De-Carbonizing the Campus: Planning, Tools & Technologies

CampusEnergy2023

February 27 – March 2, 2023

Gaylord Texan Resort & Convention Center | Grapevine, Texas

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Feasibility of a Community Heat Pump

Carbon Reduction in an Ultra Dense Urban Environment

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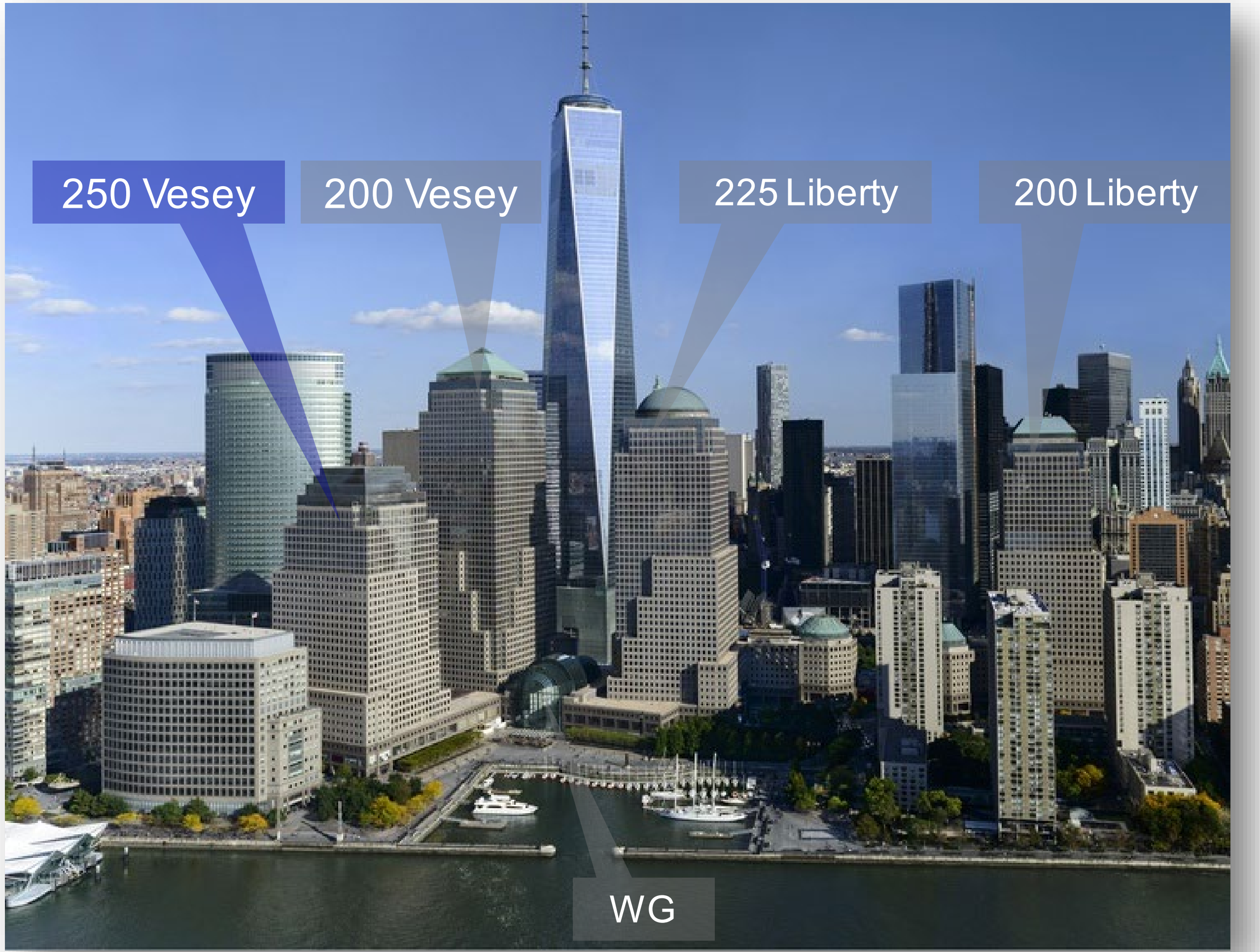
Site

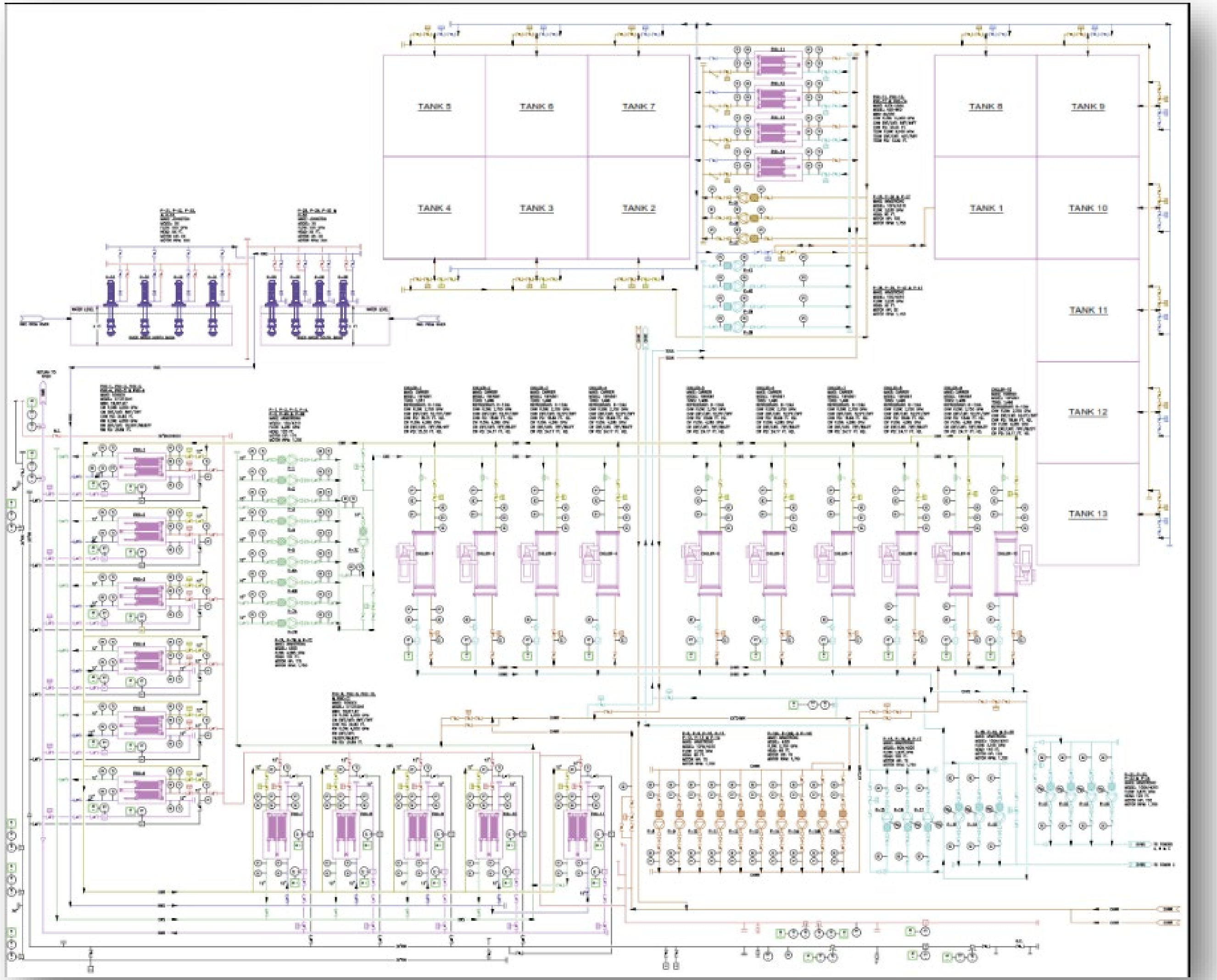


14 Acre, 5-building, 8M Sq Ft, mixed use complex on the Hudson River in Lower Manhattan.

- 200 Liberty - 1.6M SF
- 225 Liberty - 2.5M SF
- 200 Vesey – 2.3M SF
- 250 Vesey – 1.6M SF
- Winter Garden Atrium
- Plant is in basement of 250 Vesey

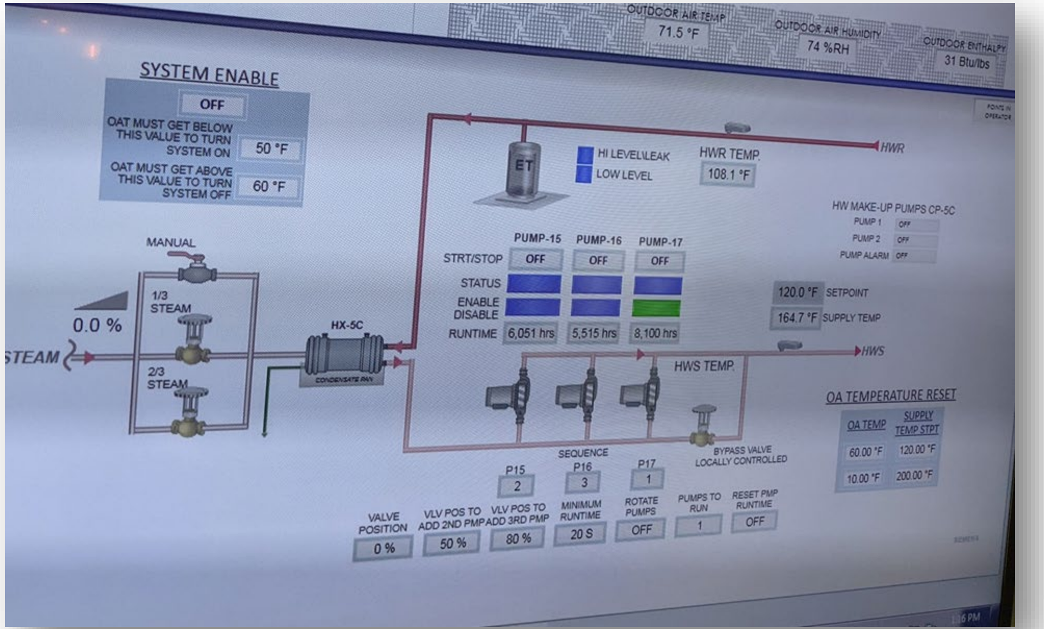
Existing Cooling Plant – Generation and Distribution

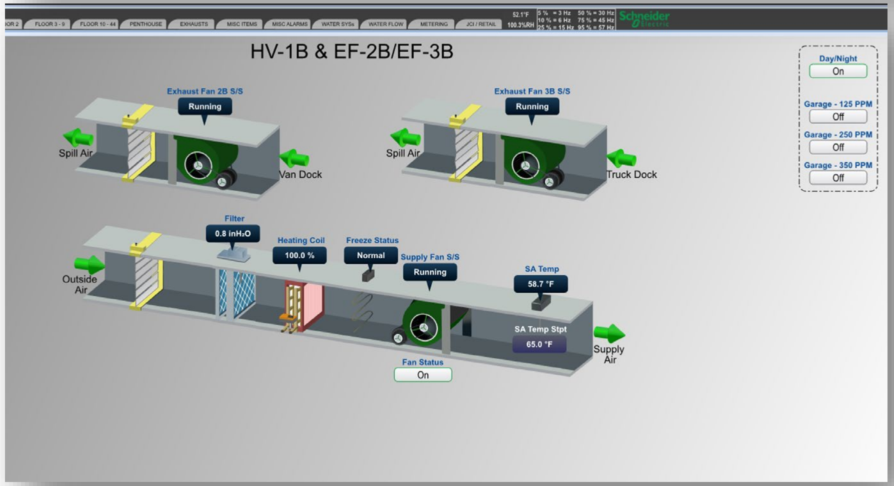
- Built in early/mid 1980s
- 15,000 Ton Plant
  - (3) 1,500 Ton Constant Speed Chillers
  - (7) 1,500 Ton VFD Chillers
- River Water Heat Rejection via 11 titanium PFHXs and 8 VT pumps
- 47 CW/TES/CHW Pumps
- (13) 280,000 Gallon TES Tanks
  - Roughly 30,000 Ton-hrs +/-
- Three CHW distribution loops
  - Building A, B Winter Garden
  - Building C
  - Building D



Existing Heating System – Distribution and Utilization

- ConEd Steam is supplied to Tower D, then distributed and utilized at:
  - Central Plant
  - Tower D
  - Tower C
  - Winter Garden
  - Tower B
  - Tower A
- The buildings consume the steam in the following way
  - Domestic hot water – Bathrooms and Kitchens
  - Podium retail and lobby AHUs
  - 100% OA Units for kitchens
  - Steam to Hot water Heat Exchangers
    - Reheat and Perimeter Radiation
    - H&V Units
    - Tempering of CHW into 100% OA reclaim coil





Existing CHW System - Utilization

- The primary chilled water is distributed to the following:
  - Central Plant and Winter Garden – AHUs
  - Tower A, B, C, and D – SCHW Heat Exchangers, Retail Loads, Lobby and Tenant area AHUs, Chilled Floors
- Secondary CHW
  - All Towers have 100% OA units with reclaim coil
  - Floor by Floor Compartment units
  - Tower B and D have a technology riser on the secondary side

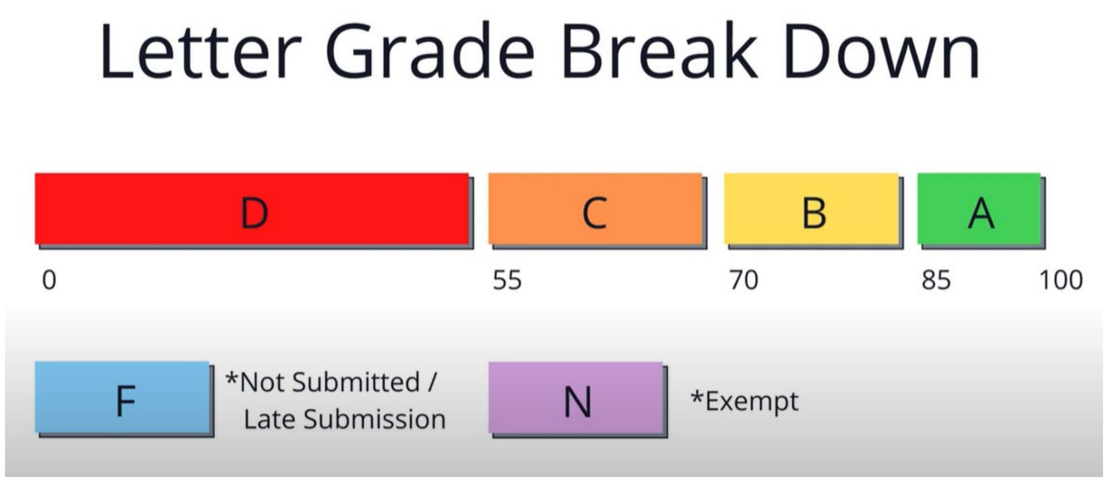
Why?

- Regulatory
  - NYC Local Law 97
  - NYC Local Law 33
- Cost
  - Reduce pass through energy costs to tenants
- ESG
  - Brookfield owns the largest renewable power business in the world.
  - Brookfield corporate sustainability goals:
    - Reduce Scope 1 and Scope 2 emissions by 1/3 by 2030 (Baseline year 2020)
    - Net-zero by 2050

NYC LOCAL LAW 97 (LL97)

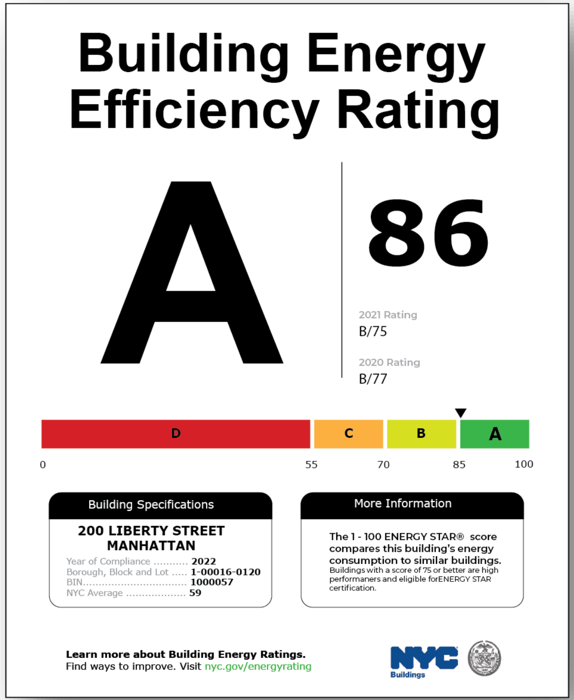
- NYC carbon neutral by 2050.
- Local Law 97 is one of the most ambitious plans for reducing emissions in the nation. Local Law 97 was included in the Climate Mobilization Act, passed in April 2019.
- Under this law, most buildings over 25,000 square feet will be required to meet new energy efficiency and greenhouse gas emissions limits by 2024, with stricter limits coming into effect in 2030.
- The goal is to reduce the emissions produced by the city’s largest buildings 40 percent by 2030 and 80 percent by 2050
- Sets increasingly stringent limits on carbon emissions per square foot in 2024 and 2030
- Flexibility to comply through renewable energy credits and/or emissions offsets
- New Office of Building Energy and Emissions Performance at Department of Buildings
- Penalties for non-compliance
  - Maximum annual penalty is the difference between a building’s annual emissions limit and its actual emissions multiplied by $268.
  - First compliance report due May 1, 2025 (and every May thereafter).
  - NYC Estimates 20-25% of buildings will exceed limits.

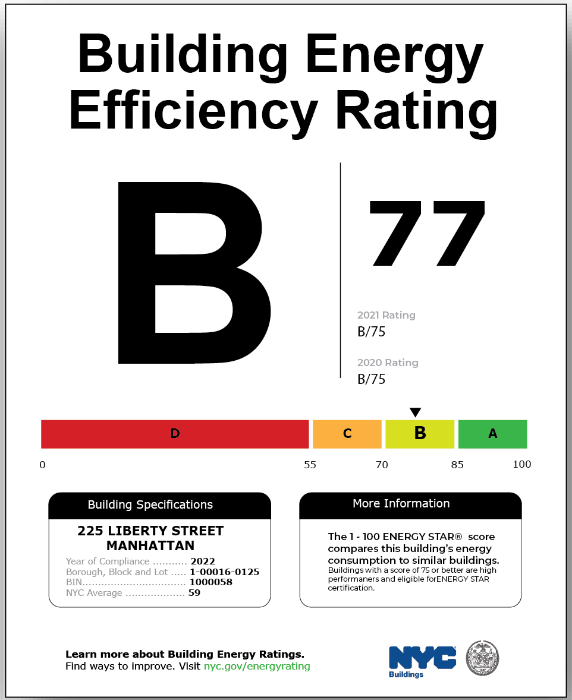
NYC LOCAL LAW 33 (LL33)



- **A** – score is equal to or greater than 85
- **B** – score is equal to or greater than 70 but less than 85
- **C** – score is equal to or greater than 55 but less than 70
- **D** – score is less than 55
- **F** – for buildings that didn't submit required benchmarking information
- **N** – for buildings exempt from benchmarking or not covered by the Energy Star program.

NYC LOCAL LAW 33 (LL33) – Brookfield





NYSERDA – Community Heat Pump

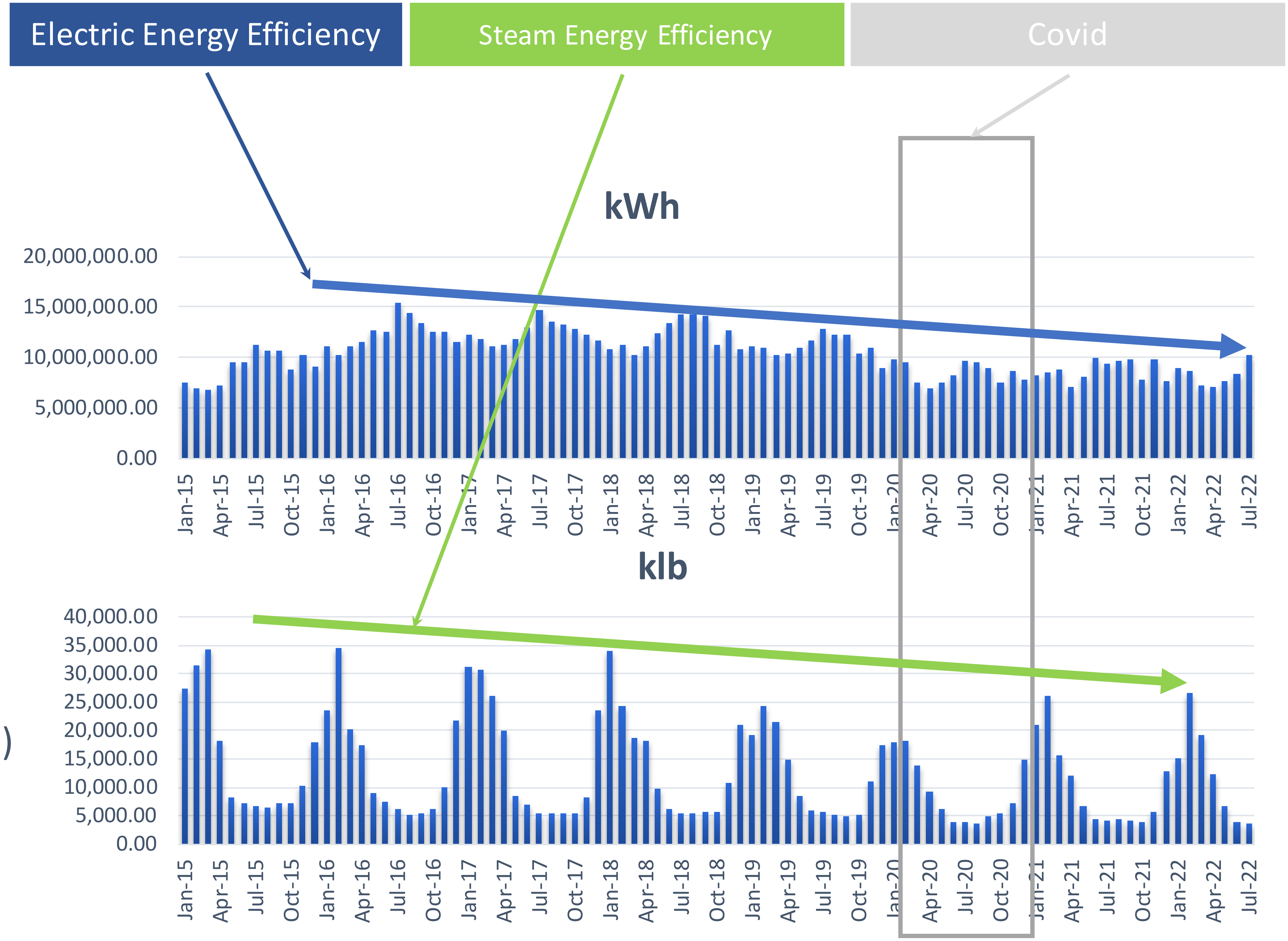
• Program Opportunity Notice 4614 (PON 4614)

- Heat pumps can be integrated with a network of distribution pipes to serve multiple buildings in a configuration referred to as Community Thermal Energy Networks. Additional names for this type of system include District Thermal, district-style heat pump systems, and community heat pump systems.
- Community Thermal Energy Networks such as:
  - Colleges/universities
  - Medical campuses
  - Residential complexes
  - Multi-owner nodes (such as downtown corridors).
- PON 4614 drives exploration of business models that can cost-effectively grow this market to scale through support for:
  - Category A (Feasibility) – Opportunity is Closed
  - Category B (Design) – Our Next Phase
  - Category C (Construction)
  - Solution providers and project sites interested in evaluating the feasibility of a community heat pump system may use the FlexTech program for funding assistance.

Project Process – Feasibility

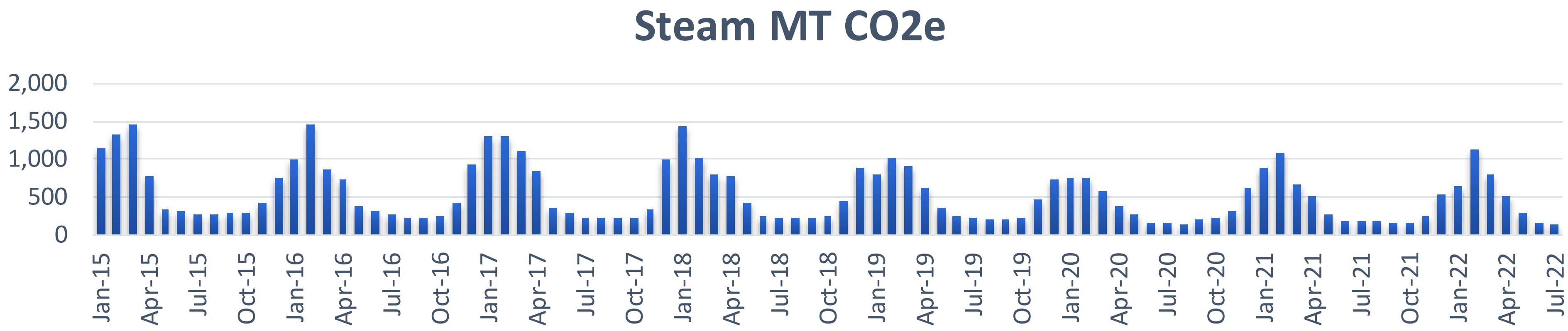
- Load Profiles
  - Hourly Heating And Cooling Loads – Avoid Estimates
  - Granular – The Quality Of Each Heat Sink And Source
- System Design
  - Full Simultaneous Heating And Cooling
  - Storage?
  - Geoexchange?
  - Control Strategy
- Economics
  - Annual Energy Cost Reduction
  - Annual Maintenance Costs
  - Installation/Construction Costs
  - Funding
    - Source
    - Cost Of Money Is Increasing

Site Utility



- Energy Efficiency Improvements have reduced both electric and steam loads.
- 2019 Electric
  - 133,346,147 kWh
- 2019 Steam
  - 170,000 klbs
  - (~45,131,887 kWh)

Carbon


Steam MT CO2e
2,000
1,500
1,000
500
0
Jan-15
Apr-15
Jul-15
Oct-15
Jan-16
Apr-16
Jul-16
Oct-16
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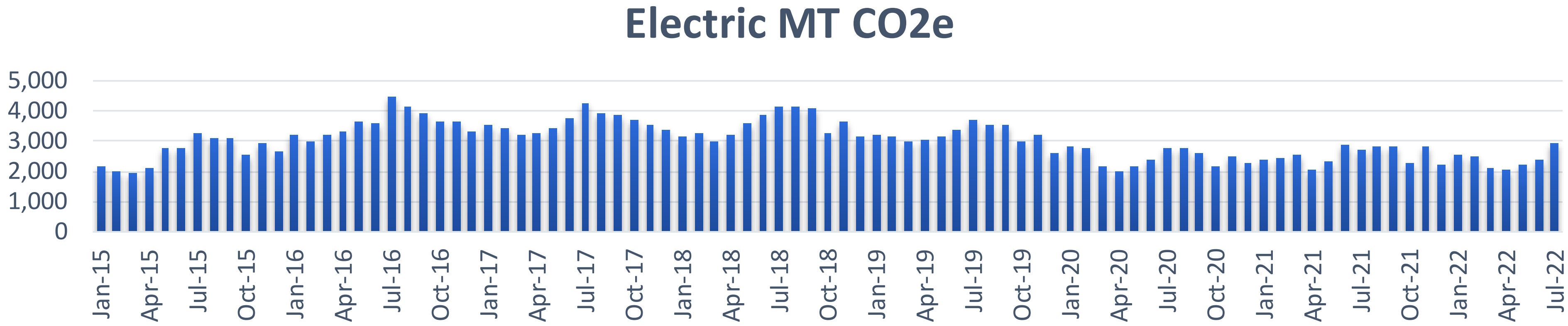
Electric MT CO2e
5,000
4,000
3,000
2,000
1,000
0
Jan-15
Apr-15
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Jan-16
Apr-16
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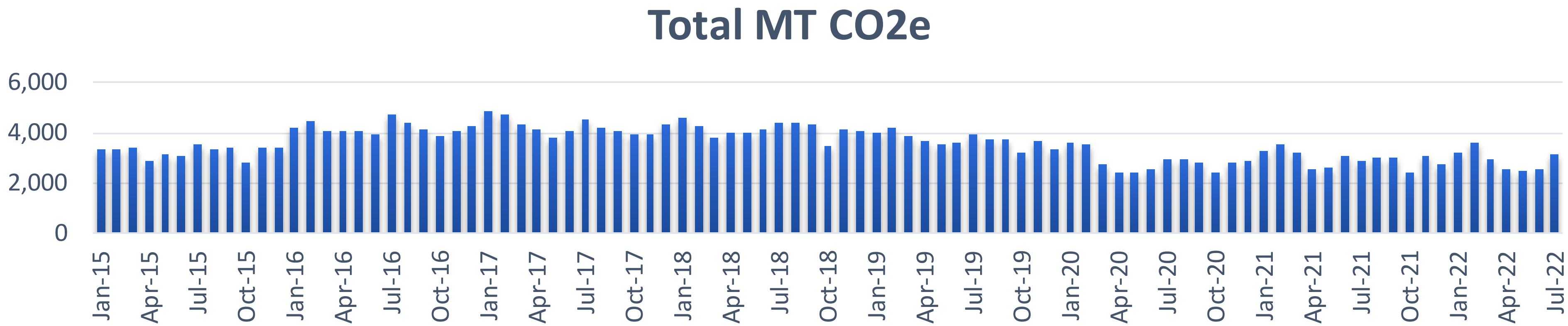
Total MT CO2e
6,000
4,000
2,000
0
Jan-15
Apr-15
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Oct-16
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Jan-20
Apr-20
Jul-20
Oct-20
Jan-21
Apr-21
Jul-21
Oct-21
Jan-22
Apr-22
Jul-22

Loads

Sample Tower B Results

- Load model using TMY3 weather data was calibrated to each submeter and the main ConEd meter.

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**

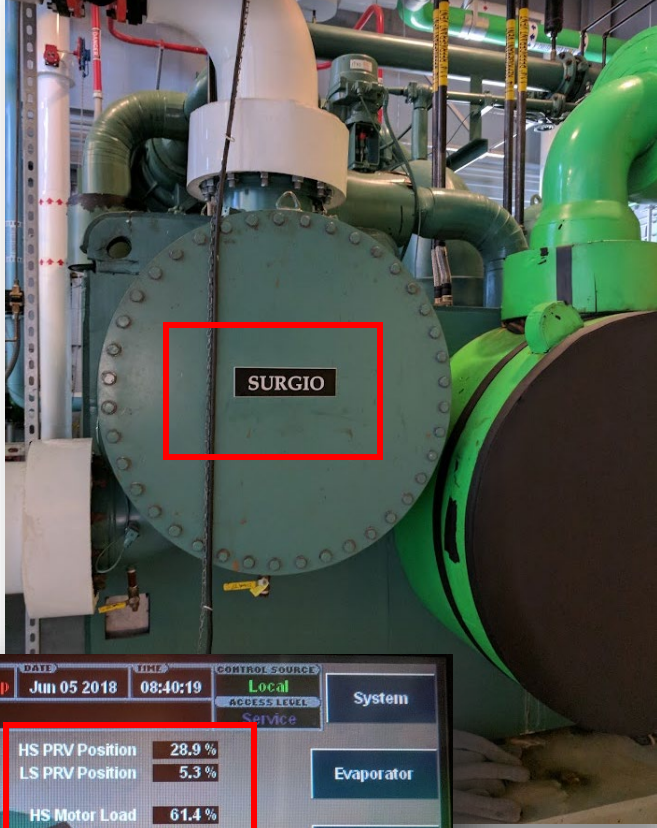
Heat Source Flexibility

- For the most part the system is sized for the following limitations:
  - Winter Cooling Load
  - Physical MER space limitation

- Operations have the following ways to increase the CHW load for the times that the cooling load does not align with available heat pump capacity and heating load
  - Reduce economizer
  - Bypass reclaim coil
  - Exchange heat between CHW system and Tower C and A Technology CW riser
  - Pull heat from the existing river water system

Controls

- We have been involved in a few heat pump projects which have one or both of the following issues:
    - Imbalanced Heat Sink and Heat Source
    - Hot water users not compatible with lower HHW temperatures
- In the plant design phase, we have reprogrammed the majority of the hot water users to be compatible with lower resets. (Or in the process of)
    - All resets have been coordinated with the central plant
- By doing this before selecting the heat pump capacity we can ensure capacities align with the system.
- This also makes savings calculations much more accurate.



Modeling

- Having Each Individual Steam And Hot Water User Modeled With Actual Unit Control Code Allows Us To Determine The Cost Benefit Of Every Unit.
  - Tower A – Schneider
  - Tower B – Schneider And Some JCI
  - Tower C – Siemens
  - Tower D – Honeywell And Some ALC
  - Winder Garden – Schneider
  - Central Plant – Schneider
- Some Units Do Not Have An Attractive ROI On Conversion. This Allows Us To Cost Optimize The System.
  - Example 1: Tower A is a light steam user compared to other towers. It is Also the furthest from the Central Plant.

	Tower B LH HHW Gen						Measure:	
	Calculation Method:	8760					Basis:	
Design	Tag	HX-3B/4B			HX-5B			
	Equip	Steam to Hot Water HX			Steam to Hot Water HX			Stea
	Make/Model	ITT / SU 204-2			ITT / SU 164-2			
	Capacity (Mbh)	6,800			3,800			
	Stm Flow (lb/Hr)	7,010			3,920			
	HHW Flow (GPM	680			380			
Existing Operation		Hours	MBH	klbs	Hours	MBH	klbs	Hours
	Jan	646	756,034	792	386	274,873	288	320
	Feb	466	540,750	566	315	216,866	227	278
	Mar	519	614,915	644	347	247,114	259	307
	Apr	88	89,304	94	16	10,009	10	5
	May	24	23,974	25	2	1,218	1	0
	Jun	0	0	0	0	0	0	0
	July	0	0	0	0	0	0	0
	Aug	0	0	0	0	0	0	0
	Sep	0	0	0	0	0	0	0
	Oct	60	59,793	63	5	3,110	3	2
	Nov	396	435,882	456	199	132,338	139	141
	Dec	650	800,784	839	490	357,278	374	444
	Total	2,849	3,321,436	3,478	1,760	1,242,808	1,301	1,497
	Total Cost	$		125,206	$		46,849	$
Modified Operation	Tag	HX-3B/4B			HX-5B			
	Equip	Steam to Hot Water HX			Steam to Hot Water HX			Stea
	Make/Model	ITT / SU 204-2			ITT / SU 164-2			
	Capacity (Mbh)	6,800			3,800			
	Stm Flow (lb/Hr)	7,010			3,920			
	HHW Flow (GPM	680			380			
		Hours	MBH	klbs	Hours	MBH	klbs	Hours
	Jan	646	11,676	12	386	6,525	7	320
	Feb	466	0	0	315	0	0	278
	Mar	519	0	0	347	0	0	307
	Apr	88	0	0	16	0	0	5
	May	24	0	0	2	0	0	0
	Jun	0	0	0	0	0	0	0
	July	0	0	0	0	0	0	0
	Aug	0	0	0	0	0	0	0
	Sep	0	0	0	0	0	0	0
	Oct	60	0	0	5	0	0	2
	Nov	396	0	0	199	0	0	141
	Dec	650	12,022	13	490	6,718	7	444
	Total	2,849	23,698	25	1,760	13,243	14	1,497
	Total Cost	$		893	$		499	$
Summary	Tag	HX-3B/4B			HX-5B			
	Change Hrs	0			0			
	Energy Reductio	3,453			1,288			
	Reduction in Cost	$		124,313	$		46,350	$

Economics

- The Community Heat Pump Program required us to analyze centralized VS decentralized options. The centralized option is much more attractive for the following reasons:
  - Capable of doing warmer HHW
  - Leverages Site Diversity
  - Able to leverage existing infrastructure
  - Able to leverage River

Breakdown of Modification Options

Option	Description	Estimated Annual Steam Reduction	Estimated Annual Electric Reduction	Estimated Annual CO2 Reduction			First Cost - Estimated			Estimated Annual Energy Cost Savings		With CO2 Tax		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	$(24,000,000)	$ -	$ (24,000,000)	$2,971,526	8.1	$ 919,313	6.2	$ 51,550,274
M.2	Tower A Heat Pump	5,954	-271,945	251	-79	173	$ (2,500,000)	$ -	$ (2,500,000)	$ 118,944	21.0	$ 46,334	15.1	$ 709,285
M.3	Tower B Heat Pump	11,324	-467,814	478	-135	343	$ (3,500,000)	$ -	$ (3,500,000)	$ 267,538	13.1	$ 91,940	9.7	$ 3,480,153
M.4	Tower C Heat Pump	2,974	-64,663	126	-19	107	$ (2,500,000)	$ -	$ (2,500,000)	$ 89,458	27.9	$ 28,659	21.1	-206,459.4
M.5	Tower D Heat Pump	4,578	-104,168	193	-30	163	$ (2,500,000)	$ -	$ (2,500,000)	$ 135,183	18.5	$ 43,750	13.9	974,431.2

Next Steps

- Finalize Feasibility
  - Finalize Schematic Design with Mechanical, Electrical and Controls Contractor
- Enter Design Phase
  - Apply to NYSERA Community Heat Pump Phase B
- Construction
  - Apply to NYSERA Community Heat Pump Phase C
  - Ideally Execute Via Design Build

Take Aways

- LL97 Is Driving The Way Building's Function Moving Forward In NYC
  - Substantial Carbon Reduction Is Required
- LL33 Letter Grade Improvement For Each Tower
- Reducing River Water Use Is A Win For The Facility
- Reprogramming and measuring heating loads in the design phase reduces project risk.
- Substantial Operational Cost Reduction For The Utility Customers
  - The HHW Rate Can Carry The Following And Still Allow For Cost Savings
    - Energy Costs
    - Construction Cost, With Cost Of Capital – Even At Current High Interest Rates
    - Current Staffing And Other Operating Fixed Costs Of The Central Plant Can Be Spread Out Onto The HHW Rate To Make CHW Rate More Competitive

Thank You!

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