Community Heat Pump Feasibility Study: LeFrak City, Queens, NY

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Final Report

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Abstract

The LeFrak City residential complex consists of 4,605 apartments with 20 apartment towers with 17 stories each, 2 large commercial/office buildings, and a retail strip. This development covers 40 acres and houses more than 14,000 people.

A series of natural gas-fired steam boilers with steam-to-hot-water heat exchangers provide hot water (HW) for space heating and domestic use to the 20 buildings, except for the Paris and London buildings, which have upgraded HW boilers. Given the scale and setup, LeFrak City presents a potential option for National Grid thermal network pilot projects. A feasibility study for a community heat pump system at Lefrak City has been completed, identifying significant potential benefits for Lefrak City.

Thermal models of the buildings simulated the hourly aggregated thermal profile of the complex during a typical meteorological year, creating 8,760 models. These models were used to evaluate three heating scenarios, leading to the development of three design options (A, B, and C), which combined several heating scenarios. A 25-year life-cycle cost analysis showed that the new design options had higher costs than the business-as-usual case. However, when cost-sharing from the New York State Energy Research and Development Authority (NYSERDA) Program Opportunity Notice (PON) 4614 program and rebate incentives from the Consolidated Edison Clean Heat Program are included, the new options became more cost-effective, despite an increase in operating cost due to the electrification of the heating system and current energy rates. Nevertheless, including avoided carbon fines from New York City Local Law 97 (LL97) reduced operating costs, resulting in payback periods ranging from 3.1 to 6.3 years.

Keywords

campus district thermal system loop, community heat pump, feasibility study, energy efficiency, electrification, centralized energy plant, heat recovery, life-cycle cost analysis, Local Law 97, in-kind equipment, Turnkey, PPA

Acknowledgments

Analysis of Scenario 3 in this report, used the 8760 rejected heat calculations provided by (Steven Winter Associates, Inc.) from refrigeration system of 59-17 Junction Blvd office building.

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Acronyms and Abbreviations

°F	degrees Fahrenheit
A	amperes
AHJ	authority having jurisdiction
ASHP	air-source heat pump
BESS	electric battery technologies systems
Btu	British thermal unit
CHW	chilled water
CO_2eq	carbon dioxide equivalent
COP	coefficient of performance
DEC	New York State Department of Environmental Conservation
DEP	New York City Department of Environmental Protection
DHW	domestic hot water
DOB	New York City Department of Buildings
ECM	energy conservation measure
ESCO	energy service company
EV	electric vehicle
GPH	gallons per hour
GPM	gallons per minute
HVAC	heating, ventilation, & air conditioning
HW	hot water
kBtu	one thousand British thermal unit
kW	kilowatt
kWh	kilowatt hours
LL97	New York City Local Law 97
MBH	thousands of Btus per hour
NYSERDA	New York State Energy Research and Development Authority
PSC	New York State Public Service Commission
PCMs	phase change materials
PPA	power purchase agreement
PV	photovoltaic
ROI	return on investment
S&R	supply and return
tCO_2eq	metric tons of carbon dioxide equivalent
Therm	100,000 British thermal units
V	volts
VFD	Variable Frequency Drive

Executive Summary

The LeFrak City, a residential complex in Queens, NY, features 4,605 apartments, and occupies the southernmost region of Corona and the easternmost part of Elmhurst. The complex comprises 20 apartment towers with 17 stories each, 2 large commercial buildings, and a retail strip, spanning 40 acres; and houses more than 14,000 residents. LeFrak organization owns the property, which primarily serves low- to moderate-income individuals.

A series of natural gas-fired steam boilers with steam-to-hot-water heat exchangers provide hot water (HW) for space heating and domestic hot water (DHW) to the 20 buildings. The Paris and London buildings have upgraded HW boilers. Each boiler plant has its own gas service from National Grid and serves two buildings. Two-boiler plants form a cluster that serves four buildings. Given its structure, LeFrak City is a potential candidate for National Grid's thermal network pilot projects.

During the preliminary stage of the feasibility study, the design team identified opportunities to increase thermal system efficiency, such as using steam boilers in the summer to provide DHW at low capacity and efficiency rates. The team concluded that electrifying the thermal system in the residential complex was the best solution. This approach involved replacing nearly 30-year-old boilers, using the existing connected basements between buildings to share the thermal load, and integrating the commercial/office building into the design. Extending a district loop to serve multiple buildings would enhance the system's resiliency.

The team studied various scenarios by grouping buildings based on site configuration and orientation. In one scenario, the team determined that combining the two buildings under a single boiler plant was advantageous for the upgrade. In another scenario, combining the two two-boiler plants that serve four buildings into one large HW plant sharing thermal load was effective. A third scenario explored an energy conservation measure (ECM) to share a district HW loop among several HW plants and clusters. The team evaluated these scenarios individually and in groups to shape three major design options. The goal was to select the optimum technology that met the New York State Energy Research and Development Authority's (NYSERDA) and the client's vision of electrifying the thermal system and reducing carbon emissions to meet New York City Local Law 97 (LL97) emission limits.

The project scope includes a standard heat loop to enable heating plants to share loads and capacity, an electric DHW heat pump, heat recovery from the new office building's heating, ventilation, and air conditioning (HVAC) system. The system also provides general cooling from the DHW heat pump's cold water loop and cools the return side of the district loop before it enters the office building's chilled water system. This system aims to reduce cooling tower operation hours and costs. The shared heat loop among heating plants allows redundancy for DHW heating and boiler HVAC loop heating. If one boiler plant fails, another heating plant can provide backup heating via a heat exchanger.

The feasibility study for the community heat pump system at Lefrak City, partially funded by the NYSERDA, has been completed and identifies significant potential benefits. The study lays the groundwork for further NYSERDA and additional funding for the design and construction phases.

The study presents various project options regarding scope and benefits and suggests that project construction might occur in phases. The total core project cost is approximately $7,300,000, offering significant energy savings with potential net savings of up to $200,000 annually. Combining energy efficiency measures and new equipment could help avoid potential LL97 penalties of $380,00 in 2030 and $665,000 in 2035. Additionally, after 2030, LL97 penalty avoidance on the office building side could increase by around $9,000. This project will also be necessary to the New York City Department of Environmental Protection (DEP), which now oversees all New York City climate-related activities and is headquartered at LeFrak City.

NYSERDA may grant up to $500,000 for the design phase, with construction funding expected to cover about 50% of the construction cost. The owner appreciates NYSERDA's support for this project. We hope the findings will encourage NYSERDA to promote the use of community heat pump systems throughout New York State.

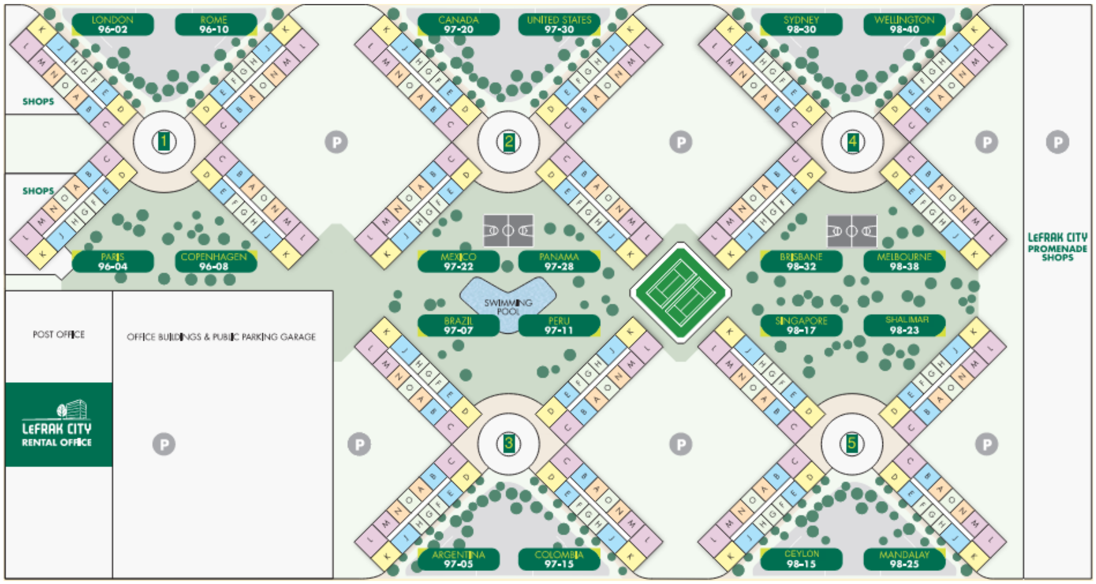
1 Characterization of Proposed Community

LeFrak City is a residential complex consisting of 20 apartment towers with 17 stories each, 2 large commercial buildings, and a retail strip. Due to the complex's size and the number of buildings, the proposed technologies and design can be implemented in phases to address site constraints and facilitate financing for the energy transitions.

1.1 Initial Installation of Buildings Assessed

Figure 1 displays a map of all the buildings, while Table 1 lists their names, addresses, and current arrangements for shared boiler plants and parking garages.

Figure 1. Map of LeFrak Residential Complex Buildings and Clusters



The layout of the residential complex and the connections between buildings can limit options for electrifying the thermal system. Applying the decarbonization method to the shared hot water (HW) system becomes easy when two buildings share a boiler plant, as outlined in scenario 1 of the report. However, when four buildings share a parking garage, additional possibilities for interaction among the four buildings arise through shared systems and the district loop as discussed in scenario 2. Combining the two scenarios involves overcoming site constraints by constructing an underground HW district loop around all or some of the nine plants studied.

Table 1. LeFrak City: Buildings List, Addresses, and Studied Scenarios

Building Number	Street Address	Notes
Building 1, London	96–02 57th Avenue	-Not included in the study -Upgraded HW boilers
Building 2, Paris	96–04 57th Avenue	
Building 3, Copenhagen	96–08 57th Avenue	-Copenhagen & Rome (boiler plant) -Canada & Mexico (boiler plant) -All four buildings share a parking garage (scenario 2)
Building 4, Rome	96–10 57th Avenue	
Building 5, Canada	97–20 57th Avenue	
Building 6, Mexico	97–22 57th Avenue	
Building 7, Argentina	97–05 Horace Harding Expressway	-Argentina & Brazil (boiler plant) -The two buildings share a parking garage (scenario 1)
Building 8, Brazil	97–07 Horace Harding Expressway	
Building 9, Peru	97–11 Horace Harding Expressway	-Peru & Colombia (boiler plant) -Ceylon & Singapore (upgraded boiler plant) -All 4 buildings share a parking garage (scenario 2)
Building 10, Colombia	97–5 Horace Harding Expressway	
Building 11, Ceylon	98 –15 Horace Harding Expressway	
Building 12, Singapore	98–17 Horace Harding Expressway	
building 13, Panama	97–28 57th Avenue	-Panama & USA (boiler plant) -Sydney & Brisbane (boiler plant) -All 4 buildings share a parking garage (scenario 2)
building 14, USA	97–30 57th Avenue	
building 15, Sydney	98–30 57th Avenue	
building 16, Brisbane	98–32 57th Avenue	
Building 17, Shalimar	98–23 Horace Harding Expressway	-Shalimar & Mandalay (boiler plant) -The two buildings share a parking garage (scenario 1)
Building 18, Mandalay	98–25 Horace Harding Expressway	
Building 19, Melbourne	98l38 57th Avenue	-Melbourne & Wellington (boiler plant) -The two buildings share a parking garage (scenario 1)
Building 20, Wellington	98–40 57th Avenue	

1.2 Site Opportunity and Available Data

The executive summary notes that the site includes a commercial high-rise building housing the New York City Department of Environmental Protection (DEP) headquarters. Due to its use as offices, the heating, ventilation, and air conditioning (HVAC) system operates year-round to cool the offices. This constant cooling generates rejected heat from the refrigeration cycle, which is directed to the cooling towers on the roof. Recovering this heat through a district loop could provide a free energy source to heat the domestic hot water (DHW) system in some heating plants.

To explore different technologies and opportunities thoroughly requires a complete 8,760-hour load profile of the heating systems in all buildings, including the end use of this heating for either space heating or DHW. The team created this profile using available utility monthly bills for natural gas services in the 18 buildings assessed and hourly data from National Grid for winter and spring 2022 (from January 1, 2022, to April 30, 2022).

2 Community Energy Conditions

To estimate the campus's heating loads, we needed the peak design building loads and an 8,760-hour load profile to determine the buildings' baseline heating load.

2.1 Estimated Energy Loads

The owner provided 12 electrical bills from October 2021 to September 2022 and thermal natural gas bills from January 2021 to December 2021. Because each boiler plant serves two buildings, we created a baseline of nine models per boiler plant rather than modeling each of the 18 buildings individually in this study.

Figure 2. LeFrak Monthly Natural Gas Consumption per Boiler Plant

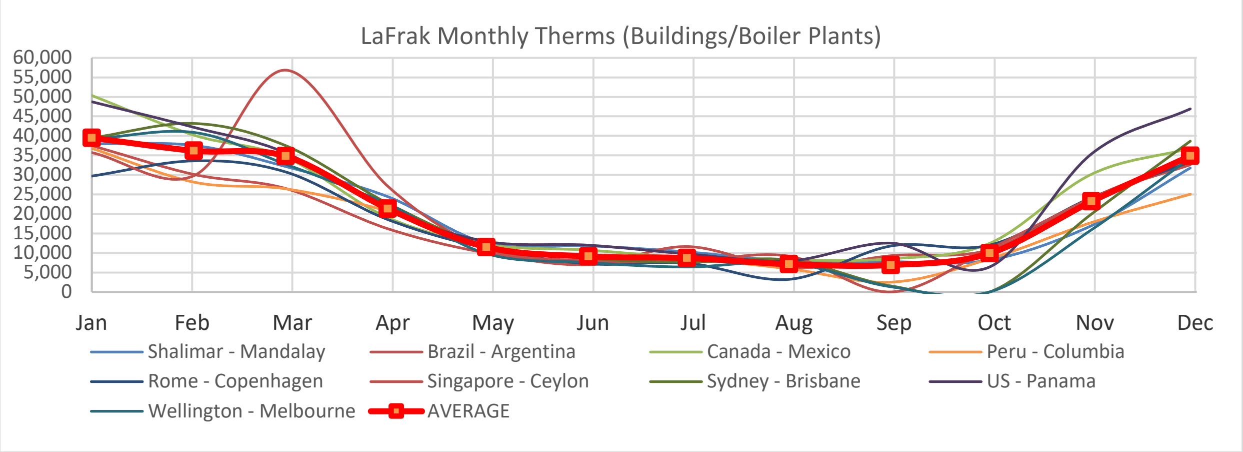
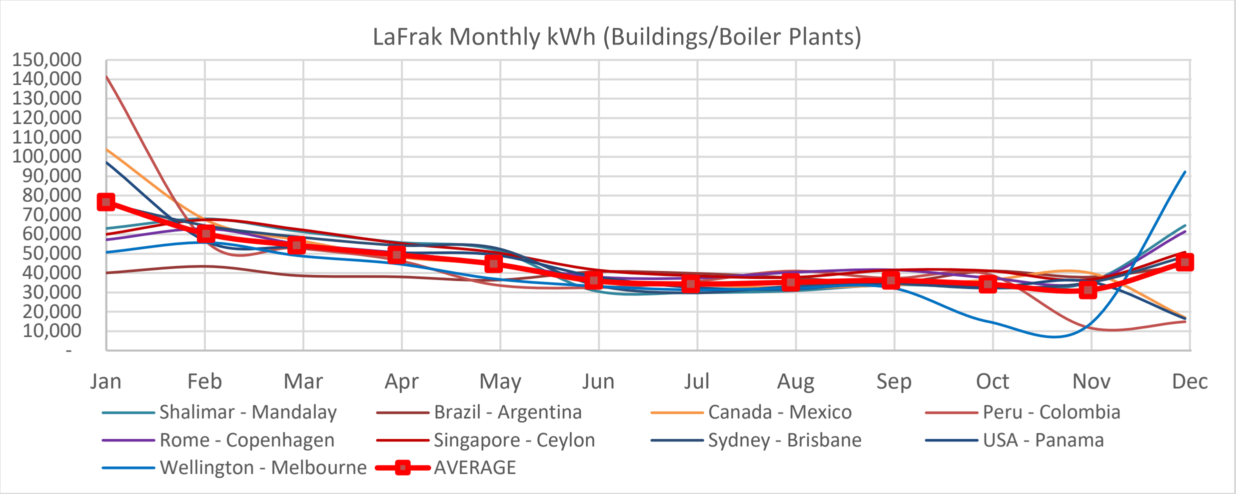


Figure 3. LeFrak Monthly Electricity Consumption per Boiler Plant



2.1.1 Natural Gas Consumption

For DHW at each plant, we assumed that the summer heating load (June to August) was used solely for the DHW load. We considered the typical DHW monthly load constant throughout the year due to the consistent temperature, which was assumed to be 55 degrees Fahrenheit (°F). We then used the average DHW monthly load to calculate the monthly space heating load.

To analyze the plants' gas consumption, the owner provided National Grid's hourly metered data from January 1, 2022, to April 30, 2022. Although this period does not include the summer months, the design team developed a model to align the gas hourly trends with the outdoor temperatures from the same period to establish a typical DHW hourly profile as shown in Figure 4.

Figure 4. Natural Gas Consumption versus Outdoor Ambient Temperature

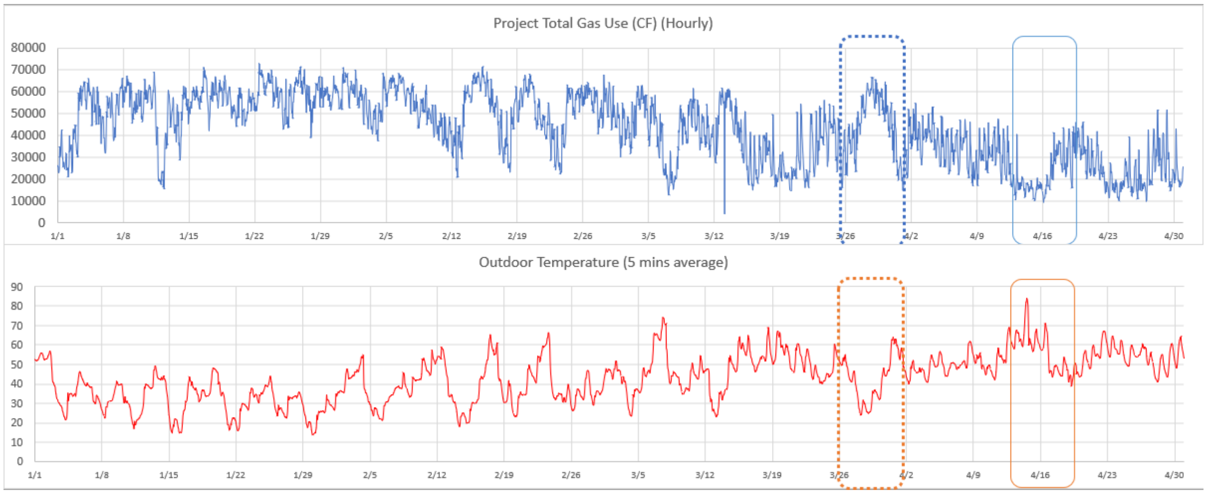
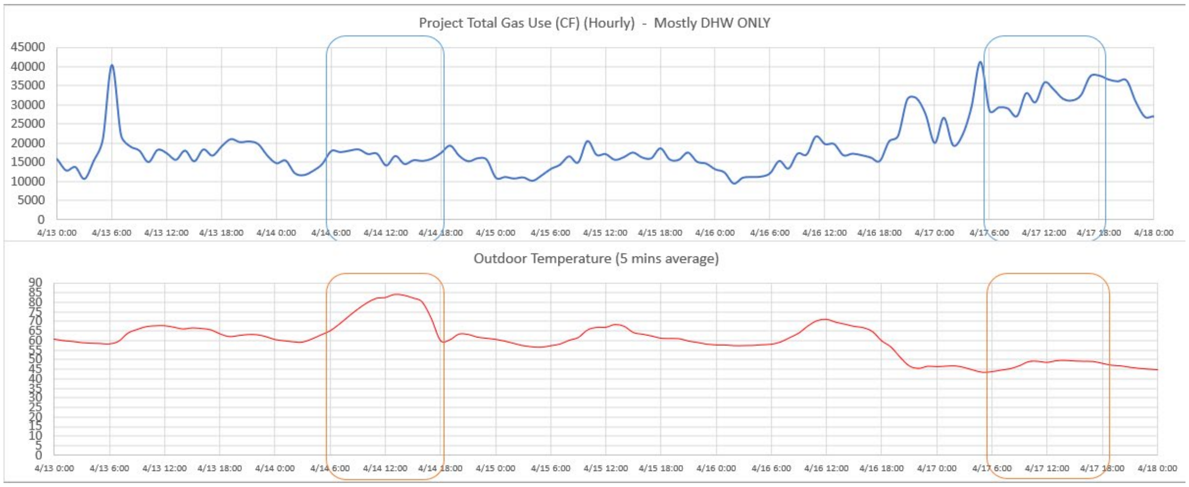


Figure 5. Detailed Trend of Natural Gas Use on a Hot Spring Day



2.1.2 Heating Hourly Profiles

The design team combined the trends provided with their experience in residential building performance and typical DHW consumption in Queens, NY. Using this information, they developed a 24-hour daily profile for DHW and space heating, which was incorporated into the 8,760-hour model for each plant, as shown in Figure 6.

Figure 6. Normalized DHW Load Profile

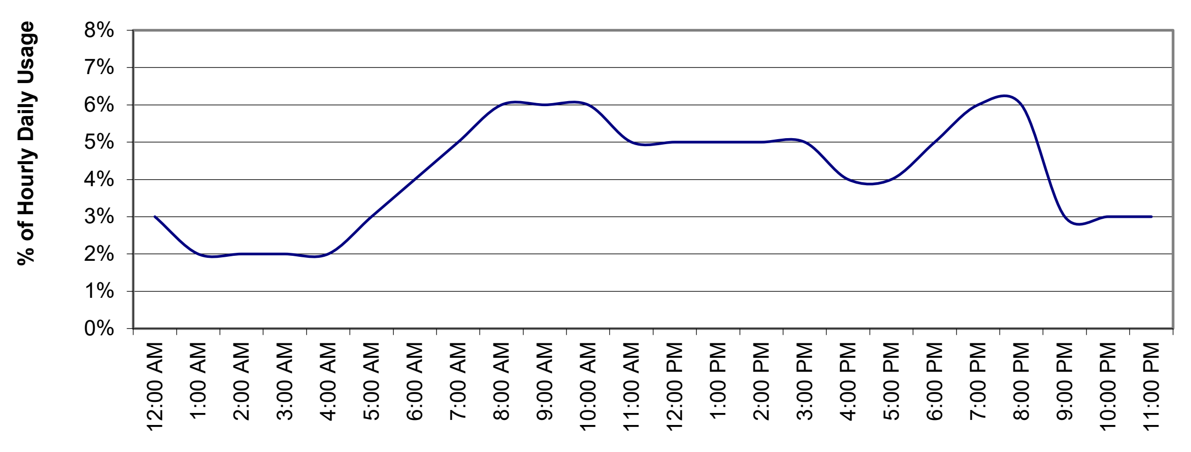
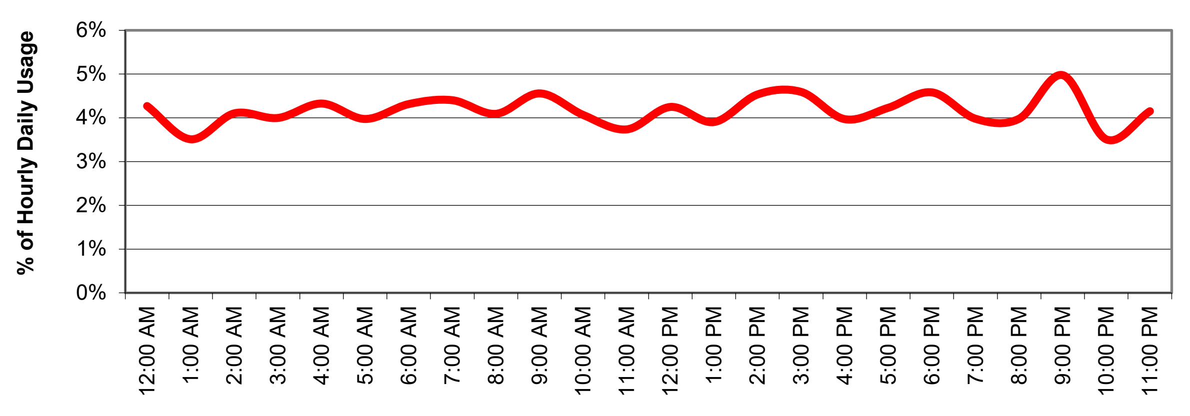


Figure 7. Normalized Space Heating Load Profile



2.2 Baseline Condition

The design team conducted a thorough examination and individual modeling of each of the nine boiler plants. They created an 8,760-hour model for each plan to study hourly natural gas and electricity consumption and to calculate the environmental impact through the carbon footprint, using existing gas-fired boilers with a 65% efficiency. The study also covered life-cycle costs, including the operation of existing boiler plants, their remaining lifespan before needing upgrades or retrofits, and estimated costs for potential future replacements with similar or equivalent equipment. The analysis used anonymized rates from the provided utility bills to estimate the running costs of the plants.

2.2.1 Thermal Model

The model used the efficiency of a typical boiler plant of similar age to calculate the building's actual thermal load for both space heating and DHW. We used this load in the simulation to predict the potential energy use of new future equipment within the heating system.

To estimate the existing running costs, the study assumed an average blended natural gas rate of $1.03 per Therm, reflecting the average natural gas rate in New York City. The owner provided 12 months of utility bills, which only showed supply costs but not delivery costs, necessitating this assumption.

The carbon footprint for each plant was calculated using emission factor rates from New York City agencies and Local Law 97 (LL97) guidance for On-Site Natural Gas Fired equipment, 0.00005311 tCO_2eq (Metric tons of carbon dioxide equivalent) of per one thousand British thermal units (kBtu).

2.3 In-Kind Equipment

Each of the nine existing plants contains two steam 350 horsepower (14700 MBH) gas-fired boilers by (A.L. Eastmond & Sons, Inc.), installed in 1993. These boilers have surpassed the average industrial lifespan of 25 years (with a typical range of 15–30 years), so the study considered the immediate replacement with in-kind equipment a valid option.

The study selected the Cleaver-Brooks (CBLE-700-250-150ST) steam boiler for an in-kind replacement. This boiler has an estimated retail price of $111,000 per unit and an average burner efficiency of 86%, with an assumed boiler cycle efficiency of 82%. Replacing two boilers at each plant would cost approximately $700,000.

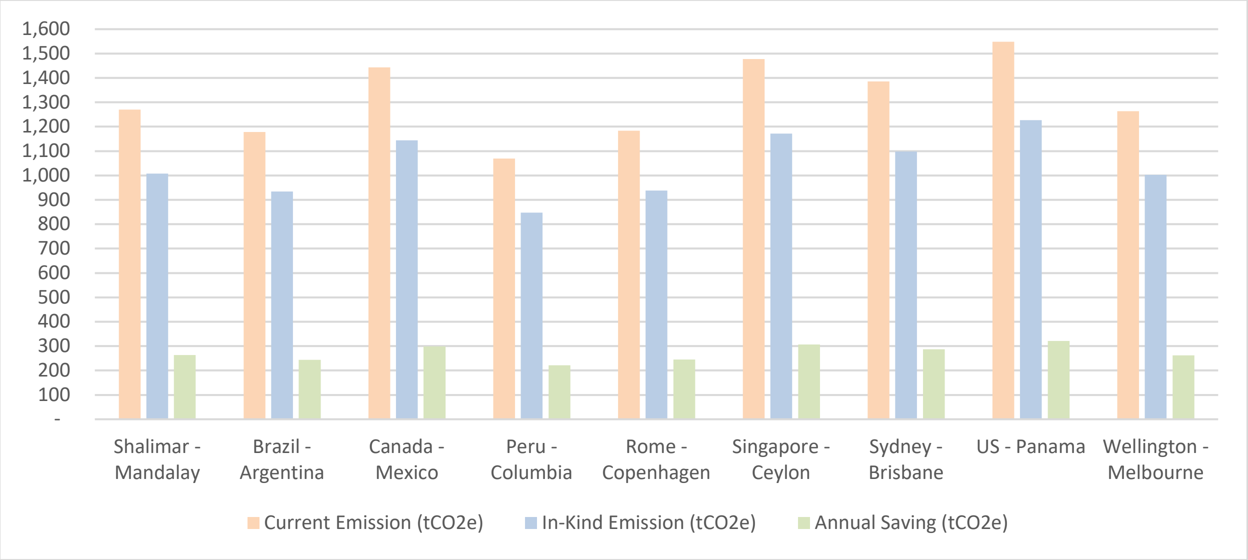
Table 2. Cleaver-Brooks CBLE Efficiencies for 350HP Model

BOILER SIZE	OPERATING PRESSURE = 10 psi			
	% OF LOAD			
	25%	50%	75%	100%
100	84.4	85.0	84.8	84.4
125	83.3	83.6	83.4	83.2
150	84.4	84.6	84.5	84.3
200	85.0	85.3	85.1	84.9
250	85.0	84.7	84.0	83.3
300	85.3	85.3	84.6	83.9
350	85.3	85.7	85.2	84.5
400	84.5	84.7	84.6	84.4
500	85.5	85.7	85.5	85.2
600	85.7	86.0	85.8	85.6
700	85.7	86.2	86.0	85.7
800	85.8	86.1	85.9	85.6

The study of a typical plant showed a 21% savings in thermal energy use, equivalent to $53,000 in annual energy operation cost savings. This results in a 14-year payback period and an annual reduction of 277 tons in carbon dioxide equivalent emissions. Considering LL97, we estimate the average annual savings on the carbon fine per plant after 2030 to be $45,000. This adjustment reduces the simple payback period to 10 years.

Figure 8. In-Kind Replacement

Emissions in tCO_2eq .



3 Technologies Assessed

This energy assessment studied different technologies that the LeFrak residential complex can use to meet the decarbonization plans by electrifying the thermal system as part of the NYSERDA PON 4614 program. The various technologies shaped different design scenarios, with opportunities to integrate some technologies to accelerate the energy transition within the project.

3.1 Basis of Technologies

Once the team created thermal models for every plant, they began investigating the available technologies to find those that best match the building's nature and thermal system end-use. The following subsections of the report present the technologies discussed and their primary purpose.

3.1.1 Hot Water Heat Pumps

The site is ideal for a community heat pump that is heating HW and DHW systems for several reasons. Economic piping installation is possible through basement corridors connecting the buildings. The facility's size and the 18 buildings it serves lead to a diversity load factor that enhances the efficiency of a community loop distribution system.

The heat pump system will provide HW for heating through the building's hydronic DHW heating loops year-round at 120°F. The existing boilers would then need to operate only for additional DHW needs and to provide space heating during colder seasons. The chosen heat pump has an average coefficient of performance (COP) of 2.2, which is efficient compared to the fossil fuels the existing 65% steam boilers consume.

3.1.2 New Efficient Boilers

The report in section 2.3 considered replacing the in-kind natural-fired steam boilers. However, after implementing heat pumps in the heating system, the space heating load proved relatively small compared to existing 350 horsepower (14,700 MBH) steam boilers. Replacing at least one of the existing boilers with a smaller, more efficient unit emerges as a better option. This new boiler would serve as the primary source of space heating and a low-carbon energy source, while the remaining boiler would be used only during extreme cold weather.

3.1.3 District Community Loop

This NYSERDA strategic initiative aims to meet buildings' thermal needs through energy-efficient heat pump technology. The district community loop was studied in various ways and stages. As section 3.1.1 and Table 1 of this report discuss, the shared parking garage among various HW plants makes this site an ideal candidate for the program.

Furthermore, the owner informed the design team about the onsite HVAC system upgrades in the commercial/office building. The heat rejection from the refrigeration system could significantly benefit the district community loop by providing free heat on the DHW side of the residential HW plants. It also offers savings on the commercial building's cooling tower energy consumption, presenting an attractive opportunity to reduce energy consumption and improve the site's reliability.

3.2 Technologies Integration

Integrating previously discussed technologies has successfully leveraged economies of scale and expanded clean energy options. Section 3.1.3 outlines how implementing a HW loop as part of the community thermal energy network has opened up additional opportunities. One idea that emerged after completing the energy study is to use the cold side of the DHW heat pumps to extract heat from the unused refrigeration cycle of commercial buildings before it returns to the cooling tower. This approach repurposes what would otherwise be wasted cold air from the DHW heat pumps, demonstrating another example of effective heat recovery.

4 Results: System Design

This project's executive summary highlighted how the study developed three scenarios for decarbonizing the thermal load using heat pump HW systems. This section discusses the three scenarios and how they shaped the main design options, which were then extensively analyzed for financial feasibility.

4.1 Different Scenarios

During a site visit, the contractor assessed the existing plant conditions and developed a layout plan for the boiler plant mechanical room and the adjacent tank room. These areas are suitable for housing any new additional equipment to the system.

We modeled different scenarios to compare the individual-plant and district-style approaches, with two combined individual plants serving four buildings instead of just two. We created mechanical schematic designs for each scenario to illustrate how connecting two plants through a single loop can enhance the system's resilience and redundancy. This configuration increases equipment lifespan and improves overall maintenance and operations.

Installing heat pumps and high-efficiency boilers (85%–90%) will significantly enhance the heating plant's efficiency compared to the current system. The site will benefit from natural gas savings by using the electric heat pump systems and high-efficiency boilers during months when the larger existing steam boilers are unnecessary.

4.1.1 Proposed Heat Pump and Boiler Plant Sequence of Operation

The heat pump systems at each boiler plant will serve as the primary DHW heaters. DHW heat exchangers, connected to the proposed boiler plant, will handle the remaining loads.

The proposed boilers will operate on their own HW loop and serve DHW loops and heating HW loops. The proposed boilers will be lead boilers during the summer and shoulder months. They will continue to operate until the building heating loads increase. At that point, the existing boilers will activate to handle the additional loads.

The additional gas-fired modular boilers will be sized to offset any additional DHW heating and some boiler HVAC heating during the shoulder seasons. This approach aims to keep the older gas-fired boilers inactive from May through October.

4.1.1.1 Scenario 1a: Heat Pumps Only

This scenario combines two boiler plants to serve four buildings, with the following details:

- Equipment addition: Four DHW heat pumps
- Estimated cost: $1,078,336
- Building pairs investigated (example in Figures 9 and 10):
  - Rome and Copenhagen; Canada and Mexico
  - US and Panama; Sydney and Brisbane
  - Singapore and Ceylon; Peru and Columbia

Figure 9. Scenario 1a: Only Heat Pump, Monthly Energy Use (Existing versus Proposed)

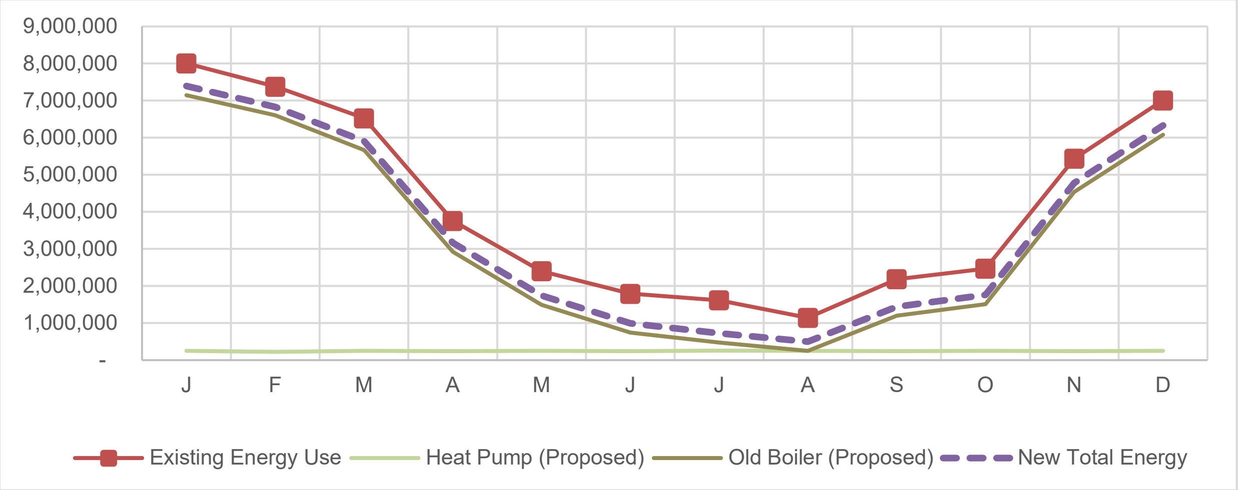
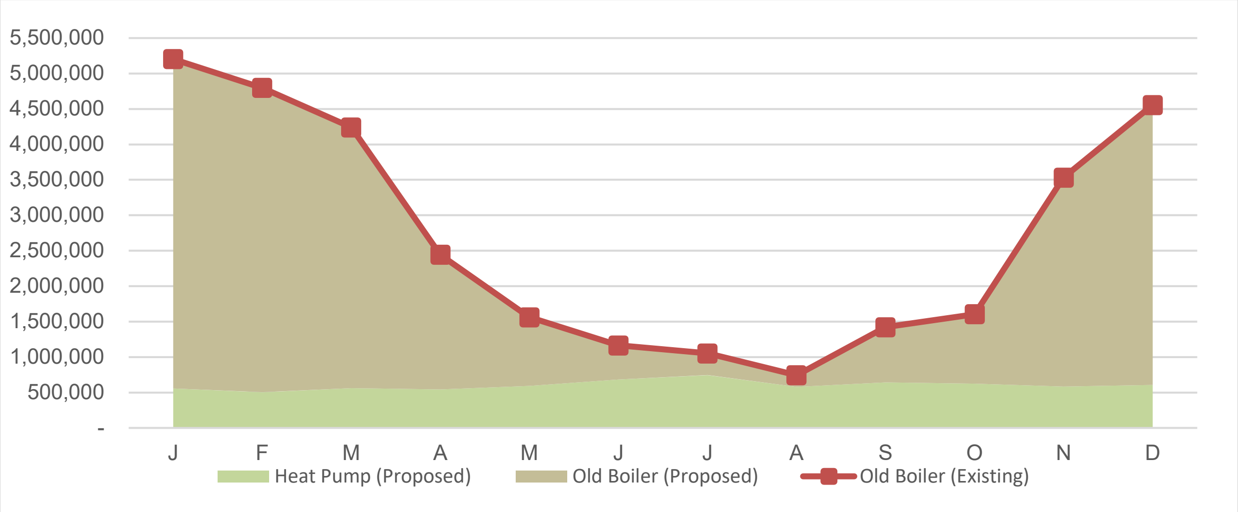


Figure 10. Scenario 1a: Only Heat Pump, Monthly Energy Load (Existing versus Proposed)



4.1.1.2 Scenario 1b: Heat Pumps and New Boilers

This scenario combines two boiler plants to serve four buildings, with the following details:

- Equipment addition:
    - Four DHW heat pumps
    - Two new supplemental high-efficiency boilers
- Estimated cost: $1,381,856
- Buildings pairs investigated (example in Figures 11 and 12):
    - Rome and Copenhagen; Canada and Mexico
    - US and Panama; Sydney and Brisbane
    - Singapore and Ceylon; Peru and Columbia

Figure 11. Scenario 1b: Heat Pump and New Boilers—Monthly Energy Use (Existing versus Proposed)

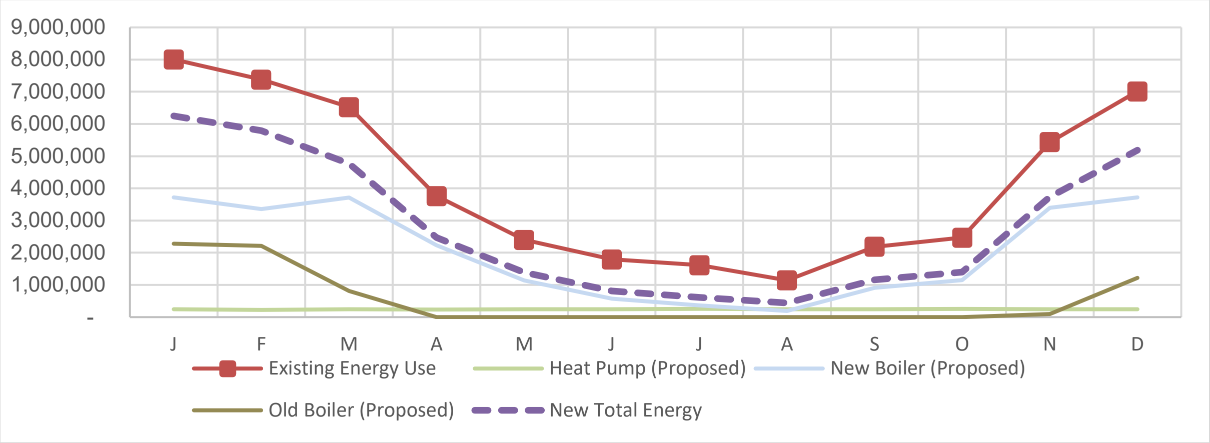
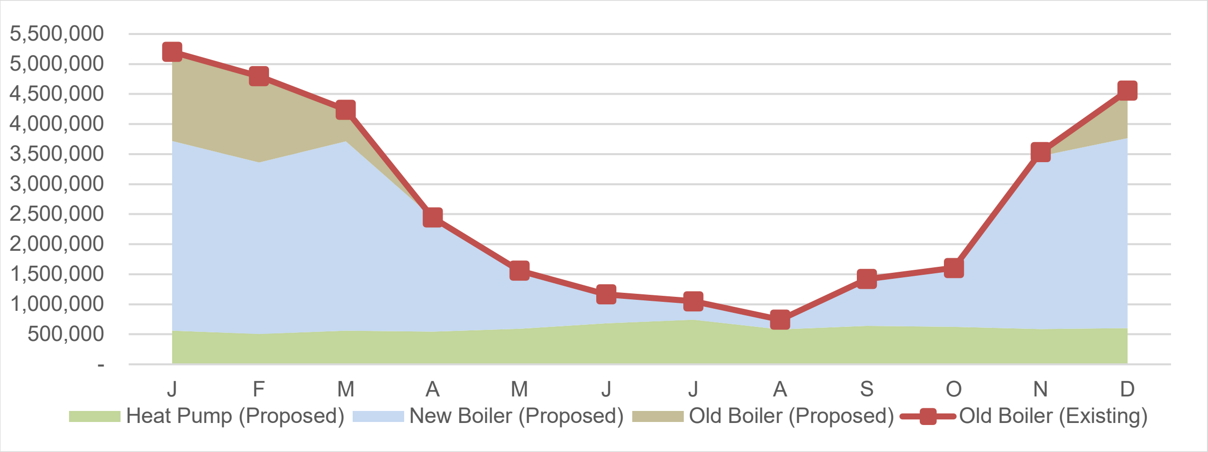


Figure 12. Scenario 1b: Heat Pump and New Boilers—Monthly Energy Load (Existing versus Proposed)



4.1.1.3 Scenario 2a: Heat Pumps Only

This scenario uses one boiler plant serving two buildings, with the following details:

- Equipment addition: Two DHW heat pumps only
- Estimated cost: $621,488
- Building pairs investigated (see example in Figures 13 and 14):
  - Brazil and Argentine
  - Wellington and Melbourne
  - Shalimar and Mandalay

Figure 13. Scenario 2a: Only Heat Pump—Monthly Energy Use (Existing versus Proposed)

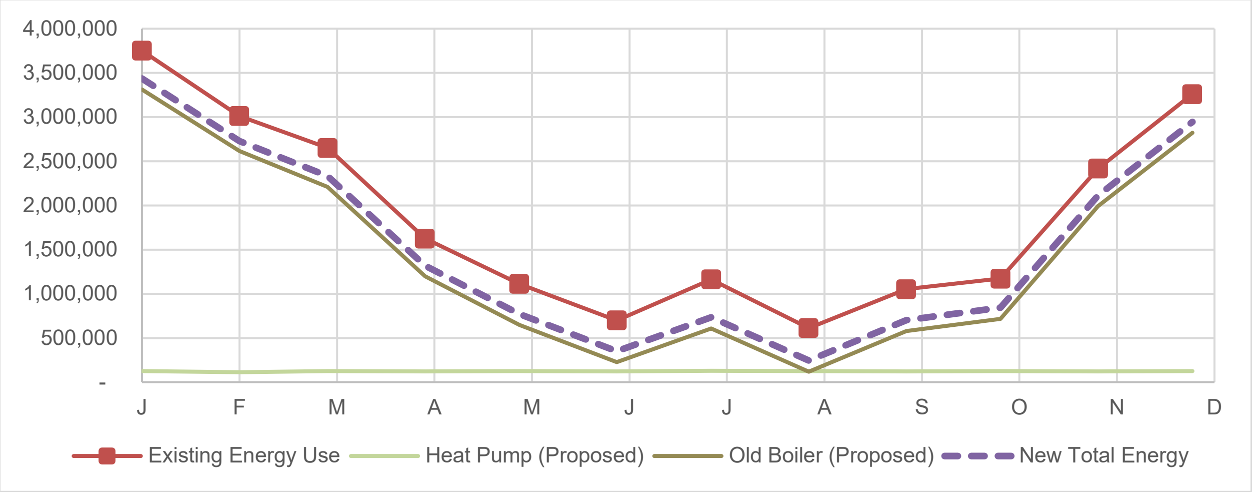
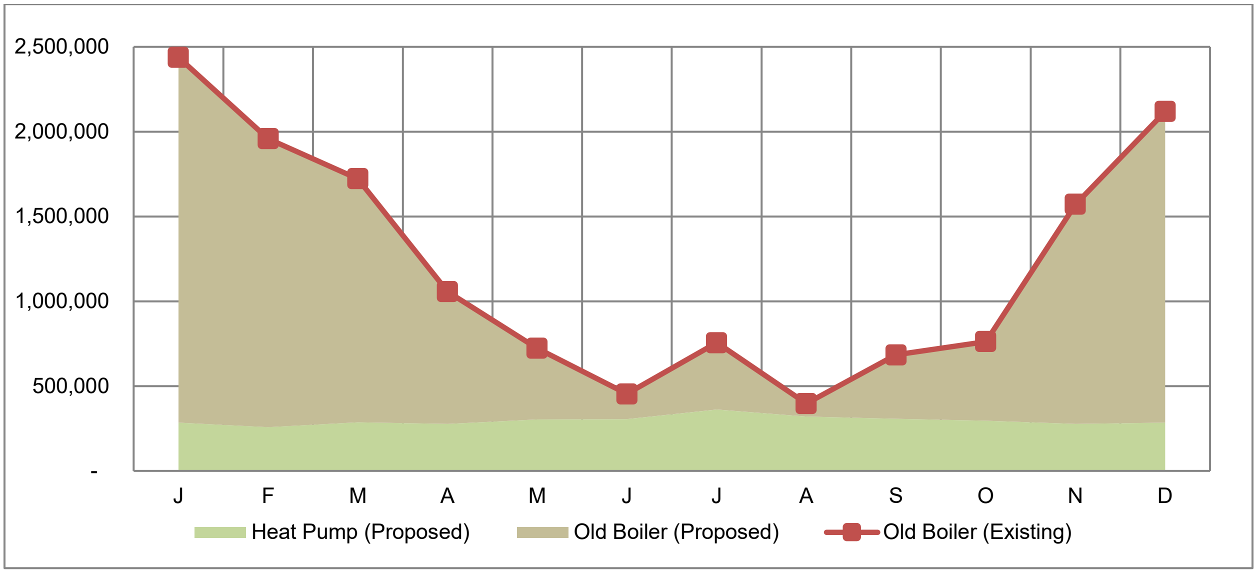


Figure 14. Scenario 2a: Only Heat Pump—Monthly Energy Load (Existing versus Proposed)



4.1.1.4 Scenario 2b: Heat Pumps and New Boilers

This scenario uses one boiler plant serving two buildings, with the following details:

- Equipment addition: Two DHW heat pumps only
- Estimated cost: $765,408
- Building pairs investigated (example in Figures 15 and 16):
  - Brazil and Argentine
  - Wellington and Melbourne
  - Shalimar and Mandalay

Figure 15. Scenario 2b: Heat Pump and New Boilers—Monthly Energy Use (Existing versus Proposed)

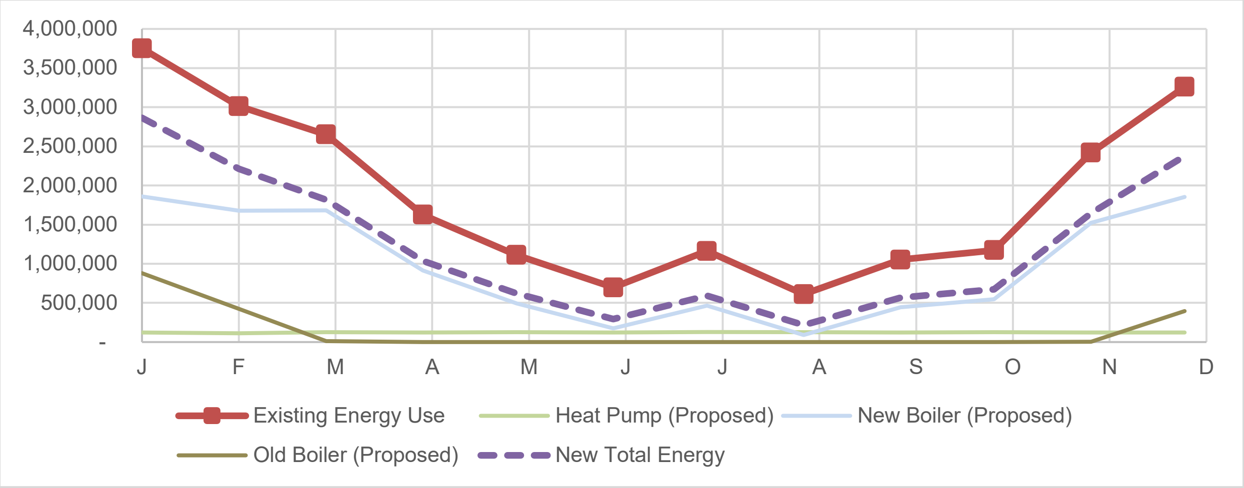
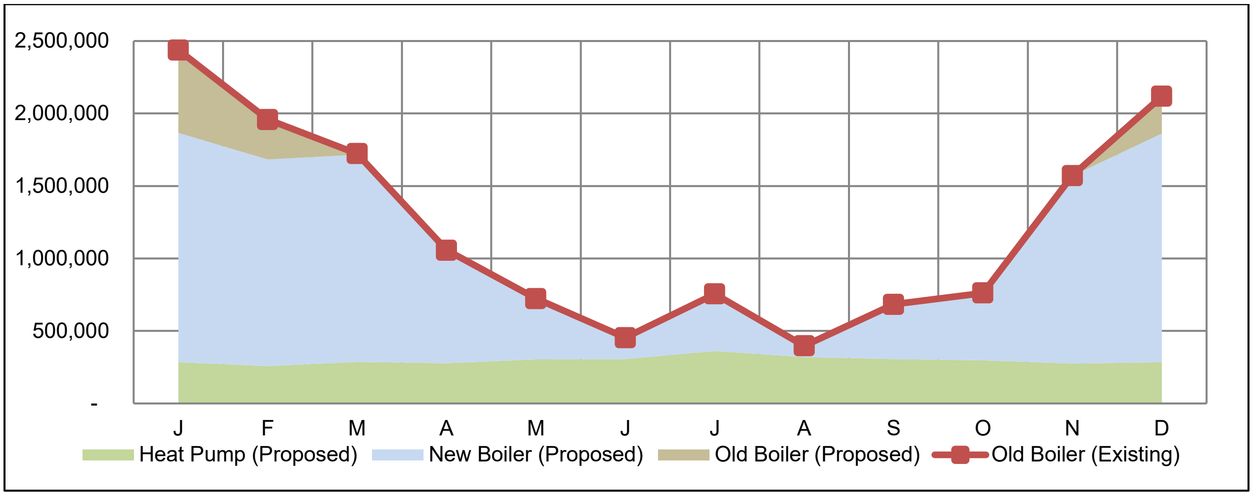


Figure 16. Scenario 2b: Heat Pump and New Boilers—Monthly Energy Load (Existing versus Proposed)



4.1.1.5 Scenario 3:Community District Loop

Scenario 3 proposes an energy conservation measure (ECM) that implements a campus DHW district loop to recover HVAC-rejected heat from commercial buildings across six plants. Heat recovery will be used only by these six plants because one of the other three plants has already been upgraded to more efficient HW boilers, and the remaining two plants are located far from the site. After simulating this opportunity, the team concluded that extending the district loop to the distant plants would not be financially beneficial compared to the small amount of heat available for recovery.

Scenario 3 will serve as the primary source of DHW heat in the plants before the DHW heat pumps. The study showed that this scenario would recover 63% of the rejected heat from commercial buildings within the six plants, saving 11% of the campus DHW heat load and 17% of the DHW heat load for these six plants.

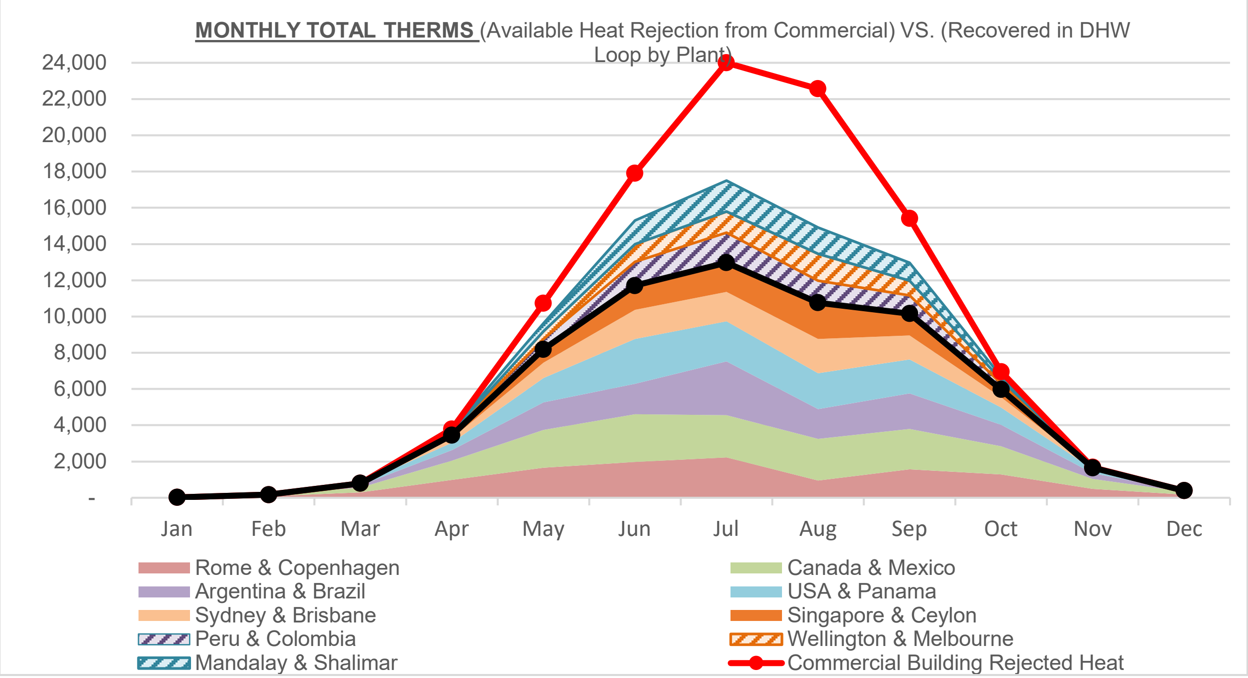
Table 3. Scenario 3: Monthly Total Therms (Available Heat versus Recovered by DHW Loops)

Available Heat from Commercial Heat Rejection		**Heat Recovered from the District Loop (Therms)***								
		Rome & Copenhagen	**Canada & Mexico**	**Argentina & Brazil**	**US & Panama**	**Sydney & Brisbane**	**Singapore & Ceylon**	**Peru & Colombia**	**Wellington & Melbourne**	**Mandalay & Shalimar**
Jan	21	16	5	—	—	—	—	—	—	—
Feb	166	88	71	7	—	—	—	—	—	—
Mar	793	295	261	139	83	15	—	—	—	—
Apr	3,789	993	1,046	589	417	241	172	111	76	83
May	10,731	1,652	2,093	1,511	1,351	849	735	575	417	435
Jun	17,912	1,978	2,632	1,683	2,472	1,603	1,336	1,313	972	1,314
Jul	23,998	2,229	2,319	2,977	2,214	1,621	1,611	1,659	1,158	1,712
Aug	22,565	957	2,285	1,654	1,966	1,907	1,993	1,220	1,473	1,449
Sep	15,419	1,573	2,215	1,975	1,872	1,317	1,208	1,005	812	984
Oct	6,953	1,281	1,568	1,178	952	563	434	331	213	182
Nov	1,677	495	536	328	206	61	32	15	4	—
Dec	389	179	147	34	20	8	1	—	—	—
Totals	**104,413**	11,736	15,178	12,075	11,553	8,185	7,521	6,229	5,124	6,158
Plant DHW Covered		26%	21%	18%	15%	13%	12%	10%	9%	8%
District Loop Used & Recovered Heat		**11,736**	**26,914**	**38,989**	**50,541**	**58,726**	**66,247**	**72,475**	**77,600**	**83,758**
		11%	**26%**	**37%**	**48%**	**56%**	**63%**	**69%**	**74%**	**80%**

* Table displays the heat recovered from the district loop within each plant's DHW system. Only the first six plants are included.

The table indicates that the Peru and Colombia plant has recently been upgraded. Extending the campus district loop through this plant to reach the other two plants (Mandalay and Shalimar; Wellington and Melbourne) does not offer a financial advantage despite the heat recovery potential. Figure 7 shows the available heat from commercial buildings and the six sites benefiting from the district loop for heat recovery within their DHW systems.

Figure 17. Scenario 3: Heat Recovery by DHW Loops in the First and Closest Six Plants



4.2 Design Options A, B, and C

This section presents various design options to determine the optimal combination of the previously discussed three scenarios. To align with the NYSERDA Program Opportunity Norice (PON) 4614 program requirements, scenarios 1a and 2a focus solely on heat pump additions. The site can introduce new boilers as future expansions in phases.

The following design options outline carbon fine savings under LL97 for two periods: 2030–2034 and 2035–2039. If this study progresses and receives approval for categories B and C of the NYSERDA PON 4614 program, we expect implementation and operation to begin before 2030. Therefore, the projected payback period falls within these two periods of LL97.

4.2.1 Design Option A

Table 4 presents the projected costs and savings for DHW heat pumps dedicated to a single heating plant or shared between two heating plants.

Table 4. Scenarios 1a Applied to Six Plants and Scenario 2a Applied to Three Plants

Description	Value
Option A cost estimate	$5,099,503
NYSERDA PON 4614 community heat pump (50% of cost)	-$2,549,736
Final cost of option A implementation	$2,549,736
Annual energy savings (Therms), 515,107 Therms	$530,560
Annual energy savings (kWh), -3,903,722 kWh	-$858,819
LL97 2030 savings, including [2,172 tCO_2eq <Existing]	$411,940
Total savings & simple payback for 2030 (30.5 years)	*$83,681*
LL97 2035 savings, including [2,172 tCO_2eq <Existing]	$582,020
Total savings & simple payback for 2035 (10 years)	***$253,762***

4.2.2 Design Option B

Table 5 presents the projected costs and savings for the heat recovery loop from the office building to DHW systems.

Option B studies only the campus DHW district loop. This includes savings on the office building cooling tower energy usage by cooling the return water in the district loop after rejecting the heat into the DHW system of the six plants.

Table 5. Scenario 3 Applied to Six Plants with No Upgrades to the Nine Plants

Description	Value
Option B cost estimate	$1,652,031
NYSERDA PON 4614 community heat pump (50% of cost)	-$826,016
Final cost of option B implementation	$826,016
Annual energy savings (Therms), 101,918 Therms	$104,975
Annual energy savings (kWh), -47,503 kWh	-$10,451
Office building energy savings (kWh), 185,381 kWh[a]	$55,614
LL97 2030 savings, including [534 tCO_2eq <Existing]	$143,225
Total savings & simple payback for 2030 (2.8 years)	$293,364
LL97 2035 savings, including [534 tCO_2eq <Existing]	$143,225
Total savings & simple payback for 2035 (2.8 years)	$293,364

[a] Electricity savings on cooling tower usage through the recovery of heat rejected by the office building’s refrigeration system.

4.2.3 Design Option C: Options A and B Combined

Table 6 presents the projected costs and savings for a combined project incorporating both options A and B. This project would be executed as a single initiative without requiring new boilers or any fossil-fueled equipment. This combined approach should qualify for the NYSERDA PON 4614 incentive because it encompasses the heat pumps upgrades. Scenario 3 applies to six plants, while scenario 2, including heat pump upgrades, applies to nine.

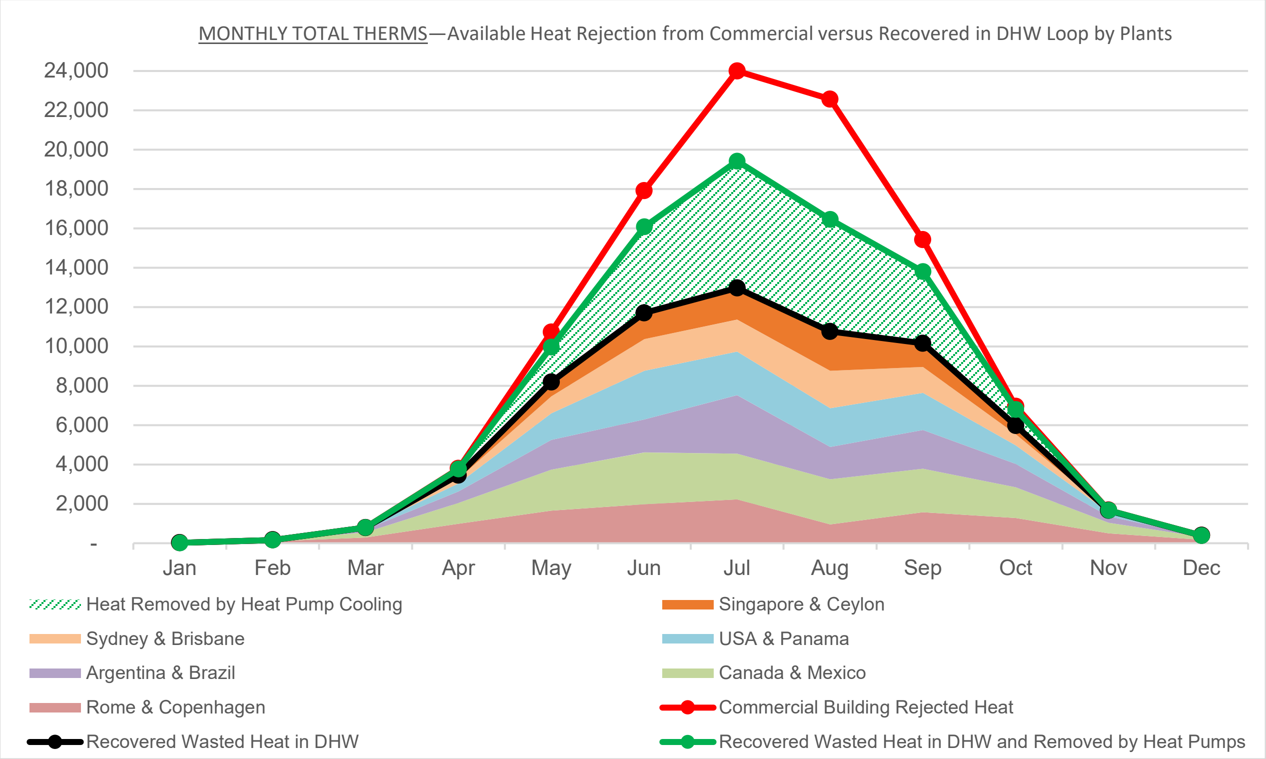
Additional cooling provided by the heat pumps cold side to the return water in the district loop reduces the office building's chilled water return temperature and increases energy savings for the cooling tower.

Table 6. Design Options A and B Combined

Description	Value
Option C cost estimate	$7,245,423
NYSERDA PON 4614 community heat pump (50% of cost)	-$3,622,712
Final cost of option C implementation	$3,622,712
Annual energy savings (Therms), 594,863 Therms	$612,709
Annual energy savings (kWh), -3,926,281 kWh	-$863,782
Office building energy savings (kWh),[a] 236,484 kWh	$70,945
LL97 2030 savings, including 2,592 tCO_2eq	$411,940
Total savings & simple payback for 2030 (15.6 years)	$231,812
LL97 2035 savings, including 2,592 tCO_2eq	$694,668
Total savings & simple payback for 2035 (7 years)	$514,650

[a] In addition to the 185,381 kilowatt hours (kWh) saved on the office building's cooling tower energy use as discussed in option B, option C introduces further energy savings by extracting additional heat from the return side of the district loop before it re-enters the office building's refrigeration system. This is achieved by adding extra cooling from the heat pump's cold side, saving an additional 51,103 kWh.

Figure 18. Design Option C: Removal of Office Building Rejected Heat Removed Using DHW District Loop AND Heat Pump Cold Side



5 Result: Business Options

This section discusses the financial metrics and business options available for the client to consider when making a funding decision for this project based on the evaluation of design options in section 4.2.

5.1 Financial Metrics

5.1.1 Energy Escalation

Energy escalation refers to the gradual increase in energy required to perform a task or activity over time. The electrification movement will contribute to this demand increase. However, the energy-efficient equipment and tools may stabilize energy consumption, potentially mitigating escalation during the 25-year life-cycle cost covered by this study.

5.1.2 Inflation and Discount Rate

The discount rate converts future cash flows into their present value, reflecting the opportunity cost and risk associated with that project. Careful consideration of these factors is crucial when selecting a discount rate.

Projecting inflation for a project involves estimating how equipment and service costs will increase, influenced by economic conditions, government policies, and global trends. In a 25-year life-cycle cost analysis, we must factor in the expected inflation rate to determine the project's future cost.

Due to the similarities in mechanical equipment (heat pumps and new efficient boilers) across the three design options in this energy study, the impact of the discount rate and inflation will be consistent for the 25-year life cycle. As a result, their effects will be negligible in the comparison.

5.1.3 Return on Investment versus Payback

Return on investment (ROI) and payback are metrics for evaluating the profitability of investments. The payback period assesses risk by dividing the initial investment by the annual cash flow:

$$\textbf{Payback Period} = \frac{\textbf{Initial Investment}}{\textbf{Annual Cash Inflows}}$$

ROI is a financial metric that compares the profitability of an investment by dividing net profit by the total investment cost over the life of the investment (this study considered 25 years for the comparison):

$$\text{ROI} = \frac{\text{Gain from Investment} - \text{Cost of Investment}}{\text{Cost of Investment}}$$

5.1.4 Avoided Capital

Avoided capital cost represents the money an organization saves by not investing in capital assets that would otherwise be required if the project had not been implemented.

Section 2.3 discussed the in-kind equivalent to the existing system and revealed a capital cost of $700,000 for replacing each boiler plant system. Although the existing plants require replacement, implementing any of the ECMs proposed in the three design options will allow the client to avoid this $700,000 expenditure per plant.

5.2 Business Model Options

Each design option is analyzed using different business models so stakeholders and decision-makers can select a preferred business model and scenario.

5.2.1 Turnkey Option: Billing Over 10–15 Years

The turnkey business model in energy projects involves a company providing a complete solution to a client, from the energy system’s design and engineering to the system’s installation and commissioning. The company delivers a fully functional energy project, ready to operate from the moment it starts.

In one payment structure of the turnkey project, the provider finances the project and then sells the energy or other outputs to the client under a long-term contract. This approach, known as a power purchase agreement (PPA), allows the client to predict energy costs throughout the contract’s duration, while enabling the turnkey provider to recoup their investment.

Under the PPA, the energy service company (ESCO) will finance the project and own the thermal system, while the building owner will purchase the energy generated by the system at a fixed rate over a long-term contract.

This energy study assumes an interest rate of 4% will be added to the billing for the energy provided to the client buildings over 15 years. PPA will have terms that the ESCO finances the project at the full cost, applies the given interest rate, and then deducts any incentives received from the total cost. This calculation will determine a fair energy rate for natural gas supplied to existing boilers, as well as the electricity supplied to the heat pumps and district loop system.

Rates vary among the design options. The total client savings during the PPA term, as detailed in the following schedule, are calculated based on the new rate compared to the original cost of energy consumption costs, along with the potential savings from avoided LL97 fines.

The impact of the turnkey option is further analyzed beyond the 15-year PPA term (until 2040), extending for an additional 10 years to compare the three design options over a 25-year life cycle.

Table 7. Business Model Comparison: Power Purchase Agreement

Design Option	Therms Rate (Originally $1.03) PPA Term	kWh Rate (Originally $0.22) PPA Term	Total Savings of (15 Years) PPA Term	Annual Savings after 15 Years (LL97 Avoided Fine) PPA Term	Annual Savings after 15 Years (Energy Cost) PPA Term	Total Annual Savings PPA Term	Total Savings over 10 Years (2040–2049) after PPA	Total Savings–25 Years (2024–2049) PPA Term + after PPA
In-Kind Equipment	$1.40	—	$2,583,530	$667,942	$483,353	$1,151,295	$11,512,948	$14,096,479
Option A	$1.18	$0.24	-$5,241,44	$582,020	-$306,788	$275,232	$2,752,321	-$2,489,122
Option B	$1.09	$0.23	$1,036,812	$143,225	$150,400	$293,626	$2,936,257	$3,973,069
Option C	$1.24	$0.26	$4,403,149	$694,668	-$158,533	$536,134	$5,361,342	$9,764,491

Although the in-kind option may appear more financially attractive, it does not align with the owner’s goals of decarbonizing the complex by switching from a fossil-fuel–based thermal energy system to an electric one. Therefore, option C is the preferred choice under this business model.

5.2.2 Client Payments Option: Incentives Going to Client

In this business model, the client funds the project through payments and recovers the capital costs through savings on utility bills, avoided LL97 carbon penalties, and state or federal incentives, such as those from NYSERDA or similar programs. Section 6 details this model, which the client has chosen as the preferred business model for funding this energy transition project.

6 Results–Impact

The client has chosen the client payments business model option if the project receives approval under categories B and C of the NYSERDA PON 4614 program.

6.1 Final Comparison: Client Payment Option

As outlined in section 5.2.2, the owner will fund the project through payments and recover the capital cost by savings on utility bills, avoiding LL97 carbon penalties, and state and federal incentives, such as those from NYSERDA and other programs. This design option may also qualify for additional incentives and federal tax programs, including the Federal Tax Credit ITC (form 3468) and National Grid's heat recovery incentive programs.

For the comparison, the team assumed project completion by year-end 2024. This assumption aids in calculating energy consumption cost savings from 2025 to 2050 for the 25-year comparison, considering changes in LL97 savings over time. This approach differs from the simple payback calculations in section 4.2, where the total project cost was divided by a fixed value representing energy costs and LL97 savings for a specific period. Table 5 presents the outcomes of this comparison.

Table 8. Financial Comparison for Business Models of All Design Options

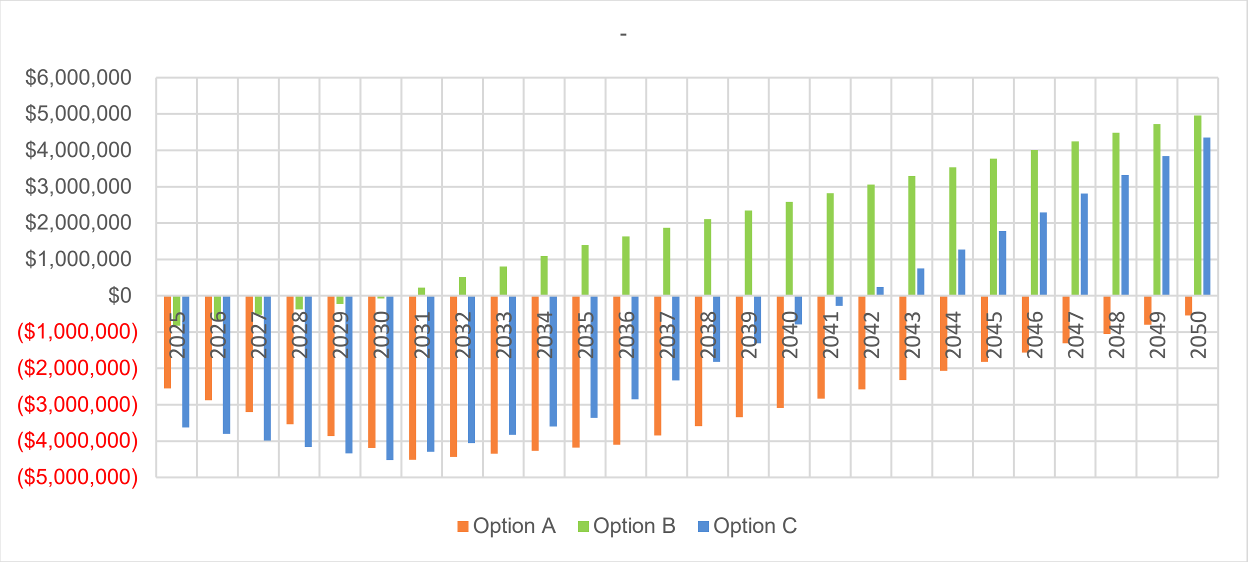
Design Option	Estimate Cost	ROI	Payback	PON 4614 Categories B & C Incentive	ROI (Incentive)	Payback (Incentive)
In-Kind Equipment	$6,291,360	273%	10	—	—	—
Option A	$5,099,472	-61%	38	$2,549,736	-22%	28
Option B	$1,652,031	292%	14	$826,016	684%	6
Option C	$7,245,423	86%	18	$3,622,712	271%	13

Although the in-kind option does not qualify for any incentives under the NYSERDA PON 4614 program because it only partially decarbonizes the thermal system without advancing the project's electrification, this option still demonstrates the highest annual energy cost savings compared to the other options. The other three design options are eligible for funding from this program, in addition to avoiding approximately $6.3 million in capital costs, as discussed in section 5.1.4.

Options A and C, which introduce heat pumps, show negative annual energy cost savings. This result directly relates to the energy rates used in the calculations. However, transitioning to an electrified thermal system reduces fossil fuel emissions. It can lead to an annual saving on LL97 carbon penalties, compensating for the negative energy cost and bringing the project's annual return to a positive value.

Beyond the 25-year analysis, option C will generate annual savings that exceed option B by 125%, attributed to significant reductions in greenhouse gas emissions from switching to heat pump DHW heating. This reduction results in savings from avoided LL97 fines. Even within 25 years, if the energy rate changes—such as a 4.5% increase in natural gas thermal rate or a 2.5% decrease in kilowatt hour (kWh) rates—option C will still outperform the other two options in the total gain.

Figure 19. Client Payment Business Option: 25-Year Life-Cycle Cumulative Cost (Total Gain)



6.2 Sensitivity Analysis

This task included various assumptions, such as energy and PPA interest rates. These assumptions had different impacts on the analysis, which this section discusses.

Electricity rates: Although the analysis used rates based on actual utility bills for the site, energy rates are expected to change over time. Rate changes will not significantly impact the in-kind design option compared to the existing design. In contrast, the other two ECM options will experience financial impacts based on rate fluctuations. A decrease in electricity rates will positively impact these options, while an increase will have a negative effect due to the reliance on heat pumps for electrified heating systems.

Natural gas rates: Similar to electricity rates, natural gas rates are subject to change despite being based on actual bills. Decreased natural gas rates will result in lower financial savings for all options. Conversely, if rates increase, the in-kind option will become less attractive because it relies solely on natural gas for the heating system.

PPA interest rate: The analysis used a 4% interest rate, reflecting a reasonable assumption based on average Small Business Administration–backed loans. Actual interest rates vary greatly between 4% and 20%, depending on various factors. Higher interest rates will reduce the total gain during the PPA period. An interest rate above 7% will result in negative gains for all three options. The ten years beyond the PPA will not be affected because the ESCO and interest rate are no longer valid.

Permits: The proposed designs poses significant regulatory hurdles. The system is entirely within LeFrak City's property boundary and does not cross any public rights-of-way. Therefore, we do not expect the district loop system to introduce novel regulatory issues.

We expect permitting for the project to flow through two key agencies:

1. New York City Department of Buildings (DOB), which will be the authority having jurisdiction (AHJ) for issuing permits related to the mechanical scope, including heat pumps, district distribution, and associated equipment.
2. New York State Department of Environmental Conservation (DEC) could play a role if environmental concerns arise.

7 Additional Technologies to Improve Project Value and Mitigate New Demand

This section of the study discusses and analyzes how integrating solar photovoltaic (PV), electric vehicle (EV) chargers, and electric battery technologies systems (BESS) can improve the project's value. These technologies offer electrification opportunities within the project. Additionally, this section explores thermal storage options and their potential impact on the overall performance of the heat pump technology and the reduction of the heating system's carbon footprint.

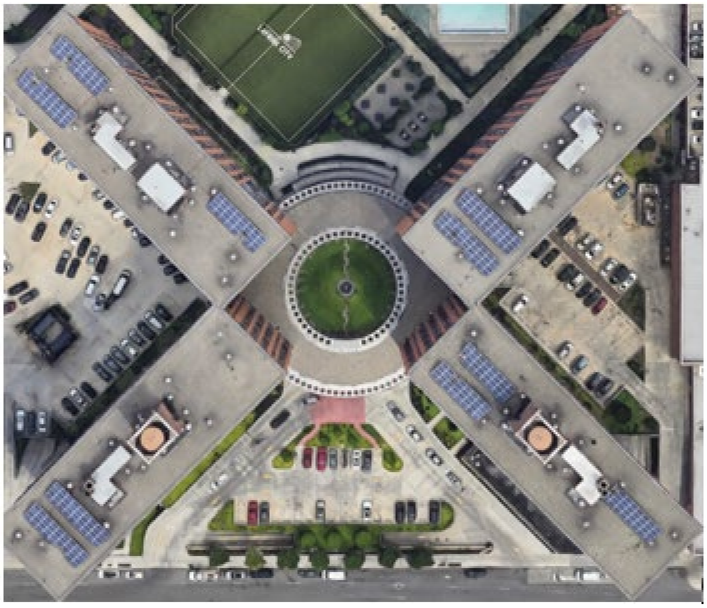
The existing utility electric service for each building is 4000 amperes (A) at 208 volts (V) 3 phase. This capacity can accommodate the increased electric load from electrifying the heating system with air-source heat pumps (ASHPs) on the DHW loops.

7.1 Additional Technologies

7.1.1 Technology: Solar Photovoltaics

The project includes solar PV on every building rooftop. Each boiler plant consists of two buildings. On average, the building housing the boiler plant has around 90 PV panels, providing between 26 kilowatts (kW) and 35 kW. The other building has approximately 70 PV panels, providing between 15 kW to 25 kW.

Figure 20. LeFrak City: Building Rooftop Solar Panels



7.1.2 Technology: Electric Vehicle Chargers

Currently, the buildings lack EV chargers in their parking garages. Any future installation of EV chargers will require an electrical load study to ensure the existing electric service is adequate to accommodate the increased demand.

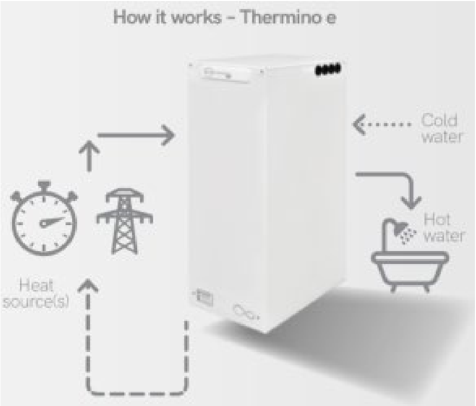
7.1.3 Technology: Sunamp Thermal Battery

Sunamp Thermino heat batteries are energy-saving thermal stores that use high-performance phase change materials (PCMs) to deliver fast-flowing HW reliably, safely, and efficiently. They are up to four times smaller than equivalent HW cylinders, which frees up valuable storage space and eliminates the need for mandatory annual maintenance.

The PCMs absorb, store, and release large amounts of latent heat during the transition between solid and liquid states. Heat is absorbed on melting and released on freezing. Water heat pumps are expected to be paired with thermal storage as the electrification movement progresses. However, space constraints may require new, high-density solutions such as PCMs to minimize space requirements.

These heat batteries can be configured in various ways. They are charged in the evening when the DHW demand and electricity rates are low. The stored heat is then discharged during periods of high DHW demand, which typically coincide with higher electricity rates in the evening. The model chosen for this study is the Thermino 70e, designed to replace directly heated water thermal storage. This model supports scheduled charging to maximize off-peak demands or variable tariffs and has a capacity of 74 liters (19.5 gallons).

Figure 21. Sunamp Technology: Simple Schematics



7.1.3.1 Sunamp Technology: Analysis

Charged by heat pumps: To replace the heat pumps analyzed in option A, which provide 58% of the DHW load, each apartment in the project will be equipped with a 2.8 kW unit. This unit can store and deliver the equivalent of 3.5 kWh of HW, approximately 12,000 British thermal units (kBtu) of heat. This amount of heat can meet the typical apartment's needs over 7.5 hours. As a result, the thermal battery will undergo a charging and discharging cycle up to seven times a day to meet the DHW capacity needs for all 18 buildings.

Sunamp thermal batteries will charge via heat pumps. Two optimization methods for using Sunamp batteries are:

- **Load shifting:** Figure 6 illustrates that the DHW load peaks in the afternoon and evening, contributing to the building's overall electrical peak demand. Using Sunamp to charge during the off-peak evening hours and discharge during the peak hours resulted in a 90 kW reduction in monthly demand peak load and an annual savings of $32,684 for the entire project (nine thermal plants).[1]
- **Energy transition:** In option A, heat pumps operate at 92% capacity to provide 58% of the DHW load; however, during DHW load usage, the heat pumps do not need to run at full capacity. Using Sunamp to charge during these times and discharge during peak hours, the project displaced fossil fuel usage, saving 28,542 Therms per year (equivalent to $45,228) and adding almost 50,000 kWh (equivalent to $10,985). This resulted in additional savings of $34,243.

Incorporating Sunamp thermal batteries with the heat pumps in design option A could reduce DHW energy costs by 4% to 7.8%. However, equipping each of the 4,144 apartments with a small Sunamp Thermino 70e unit would cost approximately $2,300 per unit at the retail price. This brings the total cost for all apartments across the nine plants to roughly $9,585,000. With this investment, the simple payback period would be around 143 years.

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[1] Consolidated Edison Tariff SC-9 uses $35.51 per kW and $28.09 per kW demand charges for summer and nonsummer months, respectively.

The energy transition method's reduction in energy consumption will further decrease the carbon footprint. Although Sunamp's technology has a lower CO_2eq value, implementing the technology will not impact the LL97 fines of option A until the 2035 limits are enforced. By that time, the project is expected to achieve additional savings of 138 tons of CO_2eq, equivalent to $36,984. This reduction is expected to shorten the payback period to 93 years.

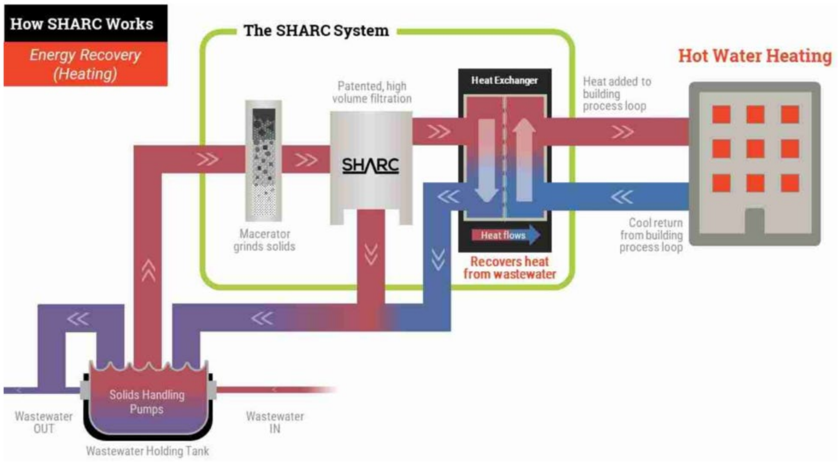
Off-peak charging and variable tariff: Although Consolidated Edison's current tariff for these central boiler plants does not have different daily rates for on-peak and off-peak hours, Sunamp thermal batteries could benefit from future changes if such rates are introduced. Sunamp technology can leverage these changes to reduce energy costs.

Sensitivity analysis: The Sunamp Thermino 70e heats the water before storing it using electricity. A key constraint when implementing 4,144 Sunamp units is the potential risk of an electrical spike in each building. Running 230 units simultaneously could draw up to 1,800 A from the existing 4,000 A electric service. This issue can be addressed by scheduling and controlling the units together, although this will incur additional costs.

7.1.4 Technology: SHARC Energy Wastewater Heat Recovery

SHARC Energy's patented filtration technology is designed to quickly meet the large capacity demands of energy districts, large multifamily residential complexes, and industrial applications. It seamlessly integrates into virtually any condenser water system and provides an optimal temperature range to increase system efficiency.

Figure 22. SHARC Energy Technology: Simple Schematics



7.1.4.1 SHARC Energy Technology: Analysis

The analysis of wastewater from a typical apartment showed a return temperature of 93.5ºF and a total flow of 137 gallons per day, with an average flow of 5.7 gallons per hour (GPH) and a maximum return water flow of 8.2 GPH during peak times.

For a building with 230 or more apartments, the total flow rate during peak hours would be 31.6 gallons per minute (GPM). This flow rate is significantly lower than the lowest flow rate of 100 GPM required for the small SHARC 660 unit. The study considered the possibility of combining more than one building's sewage system, but that would only make sense using SHARC Energy's system when up to four buildings were combined and only if the total flow rate would exceed the 100 GPM minimum flow of SHARC 660 unit, which would occur for only 12 hours per day.

Using a counter flow plate heat exchanger and with the recovering 25ºF delta T from wastewater, the system can recover 17 Therms per day, covering 48.6% of the HW energy usage for the combined four buildings.

Sensitivity analysis: Combining four buildings' wastewater systems for energy analysis is a significant development. This project will require additional financial and technical details to be considered a viable option, especially from a city municipal perspective.

In the financial analysis, implementing SHARC Energy's solution can result in an annual cost savings of up to $445,375 compared to the existing system and up to $480,750 compared to design option A (heat pumps).

7.1.5 Technology: Utility Thermal Energy Network

In September 2022, New York State Governor Kathy Hochul announced that the New York State Public Service Commission (PSC) initiated a proceeding to implement the Utility Thermal Energy Network and Jobs Act. This act will advance efforts to decarbonize buildings across the State. The law will enable the creation of utility-scale infrastructure projects that connect multiple buildings into a shared thermal network. These utility thermal networks allow utilities to supply thermal energy to customers, replacing fossil-based natural gas for space heating, water heating, and cooling needs.

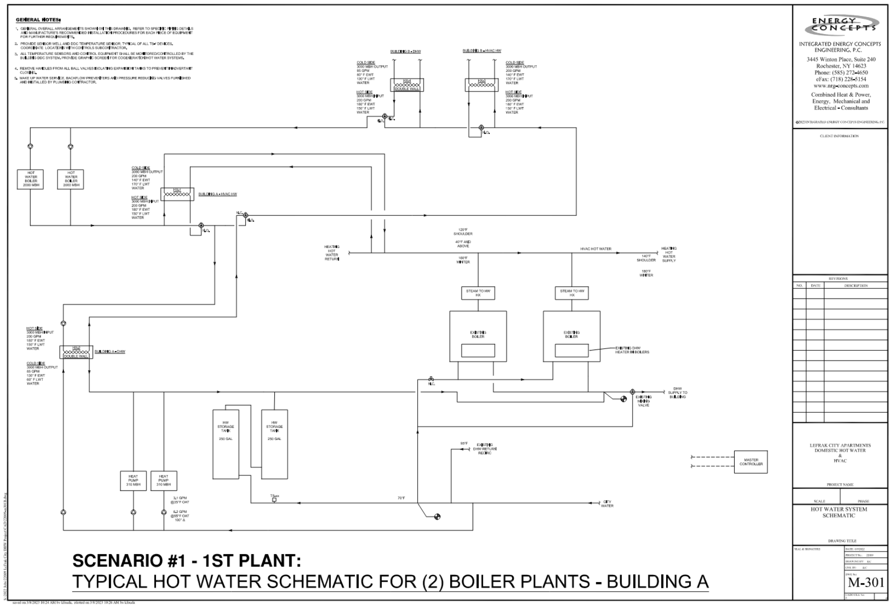
In addition to establishing the regulatory framework for the thermal energy network, the PSC ensures the development and availability of well-trained, highly skilled tradespeople. This effort aims to support timely, reliable, high-quality implementation of thermal energy networks while promoting good jobs for New Yorkers in the growing decarbonization sector.

As part of this process, the PSC will require the seven largest investor-owned utilities, including Consolidated Edison and National Grid, to submit between one and five proposed thermal network pilot projects for review. Each utility must include at least one pilot project in a disadvantaged economic community within its service territory. Additionally, the PSC will establish a working group dedicated to thermal-energy networks. This group will assist the utilities in developing their pilot project proposals before they are submitted to the PSC for review and will help create proposed rules and regulations for utility thermal services.

Appendix A. Schematics

A.1 Scenario 1b: Two Plants

A.1.1 Scenario 1b: Plant One of Two

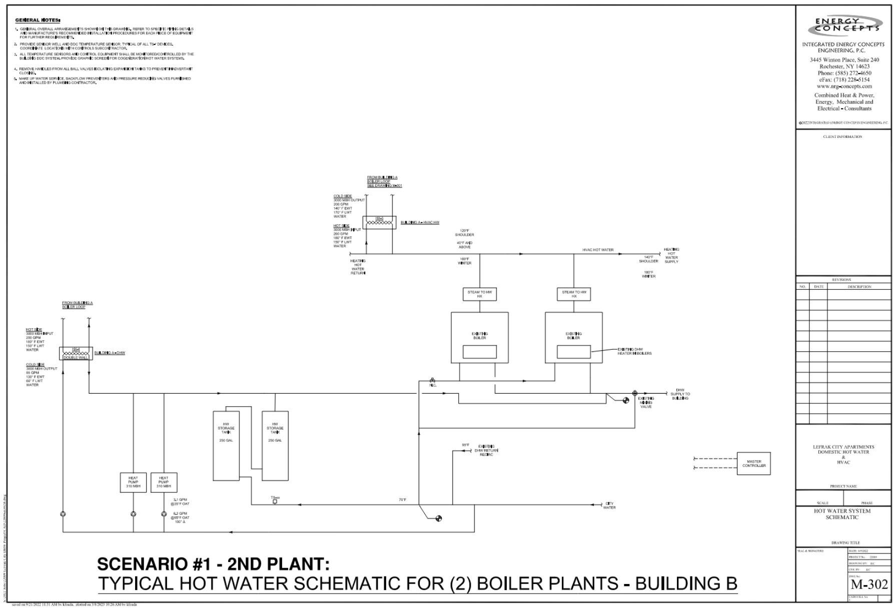


GENERAL NOTES:

1. GENERAL OVERALL ARRANGEMENTS SHOWN ON THIS DRAWING. REFER TO SPECIFIC PIPING DETAILS AND MANUFACTURE'S RECOMMENDED INSTALLATION PROCEDURES FOR EACH PIECE OF EQUIPMENT FOR FURTHER REQUIREMENTS.
2. PROVIDE SENSOR WELL AND DDC TEMPERATURE SENSOR, TYPICAL OF ALL TS-# DEVICES. COORDINATE LOCATIONS WITH CONTROLS SUBCONTRACTOR.
3. ALL TEMPERATURE SENSORS AND CONTROL EQUIPMENT SHALL BE MONITORED/CONTROLLED BY THE BUILDING DDC SYSTEM. PROVIDE GRAPHIC SCREEN FOR COGENERATION/HOT WATER SYSTEMS.
4. REMOVE HANDLES FROM ALL BALL VALVES ISOLATING EXPANSION TANKS TO PREVENT INADVERTANT CLOSING.
5. MAKE UP WATER SERVICE, BACKFLOW PREVENTERS AND PRESSURE REDUCING VALVES FURNISHED AND INSTALLED BY PLUMBING CONTRACTOR.

SCENARIO #1 - 1ST PLANT:
TYPICAL HOT WATER SCHEMATIC FOR (2) BOILER PLANTS - BUILDING A

A.1.2 Scenario 1b: Plant Two of Two

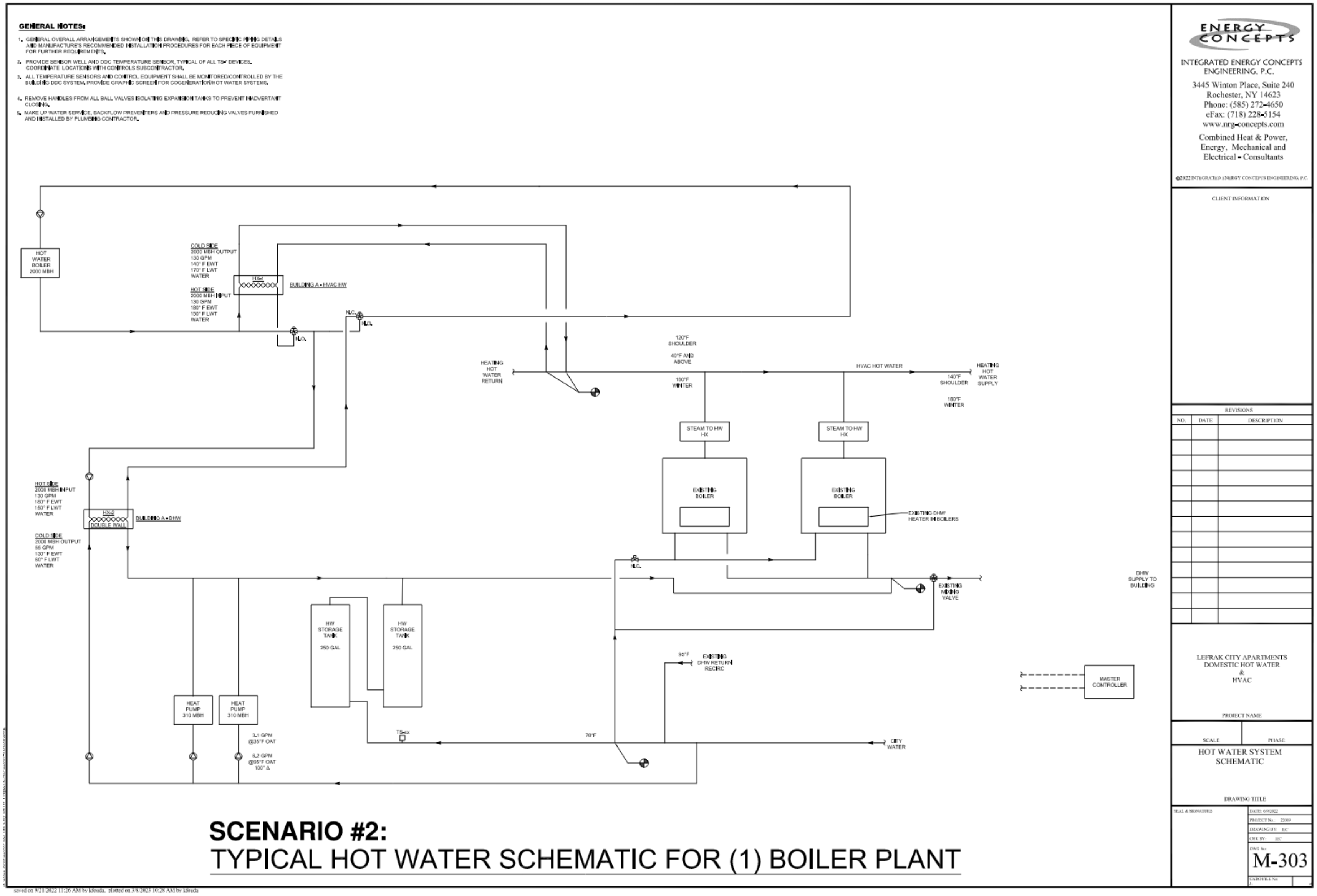


GENERAL NOTES:

1. GENERAL OVERALL ARRANGEMENTS SHOWN ON THIS DRAWING. REFER TO SPECIFIC PIPING DETAILS AND MANUFACTURE'S RECOMMENDED INSTALLATION PROCEDURES FOR EACH PIECE OF EQUIPMENT FOR FURTHER REQUIREMENTS.
2. PROVIDE SENSOR WELL AND DDC TEMPERATURE SENSOR, TYPICAL OF ALL TS-# DEVICES. COORDINATE LOCATIONS WITH CONTROLS SUBCONTRACTOR.
3. ALL TEMPERATURE SENSORS AND CONTROL EQUIPMENT SHALL BE MONITORED/CONTROLLED BY THE BUILDING DDC SYSTEM. PROVIDE GRAPHIC SCREEN FOR COGENERATION/HOT WATER SYSTEMS.
4. REMOVE HANDLES FROM ALL BALL VALVES ISOLATING EXPANSION TANKS TO PREVENT INADVERTANT CLOSING.
5. MAKE UP WATER SERVICE, BACKFLOW PREVENTERS AND PRESSURE REDUCING VALVES FURNISHED AND INSTALLED BY PLUMBING CONTRACTOR.

SCENARIO #1 - 2ND PLANT:
TYPICAL HOT WATER SCHEMATIC FOR (2) BOILER PLANTS - BUILDING B

A.2 Scenario 2b: One Plant



GENERAL NOTES:

1. GENERAL OVERALL ARRANGEMENTS SHOWN ON THIS DRAWING. REFER TO SPECIFIC PIPING DETAILS AND MANUFACTURE'S RECOMMENDED INSTALLATION PROCEDURES FOR EACH PIECE OF EQUIPMENT FOR FURTHER REQUIREMENTS.
2. PROVIDE SENSOR WELL AND DDC TEMPERATURE SENSOR. TYPICAL OF ALL TS-* DEVICES. COORDINATE LOCATIONS WITH CONTROLS SUBCONTRACTOR.
3. ALL TEMPERATURE SENSORS AND CONTROL EQUIPMENT SHALL BE MONITORED/CONTROLLED BY THE BUILDING DDC SYSTEM. PROVIDE GRAPHIC SCREEN FOR COGENERATION/HOT WATER SYSTEMS.
4. REMOVE HANDLES FROM ALL BALL VALVES ISOLATING EXPANSION TANKS TO PREVENT INADVERTANT CLOSING.
5. MAKE UP WATER SERVICE, BACKFLOW PREVENTERS AND PRESSURE REDUCING VALVES FURNISHED AND INSTALLED BY PLUMBING CONTRACTOR.

SCENARIO #2:
TYPICAL HOT WATER SCHEMATIC FOR (1) BOILER PLANT

ENERGY CONCEPTS
INTEGRATED ENERGY CONCEPTS
ENGINEERING, P.C.
3445 Winton Place, Suite 240
Rochester, NY 14623
Phone: (585) 272-4650
eFax: (718) 228-5154
www.nrg-concepts.com
Combined Heat & Power,
Energy, Mechanical and
Electrical - Consultants

CLIENT INFORMATION

REVISIONS

NO.	DATE	DESCRIPTION

LEFRAK CITY APARTMENTS
DOMESTIC HOT WATER
&
HVAC
PROJECT NAME

SCALE
PHASE

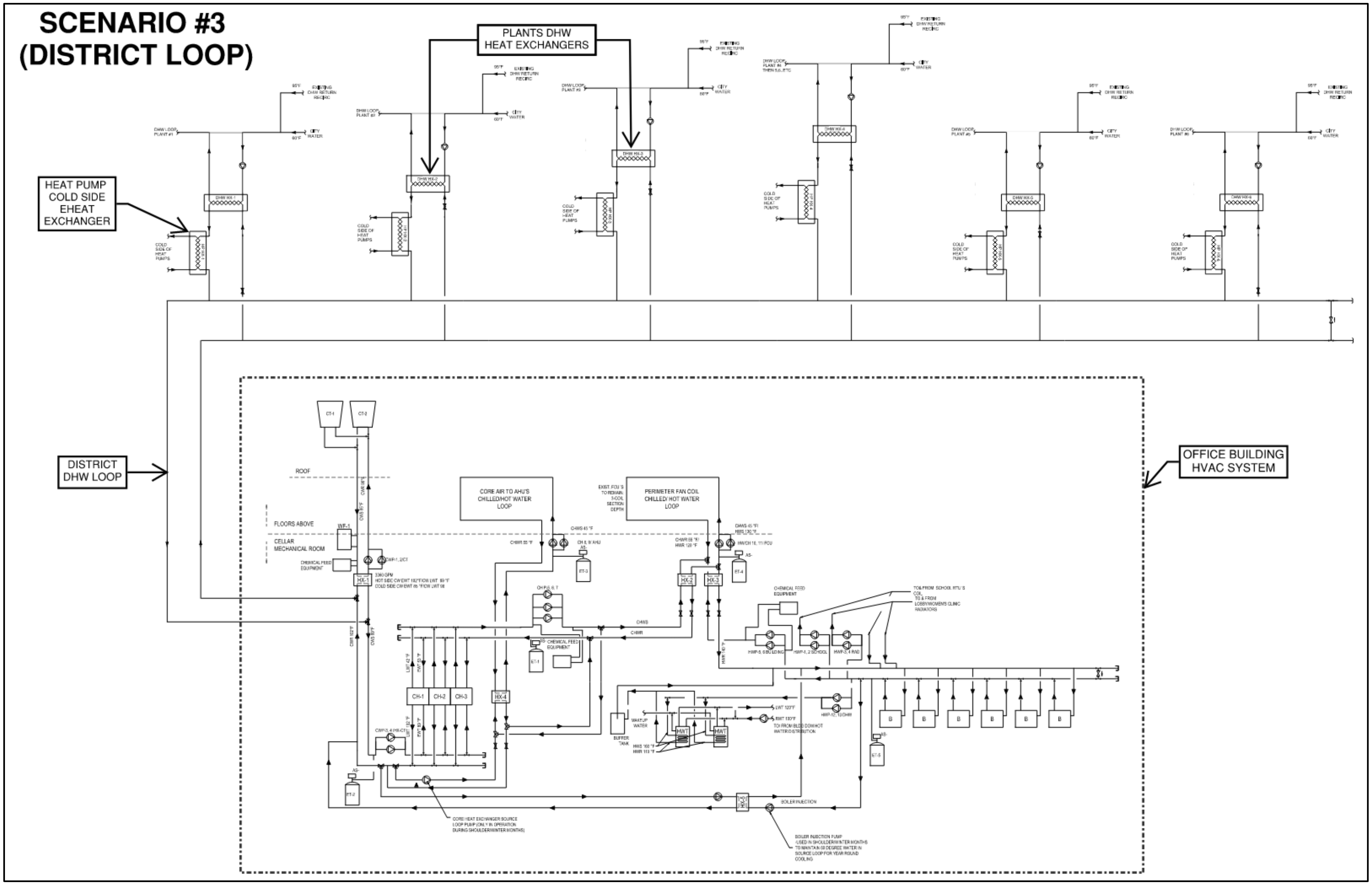
HOT WATER SYSTEM
SCHEMATIC
DRAWING TITLE

SEAL & SIGNATURE
DATE: 6/9/2022
PROJECT No.: 22009
DRAWING BY: IEC
CHK BY: IEC
DWG No:
M-303
CADD FILE No:
J:

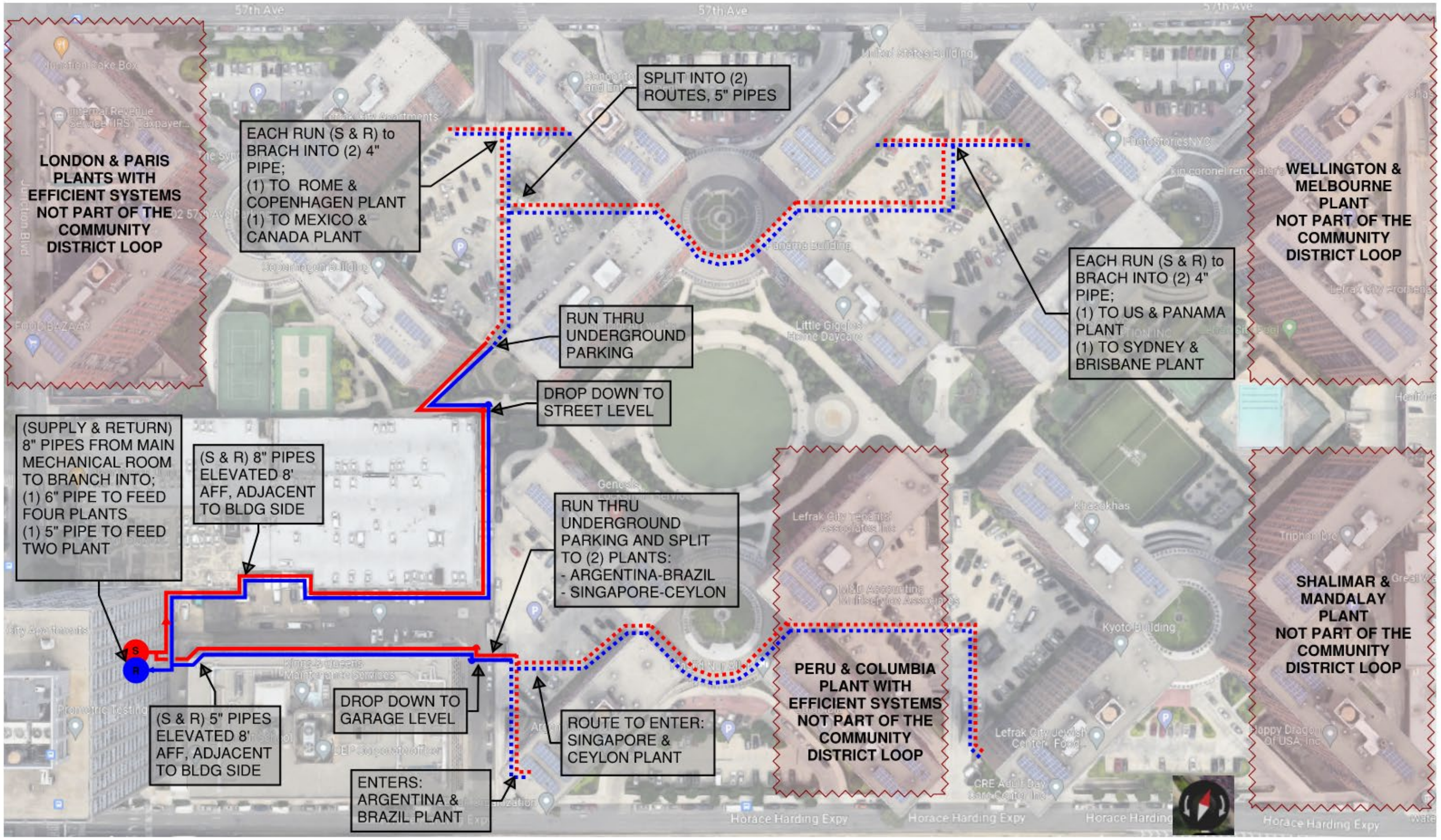
saved on 9/21/2022 11:26 AM by kfouda, plotted on 3/8/2023 10:28 AM by kfouda

A.3 Scenario 3: District Community Loop

A.3.1 Scenario 3: District Community Loop Schematics



A.3.2 Scenario 3: District Community Loop Layout



Appendix B. Cost Estimates

B.1 Scenarios 1a: Two Plants

Typical Scenario 1: 2 Plants Serving 4 Buildings

Construction Estimate

ITEM	DESCRIPTION	QTY	UNITS	MATERIAL UNIT COST	LABOR UNIT COST	MATERIAL	LABOR	TOTAL
MECHANICAL ITEMS								
1	Miscellaneous Removals	1	EA	$0	$10,000	$0	$10,000	$10,000
2	Heat Pump DHW Loop Piping	150	FT	$60	$60	$9,000	$9,000	$18,000
3	Variable Frequency Drives (VFD)	4	EA	$2,500	$700	$10,000	$2,800	$12,800
4	HW Loop Pumps	4	EA	$7,500	$5,000	$30,000	$20,000	$50,000
5	HW Loop Hydronic Accessories, CVs	1	EA	$20,000	$15,000	$20,000	$15,000	$35,000
6	Heat Exchangers	4	EA	$12,500	$10,000	$50,000	$40,000	$90,000
7	Air to Water Heat Pumps (310 MBH each)	4	EA	$73,000	$25,000	$292,000	$100,000	$392,000
8	DHW Storage Tanks	2	EA	$25,000	$10,000	$50,000	$20,000	$70,000
9	Misc. Mechanical	1	EA	$20,000	$20,000	$20,000	$20,000	$40,000
	SUBTOTAL MECHANICAL					**$481,000**	**$236,800**	**$717,800**

ITEM	DESCRIPTION	QTY	UNITS	MATERIAL UNIT COST	LABOR UNIT COST	MATERIAL	LABOR	TOTAL
ELECTRICAL ITEMS:								
1	Heat Pump Electrical Connections	4	EA	$15,000	$15,000	$60,000	$60,000	$120,000
2	Electric for Pumps, Fans, Etc.	1	EA	$30,000	$25,000	$30,000	$25,000	$55,000
3	Misc. Electric	1	EA	$15,000	$15,000	$15,000	$15,000	$30,000
	SUBTOTAL ELECTRIC					**$105,000**	**$100,000**	**$205,000**

PROJECT SUMMARY:		
MECHANICAL CONSTRUCTION		**$717,800**
ELECTRICAL CONSTRUCTION		**$205,000**
Rigging		**$15,000**
Structural and GC Work		**$25,000**
SUBTOTAL CONSTRUCTION		**$962,800**
Professional Engineering **-Design and Construction Docs** **-Bidding and Selection**	**9.0%**	**$86,652**
Construction Administration **-Supplemental Design Team Work and Commissioning**	**3.0%**	**$28,884**
TOTAL IMPLEMENTATION COST		**$1,078,336**

Note: All costs are estimates, actual construction costs should be determined by contractor pricing after completed design of project.

B.2 Scenario 2: One Plant

Typical Scenario 1: 2 Plants Serving 4 Buildings

Construction Estimate

ITEM	DESCRIPTION	QTY	UNITS	MATERIAL UNIT COST	LABOR UNIT COST	MATERIAL	LABOR	TOTAL
MECHANICAL ITEMS								
1	Miscellaneous Removals	1	EA	$0	$10,000	$0	$10,000	$10,000
2	Heat Pump DHW Loop Piping	100	FT	$60	$60	$6,000	$6,000	$12,000
3	Variable Frequency Drives (VFD)	2	EA	$2,500	$700	$5,000	$1,400	$6,400
4	HW Loop Pumps	2	EA	$7,500	$5,000	$15,000	$10,000	$25,000
5	HW Loop Hydronic Accessories, CVs	1	EA	$15,000	$15,000	$15,000	$15,000	$30,000
6	Heat Exchangers	2	EA	$12,500	$10,000	$25,000	$20,000	$45,000
7	Air to Water Heat Pumps (310 MBH each)	2	EA	$73,000	$25,000	$146,000	$50,000	$196,000
8	DHW Storage Tanks	2	EA	$25,000	$10,000	$50,000	$20,000	$70,000
9	Misc. Mechanical	1	EA	$12,500	$12,500	$12,500	$12,500	$25,000
	SUBTOTAL MECHANICAL					**$274,500**	**$144,900**	**$419,400**

ITEM	DESCRIPTION	QTY	UNITS	MATERIAL UNIT COST	LABOR UNIT COST	MATERIAL	LABOR	TOTAL
ELECTRICAL ITEMS:								
1	Heat Pump Electrical Connections	2	EA	$15,000	$15,000	$30,000	$30,000	$60,000
2	Electric for Pumps, Fans, Etc.	1	EA	$20,000	$12,500	$20,000	$12,500	$32,500
3	Misc. Electric	1	EA	$12,500	$12,500	$12,500	$12,500	$25,000
	SUBTOTAL ELECTRIC					**$62,500**	**$55,000**	**$117,500**

PROJECT SUMMARY:		
MECHANICAL CONSTRUCTION		**$419,400**
ELECTRICAL CONSTRUCTION		**$117,500**
Rigging		**$8,000**
Structural and GC Work		**$10,000**
SUBTOTAL CONSTRUCTION		**$554,900**
Professional Engineering **-Design and Construction Docs** **-Bidding and Selection**	**9.0%**	**$49,941**
Construction Administration **-Supplemental Design Team Work and Commissioning**	**3.0%**	**$16,647**
TOTAL IMPLEMENTATION COST		**$621,488**

Note: All costs are estimates, actual construction costs should be determined by contractor pricing after completed design of project.

B.3 Scenario 3: District Community Loop

Typical Scenario 3: Option B

Construction Estimate

ITEM	DESCRIPTION	QTY	UNITS	MATERIAL UNIT COST	LABOR UNIT COST	MATERIAL	LABOR	TOTAL
MECHANICAL ITEMS								
1	Site Excavation Service	12000	FT3	$0	$1.50	$0	$18,000	$18,000
2	Heat Recovery Loop Piping	12000	FT	$26	$26	$316,741	$320,954	$905,527
3	Variable Frequency Drives (VFD) [1/Plant]	6	EA	$3,000	$1,000	$18,000	$6,000	$24,000
4	DHW Heat Exchangers	6	EA	$15,000	$12,500	$90,000	$75,000	$165,000
5	DHW Loop Main Pumps [10HP]	2	EA	$10,000	$10,000	$20,000	$20,000	$40,000
6	DHW Loop Hydronic Accessories, CVs	2	EA	$10,000	$10,000	$20,000	$20,000	$40,000
7	Waterproof Insulation Package Gkycol	1	EA	$10,000	$5,000	$10,000	$5,000	$15,000
8	Misc. Mechanical	1	EA	$40,000	$40,000	$40,000	$40,000	$80,000
	SUBTOTAL MECHANICAL					**$514,741**	**$504,954**	**$1,287,527**

ITEM	DESCRIPTION	QTY	UNITS	MATERIAL UNIT COST	LABOR UNIT COST	MATERIAL	LABOR	TOTAL
ELECTRICAL ITEMS :								
1	Electric for Pumps	2	EA	$10,000	$15,000	$20,000	$30,000	$50,000
2	Misc. Electric	1	EA	$7,500	$5,000	$7,500	$5,000	$12,500
	SUBTOTAL ELECTRIC					**$27,500**	**$35,000**	**$62,500**

PROJECT SUMMARY:		
MECHANICAL CONSTRUCTION		**$1,287,527**
ELECTRICAL CONSTRUCTION		**$62,500**
Rigging		**$50,000**
Structural and GC Work		**$75,000**
SUBTOTAL CONSTRUCTION		**$1,475,027**
Professional Engineering -Design and Construction Docs -Bidding and Selection	**9.0%**	**$132,752**
Construction Administration -Supplemental Design Team Work and Commissioning	**3.0%**	**$44,251**
TOTAL IMPLEMENTATION COST		**$1,652,031**

Note: All costs are estimates, actual construction costs should be determined by contractor pricing after completed design of project.

B.4 In-Kind: Boiler Replacements

In-Kind Project

Construction Estimate

ITEM	DESCRIPTION	QTY	UNITS	MATERIAL UNIT COST	LABOR UNIT COST	MATERIAL	LABOR	TOTAL
MECHANICAL ITEMS								
1	Miscellaneous Removals	2	EA	$0	$15,000	$0	$30,000	$30,000
2	Variable Frequency Drives (VFD)	2	EA	$2,500	$700	$5,000	$1,400	$6,400
3	Cleaver-Brooks (CBLE-700-250-150ST) Steam Boiler	2	EA	$110,000	$40,000	$220,000	$80,000	$300,000
4	Misc. Mechanical	2	EA	$15,000	$20,000	$30,000	$40,000	$70,000
	SUBTOTAL MECHANICAL					**$151,400**	**$406,400**	**$255,000**

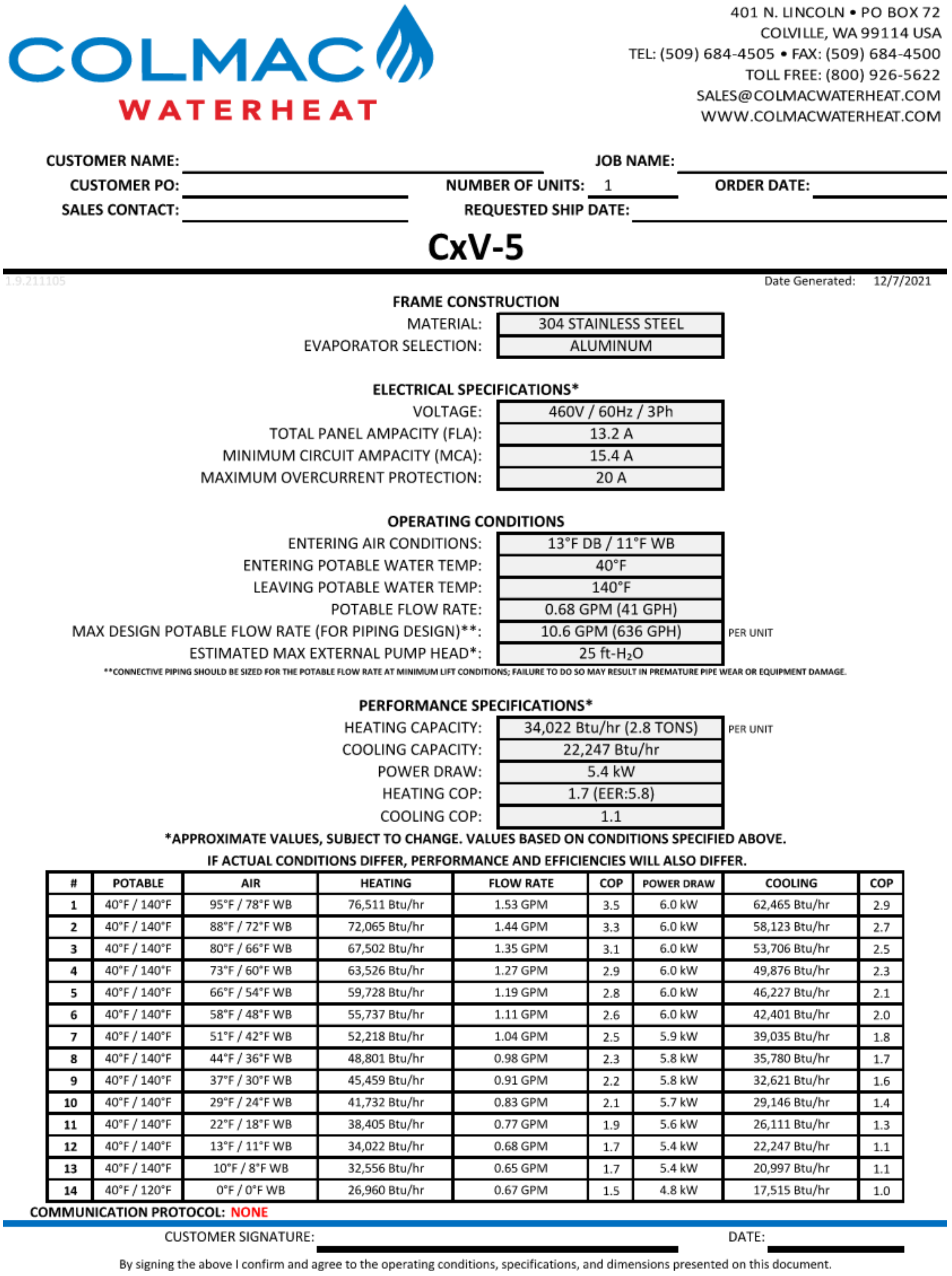
ITEM	DESCRIPTION	QTY	UNITS	MATERIAL UNIT COST	LABOR UNIT COST	MATERIAL	LABOR	TOTAL
ELECTRICAL ITEMS :								
1	Electric for Pumps, Fans, Etc.	2	EA	$20,000	$12,500	$40,000	$25,000	$65,000
2	Boiler Connections	2	EA	$5,000	$5,000	$10,000	$10,000	$20,000
3	Misc. Electric	2	EA	$15,000	$15,000	$30,000	$30,000	$60,000
SUBTOTAL ELECTRIC						**$80,000**	**$65,000**	**$145,000**

PROJECT SUMMARY:		
MECHANICAL CONSTRUCTION		**$406,400**
ELECTRICAL CONSTRUCTION		**$145,000**
Rigging		**$10,000**
Structural and GC Work		**$15,000**
Contingency	**10.00%**	**$57,640**
SUBTOTAL CONSTRUCTION		**$634,040**
Professional Engineering **-Design and Construction Docs** **-Bidding and Selection**		**$50,000**
Construction Administration **-Supplemental Design Team Work and Commissioning**		**$15,000**
TOTAL IMPLEMENTATION COST		**$699,040**

Note: All costs are estimates, actual construction costs should be determined by contractor pricing after completed design of project.

Appendix C. Manufacturer Cutsheets

C.1 Colmac Waterheat: Heat Pump



COLMAC WATERHEAT

401 N. LINCOLN • PO BOX 72
COLVILLE, WA 99114 USA
TEL: (509) 684-4505 • FAX: (509) 684-4500
TOLL FREE: (800) 926-5622
SALES@COLMACWATERHEAT.COM
WWW.COLMACWATERHEAT.COM

CUSTOMER NAME: ______ **JOB NAME:** ______
CUSTOMER PO: ______ **NUMBER OF UNITS:** 1 **ORDER DATE:** ______
SALES CONTACT: ______ **REQUESTED SHIP DATE:** ______

CxV-5

1.9.211105

Date Generated: 12/7/2021

FRAME CONSTRUCTION

MATERIAL: 304 STAINLESS STEEL
EVAPORATOR SELECTION: ALUMINUM

ELECTRICAL SPECIFICATIONS*

VOLTAGE: 460V / 60Hz / 3Ph
TOTAL PANEL AMPACITY (FLA): 13.2 A
MINIMUM CIRCUIT AMPACITY (MCA): 15.4 A
MAXIMUM OVERCURRENT PROTECTION: 20 A

OPERATING CONDITIONS

ENTERING AIR CONDITIONS: 13°F DB / 11°F WB
ENTERING POTABLE WATER TEMP: 40°F
LEAVING POTABLE WATER TEMP: 140°F
POTABLE FLOW RATE: 0.68 GPM (41 GPH)
MAX DESIGN POTABLE FLOW RATE (FOR PIPING DESIGN)**: 10.6 GPM (636 GPH) PER UNIT
ESTIMATED MAX EXTERNAL PUMP HEAD*: 25 ft-H_2O

**CONNECTIVE PIPING SHOULD BE SIZED FOR THE POTABLE FLOW RATE AT MINIMUM LIFT CONDITIONS; FAILURE TO DO SO MAY RESULT IN PREMATURE PIPE WEAR OR EQUIPMENT DAMAGE.

PERFORMANCE SPECIFICATIONS*

HEATING CAPACITY: 34,022 Btu/hr (2.8 TONS) PER UNIT
COOLING CAPACITY: 22,247 Btu/hr
POWER DRAW: 5.4 kW
HEATING COP: 1.7 (EER:5.8)
COOLING COP: 1.1

***APPROXIMATE VALUES, SUBJECT TO CHANGE. VALUES BASED ON CONDITIONS SPECIFIED ABOVE.**
IF ACTUAL CONDITIONS DIFFER, PERFORMANCE AND EFFICIENCIES WILL ALSO DIFFER.

#	POTABLE	AIR	HEATING	FLOW RATE	COP	POWER DRAW	COOLING	COP
1	40°F / 140°F	95°F / 78°F WB	76,511 Btu/hr	1.53 GPM	3.5	6.0 kW	62,465 Btu/hr	2.9
2	40°F / 140°F	88°F / 72°F WB	72,065 Btu/hr	1.44 GPM	3.3	6.0 kW	58,123 Btu/hr	2.7
3	40°F / 140°F	80°F / 66°F WB	67,502 Btu/hr	1.35 GPM	3.1	6.0 kW	53,706 Btu/hr	2.5
4	40°F / 140°F	73°F / 60°F WB	63,526 Btu/hr	1.27 GPM	2.9	6.0 kW	49,876 Btu/hr	2.3
5	40°F / 140°F	66°F / 54°F WB	59,728 Btu/hr	1.19 GPM	2.8	6.0 kW	46,227 Btu/hr	2.1
6	40°F / 140°F	58°F / 48°F WB	55,737 Btu/hr	1.11 GPM	2.6	6.0 kW	42,401 Btu/hr	2.0
7	40°F / 140°F	51°F / 42°F WB	52,218 Btu/hr	1.04 GPM	2.5	5.9 kW	39,035 Btu/hr	1.8
8	40°F / 140°F	44°F / 36°F WB	48,801 Btu/hr	0.98 GPM	2.3	5.8 kW	35,780 Btu/hr	1.7
9	40°F / 140°F	37°F / 30°F WB	45,459 Btu/hr	0.91 GPM	2.2	5.8 kW	32,621 Btu/hr	1.6
10	40°F / 140°F	29°F / 24°F WB	41,732 Btu/hr	0.83 GPM	2.1	5.7 kW	29,146 Btu/hr	1.4
11	40°F / 140°F	22°F / 18°F WB	38,405 Btu/hr	0.77 GPM	1.9	5.6 kW	26,111 Btu/hr	1.3
12	40°F / 140°F	13°F / 11°F WB	34,022 Btu/hr	0.68 GPM	1.7	5.4 kW	22,247 Btu/hr	1.1
13	40°F / 140°F	10°F / 8°F WB	32,556 Btu/hr	0.65 GPM	1.7	5.4 kW	20,997 Btu/hr	1.1
14	40°F / 120°F	0°F / 0°F WB	26,960 Btu/hr	0.67 GPM	1.5	4.8 kW	17,515 Btu/hr	1.0

COMMUNICATION PROTOCOL: NONE

CUSTOMER SIGNATURE: ______ DATE: ______

By signing the above I confirm and agree to the operating conditions, specifications, and dimensions presented on this document.

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New York State
Energy Research and
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Albany, NY 12203-6399

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New York State Energy Research
and Development Authority