	2,697	640	484,134	507	401	845,625	885	0	0	0.00							3,905,349	4,089	$ 139,039
Dec	0	0	0	0.00	737	3,600,089	3,770	737	1,036,590	1,085	460	1,658,109	1,736	0	0	0.00							6,294,788	6,591	$ 224,108
Total	0	0	0	0.00	7,250	26,738,126	27,998	4,566	4,127,510	4,322	3,147	6,835,664	7,158	0	0	0	0	0	0	0	0	0	**37,701,301**	**39,478**	**$ 1,126,936**
Total Cost	$ -				$ **749,373**			$ **141,008**			$ **236,555**			$ -											

M.1 - Central Plant Heat Pump - Tower C

Utility Rate Data

Utility	Blend Rate		
Winter Steam	$	34.000	$/klb
Summer Steam	$	13.880	$/klb
0	$	-	$/klb
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Modified Operation

Tag	Heat Pump Summary				Tower C LH HHW Gen			Tower C UH HHW Gen			Tower C LH Steam Utilization			Tower C UH Steam Utilization			Tower C LH HHW Utilization			Tower C UH HHW Utilization					
	LH HP		UH HP																						
	HP MBH	Max HP HHW Flow	HP MBH	Max HP HHW Flow	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Total MBH	Total klbs	Sum Cost
Jan	4,079,726	1,673	0	0.00	731	726,447	761	731	881,465	923	459	0	0	0	0	0.00							1,607,913	1,684	$ 57,245
Feb	3,338,000	1,543	0	0.00	610	492,974	516	610	599,259	627	373	0	0	0	0	0.00							1,092,233	1,144	$ 38,886
Mar	3,687,539	1,503	0	0.00	680	693,386	726	680	736,317	771	426	0	0	0	0	0.00							1,429,703	1,497	$ 50,900
Apr	2,047,215	1,034	0	0.00	540	3,938	4	422	160,950	169	282	0	0	0	0	0.00							164,889	173	$ 2,396
May	1,832,382	612	0	0.00	558	0	0	313	91,888	96	276	0	0	0	0	0.00							91,888	96	$ 1,335
Jun	1,501,992	176	0	0.00	540	0	0	59	11,796	12	79	0	0	0	0	0.00							11,796	12	$ 171
July	1,512,764	62	0	0.00	558	0	0	2	141	0	9	0	0	0	0	0.00							141	0	$ 2
Aug	1,518,322	74	0	0.00	558	0	0	10	937	1	46	0	0	0	0	0.00							937	1	$ 14
Sep	1,521,162	216	0	0.00	540	0	0	84	16,211	17	113	0	0	0	0	0.00							16,211	17	$ 236
Oct	1,938,398	860	0	0.00	558	132	0	278	107,822	113	223	0	0	0	0	0.00							107,954	113	$ 3,843
Nov	3,213,500	1,503	0	0.00	640	207,715	218	640	484,134	507	401	0	0	0	0	0.00							691,848	724	$ 24,631
Dec	4,151,547	1,662	0	0.00	737	1,106,651	1,159	737	1,036,590	1,085	460	0	0	0	0	0.00							2,143,241	2,244	$ 76,304
Total	30,342,547	10,917	0	0.00	7,250	3,231,243	281.96	4,566	4,127,510	4,322	3,147	0	0	0	0	0							**7,358,754**	**7,706**	**$ 255,964**
Total Cost	$ -				$ **114,956**			$ **141,008**			$ -			$ -											

Summary

Tag	Heat Pump Summary	Tower C LH HHW Gen	Tower C UH HHW Gen	Tower C LH Steam Utilization	Tower C UH Steam Utilization	Tower C LH HHW Utilization	Tower C UH HHW Utilization	Total Saving	
Change Hrs		0	0	0	0			**30,342,547**	**MBH**
Energy Reduction		23,506,883	0	6,835,664	0			**31,772**	**klbs**
Reduction in Cost	$ -	$ **634,417**	$ -	$ **236,555**	$ -			$	**870,972**

Table 69. M.1 Energy Model Tower D Heating Summary

Tower D Heating	**Measure:**	**M.1 - Central Plant Heat Pump - Tower D**	**Date:** 11/14/2022	**Client:** Brookfield
			Project:	**Community Heat Pump**

Calculation Method: 8,760
Basis: ☐ Installed ☑ Conceptual Design ☐ Final Design
Equipment Efficiency: ☐ Actual Dynamic ☑ Manufacturer Dynamic

Utility Rate Data

Utility	Blend Rate		
Winter Steam	$	36.000	$/klb
Summer Steam	$	18.000	$/klb
	$	-	$/klb
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Design

Existing Operation

Tag	Heat Pump Summary				Tower D LH HHW Gen			Tower D UH HHW Gen			Tower D LH Steam Utilization			Tower D UH Steam Utilization			Tower D LH HHW Utilization			ower D UH HHW Utilizatio					
	LH HP		UH HP																						
	HP MBH	Max HP HHW Flow	HP MBH	Max HP HHW Flow	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Total MBH	Total klbs	Sum Cost
Jan	0	0	0	0.00	720	3,417,836	3,579	731	1,993,424	2,087	459	1,406,411	1,473	0	0	0.00							6,817,671	7,139	$ 257,001
Feb	0	0	0	0.00	566	2,787,611	2,919	610	1,378,504	1,443	373	1,082,541	1,134	0	0	0.00							5,248,655	5,496	$ 197,855
Mar	0	0	0	0.00	632	3,125,735	3,273	680	1,839,320	1,926	426	1,240,808	1,299	0	0	0.00							6,205,864	6,498	$ 233,938
Apr	0	0	0	0.00	540	1,805,339	1,890	422	613,571	642	282	179,236	188	0	0	0.00							2,598,146	2,721	$ 48,970
May	0	0	0	0.00	558	1,584,368	1,659	313	430,258	451	276	73,054	76	0	0	0.00							2,087,680	2,186	$ 39,349
Jun	0	0	0	0.00	540	1,144,251	1,198	59	76,051	80	79	3,795	4	0	0	0.00							1,224,098	1,282	$ 23,072
July	0	0	0	0.00	558	1,131,227	1,185	2	2,335	2	9	0	0	0	0	0.00							1,133,561	1,187	$ 21,366
Aug	0	0	0	0.00	558	1,134,113	1,188	10	11,894	12	46	0	0	0	0	0.00							1,146,007	1,200	$ 21,600
Sep	0	0	0	0.00	540	1,167,783	1,223	84	107,709	113	113	8,370	9	0	0	0.00							1,283,862	1,344	$ 24,198
Oct	0	0	0	0.00	558	1,639,048	1,716	278	405,915	425	223	149,149	156	0	0	0.00							2,194,112	2,297	$ 82,710
Nov	0	0	0	0.00	568	2,786,238	2,918	640	1,204,441	1,261	401	802,448	840	0	0	0.00							4,793,127	5,019	$ 180,683
Dec	0	0	0	0.00	715	3,480,368	3,644	737	2,416,378	2,530	460	1,625,549	1,702	0	0	0.00							7,522,295	7,877	$ 283,563
Total	0	0	0	0.00	7,053	25,203,917	26,392	4,566	10,479,799	10,974	3,147	6,571,362	6,881	0	0	0	0	0	0	0	0	0	**42,255,078**	**44,246**	**$ 1,414,306**
Total Cost	$			-	$		**799,930**	$		**371,644**	$		**242,732**	$		-									

M.1 - Central Plant Heat Pump - Tower D

Utility Rate Data

Utility	Blend Rate		
Winter Steam	$	36.000	$/klb
Summer Steam	$	18.000	$/klb
0	$	-	$/klb
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Modified Operation

Tag	Heat Pump Summary				Tower D LH HHW Gen			Tower D UH HHW Gen			Tower D LH Steam Utilization			Tower D UH Steam Utilization			Tower D LH HHW Utilization			ower D UH HHW Utilizatio					
	LH HP		UH HP																						
	HP MBH	Max HP HHW Flow	HP MBH	Max HP HHW Flow	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Total MBH	Total klbs	Sum Cost
Jan	4,217,539	1,433	0	0.00	720	606,708	635	731	1,993,424	2,087	459	0	0	0	0	0.00							2,600,132	2,723	$ 98,015
Feb	3,476,368	1,055	0	0.00	566	393,784	412	610	1,378,504	1,443	373	0	0	0	0	0.00							1,772,287	1,856	$ 66,809
Mar	3,774,309	1,019	0	0.00	632	592,235	620	680	1,839,320	1,926	426	0	0	0	0	0.00							2,431,555	2,546	$ 91,661
Apr	1,983,625	756	0	0.00	540	950	1	422	613,571	642	282	0	0	0	0	0.00							614,521	643	$ 11,583
May	1,657,422	526	0	0.00	558	0	0	313	430,258	451	276	0	0	0	0	0.00							430,258	451	$ 8,110
Jun	1,148,047	214	0	0.00	540	0	0	59	76,051	80	79	0	0	0	0	0.00							76,051	80	$ 1,433
July	1,131,227	38	0	0.00	558	0	0	2	2,335	2	9	0	0	0	0	0.00							2,335	2	$ 44
Aug	1,134,113	38	0	0.00	558	0	0	10	11,894	12	46	0	0	0	0	0.00							11,894	12	$ 224
Sep	1,176,153	278	0	0.00	540	0	0	84	107,709	113	113	0	0	0	0	0.00							107,709	113	$ 2,030
Oct	1,788,197	620	0	0.00	558	0	0	278	405,915	425	223	0	0	0	0	0.00							405,915	425	$ 15,301
Nov	3,432,471	1,019	0	0.00	568	156,215	164	640	1,204,441	1,261	401	0	0	0	0	0.00							1,360,656	1,425	$ 51,292
Dec	4,178,680	1,424	0	0.00	715	927,237	971	737	2,416,378	2,530	460	0	0	0	0	0.00							3,343,614	3,501	$ 126,042
Total	29,098,150	1,433	0	0.00	7,053	2,677,129	233.61	4,566	10,479,799	10,974	3,147	0	0	0	0	0							**13,156,928**	**13,777**	**$ 472,544**
Total Cost	$			-	$		**100,900**	$		**371,644**	$		-	$		-									

Summary

Tag	Heat Pump Summary	Tower D LH HHW Gen	Tower D UH HHW Gen	Tower D LH Steam Utilization	Tower D UH Steam Utilization	Tower D LH HHW Utilization	ower D UH HHW Utilizatio	Total Saving	
Change Hrs		0	0	0	0			**29,098,150**	**MBH**
Energy Reduction		22,526,788	0	6,571,362	0			**30,469**	**klbs**
Reduction in Cost	$ -	$ **699,030**	$ -	$ **242,732**	$ -			$ **941,762**	

Table 70. M.1 Energy Model Winter Garden Heating Summary

WG Heating	**Measure:**	**M.1 - Central Plant Heat Pump - Winter Garden**	**Date:** 11/14/2022	**Client:** Brookfield	
			Project:	**Community Heat Pump**	
Calculation Method:	8,760	**Basis:** ☐ Installed ☑ Conceptual Design ☐ Final Design	**Equipment Efficiency:** ☐ Actual Dynamic ☑ Manufacturer Dynamic	**Utility Rate Data**	

Design

Tag	Heat Pump Summary				WG HHW Gen	WG HHW Gen	WG Steam Utilization (1 of 2)	WG Steam Utilization (2 of 2)		
	LH HP		UH HP							

Utility Rate Data

Utility		Blend Rate	
Winter Steam	$	36.000	$/klb
Summer Steam	$	18.000	$/klb
	$	-	$/klb
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Existing Operation

	HP MBH	Max HP HHW Flow	HP MBH	Max HP HHW Flow	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Total MBH	Total klbs	Sum Cost
Jan	0	0	0	0.00	720	206,511	216	0	0	0	720	977,095	1,023	0	0	0.00							1,183,607	1,239	$ 44,618
Feb	0	0	0	0.00	566	147,765	155	0	0	0	566	702,214	735	0	0	0.00							849,979	890	$ 32,041
Mar	0	0	0	0.00	632	174,967	183	0	0	0	632	829,174	868	0	0	0.00							1,004,141	1,051	$ 37,852
Apr	0	0	0	0.00	255	26,640	28	0	0	0	255	135,852	142	0	0	0.00							162,492	170	$ 3,063
May	0	0	0	0.00	166	11,813	12	0	0	0	166	63,442	66	0	0	0.00							75,256	79	$ 1,418
Jun	0	0	0	0.00	18	653	1	0	0	0	18	4,039	4	0	0	0.00							4,692	5	$ 88
July	0	0	0	0.00	0	0	0	0	0	0	0	0	0	0	0	0.00							0	0	$ -
Aug	0	0	0	0.00	0	0	0	0	0	0	0	0	0	0	0	0.00							0	0	$ -
Sep	0	0	0	0.00	26	1,083	1	0	0	0	26	6,466	7	0	0	0.00							7,549	8	$ 142
Oct	0	0	0	0.00	182	18,653	20	0	0	0	182	95,330	100	0	0	0.00							113,983	119	$ 4,297
Nov	0	0	0	0.00	568	112,299	118	0	0	0	568	542,006	568	0	0	0.00							654,305	685	$ 24,665
Dec	0	0	0	0.00	715	239,678	251	0	0	0	715	1,126,724	1,180	0	0	0.00							1,366,402	1,431	$ 51,508
Total	0	0	0	0.00	3,848	940,062	984	0	0	0	3,848	4,482,343	4,694	0	0	0	0	0	0	0	0	0	**5,422,405**	**5,678**	**$ 199,693**
Total Cost	$ -				$ 32,621			$ -			$ 165,014			$ -											

M.1 - Central Plant Heat Pump - Winter Garden

Modified Operation

Tag	Heat Pump Summary				WG HHW Gen	WG HHW Gen	WG Steam Utilization (1 of 2)	WG Steam Utilization (2 of 2)		
	LH HP		UH HP							

Utility Rate Data

Utility		Blend Rate	
Winter Steam	$	36.000	$/klb
Summer Steam	$	18.000	$/klb
0	$	-	$/klb
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

	HP MBH	Max HP HHW Flow	HP MBH	Max HP HHW Flow	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Total MBH	Total klbs	Sum Cost
Jan	1,183,607	187	0	0.00	720	0	0	0	0	0	720	0	0	0	0	0.00							0	0	$ -
Feb	849,979	155	0	0.00	566	0	0	0	0	0	566	0	0	0	0	0.00							0	0	$ -
Mar	1,004,141	167	0	0.00	632	0	0	0	0	0	632	0	0	0	0	0.00							0	0	$ -
Apr	162,492	93	0	0.00	255	0	0	0	0	0	255	0	0	0	0	0.00							0	0	$ -
May	75,256	65	0	0.00	166	0	0	0	0	0	166	0	0	0	0	0.00							0	0	$ -
Jun	4,692	24	0	0.00	18	0	0	0	0	0	18	0	0	0	0	0.00							0	0	$ -
July	0	0	0	0.00	0	0	0	0	0	0	0	0	0	0	0	0.00							0	0	$ -
Aug	0	0	0	0.00	0	0	0	0	0	0	0	0	0	0	0	0.00							0	0	$ -
Sep	7,549	28	0	0.00	26	0	0	0	0	0	26	0	0	0	0	0.00							0	0	$ -
Oct	113,983	73	0	0.00	182	0	0	0	0	0	182	0	0	0	0	0.00							0	0	$ -
Nov	654,305	147	0	0.00	568	0	0	0	0	0	568	0	0	0	0	0.00							0	0	$ -
Dec	1,366,402	187	0	0.00	715	0	0	0	0	0	715	0	0	0	0	0.00							0	0	$ -
Total	5,422,405	187	0	0.00	3,848	0	0.00	0	0	0	3,848	0	0	0	0	0							**0**	**0**	**$ -**
Total Cost	$ -				$ -			$ -			$ -			$ -											

Summary

Tag	Heat Pump Summary	WG HHW Gen	WG HHW Gen	WG Steam Utilization (1 of 2)	WG Steam Utilization (2 of 2)			Total Saving	
Change Hrs		0	0	0	0			5,422,405	MBH
Energy Reduction		940,062	0	4,482,343	0			5,678	klbs
Reduction in Cost	$ -	$ 32,621	$ -	$ 165,014	$ -			$	199,693

Table 71. M.1 Energy Model Central Plant Heating Summary

CP Heating	Measure:	M.1 - Central Plant Heat Pump - Central Plant	Date: 11/14/2022 Project:	Client: Brookfield Community Heat Pump
Calculation Method:	8,760	Basis: ☐ Installed ☑ Conceptual Design ☐ Final Design	Equipment Efficiency: ☐ Actual Dynamic ☑ Manufacturer Dynamic	

Utility Rate Data

Utility		Blend Rate	
Winter Steam	$	36.000	$/klb
Summer Steam	$	18.000	$/klb
	$	-	$/klb
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Design / Existing Operation

Tag	Heat Pump Summary				CP HHW Gen						CP Steam Utilization (1 of 2)			CP Steam Utilization (2 of 2)											
	LH HP		UH HP																						
	HP MBH	Max HP HHW Flow	HP MBH	Max HP HHW Flow	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Total MBH	Total klbs	Sum Cost
Jan	0	0	0	0.00	720	182,629	191	0	0	0	720	2,133,624	2,234	720	272,585	285.43							2,588,838	2,711	$ 97,590
Feb	0	0	0	0.00	566	130,677	137	0	0	0	566	1,526,671	1,599	566	195,043	204.23							1,852,390	1,940	$ 69,828
Mar	0	0	0	0.00	632	154,733	162	0	0	0	632	1,807,713	1,893	632	230,948	241.83							2,193,394	2,297	$ 82,683
Apr	0	0	0	0.00	255	23,559	25	0	0	0	255	275,241	288	255	35,164	36.82							333,964	350	$ 6,295
May	0	0	0	0.00	166	10,447	11	0	0	0	166	122,051	128	166	15,593	16.33							148,091	155	$ 2,791
Jun	0	0	0	0.00	18	577	1	0	0	0	18	6,743	7	18	862	0.90							8,182	9	$ 154
July	0	0	0	0.00	0	0	0	0	0	0	0	0	0	0	0	0.00							0	0	$ -
Aug	0	0	0	0.00	0	0	0	0	0	0	0	0	0	0	0	0.00							0	0	$ -
Sep	0	0	0	0.00	26	957	1	0	0	0	26	11,185	12	26	1,429	1.50							13,571	14	$ 256
Oct	0	0	0	0.00	182	16,496	17	0	0	0	182	192,718	202	182	24,621	25.78							233,835	245	$ 8,815
Nov	0	0	0	0.00	568	99,312	104	0	0	0	568	1,160,240	1,215	568	148,229	155.21							1,407,780	1,474	$ 53,068
Dec	0	0	0	0.00	715	211,960	222	0	0	0	715	2,476,291	2,593	715	316,363	331.27							3,004,614	3,146	$ 113,263
Total	0	0	0	0.00	3,848	831,347	871	0	0	0	3,848	9,712,476	10,170	3,848	1,240,835	1,299	0	0	0	0	0	0	11,784,659	12,340	$ 434,743
Total Cost	$ -				$ 30,669			$ -			$ 358,299			$ 44,670,076											

M.1 - Central Plant Heat Pump - Central Plant

Utility Rate Data

Utility		Blend Rate	
Winter Steam	$	36.000	$/klb
Summer Steam	$	18.000	$/klb
0	$	-	$/klb
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Modified Operation

Tag	Heat Pump Summary				CP HHW Gen						CP Steam Utilization (1 of 2)			CP Steam Utilization (2 of 2)											
	LH HP		UH HP																						
	HP MBH	Max HP HHW Flow	HP MBH	Max HP HHW Flow	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Total MBH	Total klbs	Sum Cost
Jan	2,588,838	445	0	0.00	720	0	0	0	0	0	720	0	0	720	0	0.00							0	0	$ -
Feb	1,852,390	367	0	0.00	566	0	0	0	0	0	566	0	0	566	0	0.00							0	0	$ -
Mar	2,193,394	395	0	0.00	632	0	0	0	0	0	632	0	0	632	0	0.00							0	0	$ -
Apr	333,964	217	0	0.00	255	0	0	0	0	0	255	0	0	255	0	0.00							0	0	$ -
May	148,091	149	0	0.00	166	0	0	0	0	0	166	0	0	166	0	0.00							0	0	$ -
Jun	8,182	49	0	0.00	18	0	0	0	0	0	18	0	0	18	0	0.00							0	0	$ -
July	0	0	0	0.00	0	0	0	0	0	0	0	0	0	0	0	0.00							0	0	$ -
Aug	0	0	0	0.00	0	0	0	0	0	0	0	0	0	0	0	0.00							0	0	$ -
Sep	13,571	60	0	0.00	26	0	0	0	0	0	26	0	0	26	0	0.00							0	0	$ -
Oct	233,835	169	0	0.00	182	0	0	0	0	0	182	0	0	182	0	0.00							0	0	$ -
Nov	1,407,780	347	0	0.00	568	0	0	0	0	0	568	0	0	568	0	0.00							0	0	$ -
Dec	3,004,614	445	0	0.00	715	0	0	0	0	0	715	0	0	715	0	0.00							0	0	$ -
Total	11,784,659	445	0	0.00	3,848	0	0.00	0	0	0	3,848	0	0	3,848	0	0							0	0	$ -
Total Cost	$ -				$ -			$ -			$ -			$ -											

Summary

Tag	Heat Pump Summary	CP HHW Gen		CP Steam Utilization (1 of 2)	CP Steam Utilization (2 of 2)			Total Saving	
Change Hrs		0	0	0	0			11,784,659	MBH
Energy Reduction		831,347	0	9,712,476	1,240,835			12,340	klbs
Reduction in Cost	$ -	$ 30,669	$ -	$ 358,299	$ 44,670,076			$ 434,743	

Table 72. M.1 Energy Model Central Plant Chilled Water Summary

Chiller Plant Operational Data	Measure:	M.1 - Central Plant Heat Pump	Date: 11/14/2022	Client: Brookfield
			Project:	Community Heat Pump

Calculation Method: Baseline - Design, Trended
Basis: ☐ Installed ☑ Conceptual Design ☐ Final Design
Equipment Efficiency: ☑ Actual Dynamic

Utility Rate Data

Utility		Blend Rate	
Elec	$	0.092	$/kWh
Elec Dmd	$	-	$/kW
Gas	$	-	$/Therm
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Design

Existing Operation

Tag	CHW Plant																							
	Hours	kTon-Hrs	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Plant Peak Demand	Demand Cost	Plant kWh	Energy (kWh) Cost	Total Cost
Jan	60	1,447	107,333	0.09																2,696	$ 30,597	107,333	$ 9,875	$ 40,472
Feb	360	1,394	680,413	0.49																5,148	$ 18,539	680,413	$ 62,598	$ 81,137
Mar	727	1,655	1,538,161	0.94																5,283	$ 20,771	1,538,161	$ 141,511	$ 162,282
Apr	720	1,588	1,506,940	0.96																6,129	$ 25,966	1,506,940	$ 138,638	$ 164,604
May	744	2,000	1,918,768	0.98																7,386	$ 68,073	1,918,768	$ 176,527	$ 244,600
Jun	720	2,803	2,414,972	0.91																7,562	$ 178,622	2,414,972	$ 222,177	$ 400,800
July	744	3,121	2,520,502	0.86																7,500	$ 160,134	2,520,502	$ 231,886	$ 392,020
Aug	744	3,081	2,537,487	0.88																7,498	$ 177,095	2,537,487	$ 233,449	$ 410,544
Sep	720	2,478	2,126,600	0.93																7,471	$ 154,435	2,126,600	$ 195,647	$ 350,083
Oct	744	1,717	1,564,803	1.01																6,033	$ 62,980	1,564,803	$ 143,962	$ 206,942
Nov	720	1,279	1,355,734	1.10																5,070	$ 23,236	1,355,734	$ 124,728	$ 147,964
Dec	728	999	923,479	0.99																3,687	$ 12,704	923,479	$ 84,960	$ 97,664
Total	7,731	23,563	19,195,193	0.84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**Peak**	**$ 933,152**	**19,195,193**	**$ 1,765,958**	**$ 2,699,110**
Total Cost	$			**1,765,958**	$		-	$		-	$		-	$		-	$		-	**7,562**				

M.1 - Central Plant Heat Pump

Utility Rate Data

Utility		Blend Rate	
Elec	$	0.092	$/kWh
Elec Dmd	$	-	$/kW
Gas	$	-	$/Therm
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Design

Modified Operation

Tag	CHW Plant				CH-2 (Heat Pump)			CH-6 (Heat Pump)			HHW Pumps													
	Hours	kTon-Hrs	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Plant Peak Demand	Demand Cost	Plant kWh	Energy (kWh) Cost	Total Cost
Jan	60	97	37,121	0.15	744	1,010,579	1.5	357	548,893	1.5	744	30,809	0.03							5,136	$ 58,291	1,627,403	$ 149,721	$ 208,012
Feb	360	736	390,392	0.66	672	827,556	1.5	257	402,380	1.5	672	23,216	0.03							5,476	$ 52,403	1,643,544	$ 151,206	$ 203,609
Mar	727	1,609	786,774	1.64	744	916,770	1.5	300	469,785	1.5	744	26,971	0.03							5,614	$ 52,428	2,200,300	$ 202,428	$ 254,855
Apr	720	1,588	1,087,714	1.12	720	490,931	1.5	41	47,960	1.5	720	4,909	0.01							5,595	$ 33,966	1,631,514	$ 150,099	$ 184,066
May	744	2,000	1,419,329	0.88	744	423,659	1.5	13	15,559	1.5	744	3,113	0.01							6,942	$ 66,850	1,861,660	$ 171,273	$ 238,123
Jun	720	2,803	2,018,458	0.81	720	319,868	1.5	0	0	1.5	720	1,585	0.01							7,183	$ 169,655	2,339,911	$ 215,272	$ 384,927
July	744	3,121	2,230,763	0.80	744	317,937	1.5	0	0	1.5	744	1,493	0.01							7,191	$ 151,165	2,550,193	$ 234,618	$ 385,782
Aug	744	3,081	2,141,307	0.80	744	319,158	1.5	0	0	1.5	744	1,502	0.01							7,188	$ 169,617	2,461,968	$ 226,501	$ 396,118
Sep	720	2,478	1,828,305	0.87	720	326,472	1.5	0	0	1.5	720	1,663	0.01							6,371	$ 150,479	2,156,441	$ 198,393	$ 348,871
Oct	744	1,717	1,184,696	0.98	744	441,872	1.5	38	44,246	1.5	744	3,954	0.01							6,050	$ 61,765	1,674,768	$ 154,079	$ 215,843
Nov	720	1,279	635,472	1.83	720	784,344	1.5	210	301,940	1.5	720	16,976	0.02							4,655	$ 44,628	1,738,733	$ 159,963	$ 204,592
Dec	728	999	336,945	0.60	744	1,057,492	1.5	380	617,617	1.5	744	36,545	0.03							5,108	$ 57,531	2,048,600	$ 188,471	$ 246,002
Total	7,731	21,508	14,097,278	0.93	8,760	7,236,638	1.5	1,596	2,448,380	1.50	8,760	152,738	0.02	0	0	#DIV/0!	0	0	#DIV/0!	**Peak**	**$ 1,068,778**	**23,935,034**	**$ 2,202,023**	**$ 3,270,801**
Total Cost	$			**1,296,950**	$		**665,771**	$		**225,251**	$		**14,052**	$		-	$		-	**7,191**				

Summary

Tag	CHW Plant	CH-2 (Heat Pump)	CH-6 (Heat Pump)	HHW Pumps	0	0		
Change Hrs	0	-8,760	-1,596	-8,760	0	0	**371**	**kW**
Energy Savings	5,097,915	-7,236,638	-2,448,380	-152,738	0	0	**-4,739,842**	**kWh**
Reduction in Cost	**$ 469,008**	**$ (665,771)**	**$ (225,251)**	**$ (14,052)**	**$ -**	**$ -**	**$**	**(571,691)**

9.1.5 Results

Table 73 summarizes the energy and financial results for this option.

Table 73. M.1 Energy Model Financial Summary

Breakdown of Modification Options														
Option	Description	Estimated Annual Steam Reduction	Estimated Annual Electric Reduction	2024 Estimated Annual CO2 Reduction			First Cost - Estimated			Estimated Annual Energy Cost Savings		With CO2 Tax (2024)		Net Present Value
		Energy	Energy	Steam	Electric	Total	First Cost	Rebate	Net Capex After Rebate	Measure Savings	SPB	CO2 Tax	SPB	20 Year NPV
		Mlbs	kWh	MT CO2e	MT CO2e	MT CO2e	$	$	$	$	Years	$	Years	$
M.1	Central Heat Pump	113,650	-4,739,842	4,800	-1,370	3,430	$ (35,657,579)	$ -	$ (35,657,579)	$ 2,971,526	12.0	$ 919,313	9.2	$ 39,892,695
Cost Estimates														
X	**Placeholder**	**Based on past experience on similar projects. This number could go down or up substantially based on further development.**												
	Estimates / Budgetary	Based on some contractor estimates and more refined scope												
	Investment Grade / Proposal	Fully developed scope, subcontractor pricing, ready for design build proposal and management approval												
Savings Calculations and Paybacks														
	Placeholder	Based on past experience on similar projects. This number could go down or up substantially based on further development.												
	Estimates / Budgetary	Energy model build based on final scope.												
X	**Investment Grade / Rebate Ready**	**Fully developed energy model calibrated with full QA/QC**												

9.2 M.2, Tower A: Decentralized Heat Pump

This section outlines the proposed modification and system descriptions, controls strategy, analysis of the proposed modifications, and first cost analysis for the energy conservation measure for the Tower A decentralized heat pump.

9.2.1 Proposed Modification Description

The team proposes the following modifications to the current system:

- Install a heat pump at the building level.
- Modify the heating hot water distribution piping to accommodate the new system.
- Replace select non-100% outside air (OA) unit steam coils with heating hot water coils.
- Replace select 100% outside air unit steam coils with hot water coils.
- Replace steam-to-hot-water domestic hot water heaters with water-to-water domestic hot water heaters.
- Implement associated controls.

9.2.2 Proposed System Description

The team proposes the following system configuration and integration for Tower A:

- Install a heat pump in the building penthouse using the building's chilled water and condenser water as the heat source. The 215-ton heat pump will generate 140°F heating hot water supply temperature.
- Tap into the existing heating hot water distribution using existing heating hot water return piping to preheat the water before it enters the heat exchangers for the following units:
    - HX-1A
    - HX-2A
- Install duplex heating hot water-to-domestic hot water heat exchangers to preheat the domestic hot water before it enters the steam-to-hot water heat exchangers for the following units:
    - H-1
    - H-2
    - H-3
    - H-4
    - H-5
    - H-6
    - H-7

9.2.3 Proposed Controls Strategy

The team proposes the following controls strategy and adjustments to optimize the system's performance:

- **Tower A heat pump:** The proposed heat pump will be installed in the Tower A penthouse. The heat pump will operate to maintain the heating hot water distribution set-point, which will adjust based on the outdoor air temperature. All building equipment must coordinate with this set-point.
- **Heating hot water:** The heating hot water generated by the heat pump will blend with the existing heating hot water return to maintain the heating hot water set-point. If the plant-generated hot water cannot maintain the local heating hot water set-point, the existing steam-to-hot water heat exchanger will trim to maintain the local set-point.
- **Domestic hot water:** The heat pump–generated heating hot water will preheat the domestic hot water before it enters the existing steam-to-hot water heat exchangers. If the heat pump-generated hot water cannot maintain the local domestic hot water set-point, the existing steam-to-domestic hot water heat exchanger will trim to maintain the local set-point.

9.2.4 Analysis of Proposed Modification: Base Case and Energy Conservation Measure Analysis

The team proposes the following modeling process for this energy conservation measure:

- **Base case:**
  - Model the base case using an 8760 Excel model built solely for each heating load.
  - Implement the schedules and controls strategy for each unit.
- **Energy conservation measure analysis:**
  - Incorporate a switch into the base model to toggle the heat pump on and off, with an adjustable heating hot water supply temperature. This hourly supply temperature dictates how much heating can transfer from steam to the heat pump. The model calculates a heating hot water flow profile based on the calculated load and differential temperature.
  - Use this flow to calculate the new energy consumption of the heating hot water pump.
  - Use the heating load to calculate the heat pump power draw using factory equipment data. The existing plant chiller 8,760-kW/ton profile is used to calculate the reduction in power consumption for the existing plant.

9.2.5 First Cost Analysis

Smith Engineering produced an estimate for the first cost of this option, which totals $3,741,971.

Table 74 details these costs.

Table 74. M.2 Energy Model Tower A Estimated Heat Pump Cost

Opinion of Probable Construction Cost			
		Date:	Wednesday, March 1, 2023
		Client:	Brookfield
For	M.2 - Tower A	Project:	BFPL Community Heat Pump Stg A

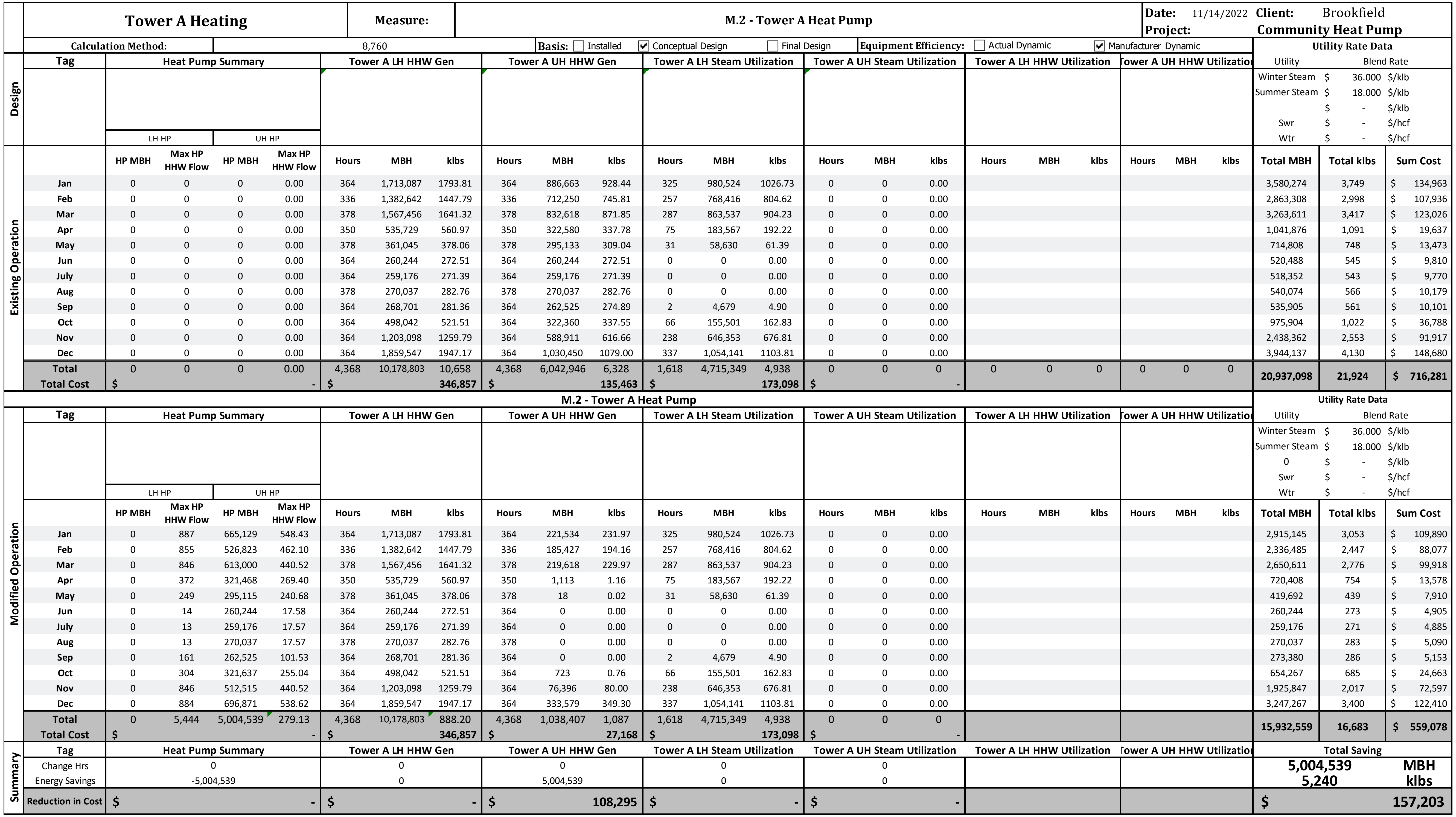
Basis of Estimate ☐ No Design ☑ Conceptual Design ☐ Final Design ☐ Actual Cost

Item #	Description	Quantity	Units	Material Cost per Unit	Total Material Cost	Labor Hour	Labor Cost per Hour	Total Labor Cost	Total Cost
	Division 01000 - General								
1	Permits and Filing	1		$ 35,000	$ 35,000	125	$ 250	$ 31,250	$ 66,250
2	Superintended	1		$ -	$ -	250	$ 225	$ 56,250	$ 56,250
3	Demolition and Protection	1		$ 25,000	$ 25,000	350	$ 195	$ 68,250	$ 93,250
4	Rigging	1		$ 150,000	$ 150,000	500	$ 225	$ 112,500	$ 262,500
5	Gen Conditions	1		$ 35,000	$ 35,000	250	$ 195	$ 48,750	$ 83,750
	Subtotal				**$ 245,000**	1475		**$ 317,000**	**$ 562,000**
	Division 23000 - Mechanical								
1	Heat Pump	1		$ 322,500	$ 322,500	325	$ 250	$ 81,250	$ 403,750
2	Heat Exchanger	1		$ 75,000	$ 75,000	200	$ 250	$ 50,000	$ 125,000
3	Plant Piping and Insulation	1		$ 80,625	$ 80,625	200	$ 250	$ 50,000	$ 130,625
4	Piping into 100% OA CC	1		$ 65,000	$ 65,000	250	$ 250	$ 62,500	$ 127,500
5	Tempered Loop HX-2A	1		$ 65,000	$ 65,000	300	$ 250	$ 75,000	$ 140,000
6	DHW HXs	1		$ 85,000	$ 85,000	350	$ 250	$ 87,500	$ 172,500
7									
8									
9									
10									
	Subtotal				**$ 693,125**	1625		**$ 406,250**	**$ 1,099,375**
	Division 25000 - Controls								
1	Schneider Software Prog and Graphics	1		$ 20,000	$ 20,000	400	$ 300	$ 120,000	$ 140,000
2	Hardware and Labor	1		$ 35,000	$ 35,000	600	$ 300	$ 180,000	$ 215,000
3					$ -			$ -	$ -
	Subtotal				**$ 55,000**	1000		**$ 300,000**	**$ 355,000**
	Division 26000 - Electrical								
1	Power Conduit and Wiring	1		$ 80,625	$ 80,625	400	$ 275	$ 110,000	$ 190,625
2	Controls Conduit and Wiring	1		$ 35,000	$ 35,000	500	$ 275	$ 137,500	$ 172,500
3					$ -			$ -	$ -
	Subtotal				**$ 115,625**	900		**$ 247,500**	**$ 363,125**
	Subtotal			Multiplier	**$1,108,750**		Multiplier	**$1,270,750**	**$ 2,379,500**
	Contingency			10%	$ 110,875		10%	$ 127,075	$ 237,950
	Subtotal				**$1,219,625**			**$1,397,825**	**$ 2,617,450**
	Construction Management Overhead			10%	$ 121,963		10%	$ 139,783	$ 261,745
	Profit			10%	$ 121,963		10%	$ 139,783	$ 261,745
	Subtotal Construction				**$1,463,550**			**$ 1,677,390**	**$ 3,140,940**
	Tax			8.875%	$ 129,890		0%	$ -	$ 129,890
	Design Engineering							$ 251,275	$ 251,275
	Construction Administration							$ 125,638	$ 125,638
	Commissioning							$ 94,228	$ 94,228
	Total Estimated Cost	**$**							**3,741,971**

9.2.6 Operational and Economic Analysis

Table 75 and Table 76 summarize the energy and financial results for this option.

Table 75. M.2 Energy Model Tower A Heating Summary



Tower A Heating **Measure:** **M.2 - Tower A Heat Pump**

Date: 11/14/2022 **Client:** Brookfield
Project: **Community Heat Pump**

Calculation Method: 8,760 **Basis:** ☐ Installed ☑ Conceptual Design ☐ Final Design **Equipment Efficiency:** ☐ Actual Dynamic ☑ Manufacturer Dynamic

Utility Rate Data

Utility		Blend Rate	
Winter Steam	$	36.000	$/klb
Summer Steam	$	18.000	$/klb
	$	-	$/klb
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Design

Existing Operation

Tag	Heat Pump Summary				Tower A LH HHW Gen			Tower A UH HHW Gen			Tower A LH Steam Utilization			Tower A UH Steam Utilization			Tower A LH HHW Utilization			Tower A UH HHW Utilization					
	LH HP		UH HP																						
	HP MBH	Max HP HHW Flow	HP MBH	Max HP HHW Flow	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Total MBH	Total klbs	Sum Cost
Jan	0	0	0	0.00	364	1,713,087	1793.81	364	886,663	928.44	325	980,524	1026.73	0	0	0.00							3,580,274	3,749	$ 134,963
Feb	0	0	0	0.00	336	1,382,642	1447.79	336	712,250	745.81	257	768,416	804.62	0	0	0.00							2,863,308	2,998	$ 107,936
Mar	0	0	0	0.00	378	1,567,456	1641.32	378	832,618	871.85	287	863,537	904.23	0	0	0.00							3,263,611	3,417	$ 123,026
Apr	0	0	0	0.00	350	535,729	560.97	350	322,580	337.78	75	183,567	192.22	0	0	0.00							1,041,876	1,091	$ 19,637
May	0	0	0	0.00	378	361,045	378.06	378	295,133	309.04	31	58,630	61.39	0	0	0.00							714,808	748	$ 13,473
Jun	0	0	0	0.00	364	260,244	272.51	364	260,244	272.51	0	0	0.00	0	0	0.00							520,488	545	$ 9,810
July	0	0	0	0.00	364	259,176	271.39	364	259,176	271.39	0	0	0.00	0	0	0.00							518,352	543	$ 9,770
Aug	0	0	0	0.00	378	270,037	282.76	378	270,037	282.76	0	0	0.00	0	0	0.00							540,074	566	$ 10,179
Sep	0	0	0	0.00	364	268,701	281.36	364	262,525	274.89	2	4,679	4.90	0	0	0.00							535,905	561	$ 10,101
Oct	0	0	0	0.00	364	498,042	521.51	364	322,360	337.55	66	155,501	162.83	0	0	0.00							975,904	1,022	$ 36,788
Nov	0	0	0	0.00	364	1,203,098	1259.79	364	588,911	616.66	238	646,353	676.81	0	0	0.00							2,438,362	2,553	$ 91,917
Dec	0	0	0	0.00	364	1,859,547	1947.17	364	1,030,450	1079.00	337	1,054,141	1103.81	0	0	0.00							3,944,137	4,130	$ 148,680
Total	0	0	0	0.00	4,368	10,178,803	10,658	4,368	6,042,946	6,328	1,618	4,715,349	4,938	0	0	0	0	0	0	0	0	0	**20,937,098**	**21,924**	**$ 716,281**
Total Cost	$ -				$ **346,857**			$ **135,463**			$ **173,098**			$ -											

M.2 - Tower A Heat Pump

Utility Rate Data

Utility		Blend Rate	
Winter Steam	$	36.000	$/klb
Summer Steam	$	18.000	$/klb
0	$	-	$/klb
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Modified Operation

Tag	Heat Pump Summary				Tower A LH HHW Gen			Tower A UH HHW Gen			Tower A LH Steam Utilization			Tower A UH Steam Utilization			Tower A LH HHW Utilization			Tower A UH HHW Utilization					
	LH HP		UH HP																						
	HP MBH	Max HP HHW Flow	HP MBH	Max HP HHW Flow	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Total MBH	Total klbs	Sum Cost
Jan	0	887	665,129	548.43	364	1,713,087	1793.81	364	221,534	231.97	325	980,524	1026.73	0	0	0.00							2,915,145	3,053	$ 109,890
Feb	0	855	526,823	462.10	336	1,382,642	1447.79	336	185,427	194.16	257	768,416	804.62	0	0	0.00							2,336,485	2,447	$ 88,077
Mar	0	846	613,000	440.52	378	1,567,456	1641.32	378	219,618	229.97	287	863,537	904.23	0	0	0.00							2,650,611	2,776	$ 99,918
Apr	0	372	321,468	269.40	350	535,729	560.97	350	1,113	1.16	75	183,567	192.22	0	0	0.00							720,408	754	$ 13,578
May	0	249	295,115	240.68	378	361,045	378.06	378	18	0.02	31	58,630	61.39	0	0	0.00							419,692	439	$ 7,910
Jun	0	14	260,244	17.58	364	260,244	272.51	364	0	0.00	0	0	0.00	0	0	0.00							260,244	273	$ 4,905
July	0	13	259,176	17.57	364	259,176	271.39	364	0	0.00	0	0	0.00	0	0	0.00							259,176	271	$ 4,885
Aug	0	13	270,037	17.57	378	270,037	282.76	378	0	0.00	0	0	0.00	0	0	0.00							270,037	283	$ 5,090
Sep	0	161	262,525	101.53	364	268,701	281.36	364	0	0.00	2	4,679	4.90	0	0	0.00							273,380	286	$ 5,153
Oct	0	304	321,637	255.04	364	498,042	521.51	364	723	0.76	66	155,501	162.83	0	0	0.00							654,267	685	$ 24,663
Nov	0	846	512,515	440.52	364	1,203,098	1259.79	364	76,396	80.00	238	646,353	676.81	0	0	0.00							1,925,847	2,017	$ 72,597
Dec	0	884	696,871	538.62	364	1,859,547	1947.17	364	333,579	349.30	337	1,054,141	1103.81	0	0	0.00							3,247,267	3,400	$ 122,410
Total	0	5,444	5,004,539	279.13	4,368	10,178,803	888.20	4,368	1,038,407	1,087	1,618	4,715,349	4,938	0	0	0							**15,932,559**	**16,683**	**$ 559,078**
Total Cost	$ -				$ **346,857**			$ **27,168**			$ **173,098**			$ -											

Summary

Tag	Heat Pump Summary	Tower A LH HHW Gen	Tower A UH HHW Gen	Tower A LH Steam Utilization	Tower A UH Steam Utilization	Tower A LH HHW Utilization	Tower A UH HHW Utilization	Total Saving	
Change Hrs	0	0	0	0	0			**5,004,539**	**MBH**
Energy Savings	-5,004,539	0	5,004,539	0	0			**5,240**	**klbs**
Reduction in Cost	$ -	$ -	$ **108,295**	$ -	$ -			**$ 157,203**	

Table 76. M.2 Energy Model Tower A Cooling Summary

Chiller Plant Operational Data	**Measure:**	**M.2 - Tower A Heat Pump**	**Date:** 11/14/2022 **Client:** Brookfield **Project:** **Community Heat Pump**
Calculation Method:	Baseline - Design, Trended	**Basis:** ☐ Installed ☑ Conceptual Design ☐ Final Design	**Equipment Efficiency:** ☑ Actual Dynamic

Utility Rate Data

Utility		Blend Rate	
Elec	$	0.092	$/kWh
Elec Dmd	$	-	$/kW
Gas	$	-	$/Therm
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Design / Existing Operation

Tag	CHW Plant																							
	Hours	Ton-Hrs	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Plant Peak Demand	Demand Cost	Plant kWh	Energy (kWh) Cost	Total Cost
Jan	60	1,447	107,333	0.09																2,696	$ 30,597	107,333	$ 9,875	$ 40,472
Feb	360	1,394	680,413	0.49																5,148	$ 18,539	680,413	$ 62,598	$ 81,137
Mar	727	1,655	1,538,161	0.94																5,283	$ 20,771	1,538,161	$ 141,511	$ 162,282
Apr	720	1,588	1,506,940	0.96																6,129	$ 25,966	1,506,940	$ 138,638	$ 164,604
May	744	2,000	1,918,768	0.98																7,386	$ 68,073	1,918,768	$ 176,527	$ 244,600
Jun	720	2,803	2,414,972	0.91																7,562	$ 178,622	2,414,972	$ 222,177	$ 400,800
July	744	3,121	2,520,502	0.86																7,500	$ 160,134	2,520,502	$ 231,886	$ 392,020
Aug	744	3,081	2,537,487	0.88																7,498	$ 177,095	2,537,487	$ 233,449	$ 410,544
Sep	720	2,478	2,126,600	0.93																7,471	$ 154,435	2,126,600	$ 195,647	$ 350,083
Oct	744	1,717	1,564,803	1.01																6,033	$ 62,980	1,564,803	$ 143,962	$ 206,942
Nov	720	1,279	1,355,734	1.10																5,070	$ 23,236	1,355,734	$ 124,728	$ 147,964
Dec	728	999	923,479	0.99																3,687	$ 12,704	923,479	$ 84,960	$ 97,664
Total	7,731	23,563	19,195,193	0.84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**Peak**	**$ 933,152**	**19,195,193**	**$ 1,765,958**	**$ 2,699,110**
Total Cost	$			**1,765,958**	$		-	$		-	$		-	$		-	$		-	**7,562**				

M.2 - Tower A Heat Pump

Utility Rate Data

Utility		Blend Rate	
Elec	$	0.092	$/kWh
Elec Dmd	$	-	$/kW
Gas	$	-	$/Therm
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Design / Modified Operation

Tag	CHW Plant				CH-1 (Heat Pump)			HHW Pumps																
	Hours	Ton-Hrs	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Plant Peak Demand	Demand Cost	Plant kWh	Energy (kWh) Cost	Total Cost
Jan	60	1,401	105,257	0.09	744	69,210	1.5	744	2,628	0.02										2,868	$ 32,551	177,095	$ 16,293	$ 48,844
Feb	360	1,355	673,943	0.50	672	58,774	1.5	672	2,183	0.0										5,148	$ 19,517	734,900	$ 67,611	$ 87,128
Mar	727	1,612	1,493,679	0.94	744	65,908	1.5	744	2,467	0.0										5,283	$ 21,627	1,562,054	$ 143,709	$ 165,336
Apr	720	1,570	1,492,467	0.97	720	28,002	1.5	720	353	0.0										6,129	$ 26,370	1,520,822	$ 139,916	$ 166,285
May	744	1,983	1,906,251	0.98	744	25,619	1.5	744	186	0.0										7,386	$ 68,742	1,932,055	$ 177,749	$ 246,491
Jun	720	2,788	2,415,337	0.91	720	22,591	1.5	720	99	0.0										7,604	$ 179,452	2,438,026	$ 224,298	$ 403,750
July	744	3,106	2,514,355	0.86	744	22,498	1.5	744	99	0.0										8,395	$ 161,102	2,536,951	$ 233,399	$ 394,501
Aug	744	3,066	2,530,251	0.88	744	23,441	1.5	744	102	0.0										7,535	$ 177,965	2,553,794	$ 234,949	$ 412,914
Sep	720	2,462	2,118,641	0.93	720	22,789	1.5	720	105	0.0										7,516	$ 156,091	2,141,534	$ 197,021	$ 353,112
Oct	744	1,698	1,559,742	1.02	744	27,983	1.5	744	319	0.0										6,033	$ 63,397	1,588,044	$ 146,100	$ 209,497
Nov	720	1,246	1,247,320	1.03	720	49,921	1.5	720	1,450	0.0										5,070	$ 23,946	1,298,691	$ 119,480	$ 143,426
Dec	728	950	903,061	1.04	744	76,864	1.5	744	3,246	0.0										3,687	$ 15,634	983,171	$ 90,452	$ 106,086
Total	7,731	23,237	18,960,303	0.85	8,760	493,599	1.5	8,760	13,236	0.01	0	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!	**Peak**	**$ 946,393**	**19,467,138**	**$ 1,790,977**	**$ 2,737,370**
Total Cost	$			**1,744,348**	$		**45,411**	$		**1,218**	$		-	$		-	$		-	**8,395**				

Summary

Tag	CHW Plant	CH-1 (Heat Pump)	HHW Pumps	0	0	0		
Change Hrs	0	-8,760	-8,760	0	0	0	**-832**	**kW**
Energy Savings	234,889	-493,599	-13,236	0	0	0	**-271,945**	**kWh**
Reduction in Cost	**$ 21,610**	**$ (45,411)**	**$ (1,218)**	**$ -**	**$ -**	**$ -**	**$**	**(38,259)**

9.2.7 Results

Table 77 summarizes the energy and financial results for this option.

Table 77. M.2 Energy Model Financial Summary

Breakdown of Modification Options														
Option	Description	Estimated Annual Steam Reduction	Estimated Annual Electric Reduction	2024 Estimated Annual CO2 Reduction			First Cost - Estimated			Estimated Annual Energy Cost Savings		With CO2 Tax (2024)		Net Present Value
		Energy	Energy	Steam	Electric	Total	First Cost	Rebate	Net Capex After Rebate	Measure Savings	SPB	CO2 Tax	SPB	20 Year NPV
		Mlbs	kWh	MT CO2e	MT CO2e	MT CO2e	$	$	$	$	Years	$	Years	$
M.2	Tower A Heat Pump	5,954	-271,945	251	-79	173	$ (3,741,971)	$ -	$ (3,741,971)	$ 118,944	31.5	$ 46,334	22.6	$ (532,686)

Cost Estimates		
X	**Placeholder**	**Based on past experience on similar projects. This number could go down or up substantially based on further development.**
	Estimates / Budgetary	Based on some contractor estimates and more refined scope
	Investment Grade / Proposal	Fully developed scope, subcontractor pricing, ready for design build proposal and management approval
Savings Calculations and Paybacks		
	Placeholder	Based on past experience on similar projects. This number could go down or up substantially based on further development.
	Estimates / Budgetary	Energy model build based on final scope.
X	**Investment Grade / Rebate Ready**	**Fully developed energy model calibrated with full QA/QC**

9.3 M.3, Tower B: Decentralized Heat Pump

This section outlines the proposed modification and system descriptions, controls strategy, analysis of the proposed modifications, and first cost analysis for the energy conservation measure for the Tower B decentralized heat pump.

9.3.1 Proposed Modification Description

The team proposes the following modifications to the current system:

- Install a heat pump at the building level
- Modify the heating hot water distribution piping
- Replace select non-100% outside air unit steam coils with heating hot water coils
- Replace select 100% outside air unit steam coils with hot water coils
- Replace steam-to-hot water domestic hot water heaters with water-to-water domestic hot water heaters
- Implement associated controls

9.3.2 Proposed System Description

The team proposes the following system configuration and integration for Tower B:

- Install a heat pump in the building penthouse, using the building's chilled water and condenser water as a heat source. The 250-ton heat pump will generate 130°F heating hot water supply temperature.
- Install duplex heating hot water-to-domestic hot water heat exchangers to preheat the domestic hot water before it enters the steam-to-hot water heat exchangers for the following units:
    - H-1
    - H-2
    - H-3
    - H-4
    - H-5
    - H-6
    - H-7

9.3.3 Proposed Controls Strategy

The team proposes the following controls strategy and adjustments to optimize the system's performance:

- **Tower B heat pump:** Install a new heat pump in the Tower B plant. The heat pump will operate to maintain the heating hot water distribution set-point, which will adjust based on the outdoor air temperature. All building equipment must coordinate with this set-point.
- **Domestic hot water:** Use the heat pump-generated heating hot water to preheat the domestic water before it enters the existing steam-to-hot water heat exchangers. If the

heat pump-generated hot water cannot maintain the local domestic hot water set-point, the existing steam-to-domestic hot water heat exchanger will trim to maintain the local set-point.

9.3.4 Analysis of Proposed Modification: Base Case and Energy Conservation Measures

The team proposes the following modeling process for this energy conservation measure:

- **Base case:**
    - Model the base case using an 8760 Excel model built solely for each heating load.
    - Implement the schedules and controls strategy for each unit.
- **Energy conservation measure analysis:**
    - Incorporate a switch into the base model to toggle the heat pump on and off, with an adjustable heating hot water supply temperature. This hourly supply temperature value dictates how much heating can transfer from steam to the heat pump. The model calculates a heating hot water flow profile based on the calculated load and differential temperature.
    - Use this flow to calculate the energy consumption of the new heating hot water pump.
    - Use this heating load to calculate the heat pump power draw using factory equipment data. The existing plant chiller 8,760-kW/ton profile is used to calculate the reduction in power consumption for the existing plant.

9.3.5 First Cost Analysis

Smith Engineering produced an estimate for the first cost of this option, which totals $3,210,609.

Table 78 details these costs.

Table 78. M.3 Energy Model Tower B Estimated Heat Pump Cost

Opinion of Probable Construction Cost					Date:	Wednesday, March 1, 2023			
					Client:	Brookfield			
For	M.3 - Tower B				Project:	BFPL Community Heat Pump Stg A			
Basis of Estimate		☐ No Design		☑ Conceptual Design		☐ Final Design		☐ Actual Cost	
Item #	Description	Quantity	Units	Material Cost per Unit	Total Material Cost	Labor Hour	Labor Cost per Hour	Total Labor Cost	Total Cost
	Division 01000 - General								
1	Permits and Filing	1		$ 35,000	$ 35,000	125	$ 250	$ 31,250	$ 66,250
2	Superintended	1		$ -	$ -	250	$ 225	$ 56,250	$ 56,250
3	Demolition and Protection	1		$ 25,000	$ 25,000	350	$ 195	$ 68,250	$ 93,250
4	Rigging	1		$ 150,000	$ 150,000	500	$ 225	$ 112,500	$ 262,500
5	Gen Conditions	1		$ 35,000	$ 35,000	250	$ 195	$ 48,750	$ 83,750
	Subtotal				**$ 245,000**	1475		**$ 317,000**	**$ 562,000**
	Division 23000 - Mechanical								
1	DHW HXs	1		$ 110,000	$ 110,000	400	$ 250	$ 100,000	$ 210,000
2	Heat Pump	1		$ 375,000	$ 375,000	325	$ 250	$ 81,250	$ 456,250
3	Plant Piping and Insulation	1		$ 27,500	$ 27,500	200	$ 250	$ 50,000	$ 77,500
4									
5									
6									
7									
8									
9									
	Subtotal				**$ 512,500**	925		**$ 231,250**	**$ 743,750**
	Division 25000 - Controls								
1	Schneider Software Prog and Graphics	1		$ 25,000	$ 25,000	400	$ 300	$ 120,000	$ 145,000
2	Hardware and Labor	1		$ 35,000	$ 35,000	600	$ 300	$ 180,000	$ 215,000
3					$ -			$ -	$ -
	Subtotal				**$ 60,000**	1000		**$ 300,000**	**$ 360,000**
	Division 26000 - Electrical								
1	Power Conduit and Wiring	1		$ 93,750	$ 93,750	400	$ 275	$ 110,000	$ 203,750
2	Controls Conduit and Wiring	1		$ 35,000	$ 35,000	500	$ 275	$ 137,500	$ 172,500
3					$ -			$ -	$ -
	Subtotal				**$ 128,750**	900		**$ 247,500**	**$ 376,250**
	Subtotal		Multiplier		**$ 946,250**	Multiplier		**$1,095,750**	**$ 2,042,000**
	Contingency		10%		$ 94,625	10%		$ 109,575	$ 204,200
	Subtotal				**$1,040,875**			**$1,205,325**	**$ 2,246,200**
	Construction Management Overhead		10%		$ 104,088	10%		$ 120,533	$ 224,620
	Profit		10%		$ 104,088	10%		$ 120,533	$ 224,620
	Subtotal Construction				**$1,249,050**			**$ 1,446,390**	**$ 2,695,440**
	Tax		8.875%		$ 110,853	0%		$ -	$ 110,853
	Design Engineering							$ 215,635	$ 215,635
	Construction Administration							$ 107,818	$ 107,818
	Commissioning							$ 80,863	$ 80,863
	Total Estimated Cost	**$**							**3,210,609**

9.3.6 Operational and Economic Analysis

Table 79 and Table 80 summarize the energy and financial results for this option.

Table 79. M.3 Energy Model Tower B Heating Summary

Tower B Heating | **Measure:** | **M.3 - Tower B Heat Pump** | **Date:** 11/14/2022 | **Client:** Brookfield | **Project:** Community Heat Pump

Calculation Method: 8,760 | **Basis:** ☐ Installed ☑ Conceptual Design ☐ Final Design | **Equipment Efficiency:** ☐ Actual Dynamic ☑ Manufacturer Dynamic

Utility Rate Data

Utility		Blend Rate	
Winter Steam	$	36.000	$/klb
Summer Steam	$	18.000	$/klb
	$	-	$/klb
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Design

Existing Operation

Tag	Heat Pump Summary				Tower B LH HHW Gen			Tower B UH HHW Gen			Tower B LH Steam Utilization			Tower B UH Steam Utilization			Tower B LH HHW Utilization			ower B UH HHW Utilizatio					
	LH HP		UH HP																						
	HP MBH	Max HP HHW Flow	HP MBH	Max HP HHW Flow	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Total MBH	Total klbs	Sum Cost
Jan	0	0	0	0.00	646	2,013,514	2,108	320	1,247,602	1,306	459	3,644,082	3,816	0	0	0.00							6,905,199	7,231	$ 260,301
Feb	0	0	0	0.00	504	1,620,557	1,697	278	769,253	806	373	2,796,646	2,928	0	0	0.00							5,186,456	5,431	$ 195,510
Mar	0	0	0	0.00	558	1,823,227	1,909	307	1,213,777	1,271	426	3,230,191	3,382	0	0	0.00							6,267,195	6,563	$ 236,250
Apr	0	0	0	0.00	540	854,291	895	5	9,183	10	313	577,173	604	0	0	0.00							1,440,647	1,509	$ 27,154
May	0	0	0	0.00	558	797,245	835	0	0	0	302	292,331	306	0	0	0.00							1,089,576	1,141	$ 20,537
Jun	0	0	0	0.00	540	740,963	776	0	0	0	103	34,017	36	0	0	0.00							774,980	811	$ 14,607
July	0	0	0	0.00	558	763,578	800	0	0	0	13	536	1	0	0	0.00							764,114	800	$ 14,402
Aug	0	0	0	0.00	558	765,526	802	0	0	0	93	3,568	4	0	0	0.00							769,094	805	$ 14,496
Sep	0	0	0	0.00	540	742,680	778	0	0	0	165	52,284	55	0	0	0.00							794,964	832	$ 14,984
Oct	0	0	0	0.00	558	836,007	875	2	3,520	4	247	432,704	453	0	0	0.00							1,272,231	1,332	$ 47,958
Nov	0	0	0	0.00	540	1,417,509	1,484	141	353,280	370	401	2,137,358	2,238	0	0	0.00							3,908,146	4,092	$ 147,323
Dec	0	0	0	0.00	650	2,202,534	2,306	444	1,916,515	2,007	460	4,155,904	4,352	0	0	0.00							8,274,953	8,665	$ 311,935
Total	0	0	0	0.00	6,750	14,577,630	15,265	1,497	5,513,132	5,773	3,355	17,356,794	18,175	0	0	0	0	0	0	0	0	0	37,447,556	39,212	$ 1,305,457
Total Cost	$ -				$ 461,610			$ 207,652			$ 636,195			$ -											

M.3 - Tower B Heat Pump

Utility Rate Data

Utility		Blend Rate	
Winter Steam	$	36.000	$/klb
Summer Steam	$	18.000	$/klb
0	$	-	$/klb
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Modified Operation

Tag	Heat Pump Summary				Tower B LH HHW Gen			Tower B UH HHW Gen			Tower B LH Steam Utilization			Tower B UH Steam Utilization			Tower B LH HHW Utilization			ower B UH HHW Utilizatio					
	LH HP		UH HP																						
	HP MBH	Max HP HHW Flow	HP MBH	Max HP HHW Flow	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Total MBH	Total klbs	Sum Cost
Jan	1,191,845	1,372	0	0.00	646	821,670	860	320	1,247,602	1,306	459	3,644,082	3,816	0	0	0.00							5,713,354	5,983	$ 215,373
Feb	950,631	1,372	0	0.00	504	669,926	701	278	769,253	806	373	2,796,646	2,928	0	0	0.00							4,235,825	4,435	$ 159,675
Mar	1,048,277	1,372	0	0.00	558	774,951	811	307	1,213,777	1,271	426	3,230,191	3,382	0	0	0.00							5,218,918	5,465	$ 196,734
Apr	841,201	1,372	0	0.00	540	13,090	14	5	9,183	10	313	577,173	604	0	0	0.00							599,447	628	$ 11,298
May	797,138	1,364	0	0.00	558	106	0	0	0	0	302	292,331	306	0	0	0.00							292,438	306	$ 5,512
Jun	740,963	34	0	0.00	540	0	0	0	0	0	103	34,017	36	0	0	0.00							34,017	36	$ 641
July	763,578	34	0	0.00	558	0	0	0	0	0	13	536	1	0	0	0.00							536	1	$ 10
Aug	765,526	34	0	0.00	558	0	0	0	0	0	93	3,568	4	0	0	0.00							3,568	4	$ 67
Sep	742,680	34	0	0.00	540	0	0	0	0	0	165	52,284	55	0	0	0.00							52,284	55	$ 985
Oct	831,894	1,372	0	0.00	558	4,113	4	2	3,520	4	247	432,704	453	0	0	0.00							440,337	461	$ 16,599
Nov	1,081,799	1,372	0	0.00	540	335,710	352	141	353,280	370	401	2,137,358	2,238	0	0	0.00							2,826,347	2,960	$ 106,543
Dec	1,058,422	1,372	0	0.00	650	1,144,111	1,198	444	1,916,515	2,007	460	4,155,904	4,352	0	0	0.00							7,216,531	7,557	$ 272,037
Total	10,813,954	11,101	0	0.00	6,750	3,763,676	328.42	1,497	5,513,132	5,773	3,355	17,356,794	18,175	0	0	0							26,633,601	27,889	$ 985,475
Total Cost	$ -				$ 141,628			$ 207,652			$ 636,195			$ -											

Summary

Tag	Heat Pump Summary	Tower B LH HHW Gen	Tower B UH HHW Gen	Tower B LH Steam Utilization	Tower B UH Steam Utilization	Tower B LH HHW Utilization	ower B UH HHW Utilizatio	Total Saving	
Change Hrs		0	0	0	0			10,813,954	MBH
Energy Reduction		10,813,954	0	0	0			11,324	klbs
Reduction in Cost	$ -	$ 319,982	$ -	$ -	$ -			$ 319,982	

Table 80. M.3 Energy Model Tower B Cooling Summary

Chiller Plant Operational Data	**Measure:**	**M.3 - Tower B Heat Pump**	**Date:** 11/14/2022 **Client:** Brookfield **Project:** **Community Heat Pump**
Calculation Method:	Baseline - Design, Trended	**Basis:** ☐ Installed ☑ Conceptual Design ☐ Final Design	**Equipment Efficiency:** ☑ Actual Dynamic

Design

Tag	CHW Plant					

Utility Rate Data

Utility		Blend Rate	
Elec	$	0.092	$/kWh
Elec Dmd	$	-	$/kW
Gas	$	-	$/Therm
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Existing Operation

Tag	CHW Plant																		
	Hours	kTon-Hrs	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton
Jan	60	1,447	107,333	0.09															
Feb	360	1,394	680,413	0.49															
Mar	727	1,655	1,538,161	0.94															
Apr	720	1,588	1,506,940	0.96															
May	744	2,000	1,918,768	0.98															
Jun	720	2,803	2,414,972	0.91															
July	744	3,121	2,520,502	0.86															
Aug	744	3,081	2,537,487	0.88															
Sep	720	2,478	2,126,600	0.93															
Oct	744	1,717	1,564,803	1.01															
Nov	720	1,279	1,355,734	1.10															
Dec	728	999	923,479	0.99															
Total	7,731	23,563	19,195,193	0.84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Cost	$			**1,765,958**	$		-	$		-	$		-	$		-	$		-

Tag	Plant Peak Demand	Demand Cost	Plant kWh	Energy (kWh) Cost	Total Cost
Jan	2,696	$ 30,597	107,333	$ 9,875	$ 40,472
Feb	5,148	$ 18,539	680,413	$ 62,598	$ 81,137
Mar	5,283	$ 20,771	1,538,161	$ 141,511	$ 162,282
Apr	6,129	$ 25,966	1,506,940	$ 138,638	$ 164,604
May	7,386	$ 68,073	1,918,768	$ 176,527	$ 244,600
Jun	7,562	$ 178,622	2,414,972	$ 222,177	$ 400,800
July	7,500	$ 160,134	2,520,502	$ 231,886	$ 392,020
Aug	7,498	$ 177,095	2,537,487	$ 233,449	$ 410,544
Sep	7,471	$ 154,435	2,126,600	$ 195,647	$ 350,083
Oct	6,033	$ 62,980	1,564,803	$ 143,962	$ 206,942
Nov	5,070	$ 23,236	1,355,734	$ 124,728	$ 147,964
Dec	3,687	$ 12,704	923,479	$ 84,960	$ 97,664
Total / **Total Cost**	**Peak** **7,562**	**$ 933,152**	**19,195,193**	**$ 1,765,958**	**$ 2,699,110**

M.3 - Tower B Heat Pump

Design

Tag	CHW Plant	CH-1 (Heat Pump)	HHW Pumps			

Utility Rate Data

Utility		Blend Rate	
Elec	$	0.092	$/kWh
Elec Dmd	$	-	$/kW
Gas	$	-	$/Therm
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Modified Operation

Tag	CHW Plant				CH-1 (Heat Pump)			HHW Pumps											
	Hours	kTon-Hrs	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton
Jan	60	1,375	100,661	0.09	744	93,498	1.3	744	12,553	0.17									
Feb	360	1,337	664,365	0.50	672	74,575	1.3	672	9,850	0.1									
Mar	727	1,592	1,493,611	0.96	744	82,235	1.3	744	10,806	0.1									
Apr	720	1,538	1,473,655	0.98	720	65,991	1.3	720	1,209	0.0									
May	744	1,952	1,874,640	0.97	744	62,534	1.3	744	560	0.0									
Jun	720	2,759	2,379,775	0.90	720	58,127	1.3	720	368	0.0									
July	744	3,075	2,550,731	0.88	744	59,901	1.3	744	380	0.0									
Aug	744	3,035	2,510,284	0.89	744	60,054	1.3	744	380	0.0									
Sep	720	2,433	2,131,069	0.95	720	58,262	1.3	720	368	0.0									
Oct	744	1,667	1,542,332	1.04	744	65,261	1.3	744	808	0.0									
Nov	720	1,214	1,136,550	0.96	720	84,865	1.3	720	7,032	0.1									
Dec	728	936	898,040	1.13	744	83,031	1.3	744	14,645	0.2									
Total	7,731	22,912	18,755,712	0.85	8,760	848,336	1.3	8,760	58,958	0.07	0	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!
Total Cost	$			**1,725,526**	$		**78,047**	$		**5,424**	$		-	$		-	$		-

Tag	Plant Peak Demand	Demand Cost	Plant kWh	Energy (kWh) Cost	Total Cost
Jan	2,851	$ 32,363	206,713	$ 19,018	$ 51,381
Feb	5,148	$ 19,842	748,790	$ 68,889	$ 88,730
Mar	5,337	$ 21,486	1,586,653	$ 145,972	$ 167,458
Apr	6,129	$ 26,365	1,540,854	$ 141,759	$ 168,124
May	7,386	$ 69,286	1,937,734	$ 178,272	$ 247,557
Jun	7,628	$ 179,923	2,438,270	$ 224,321	$ 404,243
July	8,415	$ 161,679	2,611,012	$ 240,213	$ 401,892
Aug	7,604	$ 179,597	2,570,719	$ 236,506	$ 416,103
Sep	7,539	$ 157,073	2,189,698	$ 201,452	$ 358,525
Oct	6,033	$ 63,622	1,608,401	$ 147,973	$ 211,595
Nov	5,070	$ 16,338	1,228,447	$ 113,017	$ 129,355
Dec	3,800	$ 14,984	995,716	$ 91,606	$ 106,590
Total / **Total Cost**	**Peak** **8,415**	**$ 942,558**	**19,663,006**	**$ 1,808,997**	**$ 2,751,554**

Summary

Tag	CHW Plant	CH-1 (Heat Pump)	HHW Pumps	0	0	0		
Change Hrs	0	-8,760	-8,760	0	0	0	**-853**	**kW**
Energy Savings	439,480	-848,336	-58,958	0	0	0	**-467,814**	**kWh**
Reduction in Cost	**$ 40,432**	**$ (78,047)**	**$ (5,424)**	**$ -**	**$ -**	**$ -**	**$**	**(52,444)**

9.3.7 Results

Table 81 summarizes the energy and financial results for this option.

Table 81. M.3 Energy Model Financial Summary

Breakdown of Modification Options														
Option	Description	Estimated Annual Steam Reduction	Estimated Annual Electric Reduction	2024 Estimated Annual CO2 Reduction			First Cost - Estimated			Estimated Annual Energy Cost Savings		With CO2 Tax (2024)		Net Present Value
		Energy	Energy	Steam	Electric	Total	First Cost	Rebate	Net Capex After Rebate	Measure Savings	SPB	CO2 Tax	SPB	20 Year NPV
		Mlbs	kWh	MT CO2e	MT CO2e	MT CO2e	$	$	$	$	Years	$	Years	$
M.3	Tower B Heat Pump	11,324	-467,814	478	-135	343	$ (3,210,609)	$ -	$ (3,210,609)	$ 267,538	12.0	$ 91,940	8.9	$ 3,769,543

Cost Estimates		
X	**Placeholder**	**Based on past experience on similar projects. This number could go down or up substantially based on further development.**
	Estimates / Budgetary	Based on some contractor estimates and more refined scope
	Investment Grade / Proposal	Fully developed scope, subcontractor pricing, ready for design build proposal and management approval
Savings Calculations and Paybacks		
	Placeholder	Based on past experience on similar projects. This number could go down or up substantially based on further development.
	Estimates / Budgetary	Energy model build based on final scope.
X	**Investment Grade / Rebate Ready**	**Fully developed energy model calibrated with full QA/QC**

9.4 M.4, Tower C: Decentralized Heat Pump

This section outlines the proposed modification and system descriptions, controls strategy, analysis of the proposed modifications, and first cost analysis for the energy conservation measure for the Tower C decentralized heat pump.

9.4.1 Proposed Modification Description

The team proposes the following modifications to the current system:

- Install a heat pump at the building level
- Modify the heating hot water distribution piping
- Replace select non-100% outdoor air unit steam coils with heating hot water coils
- Replace select 100% outdoor air unit steam coils with hot water coils
- Replace steam-to-hot water domestic hot water heaters with water-to-water domestic hot water heaters
- Implement associated controls

9.4.2 Proposed System Description

The team proposes the following system configuration and integration for Tower C:

- Install a heat pump in the building penthouse using the building's chilled water as the heat source. The 210-ton heat pump will generate 130°F heating hot water supply temperature.
- Tap into the AC-52C chilled water coil and the secondary chilled water return to provide the chilled water supply to the heat pump.
- Tap the heating hot water distribution from the heat pump into the existing heating hot water return piping to preheat the heating hot water before it enters the heat exchangers for the following units:
    - HX-5C
    - HX-4C

9.4.3 Proposed Controls Strategy

The team proposes the following controls strategy and adjustments to optimize the system's performance:

- **Tower C heat pump:** Install a new heat pump in building C penthouse. The heat pump will operate to maintain the heating hot water distribution set-point, which will adjust based on the outdoor air temperature. All building equipment must coordinate with this set-point.
- **Air handling units:** The heating hot water will feed AC-52C to provide heating to the 100% outdoor air. If the mixed air temperature (MAT) exceeds the acceptable level for an individual floor, the compartment unit's chilled water will trim the mixed air temperature per floor.

- **Heating hot water:** The heat pump–generated heating hot water will blend with the heating hot water return to maintain the heating hot water set-point. If the heat pump-generated hot water is insufficient to maintain the local heating hot water set-point, the existing steam-to-hot water heat exchanger will trim to maintain the local set-point.

9.4.4 Analysis of Proposed Modification: Base Case and Energy Conservation Measure Analysis

The team proposes the following modeling process for this energy conservation measure:

- **Base case:**
  - Model the base case using an 8760 Excel model built solely for each heating load.
  - Implement the schedules and controls strategy for each unit.
- **Energy conservation measure analysis:**
  - Incorporate a switch into the base model to toggle the heat pump on and off, with an adjustable heating hot water supply temperature. This hourly supply temperature dictates how much heating can transfer from steam to the heat pump. The model calculates a heating hot water flow profile based on the calculated load and differential temperature.
  - Use this flow to calculate the energy consumption of the new heating hot water pump.
  - Use the heating load to calculate the heat pump power draw using factory equipment data. The existing plant chiller 8,760-kW/ton profile is used to calculate the reduction in power consumption for the existing plant.

9.4.5 First Cost Analysis

Smith Engineering produced an estimate for the first cost of this option, which totals $3,210,609.

Table 82 details these costs.

Table 82. M.4 Energy Model Tower C Estimated Heat Pump Cost

Opinion of Probable Construction Cost

For M.4 - Tower C

Date: Wednesday, March 1, 2023
Client: Brookfield
Project: BFPL Community Heat Pump Stg A

Basis of Estimate ☐ No Design ☑ Conceptual Design ☐ Final Design ☐ Actual Cost

Item #	Description	Quantity	Units	Material Cost per Unit	Total Material Cost	Labor Hour	Labor Cost per Hour	Total Labor Cost	Total Cost
	Division 01000 - General								
1	Permits and Filing	1		$ 35,000	$ 35,000	125	$ 250	$ 31,250	$ 66,250
2	Superintended	1		$ -	$ -	250	$ 225	$ 56,250	$ 56,250
3	Demolition and Protection	1		$ 25,000	$ 25,000	350	$ 195	$ 68,250	$ 93,250
4	Rigging	1		$ 150,000	$ 150,000	500	$ 225	$ 112,500	$ 262,500
5	Gen Conditions	1		$ 35,000	$ 35,000	250	$ 195	$ 48,750	$ 83,750
	Subtotal				**$ 245,000**	1475		**$ 317,000**	**$ 562,000**
	Division 23000 - Mechanical								
1	Heat Pump	1		$ 375,000	$ 375,000	325	$ 250	$ 81,250	$ 456,250
2	Plant Piping and Insulation	1		$ 93,750	$ 93,750	200	$ 250	$ 50,000	$ 143,750
3	Tempered Loop HX-5C	1		$ 65,000	$ 65,000	300	$ 250	$ 75,000	$ 140,000
4	Piping into 100% OA CC	1		$ 65,000	$ 65,000	250	$ 250	$ 62,500	$ 127,500
5									
6									
7									
8									
9									
10									
	Subtotal				**$ 598,750**	1075		**$ 268,750**	**$ 867,500**
	Division 25000 - Controls								
1	Schneider Software Prog and Graphics	1		$ 20,000	$ 20,000	400	$ 300	$ 120,000	$ 140,000
2	Hardware and Labor	1		$ 35,000	$ 35,000	600	$ 300	$ 180,000	$ 215,000
3					$ -			$ -	$ -
	Subtotal				**$ 55,000**	1000		**$ 300,000**	**$ 355,000**
	Division 26000 - Electrical								
1	Power Conduit and Wiring	1		$ 93,750	$ 93,750	400	$ 275	$ 110,000	$ 203,750
2	Controls Conduit and Wiring	1		$ 35,000	$ 35,000	500	$ 275	$ 137,500	$ 172,500
3					$ -			$ -	$ -
	Subtotal				**$ 128,750**	900		**$ 247,500**	**$ 376,250**
	Subtotal		Multiplier		**$ 1,027,500**	Multiplier		**$ 1,133,250**	**$ 2,160,750**
	Contingency		10%		$ 102,750	10%		$ 113,325	$ 216,075
	Subtotal				**$ 1,130,250**			**$ 1,246,575**	**$ 2,376,825**
	Construction Management Overhead		10%		$ 113,025	10%		$ 124,658	$ 237,683
	Profit		10%		$ 113,025	10%		$ 124,658	$ 237,683
	Subtotal Construction				**$ 1,356,300**			**$ 1,495,890**	**$ 2,852,190**
	Tax		8.875%		$ 120,372	0%		$ -	$ 120,372
	Design Engineering							$ 228,175	$ 228,175
	Construction Administration							$ 114,088	$ 114,088
	Commissioning							$ 85,566	$ 85,566
	Total Estimated Cost	**$**							**3,400,390**

9.4.6 Operational and Economic Analysis

Table 83 summarizes the energy and financial results for this option.

Table 83. M.4 Energy Model Tower C Heating Summary

Chiller Plant Operational Data	Measure:	M.4 - Tower C Heat Pump	Date: 11/14/2022	Client: Brookfield
Calculation Method:	Baseline - Design, Trended	Basis: ☐ Installed ☑ Conceptual Design ☐ Final Design	Equipment Efficiency: ☑ Actual Dynamic	Project: Community Heat Pump

Utility Rate Data

Utility		Blend Rate	
Elec	$	0.092	$/kWh
Elec Dmd	$	-	$/kW
Gas	$	-	$/Therm
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Design / Existing Operation

Tag	CHW Plant																								
	Hours	kTon-Hrs	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Plant Peak Demand	Demand Cost	Plant kWh	Energy (kWh) Cost	Total Cost
Jan	60	1,447	107,333	0.09																2,696	$ 30,597	107,333	$ 9,875	$ 40,472
Feb	360	1,394	680,413	0.49																5,148	$ 18,539	680,413	$ 62,598	$ 81,137
Mar	727	1,655	1,538,161	0.94																5,283	$ 20,771	1,538,161	$ 141,511	$ 162,282
Apr	720	1,588	1,506,940	0.96																6,129	$ 25,966	1,506,940	$ 138,638	$ 164,604
May	744	2,000	1,918,768	0.98																7,386	$ 68,073	1,918,768	$ 176,527	$ 244,600
Jun	720	2,803	2,414,972	0.91																7,562	$ 178,622	2,414,972	$ 222,177	$ 400,800
July	744	3,121	2,520,502	0.86																7,500	$ 160,134	2,520,502	$ 231,886	$ 392,020
Aug	744	3,081	2,537,487	0.88																7,498	$ 177,095	2,537,487	$ 233,449	$ 410,544
Sep	720	2,478	2,126,600	0.93																7,471	$ 154,435	2,126,600	$ 195,647	$ 350,083
Oct	744	1,717	1,564,803	1.01																6,033	$ 62,980	1,564,803	$ 143,962	$ 206,942
Nov	720	1,279	1,355,734	1.10																5,070	$ 23,236	1,355,734	$ 124,728	$ 147,964
Dec	728	999	923,479	0.99																3,687	$ 12,704	923,479	$ 84,960	$ 97,664
Total	7,731	23,563	19,195,193	0.84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**Peak**	**$ 933,152**	**19,195,193**	**$ 1,765,958**	**$ 2,699,110**
Total Cost	**$ 1,765,958**				$ -			$ -			$ -			$ -			$ -			**7,562**				

M.4 - Tower C Heat Pump

Utility Rate Data

Utility		Blend Rate	
Elec	$	0.092	$/kWh
Elec Dmd	$	-	$/kW
Gas	$	-	$/Therm
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Design / Modified Operation

Tag	CHW Plant				CH-1 (Heat Pump)			HHW Pumps																
	Hours	kTon-Hrs	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Plant Peak Demand	Demand Cost	Plant kWh	Energy (kWh) Cost	Total Cost
Jan	60	1,436	106,544	0.09	744	15,143	1.3	744	4,860	0.04										2,696	$ 30,597	126,547	$ 11,642	$ 42,240
Feb	360	1,392	679,899	0.49	672	2,911	1.3	672	3,822	0.1										5,154	$ 18,539	686,632	$ 63,170	$ 81,709
Mar	727	1,649	1,535,557	0.95	744	8,700	1.3	744	4,186	0.1										5,283	$ 20,771	1,548,442	$ 142,457	$ 163,228
Apr	720	1,587	1,505,712	0.96	720	1,845	1.3	720	1,868	0.2										6,129	$ 25,966	1,509,425	$ 138,867	$ 164,833
May	744	1,999	1,915,682	0.97	744	1,643	1.3	744	1,166	0.1										7,386	$ 68,073	1,918,491	$ 176,501	$ 244,574
Jun	720	2,803	2,414,910	0.91	720	430	1.3	720	148	0.0										7,562	$ 178,622	2,415,487	$ 222,225	$ 400,847
July	744	3,121	2,520,497	0.86	744	8	1.3	744	1	0.0										7,500	$ 160,134	2,520,506	$ 231,887	$ 392,021
Aug	744	3,081	2,537,271	0.88	744	52	1.3	744	4	0.0										7,498	$ 177,095	2,537,328	$ 233,434	$ 410,529
Sep	720	2,477	2,126,269	0.93	720	543	1.3	720	202	0.0										7,471	$ 154,435	2,127,014	$ 195,685	$ 350,121
Oct	744	1,716	1,564,566	1.01	744	861	1.3	744	1,205	0.1										6,033	$ 62,980	1,566,632	$ 144,130	$ 207,110
Nov	720	1,277	1,354,440	1.10	720	1,955	1.3	720	3,738	0.1										5,070	$ 23,592	1,360,133	$ 125,132	$ 148,724
Dec	728	985	919,610	1.00	744	18,634	1.3	744	4,851	0.1										3,687	$ 13,362	943,096	$ 86,765	$ 100,127
Total	7,731	23,524	19,180,956	0.85	8,760	52,725	1.3	8,760	26,051	0.07	0	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!	**Peak**	**$ 934,167**	**19,259,733**	**$ 1,771,895**	**$ 2,706,062**
Total Cost	**$ 1,764,648**				**$ 4,851**			**$ 2,397**			$ -			$ -			$ -			**7,562**				

Summary

Tag	CHW Plant	CH-1 (Heat Pump)	HHW Pumps	0	0	0		
Change Hrs	0	-8,760	-8,760	0	0	0	**0**	**kW**
Energy Savings	14,237	-52,725	-26,051	0	0	0	**-64,540**	**kWh**
Reduction in Cost	**$ 1,310**	**$ (4,851)**	**$ (2,397)**	**$ -**	**$ -**	**$ -**	**$ (6,952)**	

Table 84. M.4 Energy Model Tower C Cooling Summary

Tower C Heating

Measure: M.4 - Tower C Heat Pump

Date: 11/14/2022 **Client:** Brookfield

Project: Community Heat Pump

Calculation Method: 8,760

Basis: ☐ Installed ☑ Conceptual Design ☐ Final Design

Equipment Efficiency: ☐ Actual Dynamic ☑ Manufacturer Dynamic

Design

Utility Rate Data		
Utility	Blend Rate	
Winter Steam	$ 34.000	$/klb
Summer Steam	$ 13.880	$/klb
	$ -	$/klb
Swr	$ -	$/hcf
Wtr	$ -	$/hcf

Existing Operation

Tag	Heat Pump Summary				Tower C LH HHW Gen			Tower C UH HHW Gen			Tower C LH Steam Utilization			Tower C UH Steam Utilization			Tower C LH HHW Utilization			Tower C UH HHW Utilization					
	LH HP		UH HP																						
	HP MBH	Max HP HHW Flow	HP MBH	Max HP HHW Flow	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Total MBH	Total klbs	Sum Cost
Jan	0	0	0	0.00	731	3,355,515	3,514	731	881,465	923	459	1,450,658	1,519	0	0	0.00							5,687,638	5,956	$ 202,492
Feb	0	0	0	0.00	610	2,720,925	2,849	610	599,259	627	373	1,110,049	1,162	0	0	0.00							4,430,233	4,639	$ 157,726
Mar	0	0	0	0.00	680	3,100,273	3,246	680	736,317	771	426	1,280,651	1,341	0	0	0.00							5,117,242	5,358	$ 182,185
Apr	0	0	0	0.00	540	1,845,934	1,933	422	160,950	169	282	205,220	215	0	0	0.00							2,212,104	2,316	$ 32,151
May	0	0	0	0.00	558	1,735,615	1,817	313	91,888	96	276	96,767	101	0	0	0.00							1,924,270	2,015	$ 27,967
Jun	0	0	0	0.00	540	1,494,308	1,565	59	11,796	12	79	7,684	8	0	0	0.00							1,513,788	1,585	$ 22,001
July	0	0	0	0.00	558	1,512,764	1,584	2	141	0	9	0	0	0	0	0.00							1,512,905	1,584	$ 21,989
Aug	0	0	0	0.00	558	1,518,322	1,590	10	937	1	46	0	0	0	0	0.00							1,519,259	1,591	$ 22,081
Sep	0	0	0	0.00	540	1,507,634	1,579	84	16,211	17	113	13,527	14	0	0	0.00							1,537,373	1,610	$ 22,344
Oct	0	0	0	0.00	558	1,771,157	1,855	278	107,822	113	223	167,374	175	0	0	0.00							2,046,352	2,143	$ 72,854
Nov	0	0	0	0.00	640	2,575,590	2,697	640	484,134	507	401	845,625	885	0	0	0.00							3,905,349	4,089	$ 139,039
Dec	0	0	0	0.00	737	3,600,089	3,770	737	1,036,590	1,085	460	1,658,109	1,736	0	0	0.00							6,294,788	6,591	$ 224,108
Total	0	0	0	0.00	7,250	26,738,126	27,998	4,566	4,127,510	4,322	3,147	6,835,664	7,158	0	0	0	0	0	0	0	0	0	**37,701,301**	**39,478**	**$ 1,126,936**
Total Cost	$			-	$		**749,373**	$		**141,008**	$		**236,555**	$		-									

M.4 - Tower C Heat Pump

Utility Rate Data		
Utility	Blend Rate	
Winter Steam	$ 34.000	$/klb
Summer Steam	$ 13.880	$/klb
0	$ -	$/klb
Swr	$ -	$/hcf
Wtr	$ -	$/hcf

Modified Operation

Tag	Heat Pump Summary				Tower C LH HHW Gen			Tower C UH HHW Gen			Tower C LH Steam Utilization			Tower C UH Steam Utilization			Tower C LH HHW Utilization			Tower C UH HHW Utilization					
	LH HP		UH HP																						
	HP MBH	Max HP HHW Flow	HP MBH	Max HP HHW Flow	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Total MBH	Total klbs	Sum Cost
Jan	0	0	172,915	439.07	731	3,108,815	3,255	731	526,507	551	459	1,450,658	1,519	0	0	0.00							5,085,980	5,326	$ 181,072
Feb	0	0	37,761	393.44	610	2,542,216	2,662	610	382,903	401	373	1,110,049	1,162	0	0	0.00							4,035,169	4,225	$ 143,660
Mar	0	0	110,289	410.70	680	2,888,614	3,025	680	448,055	469	426	1,280,651	1,341	0	0	0.00							4,617,320	4,835	$ 164,386
Apr	0	0	23,473	325.00	540	1,800,064	1,885	422	87,785	92	282	205,220	215	0	0	0.00							2,093,069	2,192	$ 30,421
May	0	0	20,941	325.00	558	1,709,860	1,790	313	43,046	45	276	96,767	101	0	0	0.00							1,849,673	1,937	$ 26,883
Jun	0	0	5,479	325.00	540	1,491,075	1,561	59	2,815	3	79	7,684	8	0	0	0.00							1,501,574	1,572	$ 21,824
July	0	0	100	19.07	558	1,512,727	1,584	2	0	0	9	0	0	0	0	0.00							1,512,727	1,584	$ 21,986
Aug	0	0	664	61.14	558	1,518,071	1,590	10	0	0	46	0	0	0	0	0.00							1,518,071	1,590	$ 22,064
Sep	0	0	6,960	325.00	540	1,503,182	1,574	84	4,428	5	113	13,527	14	0	0	0.00							1,521,137	1,593	$ 22,108
Oct	0	0	11,351	325.00	558	1,740,459	1,822	278	63,216	66	223	167,374	175	0	0	0.00							1,971,049	2,064	$ 70,173
Nov	0	0	24,799	381.04	640	2,432,684	2,547	640	310,764	325	401	845,625	885	0	0	0.00							3,589,073	3,758	$ 127,779
Dec	0	0	270,552	439.07	737	3,315,925	3,472	737	591,874	620	460	1,658,109	1,736	0	0	0.00							5,565,908	5,828	$ 198,158
Total	0	0	685,284	314.04	7,250	25,563,692	2230.69	4,566	2,461,392	2,577	3,147	6,835,664	7,158	0	0	0							**34,860,748**	**36,503**	**$ 1,030,514**
Total Cost	$			-	$		**709,237**	$		**84,722**	$		**236,555**	$		-									

Summary

Tag	Heat Pump Summary	Tower C LH HHW Gen	Tower C UH HHW Gen	Tower C LH Steam Utilization	Tower C UH Steam Utilization	Tower C LH HHW Utilization	Tower C UH HHW Utilization	Total Saving	
Change Hrs		0	0	0	0			**2,840,552**	**MBH**
Energy Reduction		1,174,434	1,666,118	0	0			**2,974**	**klbs**
Reduction in Cost	$ -	**$ 40,135**	**$ 56,287**	$ -	$ -			**$ 96,422**	

9.4.7 Results

Table 85 summarizes the energy and financial results for this option.

Table 85. M.4 Energy Model Financial Summary

Breakdown of Modification Options														
Option	Description	Estimated Annual Steam Reduction	Estimated Annual Electric Reduction	2024 Estimated Annual CO2 Reduction			First Cost - Estimated			Estimated Annual Energy Cost Savings		With CO2 Tax (2024)		Net Present Value
		Energy	Energy	Steam	Electric	Total	First Cost	Rebate	Net Capex After Rebate	Measure Savings	SPB	CO2 Tax	SPB	20 Year NPV
		Mlbs	kWh	MT CO2e	MT CO2e	MT CO2e	$	$	$	$	Years	$	Years	$
M.4	Tower C Heat Pump	2,974	-64,663	126	-19	107	$ (3,400,390)	$ -	$ (3,400,390)	$ 89,458	38.0	$ 28,659	28.7	-1,106,849.5

Cost Estimates

X	**Placeholder**	**Based on past experience on similar projects. This number could go down or up substantially based on further development.**
	Estimates / Budgetary	Based on some contractor estimates and more refined scope
	Investment Grade / Proposal	Fully developed scope, subcontractor pricing, ready for design build proposal and management approval

Savings Calculations and Paybacks

	Placeholder	Based on past experience on similar projects. This number could go down or up substantially based on further development.
	Estimates / Budgetary	Energy model build based on final scope.
X	**Investment Grade / Rebate Ready**	**Fully developed energy model calibrated with full QA/QC**

9.5 M.5, Tower D: Decentralized Heat Pump

This section outlines the proposed modification and system descriptions, controls strategy, analysis of the proposed modifications, and first cost analysis for the energy conservation measure for the Tower D decentralized heat pump.

9.5.1 Proposed Modification Description

The team proposes the following modifications to the current system:

- Installing a heat pump at the building level
- Modifying the heating hot water distribution piping
- Replacing select non-100% outdoor air unit steam coils with heating hot water coils
- Replacing select 100% outdoor air unit steam coils with hot water coils
- Replacing steam-to-hot water domestic hot water heaters with water-to-water domestic hot water heaters
- Implementing associated controls.

9.5.2 Proposed System Description

The team proposes the following system configuration and integration for Tower D:

- Install a heat pump in the building penthouse using the building's chilled water as the heat source. The 275-ton heat pump will generate 130°F heating hot water supply temperature.
- Tap into the AC-35D chilled water coil and the secondary chilled water return to provide the chilled water supply to the heat pump.
- Tap the heating hot water distribution from the heat pump into the existing heating hot water return piping to preheat the heating hot water before it enters the heat exchangers for the following units:
  - HX-5D
  - HX-1D

9.5.3 Proposed Controls Strategy

The team proposes the following controls strategy and adjustments to optimize the system's performance:

- **Tower D Plant heat pump:** Install a new heat pump in building D plant. The heat pump will operate to maintain the heating hot water distribution set-point, which will adjust based on the outdoor air temperature. All building equipment must coordinate with this set-point.
- **Air handling units:** The heating hot water will feed AC-35D to provide heating to the 100% outdoor air. If the mixed air temperature exceeds the acceptable level for an individual floor. The compartment unit's chilled water will trim the mixed air temperature per floor.
- **Heating hot water:** The heat pump–generated heating hot water will blend with the heating hot water return to maintain the heating hot water set-point. If the heat pump–generated hot water is

insufficient to maintain the local heating hot water set-point, the existing steam-to-hot water heat exchanger will trim to maintain the local set-point.

9.5.4 Analysis of Proposed Modification: Base Case and Energy Conservation Measures

The team proposes the following modeling process for this energy conservation measure.

- **Base case:**
  - Model the base case using an 8760 Excel model built solely for each heating load.
  - Implement the schedules and controls strategy for each unit.
- **Energy conservation measure analysis:**
  - Incorporate a switch into the base model to toggle the heat pump on and off, with an adjustable heating hot water supply temperature. This hourly supply temperature dictates how much heating can transfer from steam to the heat pump. The model calculates a heating hot water flow profile based on the calculated load and differential temperature.
  - Use this flow to calculate the energy conservation of the new heating hot water pump.
  - Use this heating load to calculate the heat pump power draw using factory equipment data. The existing plant chiller 8,760-kW/ton profile is used to calculate the reduction in power consumption for the existing plant.

9.5.5 First Cost Analysis

Smith Engineering produced an estimate for the first cost of this option, which totals $3,158,404.

Table 86 details these costs.

Table 86. M.5 Energy Model Tower D Estimated Heat Pump Cost

Opinion of Probable Construction Cost

Date: Wednesday, March 1, 2023
Client: Brookfield
For M.5 - Tower D
Project: BFPL Community Heat Pump Stg A

Basis of Estimate ☐ No Design ☑ Conceptual Design ☐ Final Design ☐ Actual Cost

Item #	Description	Quantity	Units	Material Cost per Unit	Total Material Cost	Labor Hour	Labor Cost per Hour	Total Labor Cost	Total Cost
	Division 01000 - General								
1	Permits and Filing	1		$ 35,000	$ 35,000	125	$ 250	$ 31,250	$ 66,250
2	Superintended	1		$ -	$ -	250	$ 225	$ 56,250	$ 56,250
3	Demolition and Protection	1		$ 25,000	$ 25,000	350	$ 195	$ 68,250	$ 93,250
4	Rigging	1		$ 150,000	$ 150,000	500	$ 225	$ 112,500	$ 262,500
5	Gen Conditions	1		$ 35,000	$ 35,000	250	$ 195	$ 48,750	$ 83,750
	Subtotal				**$ 245,000**	1475		**$ 317,000**	**$ 562,000**
	Division 23000 - Mechanical								
1	Heat Pump	1		$ 412,500	$ 412,500	325	$ 250	$ 81,250	$ 493,750
2	Plant Piping and Insulation	1		$ 103,125	$ 103,125	200	$ 250	$ 50,000	$ 153,125
3	Piping into 100% OA CC	1		$ 65,000	$ 65,000	250	$ 250	$ 62,500	$ 127,500
4	Tempered Loop HX-1D	1		$ 65,000	$ 65,000	300	$ 250	$ 75,000	$ 140,000
5									
6									
7									
8									
9									
	Subtotal				**$ 645,625**	1075		**$ 268,750**	**$ 914,375**
	Division 25000 - Controls								
1	Schneider Software Prog and Graphics	1		$ 20,000	$ 20,000	275	$ 300	$ 82,500	$ 102,500
2	Hardware and Labor	1		$ 35,000	$ 35,000	250	$ 300	$ 75,000	$ 110,000
3					$ -			$ -	$ -
	Subtotal				**$ 55,000**	525		**$ 157,500**	**$ 212,500**
	Division 26000 - Electrical								
1	Power Conduit and Wiring	1		$ 95,000	$ 95,000	400	$ 275	$ 110,000	$ 205,000
2	Controls Conduit and Wiring	1		$ 35,000	$ 35,000	250	$ 275	$ 68,750	$ 103,750
3					$ -			$ -	$ -
	Subtotal				**$ 130,000**	650		**$ 178,750**	**$ 308,750**
	Subtotal			Multiplier	**$ 1,075,625**		Multiplier	**$ 922,000**	**$ 1,997,625**
	Contingency			10%	$ 107,563		10%	$ 92,200	$ 199,763
	Subtotal				**$ 1,183,188**			**$ 1,014,200**	**$ 2,197,388**
	Construction Management Overhead			10%	$ 118,319		10%	$ 101,420	$ 219,739
	Profit			10%	$ 118,319		10%	$ 101,420	$ 219,739
	Subtotal Construction				**$ 1,419,825**			**$ 1,217,040**	**$ 2,636,865**
	Tax			8.875%	$ 126,009		0%	$ -	$ 126,009
	Design Engineering							$ 210,949	$ 210,949
	Construction Administration							$ 105,475	$ 105,475
	Commissioning							$ 79,106	$ 79,106
	Total Estimated Cost	**$**							**3,158,404**

9.5.6 Operational and Economic Analysis

Table 87 and Table 88 summarize the energy and financial results for this option.

Table 87. M.5 Energy Model Tower D Heating Summary

Tower D Heating | **Measure:** | **M.5 - Central Plant Heat Pump - Tower D** | **Date:** 11/14/2022 | **Client:** Brookfield

Project: **Community Heat Pump**

Calculation Method: 8,760

Basis: ☐ Installed ☑ Conceptual Design ☐ Final Design

Equipment Efficiency: ☐ Actual Dynamic ☑ Manufacturer Dynamic

Utility Rate Data

Utility		Blend Rate	
Winter Steam	$	36.000	$/klb
Summer Steam	$	18.000	$/klb
	$	-	$/klb
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Design

Existing Operation

Tag	Heat Pump Summary				Tower D LH HHW Gen			Tower D UH HHW Gen			Tower D LH Steam Utilization			Tower D UH Steam Utilization			Tower D LH HHW Utilization			Tower D UH HHW Utilizatio					
	LH HP		UH HP																						
	HP MBH	Max HP HHW Flow	HP MBH	Max HP HHW Flow	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Total MBH	Total klbs	Sum Cost
Jan	0	0	0	0.00	720	3,417,836	3,579	731	1,993,424	2,087	459	1,406,411	1,473	0	0	0.00							6,817,671	7,139	$ 257,001
Feb	0	0	0	0.00	566	2,787,611	2,919	610	1,378,504	1,443	373	1,082,541	1,134	0	0	0.00							5,248,655	5,496	$ 197,855
Mar	0	0	0	0.00	632	3,125,735	3,273	680	1,839,320	1,926	426	1,240,808	1,299	0	0	0.00							6,205,864	6,498	$ 233,938
Apr	0	0	0	0.00	540	1,805,339	1,890	422	613,571	642	282	179,236	188	0	0	0.00							2,598,146	2,721	$ 48,970
May	0	0	0	0.00	558	1,584,368	1,659	313	430,258	451	276	73,054	76	0	0	0.00							2,087,680	2,186	$ 39,349
Jun	0	0	0	0.00	540	1,144,251	1,198	59	76,051	80	79	3,795	4	0	0	0.00							1,224,098	1,282	$ 23,072
July	0	0	0	0.00	558	1,131,227	1,185	2	2,335	2	9	0	0	0	0	0.00							1,133,561	1,187	$ 21,366
Aug	0	0	0	0.00	558	1,134,113	1,188	10	11,894	12	46	0	0	0	0	0.00							1,146,007	1,200	$ 21,600
Sep	0	0	0	0.00	540	1,167,783	1,223	84	107,709	113	113	8,370	9	0	0	0.00							1,283,862	1,344	$ 24,198
Oct	0	0	0	0.00	558	1,639,048	1,716	278	405,915	425	223	149,149	156	0	0	0.00							2,194,112	2,297	$ 82,710
Nov	0	0	0	0.00	568	2,786,238	2,918	640	1,204,441	1,261	401	802,448	840	0	0	0.00							4,793,127	5,019	$ 180,683
Dec	0	0	0	0.00	715	3,480,368	3,644	737	2,416,378	2,530	460	1,625,549	1,702	0	0	0.00							7,522,295	7,877	$ 283,563
Total	0	0	0	0.00	7,053	25,203,917	26,392	4,566	10,479,799	10,974	3,147	6,571,362	6,881	0	0	0	0	0	0	0	0	0	**42,255,078**	**44,246**	**$ 1,414,306**
Total Cost	$ -				$ **799,930**			$ **371,644**			$ **242,732**			$ -											

M.5 - Central Plant Heat Pump - Tower D

Utility Rate Data

Utility		Blend Rate	
Winter Steam	$	36.000	$/klb
Summer Steam	$	18.000	$/klb
0	$	-	$/klb
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Modified Operation

Tag	Heat Pump Summary				Tower D LH HHW Gen			Tower D UH HHW Gen			Tower D LH Steam Utilization			Tower D UH Steam Utilization			Tower D LH HHW Utilization			Tower D UH HHW Utilizatio					
	LH HP		UH HP																						
	HP MBH	Max HP HHW Flow	HP MBH	Max HP HHW Flow	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Hours	MBH	klbs	Total MBH	Total klbs	Sum Cost
Jan	0	0	525,960	562.53	720	3,246,618	3,400	731	1,467,464	1,537	459	1,406,411	1,473	0	0	0.00							6,120,494	6,409	$ 230,720
Feb	0	0	298,428	562.53	566	2,657,477	2,783	610	1,080,076	1,131	373	1,082,541	1,134	0	0	0.00							4,820,093	5,047	$ 181,700
Mar	0	0	602,860	562.53	632	2,977,374	3,118	680	1,236,460	1,295	426	1,240,808	1,299	0	0	0.00							5,454,643	5,712	$ 205,620
Apr	0	0	315,004	439.31	540	1,758,934	1,842	422	298,567	313	282	179,236	188	0	0	0.00							2,236,737	2,342	$ 42,158
May	0	0	288,491	439.31	558	1,555,852	1,629	313	141,768	148	276	73,054	76	0	0	0.00							1,770,673	1,854	$ 33,374
Jun	0	0	69,474	439.31	540	1,141,352	1,195	59	6,577	7	79	3,795	4	0	0	0.00							1,151,724	1,206	$ 21,708
July	0	0	2,335	197.05	558	1,131,227	1,185	2	0	0	9	0	0	0	0	0.00							1,131,227	1,185	$ 21,322
Aug	0	0	11,894	274.25	558	1,134,113	1,188	10	0	0	46	0	0	0	0	0.00							1,134,113	1,188	$ 21,376
Sep	0	0	95,404	439.31	540	1,163,552	1,218	84	12,305	13	113	8,370	9	0	0	0.00							1,184,226	1,240	$ 22,320
Oct	0	0	182,443	439.31	558	1,606,038	1,682	278	223,472	234	223	149,149	156	0	0	0.00							1,978,659	2,072	$ 74,588
Nov	0	0	257,571	562.53	568	2,666,661	2,792	640	946,870	991	401	802,448	840	0	0	0.00							4,415,979	4,624	$ 166,466
Dec	0	0	857,156	562.53	715	3,299,747	3,455	737	1,559,222	1,633	460	1,625,549	1,702	0	0	0.00							6,484,518	6,790	$ 244,443
Total	0	0	3,507,018	456.71	7,053	24,338,943	2123.82	4,566	6,972,781	7,301	3,147	6,571,362	6,881	0	0	0							**37,883,085**	**39,668**	**$ 1,265,795**
Total Cost	$ -				$ **768,871**			$ **254,193**			$ **242,732**			$ -											

Summary

Tag	Heat Pump Summary	Tower D LH HHW Gen	Tower D UH HHW Gen	Tower D LH Steam Utilization	Tower D UH Steam Utilization	Tower D LH HHW Utilization	Tower D UH HHW Utilizatio	Total Saving	
Change Hrs		0	0	0	0			**4,371,992**	**MBH**
Energy Reduction		864,974	3,507,018	0	0			**4,578**	**klbs**
Reduction in Cost	$ -	$ **31,060**	$ **117,451**	$ -	$ -			**$**	**148,511**

Table 88. M.5 Energy Model Tower D Cooling Summary

Chiller Plant Operational Data	**Measure:**	**M.5 - Tower D Heat Pump**	**Date:** 11/14/2022	**Client:** Brookfield
			Project:	**Community Heat Pump**

Calculation Method: Baseline - Design, Trended

Basis: ☐ Installed ☑ Conceptual Design ☐ Final Design

Equipment Efficiency: ☑ Actual Dynamic

Utility Rate Data

Utility		Blend Rate	
Elec	$	0.092	$/kWh
Elec Dmd	$	-	$/kW
Gas	$	-	$/Therm
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Existing Operation

Tag	CHW Plant																							
	Hours	kTon-Hrs	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Plant Peak Demand	Demand Cost	Plant kWh	Energy (kWh) Cost	Total Cost
Jan	60	1,447	107,333	0.09																2,696	$ 30,597	107,333	$ 9,875	$ 40,472
Feb	360	1,394	680,413	0.49																5,148	$ 18,539	680,413	$ 62,598	$ 81,137
Mar	727	1,655	1,538,161	0.94																5,283	$ 20,771	1,538,161	$ 141,511	$ 162,282
Apr	720	1,588	1,506,940	0.96																6,129	$ 25,966	1,506,940	$ 138,638	$ 164,604
May	744	2,000	1,918,768	0.98																7,386	$ 68,073	1,918,768	$ 176,527	$ 244,600
Jun	720	2,803	2,414,972	0.91																7,562	$ 178,622	2,414,972	$ 222,177	$ 400,800
July	744	3,121	2,520,502	0.86																7,500	$ 160,134	2,520,502	$ 231,886	$ 392,020
Aug	744	3,081	2,537,487	0.88																7,498	$ 177,095	2,537,487	$ 233,449	$ 410,544
Sep	720	2,478	2,126,600	0.93																7,471	$ 154,435	2,126,600	$ 195,647	$ 350,083
Oct	744	1,717	1,564,803	1.01																6,033	$ 62,980	1,564,803	$ 143,962	$ 206,942
Nov	720	1,279	1,355,734	1.10																5,070	$ 23,236	1,355,734	$ 124,728	$ 147,964
Dec	728	999	923,479	0.99																3,687	$ 12,704	923,479	$ 84,960	$ 97,664
Total	7,731	23,563	19,195,193	0.84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**Peak**	**$ 933,152**	**19,195,193**	**$ 1,765,958**	**$ 2,699,110**
Total Cost	$ **1,765,958**				$ -			$ -			$ -			$ -			$ -			**7,562**				

M.5 - Tower D Heat Pump

Utility Rate Data

Utility		Blend Rate	
Elec	$	0.092	$/kWh
Elec Dmd	$	-	$/kW
Gas	$	-	$/Therm
Swr	$	-	$/hcf
Wtr	$	-	$/hcf

Modified Operation

Tag	CHW Plant				CH-1 (Heat Pump)			HHW Pumps																
	Hours	kTon-Hrs	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Hours	kWh	kW/Ton	Plant Peak Demand	Demand Cost	Plant kWh	Energy (kWh) Cost	Total Cost
Jan	60	1,415	106,900	0.09	744	22,374	1.3	744	6,672	0.03										2,696	$ 30,597	135,947	$ 12,507	$ 43,104
Feb	360	1,376	675,053	0.49	672	16,174	1.3	672	5,320	0.0										5,175	$ 18,539	696,548	$ 64,082	$ 82,621
Mar	727	1,619	1,510,757	0.95	744	28,407	1.3	744	6,077	0.0										5,378	$ 20,932	1,545,241	$ 142,162	$ 163,094
Apr	720	1,569	1,489,352	0.97	720	24,712	1.3	720	3,057	0.1										6,199	$ 25,966	1,517,121	$ 139,575	$ 165,541
May	744	1,982	1,911,740	0.98	744	22,632	1.3	744	2,144	0.1										7,386	$ 68,860	1,936,516	$ 178,159	$ 247,019
Jun	720	2,799	2,411,387	0.91	720	5,450	1.3	720	356	0.0										7,562	$ 178,622	2,417,193	$ 222,382	$ 401,004
July	744	3,121	2,520,410	0.86	744	183	1.3	744	7	0.0										7,500	$ 160,134	2,520,600	$ 231,895	$ 392,029
Aug	744	3,081	2,537,483	0.88	744	933	1.3	744	40	0.0										7,498	$ 177,095	2,538,456	$ 233,538	$ 410,633
Sep	720	2,472	2,123,419	0.93	720	7,484	1.3	720	490	0.0										7,471	$ 154,435	2,131,393	$ 196,088	$ 350,524
Oct	744	1,706	1,556,887	1.02	744	14,312	1.3	744	2,034	0.0										6,033	$ 62,980	1,573,234	$ 144,738	$ 207,718
Nov	720	1,263	1,329,389	1.10	720	17,558	1.3	720	5,407	0.1										5,070	$ 23,941	1,352,355	$ 124,417	$ 148,357
Dec	728	951	892,436	1.00	744	35,471	1.3	744	6,849	0.0										3,687	$ 14,796	934,757	$ 85,998	$ 100,794
Total	7,731	23,356	19,065,215	0.85	8,760	195,691	1.3	8,760	38,454	0.03	0	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!	**Peak**	**$ 936,897**	**19,299,361**	**$ 1,775,541**	**$ 2,712,438**
Total Cost	$ **1,754,000**				$ **18,004**			$ **3,538**			$ -			$ -			$ -			**7,562**				

Summary

Tag	CHW Plant	CH-1 (Heat Pump)	HHW Pumps	0	0	0		
Change Hrs	0	-8,760	-8,760	0	0	0	**0**	**kW**
Energy Savings	129,977	-195,691	-38,454	0	0	0	**-104,168**	**kWh**
Reduction in Cost	**$ 11,958**	**$ (18,004)**	**$ (3,538)**	**$ -**	**$ -**	**$ -**	**$**	**(13,328)**

9.5.7 Results

Table 89 summarizes the energy and financial results for this option.

Table 89. M.5 Energy Model Financial Summary

Breakdown of Modification Options														
Option	Description	Estimated Annual Steam Reduction	Estimated Annual Electric Reduction	2024 Estimated Annual CO2 Reduction			First Cost - Estimated			Estimated Annual Energy Cost Savings		With CO2 Tax (2024)		Net Present Value
		Energy	Energy	Steam	Electric	Total	First Cost	Rebate	Net Capex After Rebate	Measure Savings	SPB	CO2 Tax	SPB	20 Year NPV
		Mlbs	kWh	MT CO2e	MT CO2e	MT CO2e	$	$	$	$	Years	$	Years	$
M.5	Tower D Heat Pump	4,578	-104,168	193	-30	163	$ (3,158,404)	$ -	$ (3,158,404)	$ 135,183	23.4	$ 43,750	17.6	316,027.0
Cost Estimates														
X	**Placeholder**	**Based on past experience on similar projects. This number could go down or up substantially based on further development.**												
	Estimates / Budgetary	Based on some contractor estimates and more refined scope												
	Investment Grade / Proposal	Fully developed scope, subcontractor pricing, ready for design build proposal and management approval												
Savings Calculations and Paybacks														
	Placeholder	Based on past experience on similar projects. This number could go down or up substantially based on further development.												
	Estimates / Budgetary	Energy model build based on final scope.												
X	**Investment Grade / Rebate Ready**	**Fully developed energy model calibrated with full QA/QC**												

10 Conclusion and Recommendations

10.1 Subject and Purpose

This report presents the preliminary findings of a Smith Engineering study that Brookfield Properties and NYSERDA commissioned to conduct a community heat pump feasibility study at the 250 Vesey St. facility in New York, NY.

10.2 Conclusion

The complex experiences a significant amount of simultaneous heating and cooling—creating an opportunity for a heat pump application. Initially, the central heat pump option appeared more attractive since it could effectively leverage the site's diversity. The site offers substantial carbon reduction potential. As the carbon content of electricity decreases, these measures will improve annual carbon reduction and account for a higher percentage of the total site reduction.

Table 90. Financial Summary of Modifications

Breakdown of Modification Options														
Option	Description	Estimated Annual Steam Reduction	Estimated Annual Electric Reduction	2024 Estimated Annual CO2 Reduction			First Cost - Estimated			Estimated Annual Energy Cost Savings		With CO2 Tax (2024)		Net Present Value
		Energy	Energy	Steam	Electric	Total	First Cost	Rebate	Net Capex After Rebate	Measure Savings	SPB	CO2 Tax	SPB	20 Year NPV
		Mlbs	kWh	MT CO2e	MT CO2e	MT CO2e	$	$	$	$	Years	$	Years	$
M.1	Central Heat Pump	113,650	-4,739,842	4,800	-1,370	3,430	$ (35,657,579)	$ -	$ (35,657,579)	$ 2,971,526	12.0	$ 919,313	9.2	$ 39,892,695
M.2	Tower A Heat Pump	5,954	-271,945	251	-79	173	$ (3,741,971)	$ -	$ (3,741,971)	$ 118,944	31.5	$ 46,334	22.6	$ (532,686)
M.3	Tower B Heat Pump	11,324	-467,814	478	-135	343	$ (3,210,609)	$ -	$ (3,210,609)	$ 267,538	12.0	$ 91,940	8.9	$ 3,769,543
M.4	Tower C Heat Pump	2,974	-64,663	126	-19	107	$ (3,400,390)	$ -	$ (3,400,390)	$ 89,458	38.0	$ 28,659	28.7	-1,106,849.5
M.5	Tower D Heat Pump	4,578	-104,168	193	-30	163	$ (3,158,404)	$ -	$ (3,158,404)	$ 135,183	23.4	$ 43,750	17.6	316,027.0
Cost Estimates														
X	**Placeholder**		**Based on past experience on similar projects. This number could go down or up substantially based on further development.**											
	Estimates / Budgetary		Based on some contractor estimates and more refined scope											
	Investment Grade / Proposal		Fully developed scope, subcontractor pricing, ready for design build proposal and management approval											
Savings Calculations and Paybacks														
	Placeholder		Based on past experience on similar projects. This number could go down or up substantially based on further development.											
	Estimates / Budgetary		Energy model build based on final scope.											
X	**Investment Grade / Rebate Ready**		**Fully developed energy model calibrated with full QA/QC**											

10.3 Recommendations

Smith Engineering recommends proceeding to the next task: determining the system costs.

11 Results Impact and Lessons Learned

11.1 Results Impact

The opportunity to reduce carbon emissions and operating expenses is significantly greater than initially considered with the plant option. The Central Plant option offers substantial advantages over the distributed model because it directs heating and cooling where needed. In the distributed model, operating a heat pump is less beneficial when Tower C is cooling-dominant and Tower B is heating-dominant compared to the Central Plant model.

11.2 Key Takeaways

The following lessons highlight key takeaways from the project:

- **Takeaway 1:** The large, complex site posed complex challenges in distributing large-diameter piping across the 14-acre campus. The team conducted an extensive site investigation to address these challenges.
- **Takeaway 2:** The team found the cost-benefit of individual loads to be highly beneficial. A 7,000-MBH load near the piping mains provided an attractive return on investment per ton of CO_2 saved. In contrast, a 70-MBH load, located multiple levels away and thousands of feet from the mains, resulted in a much lower return on investment. The embodied carbon for the latter may never be recouped through the carbon savings.
- **Takeaway 3:** The original design of the facility, with 160°F–140°F hot water on the non-steam heating units, significantly improved the project's feasibility.
- **Takeaway 4:** The team faced challenges fitting the larger York CYK heat pump into an existing New York City building.
- **Takeaway 5:** Understanding the existing control strategies for all heating equipment allowed the team to assess the feasibility more accurately when determining load-by-load return on investment.

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