Value of Geothermal Heat Pumps Beyond Energy Savings

Moderator: **Joseph Hitt / *NYS Department of Public Service***

Panel: **Jennifer Livermore / *U.S. Department of Energy***
Akhilesh Ramakrishnan / *The Brattle Group*
Robert Greig / *Consolidated Edison Company of New York*
Jens Ponikau / *Buffalo Geothermal & NY-GEO Board*

U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Value of GHP - Beyond Energy Savings

NY-GEO NYC 2024

Jen Livermore

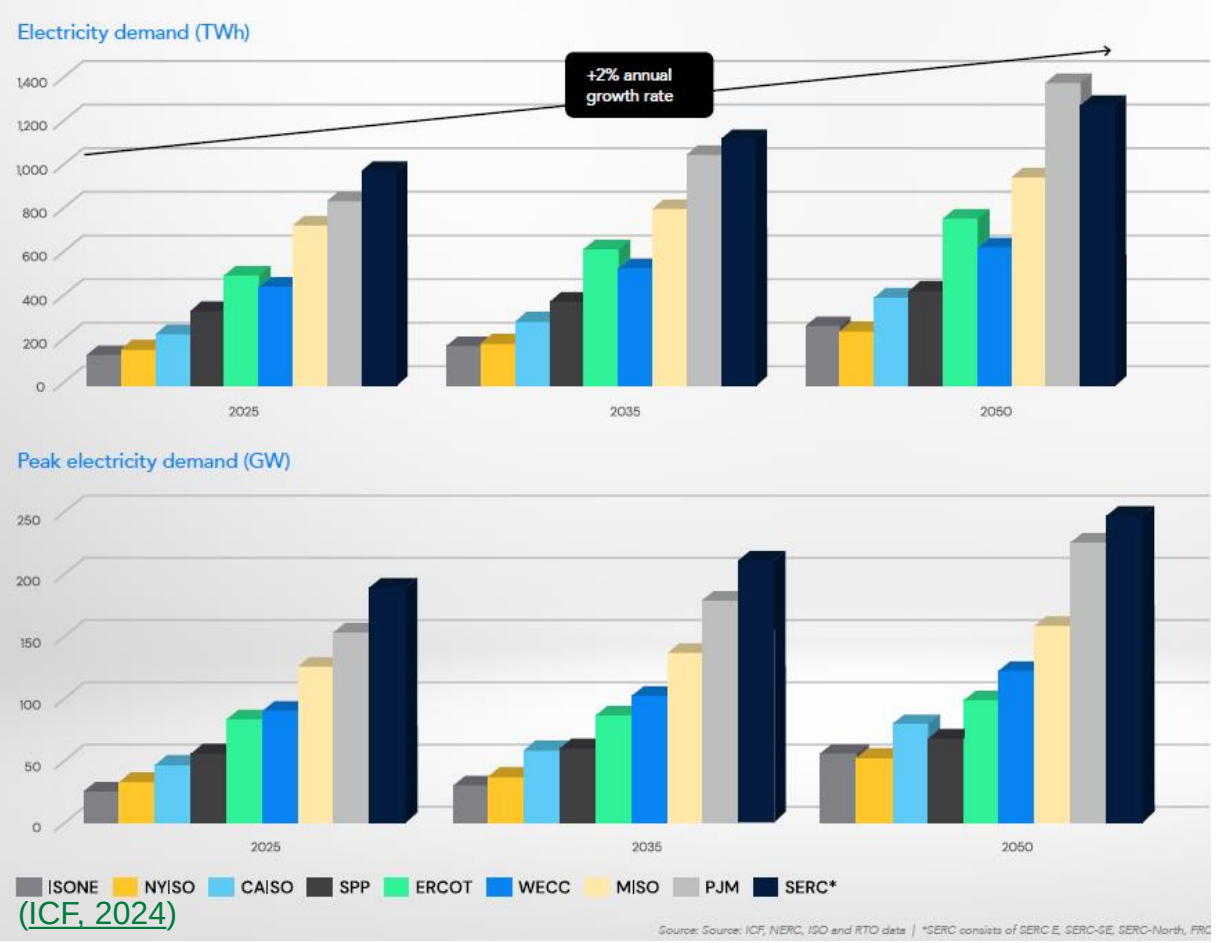
General Engineer; Data, Modeling, and Analysis Subprogram

Geothermal Technologies Office

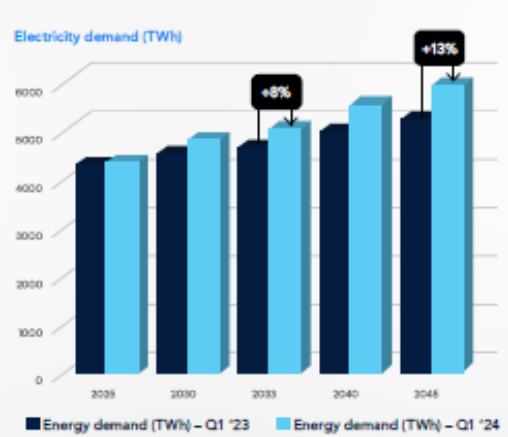
October 22, 2024

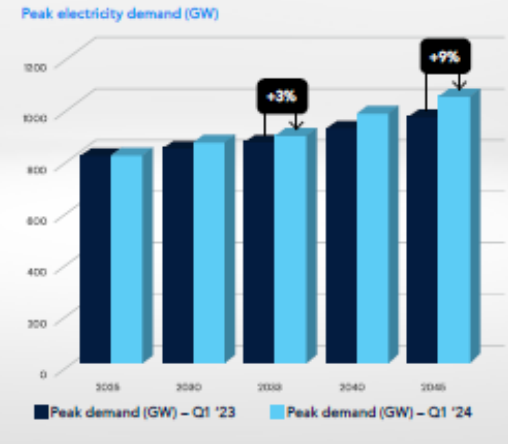
Electricity Demand Projections through 2050

- 57% increase in US electricity demand by 2050
- Peak demand growth of 124% projected in ISO New England by 2050
- Upward revision observed in projections



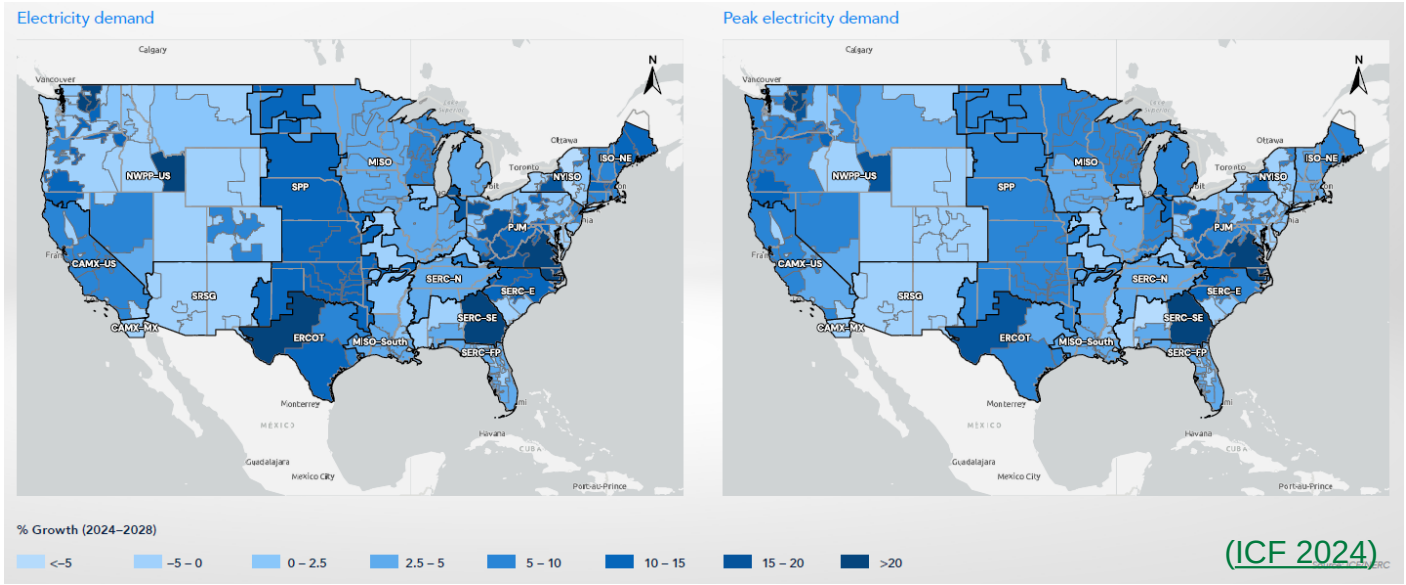
(ICF, 2024)



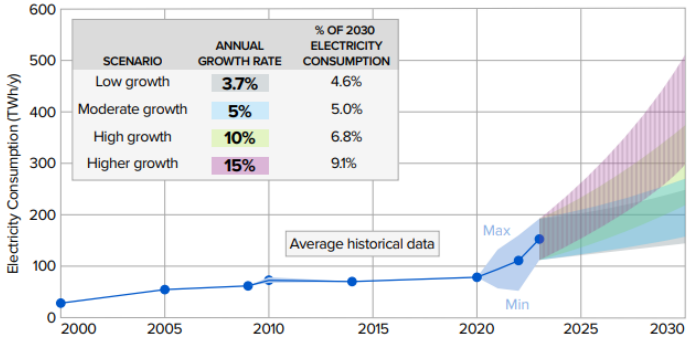


Near-Term Electricity Demand Projections

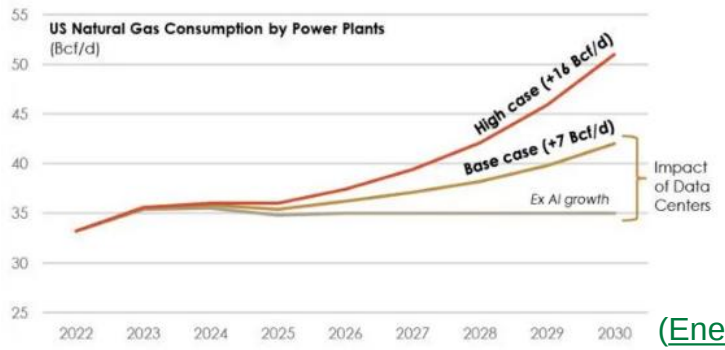
- 9% growth in US electricity demand by 2028; >2% per year increase
- Summer peak demand increase of 5% by 2028
- Wholesale electricity price increase of 19% by 2028



(ICF 2024)

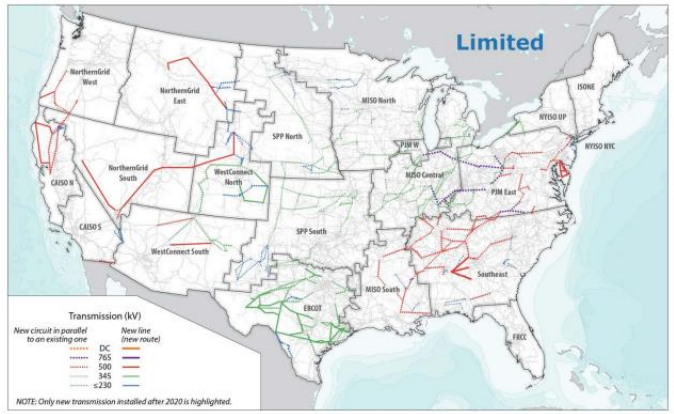


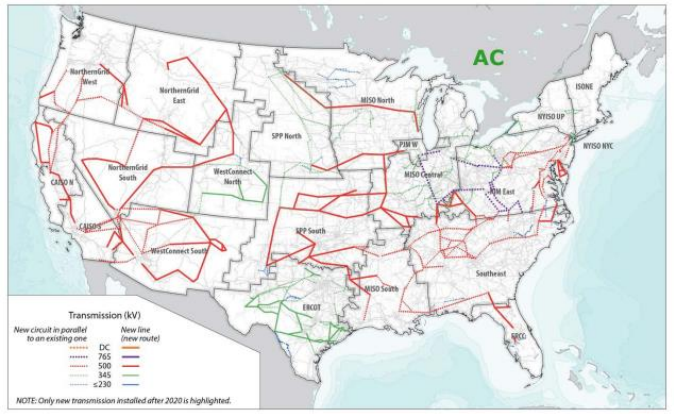
(EPRI 2024) *Figure ES-1. Projections of potential electricity consumption by U.S. data centers: 2023–2030 . % of 2030 electricity consumption projections assume that all other (non-data center) load increases at 1% annually.*



(Enervus 2024)

DOE National Transmission Planning Study





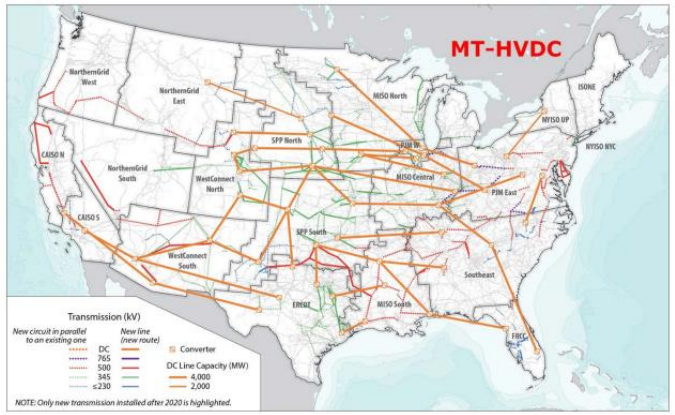


Table I. Summary of Scenarios for Zonal-to-Nodal Translation

Dimension	Limited	AC	MT-HVDC
Transmission framework[1]	AC expansion within transmission planning regions	AC expansion within interconnects	HVDC expansion across interconnects (+AC within transmission planning regions)
Model year	2035		
Annual electricity demand	Mid Demand[1] CONUS: 5620 TWh (916 GW) Western Interconnection: 1097 TWh (186 GW) ERCOT: 509 TWh (93 GW) Eastern Interconnection: 4014 TWh (665 GW)		
CO_2 emissions target	CONUS: 90% reduction by 2035 (relative to 2005)		

[1] *See Chapter 2 for further details.*

CO_2 = carbon dioxide; AC = alternating current; TWh = terawatt-hour; GW = gigawatt; HVDC = high-voltage direct current

"Under a U.S. electricity system carbon target that achieves a 90% greenhouse gas emissions reduction by 2035 and 100% by 2050, the United States transmission system expands 2.4 to 3.5 times the size of the 2020 system by 2050."

(DOE, 2024)

New York ISO Load Growth Projections

Baseline Forecast Summary

Year	NYCA Annual Energy (GWh)	NYCA Summer Peak (MW)	NYCA Winter Peak (MW)
2025	153,631	33,219	24,406
2030	158,567	33,290	27,816
2035	179,261	35,546	34,956
2040	207,241	38,025	43,804
2042	216,709	38,969	46,541

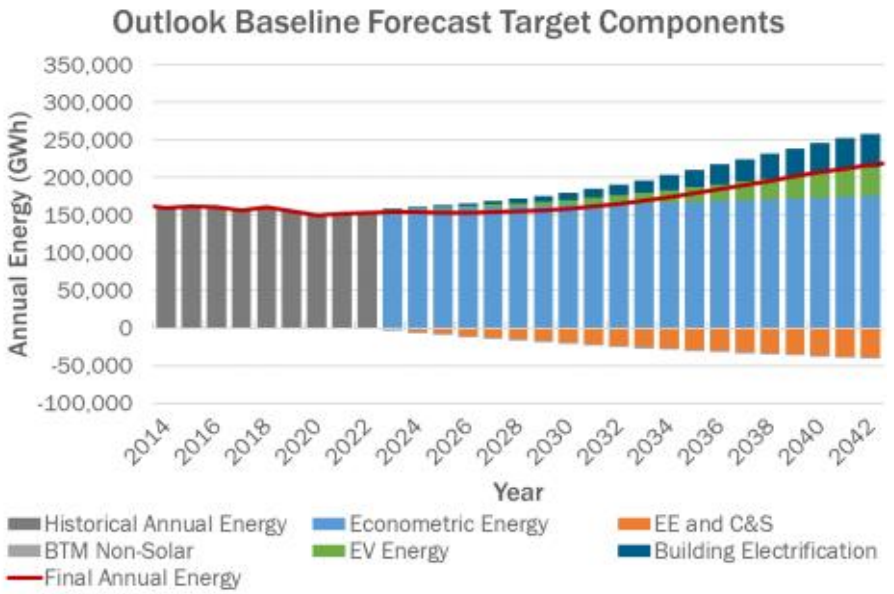
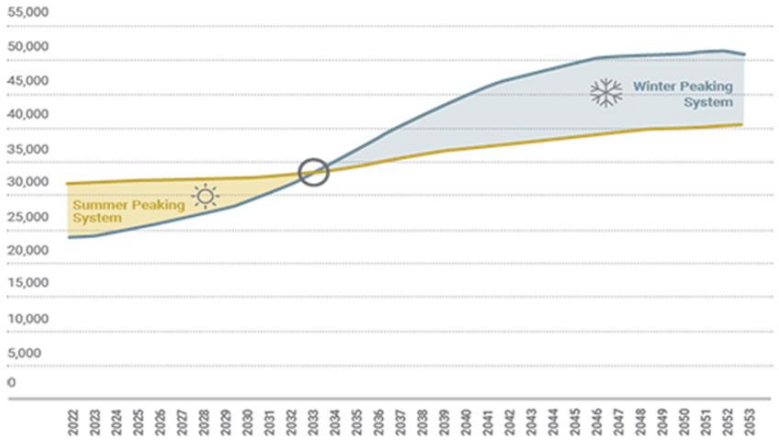


Table is accurate to forecast totals. Figure represents targets only, not forecast totals.

New York ISO

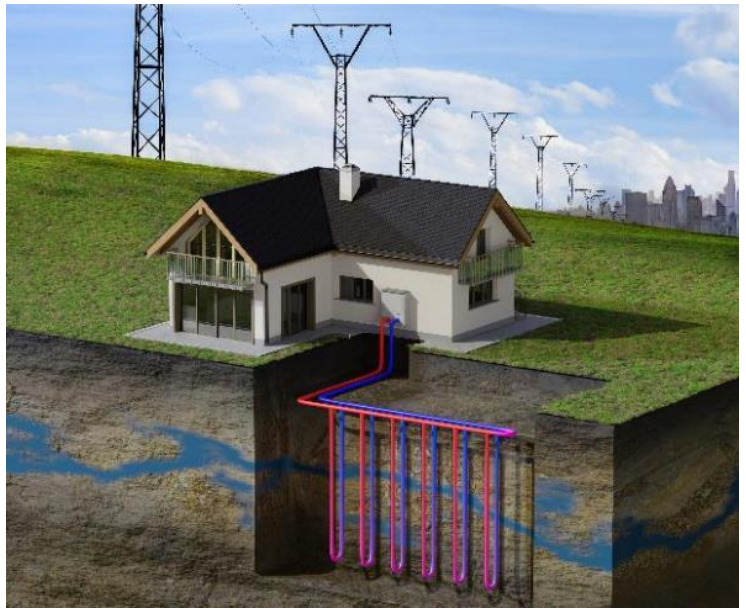


(NYISO 2023) (NYISO 2024)

Grid Benefits of GHPs

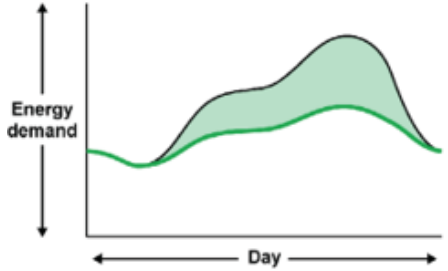
(results from 4 recent studies)

- 250 GHP homes ~ 1MW of demand reduction
- GHPs reduce New England winter peak demand by 36,000 MW (77%)
  - relative to ASHP
- GHPs reduce winter peak demand by 20%
  - compared to ccASHPs with fossil fuel backup
  - reduction would be even larger for ccASHP with electric resistance backup
- US-wide GHPs coupled with energy efficiency measures reduces:
  - New transmission by >40,000 miles
  - New generation by >400,000 MW
  - CO2eq emissions by >7,000 million tons



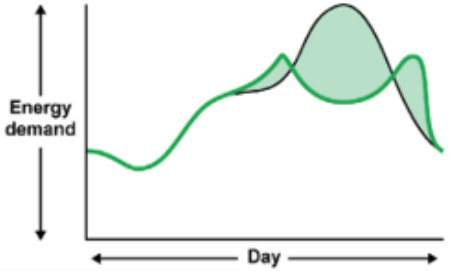
(AECOM 2023)
(Brattle 2020)
(NYSERDA 2024)
(ORNL 2023)

GHP Value in Utility Load Management



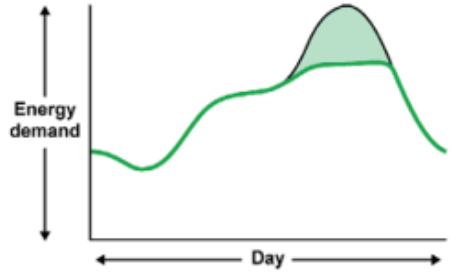
Shape:

- GHP reduces peak demand, flattens annual profile, enhances resource adequacy, reduces reserve margin requirements, and increases system reliability at scale
- Energy efficiency measures (weatherization, envelope improvements) further effects



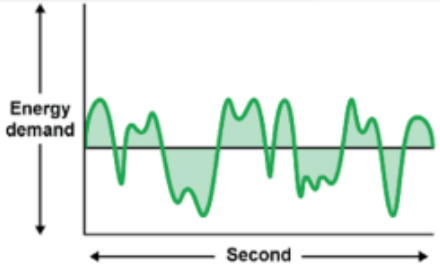
Shift:

- Geothermal heat pump dispatch strategies in response to price incentives or signals (pre-cooling a building outside of peak hours, thermostat set-point controls, dual source GHP-ASHP with time-of-use control strategy, energy pile thermal energy storage, borehole or reservoir thermal energy storage, seasonal storage, …)



Shed:

- Commercial and industrial curtailment service providers, thermostat setpoint controls

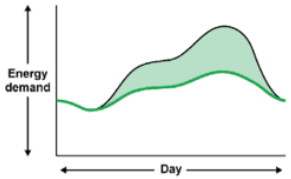


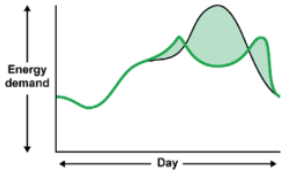
Shimmy:

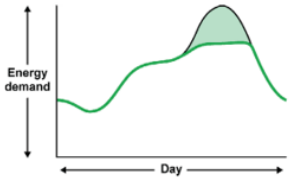
- Smart electric water heaters as thermal battery
- Sewage waste heat recovery interaction

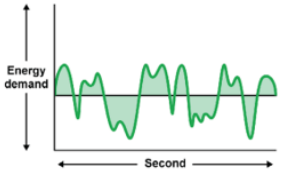
Figures modified from (DOE 2023)

Potential Incentive Structure Approaches









Shape	Shift	Shed	Shimmy

- % peak load reduction performance-based incentive mechanism
- Avoided costs valuation to capture benefit of GHP
- System-wide integrated planning to allocate GHP benefits and costs equitably across gas and electric systems/ ratepayers

- Energy savings ($/MMBtu)
- Time-of-Use rate structures
- Class of Service rate structures for Interruptible Loads
- GHG emissions reduction performance-based incentives or GHG emissions pricing
- Smart grid with dynamic price signals and automated individual building controls
- Aggregated GHP loads in virtual power plant system with direct load control

Figures modified from (DOE 2023)

Thank You!

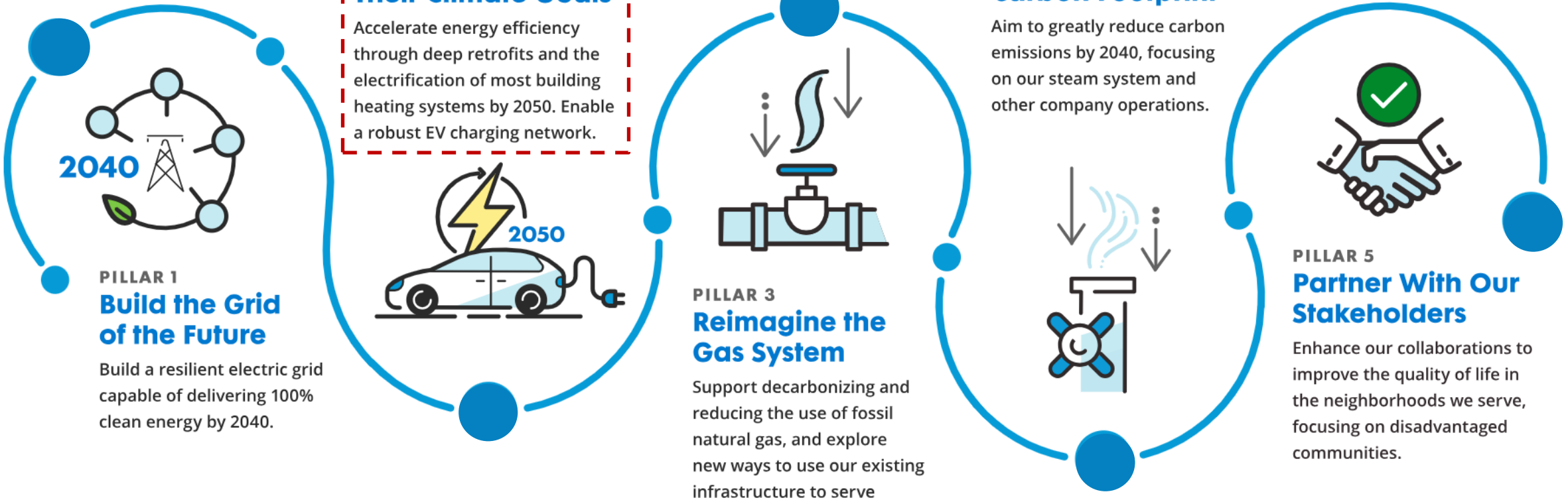
Value of GHP – Beyond Energy Savings

October 2024

Rob Greig, Director Customer Clean Energy Programs

Our Clean Energy Commitment: 5 Pillars

Our Clean Energy Commitment is a blueprint for helping achieve the state's climate and renewable energy goals.



PILLAR 1

Build the Grid of the Future

Build a resilient electric grid capable of delivering 100% clean energy by 2040.

PILLAR 2

Empower All of Our Customers to Meet Their Climate Goals

Accelerate energy efficiency through deep retrofits and the electrification of most building heating systems by 2050. Enable a robust EV charging network.

PILLAR 3

Reimagine the Gas System

Support decarbonizing and reducing the use of fossil natural gas, and explore new ways to use our existing infrastructure to serve customers' future needs.

PILLAR 4

Lead by Reducing Our Company's Carbon Footprint

Aim to greatly reduce carbon emissions by 2040, focusing on our steam system and other company operations.

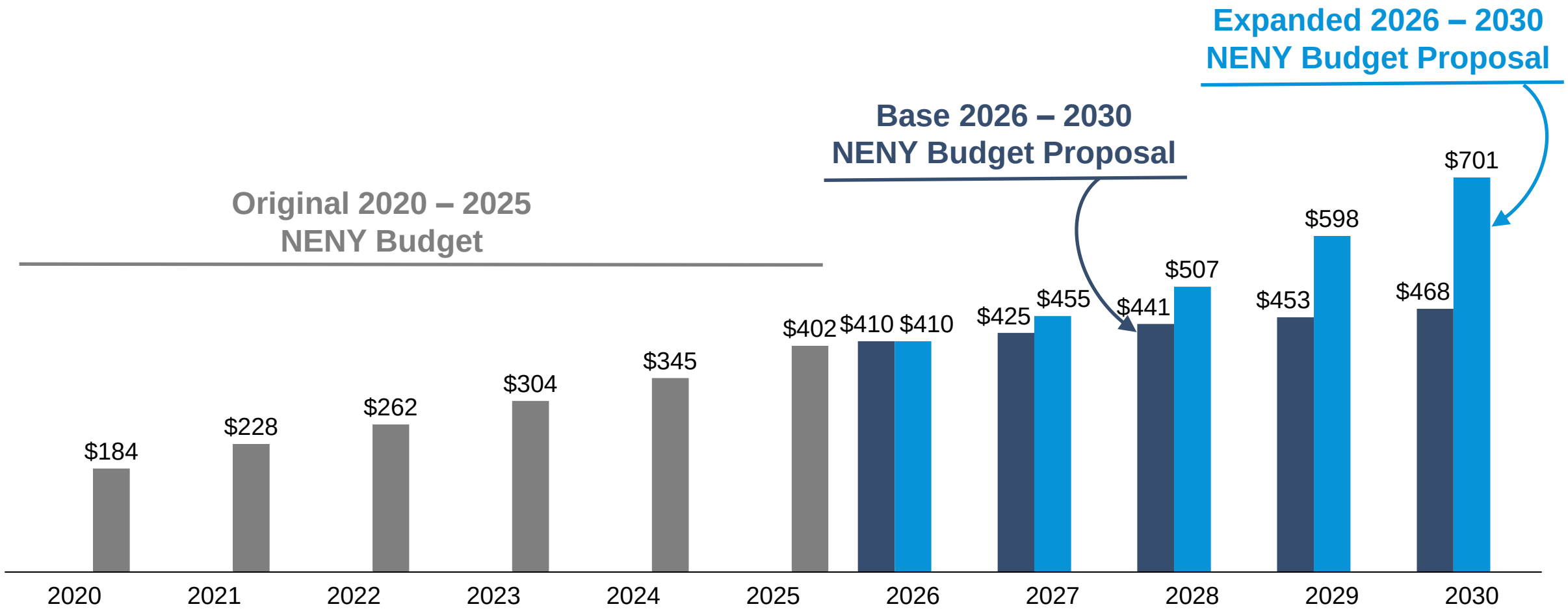
PILLAR 5

Partner With Our Stakeholders

Enhance our collaborations to improve the quality of life in the neighborhoods we serve, focusing on disadvantaged communities.

We propose to run significant programs through 2030

Historical and Proposed New Efficiency New York (NENY) Energy Efficiency and Building Electrification Program Spend ($M)



We have steadily grown geothermal Clean Heat savings

Energy savings from geothermal (Lifetime MMBtu, ’000)

Summary statistics

# of dwelling units:
- Single-family: **724**
- Multi-family: **3,268** across 16 projects

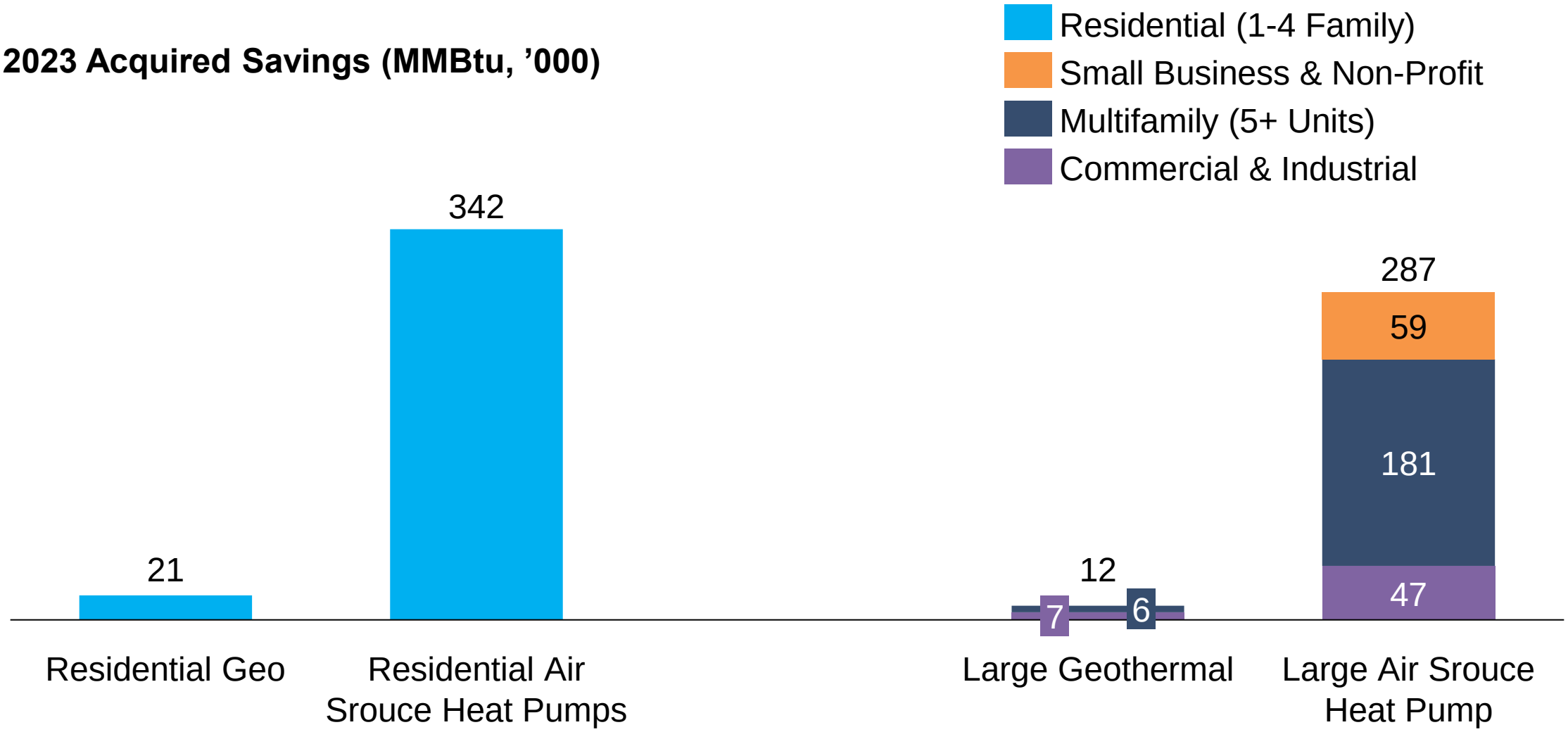
Commercial space: **1.71M sq ft** across 7 projects

Total incentive commitments: **$64M**

5

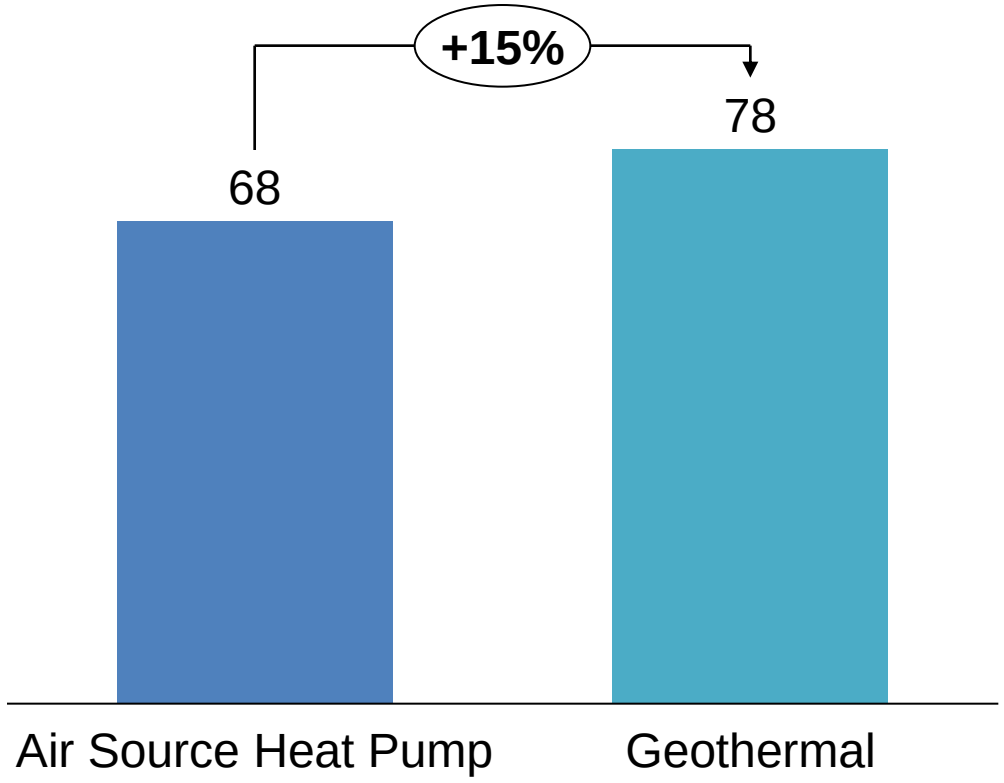
But, Clean Heat continues to be driven by Air Source Heat Pumps

2023 Acquired Savings (MMBtu, ’000)

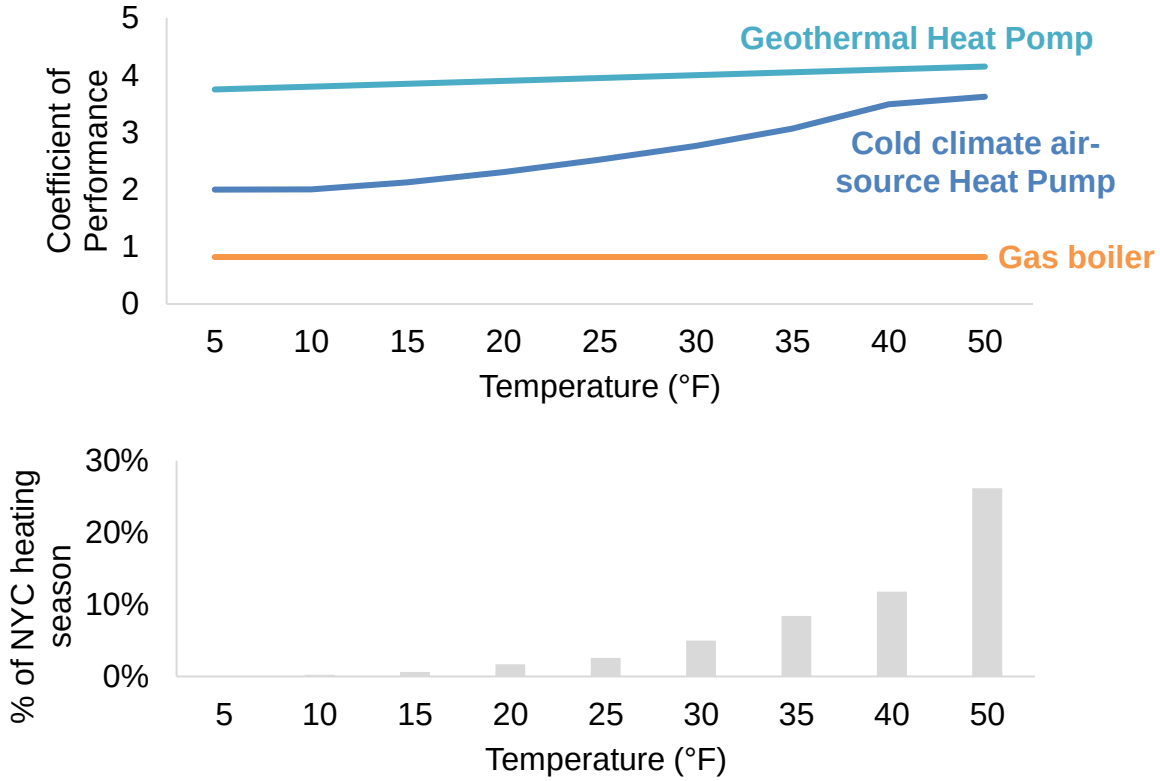


Geothermal is more efficient than Air Source Heat Pumps

Deemed MMBtu Savings per Residential Project



Geothermal performs well when it is cold



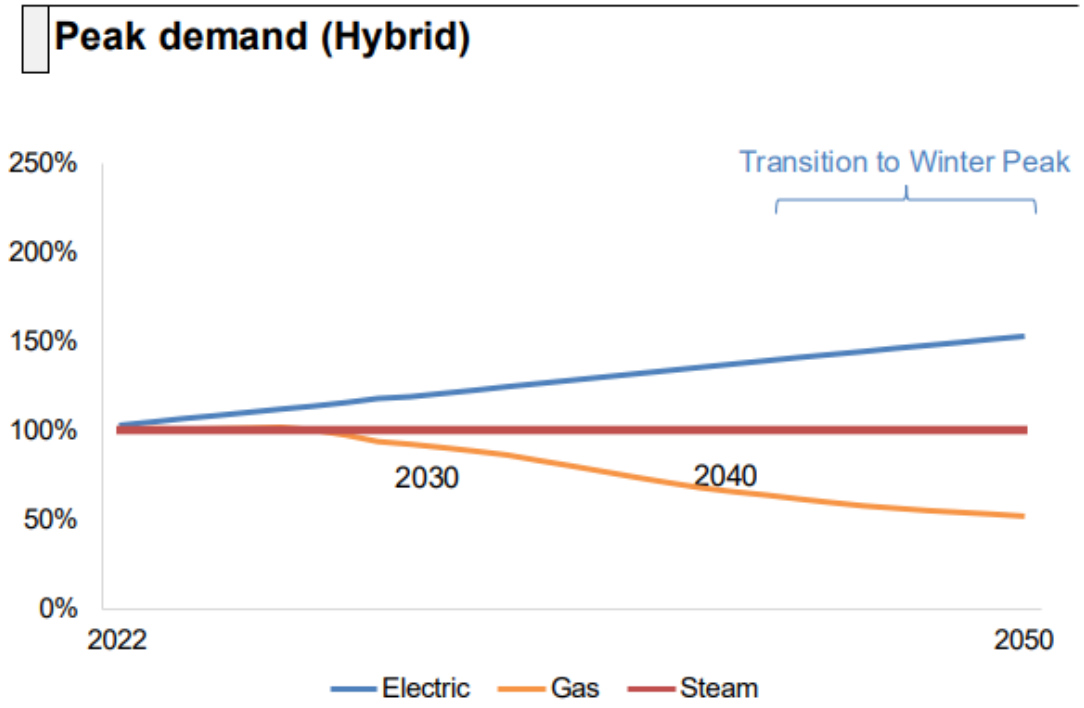
Note: Weather data represents average daily temperature from 2012-2017

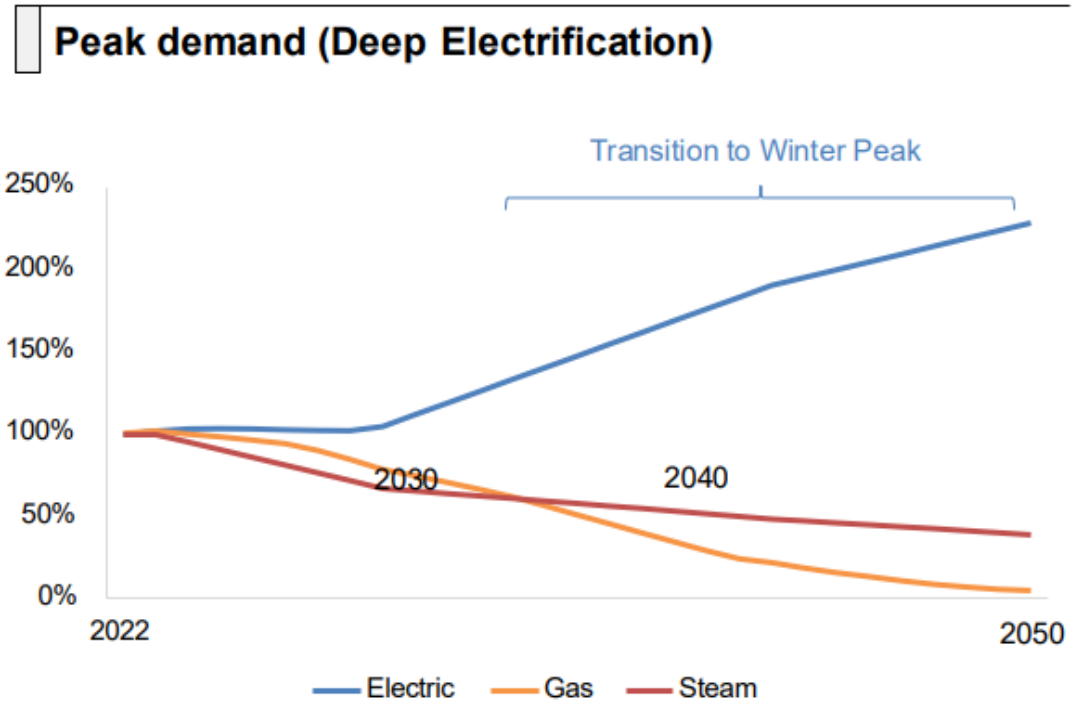
Source: EPRI, Posterity Group, Navigant

Electric Peak Demand Growth Scenarios

See electric peak demand growing ~1.5 – 2x by 2050

Annual Peak Electric Demand for Combined CECONY and O&R: Hybrid vs. Deep Electrification Scenario





Introduced residential demand-based rate in 2019
Select Pricing Plan (SPP) or SC1 Rate 4

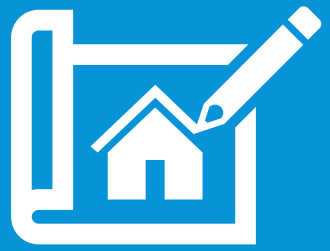
- Offer “price guarantee” for up to 500 Air Source and 500 Geo customers enrolling in the rate in the ’23-’25 rate period; currently have 168 HP customers enrolled
- In 2023, 80% of Air Source and 100% of Geo customers enrolled for a whole year (55 ASHP and 4 GSHP customers) saved on electricity bill compared to staying on standard volumetric rate
  - 14% savings on total bill for Air Source customers
  - 20% savings on total bill for Geo customers

Comparison of standard SC1 Rate I against SC1 Rate IV

	SC1 Rate I	SC1 Rate IV[1]
Monthly Customer Charge	$19/month	$29/month
Delivery	Volumetric (¢/kWh)	Time of use demand ($/kW)
Supply	Volumetric (¢/kWh)	Time of use volumetric (¢/kWh)

1 Peak hours are from noon to 8 PM on weekdays except holidays

Opportunities



How much can geo mitigate peak impacts through growth, technology innovation, and optimization of design?

How do we complement our current MMBtu metric of program success to drive incremental peak benefits?


Thank you!

Compensating Geothermal for Grid Capacity Benefits

PRESENTED BY

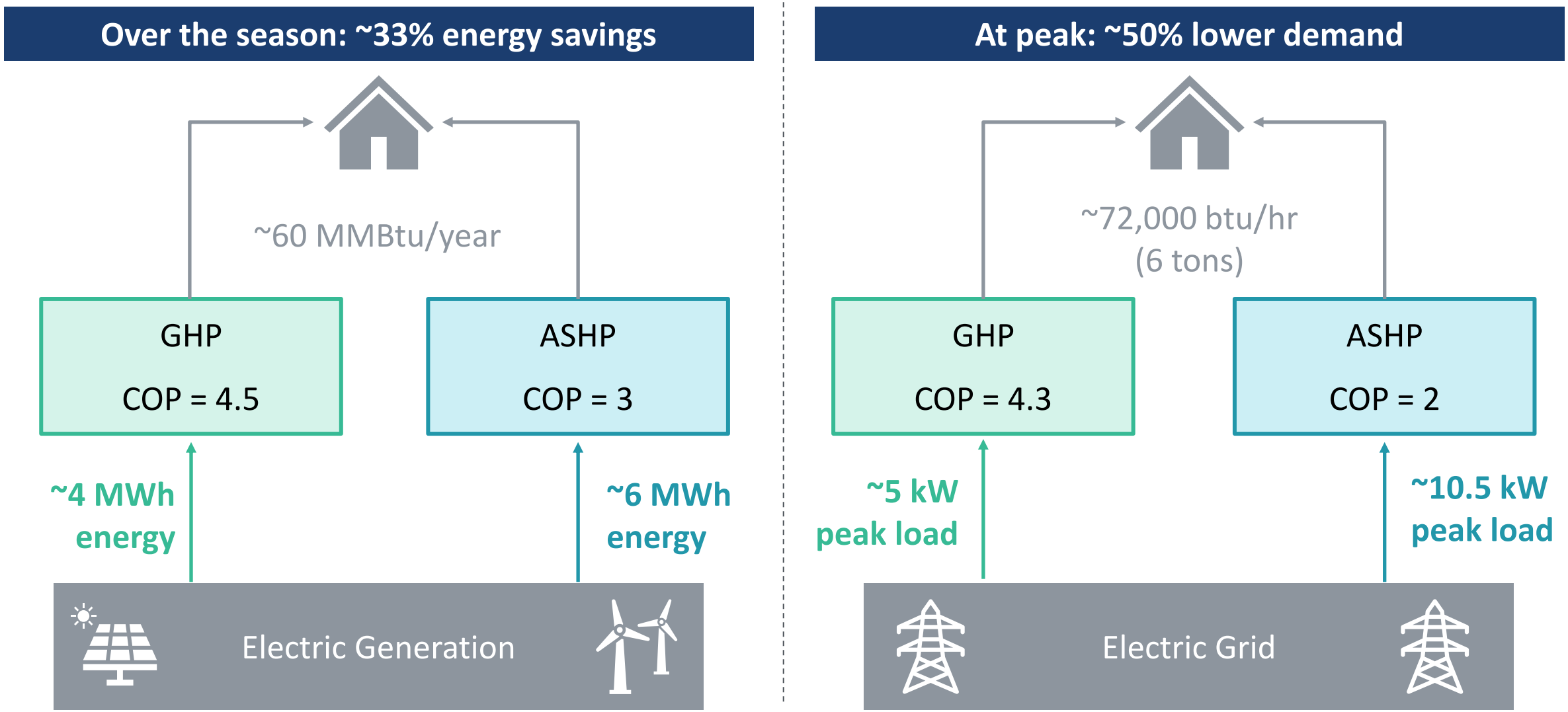
AKHILESH RAMAKRISHNAN

NY-GEO

OCTOBER 22, 2024

Brattle

GHP Power System Benefits



How much is 5 kW reduction worth?

	Marginal Costs	X	Peak reduction of a GHP	=	Savings
Generation Capacity	$50/kW-yr		5kW		**$250/yr**
Delivery	$15-$200/kW-yr		5kW		**$75-$1000/yr**

Depends on location and existing capacity headroom

Sources: Marginal costs are based on 2023-24 NYCA capacity prices and demand reduction value (DRV) range across NY utilities from VDER calculator.

What is already reflected in electricity rates?

		Basis for Electricity Bills	
Cost Component	**Primary Cost Driver**	**Residential**	**Large Commercial**
Energy	Volume	Volume	Volume
Generation Capacity	Peak demand	Volume	Peak demand
Delivery	Peak demand	Volume	Peak demand
GHG (RGGI)	Volume	Volume	Volume

Not perfect but reasonably cost-reflective

Disconnect means:

1. High load factor customers pay more than they should.
2. Peak reduction is undervalued.

Options to send the missing peak reduction signal

1 New Program for Peak Reduction

- Program target in kW
- BCA test similar to existing EE program BCA
- Could incentivize any firm, permanent, beneficial change to customer load shape. For example:
  - GHPs
  - Meter socket adaptors
  - Smart panels
  - Lower EV charger power

2 Incremental Modifications to EE Program

For example:

- Add sub-target for kWh savings in a certain time window (e.g., summer 2-6PM)
- Add sub-target for kW savings
- Additional incentive based on measure load factor

3 Improve electricity rate design

- Iterative, long-term process
- Many trade-offs to consider

Thank You!

Brattle

It is the peak KW, not the average KWH, which matters !

1 KW = 3,412 BTU

Jens Ponikau CGD

President, New York Geothermal Energy Organization

Buffalo Geothermal LLC

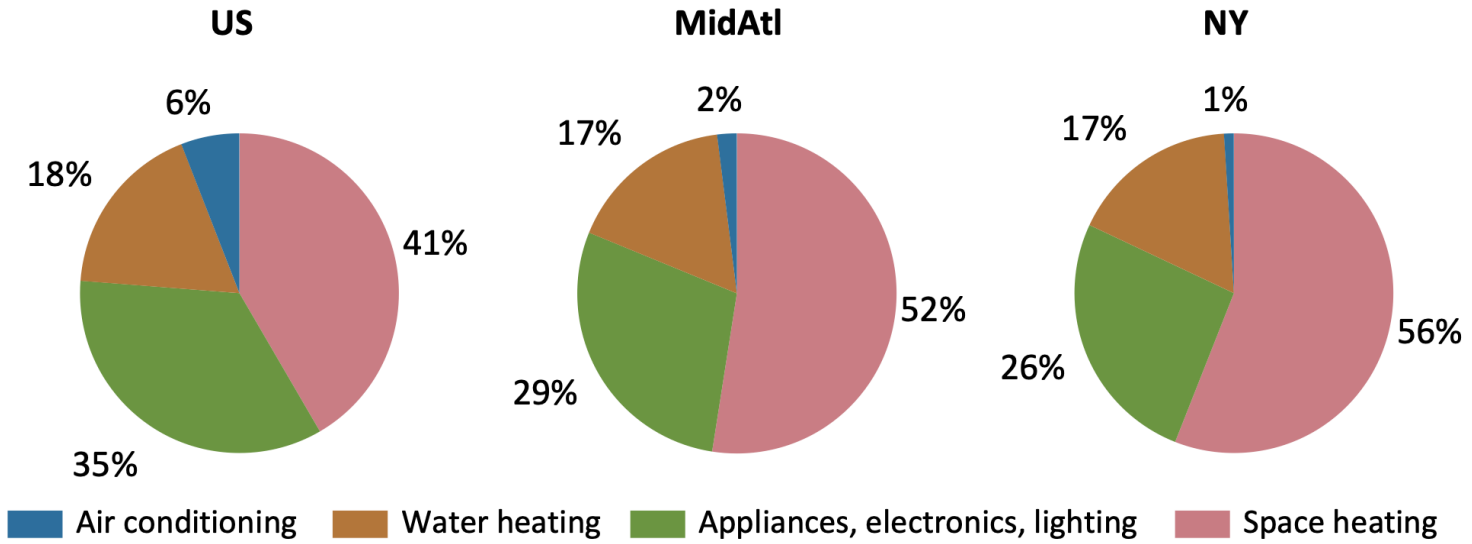
BUFFALO GEOTHERMAL HEATING™

www.BuffaloGeothermalHeating.com

NY-GEO

Fossil fuels are used mainly for Heating/Hot Water (NorthEastern U.S.) in Buildings

1% of total building energy use (A/C) creates a 7 GW higher summer peak versus winter peak (NY)



CONSUMPTION BY END USE

Since the weather in New York is cooler than most other areas of the United States, space heating (56%) makes up a greater portion of energy use in homes compared to the U.S. average, and air conditioning makes up only 1% of energy use.

https://www.eia.gov/state/print.php?sid=NY

Heat Pump Assessment Study – an EPRI Report

New York ISO
Independent System Operator

Load Forecasting Task Force
December 19, 2022

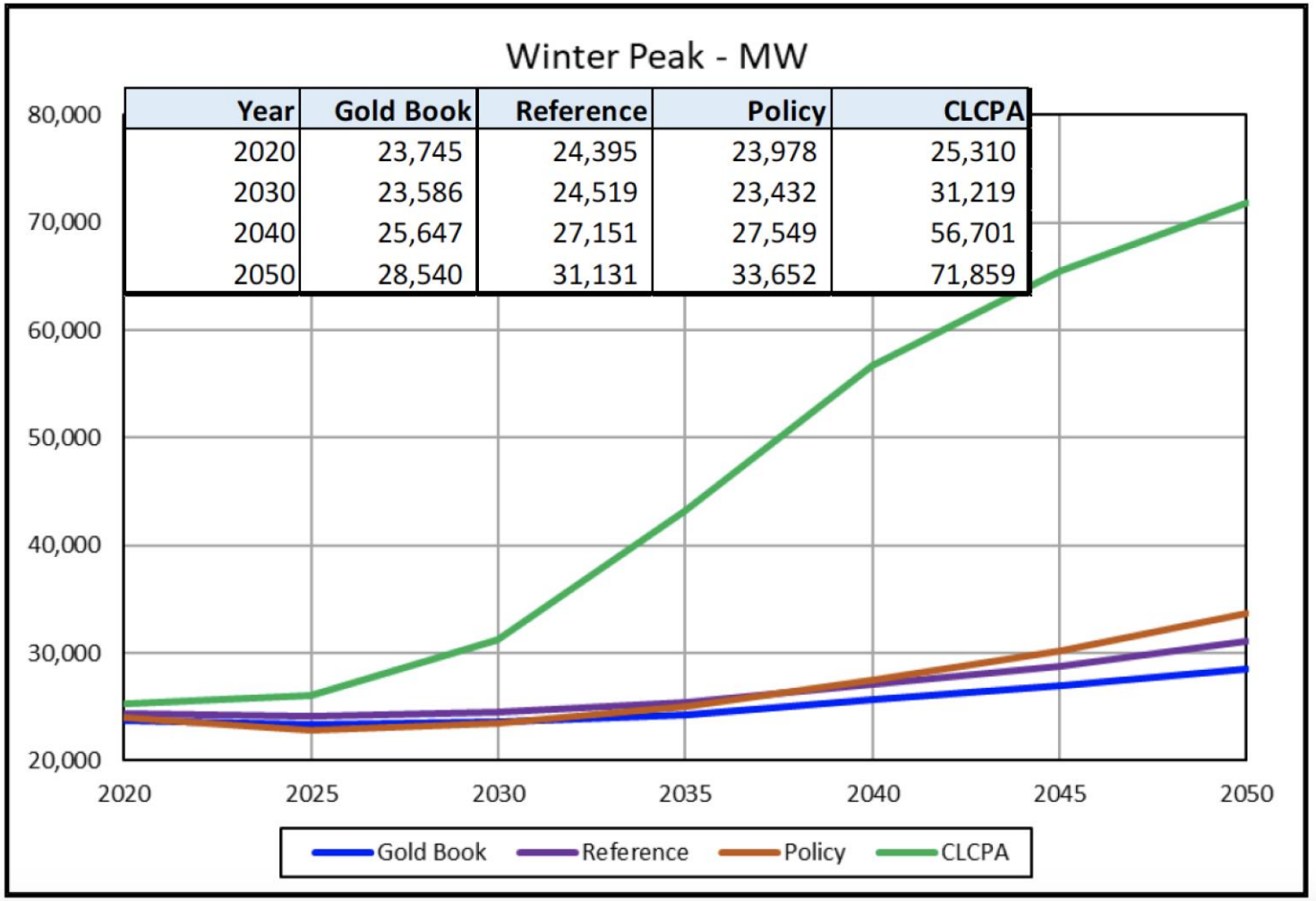
- Model home 2,600 sqft house in Albany
- Average COP was 2.30 at design conditions in Albany
- At -3°F the COP was 1.12 (incl. supplemental heat)
- Supplemental power is required when demand exceeds 6 kW.
- 17.53 KW peak demand

Resilience

Buffalo NY Dec 2022

NYISO winter peak impact projection

Figure 47: Winter Peak Forecast Comparison



Year	Gold Book	Reference	Policy	CLCPA
2020	23,745	24,395	23,978	25,310
2030	23,586	24,519	23,432	31,219
2040	25,647	27,151	27,549	56,701
2050	28,540	31,131	33,652	71,859

New Efficiency: New York

Analysis of Residential Heat Pump Potential and Economics

Table 2.2 - FLH Appropriate for Use with GSHP Nominal Capacity	
Albany	1,345
Binghamton	1,534
Buffalo	1,415
Massena	1,469
New York (LGA)	1,222
Poughkeepsie (Newburgh)	1,350
Syracuse	1,412

Statewide weighted average EFLH = 1,321

BTU to Watt conversion factor = 3.412

Heating load = 557 TerraBTU

Peak Load = 557,000 Giga BTU/(3.412 x 1,321)

= 123.58 Giga Watt

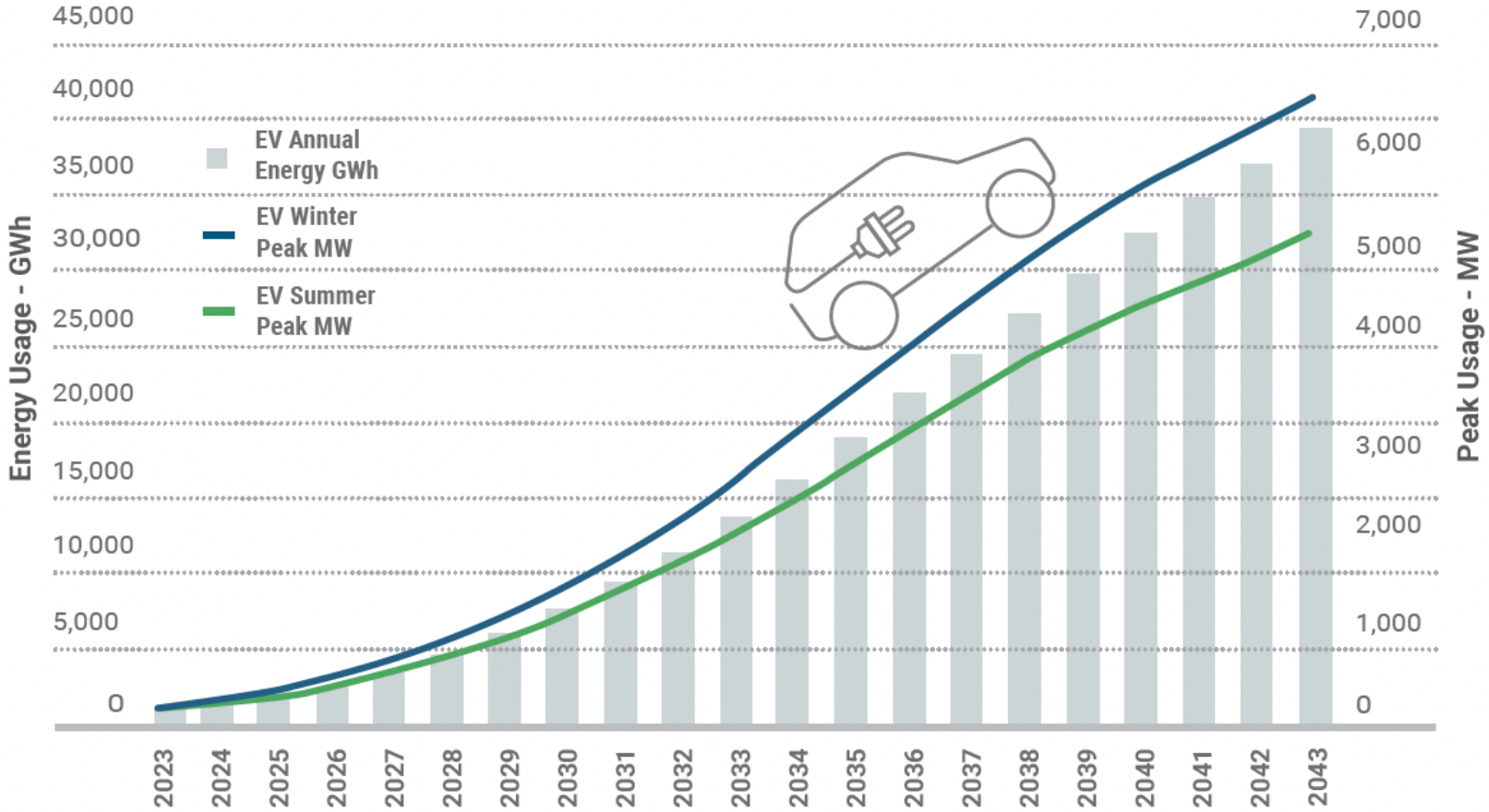
- Without the hot water load
- Without Process heat
- Without EV charging

NYISO issued the *2021 – 2040 System & Resource Outlook (NYISO Powertrends 2023)*

- *"The Outlook* concludes that unprecedented levels of investment in generation will be necessary to reliably deliver sufficient energy to meet future demand.
- *The Outlook* concludes that by 2040 New York's grid would need the following to reliably meet the goals of the CLCPA and expected peak demand:
  - **111-124 GW of generating capacity,** or roughly three times the current capacity connected to the system.
  - **27-45 GW of this capacity** must be from non-emitting resources capable of performing like today's fossil fuel-fired generation fleet depending on the scenario. **It is especially important to note that commercially available technologies to provide dispatchable, non-emitting supply do not exist at scale at this time. "**

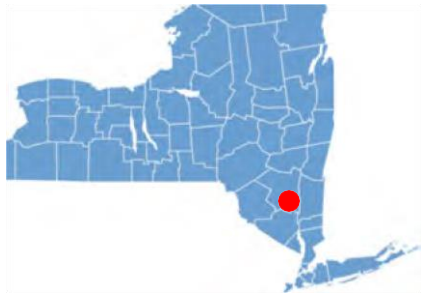
Heating Peak Dwarfs Electric Vehicle Peak 2023 Power Trends NYISO

FIGURE 15: **ELECTRIC VEHICLE ENERGY & PEAK IMPACTS: 2023-2043**



Requirements for Future Heating System

- 1) The heating system's efficiency and capacity must operate independent of the outside temperature
- 2) It must cover the full load without supplement resistance heat
- 3) It must not only reduce the heating but also the significantly the cooling load
- 4) It must make all the domestic hot water without electric resistance heat.



ZerOPlace

- **Mixed use, net-zero energy building**
  - **46 residential units**
  - **56,000 sqft**

BUFFALO GEOTHERMAL HEATING™

www.BuffaloGeothermalHeating.com

BUFFALO GEOTHERMAL HEATING™
www.BuffaloGeothermalHeating.com

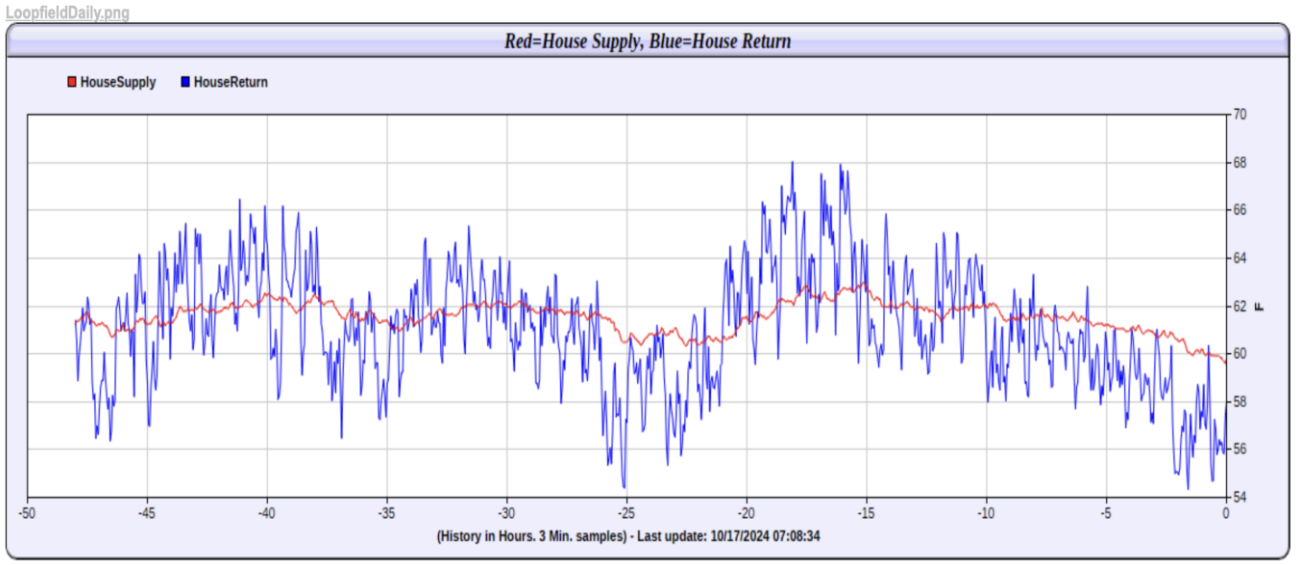
Geothermal System: Integrated HVAC and DHW

ZerOPlace

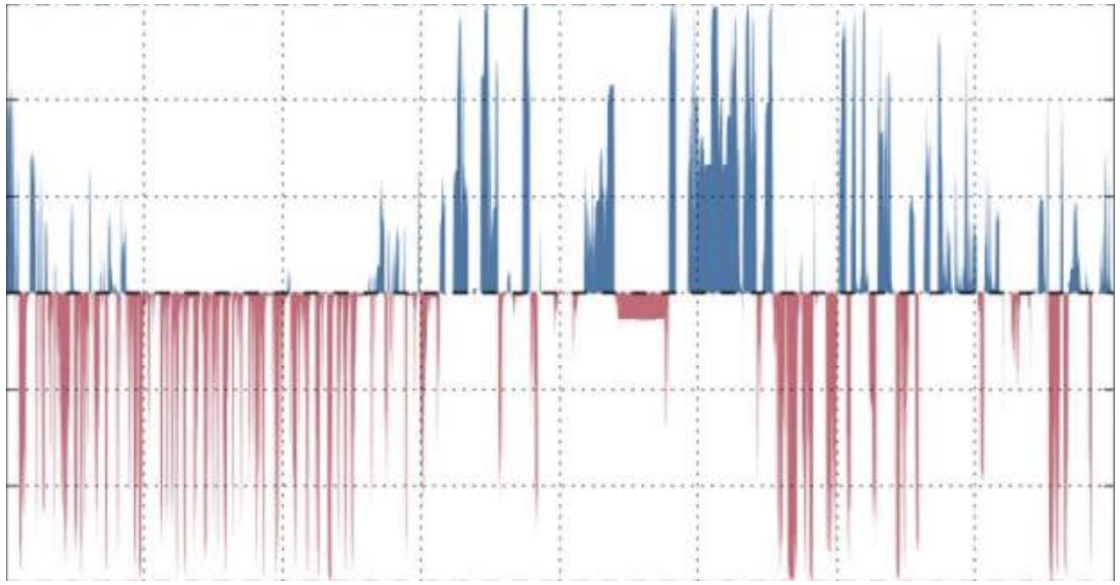
- Ground-source Heat Pump (GSHP) System provides 100% Space Heating, Cooling, and Domestic Hot Water (DHW)
- NO Backup Electric Heat, NO Supplement Heat
- NYSERDA monitored and verified

Thermal Battery versus Electric Battery

Thermal Ground Battery ZeroPlace
New Paltz NY 10/17/2024

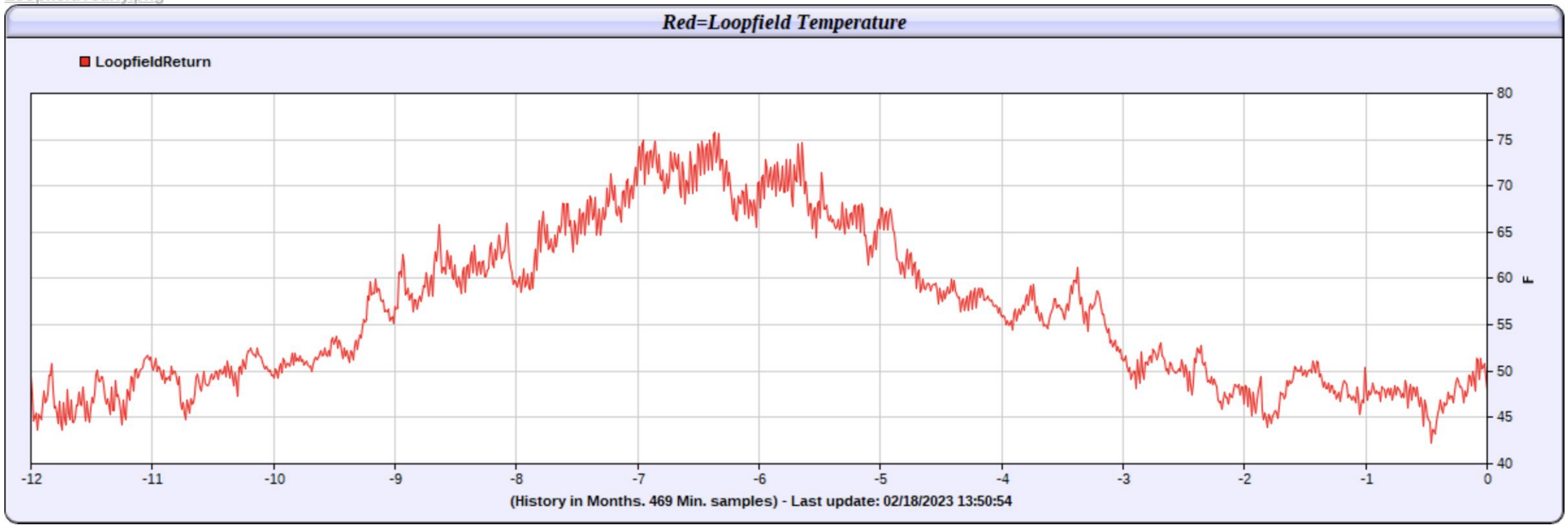


Tesla Grid Battery, Hornsdale Power Reserve
Hornsdale, Australia



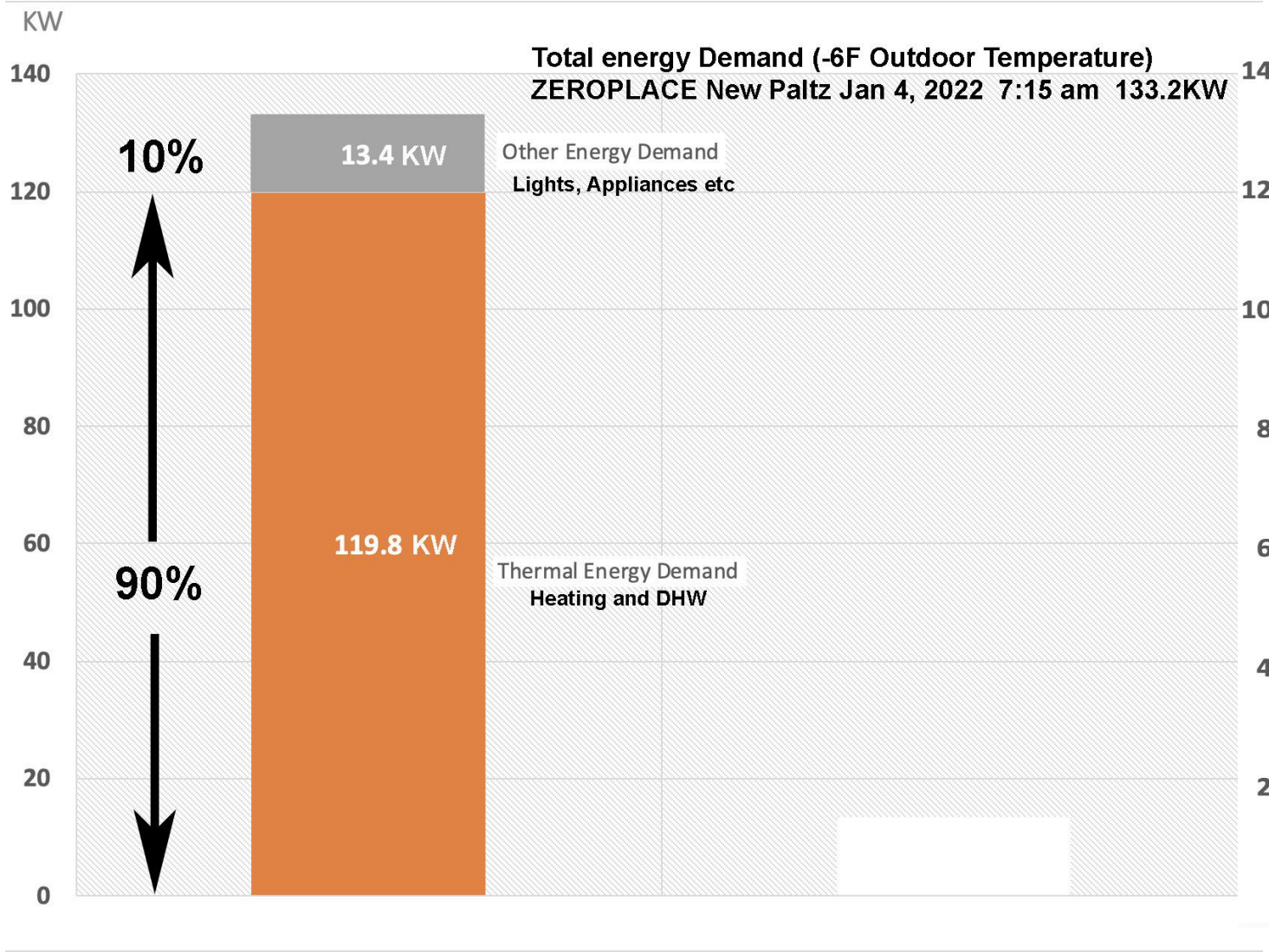
12 Month Annual Entering Water Temperatures 2/18/2022 -2/18/2023

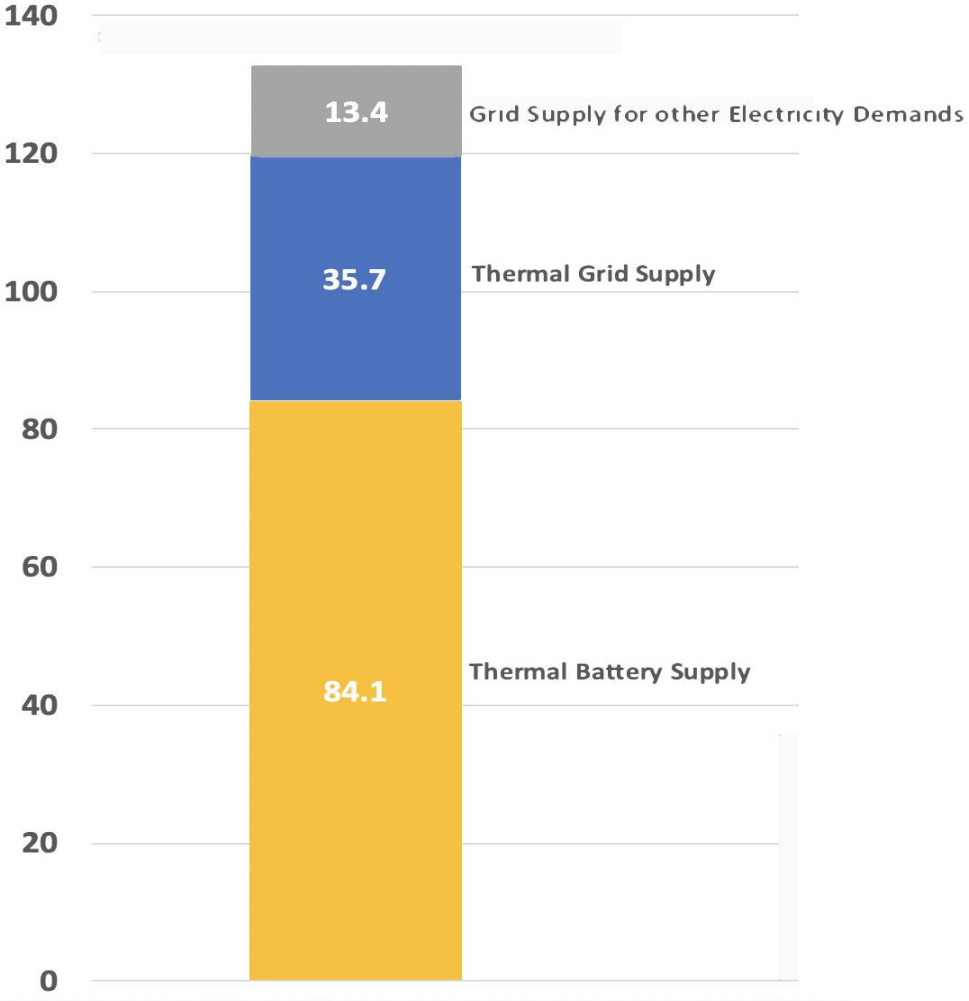
LoopfieldYearly.png



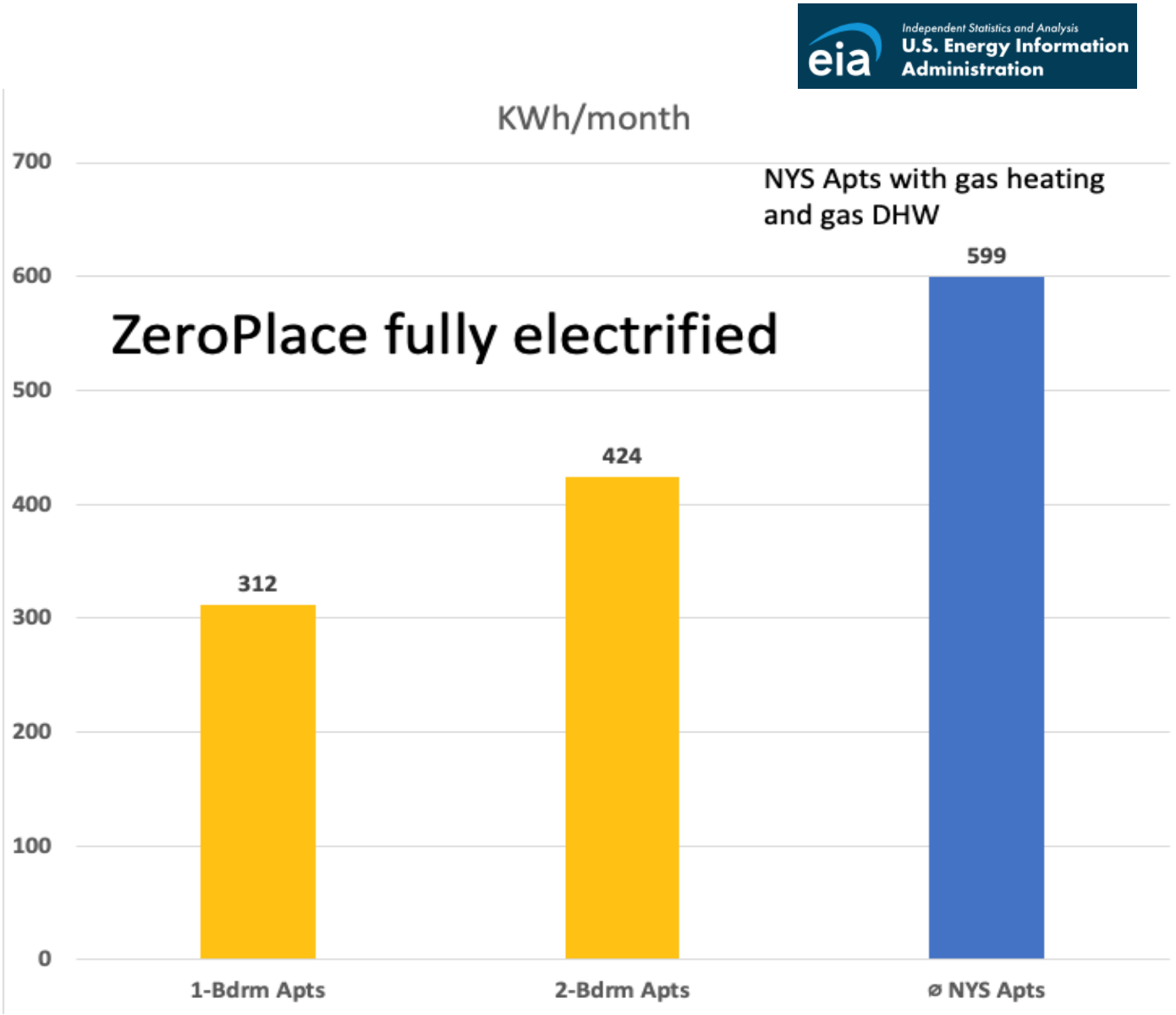
Peak Hour Energy Use

90% of the entire energy load of the building was DHW and heating (Thermal Load)





Average electricity usage per Apartment (inclusive of all space conditioning and central DHW)



Heating Peak
Feb 4th 2023, 7:30-7:45 am
- *Outdoor Temp = -6°F*
- *All WSHPs = 29.3 kW*
- *DHW HPs = 2.8 kW*
- *Loop Pumps = 0.45 kW*
- *Building = 43.8 kW*

Cooling Peak
July 28th, 2022 5:00-5:15 pm
Outdoor Temp = ~95°F
All WSHPs = 28.5 kW
DHW HPs = 0.0 kW
Loop Pumps = 0.50 kW
Building = 43.5 kW

ZeroPlace Loop Field Thermal Energy Delivery

Monetary Value @567/kWh*

Peak Day (Feb 4)		1,706.81	kWh	$ 967,762

*”Among projects awarded NYSERDA incentives, average total installed costs for non-residential, retail projects averaged $567/kWh for installations occurring in 2022 and 2023”
Case 18-E-0130 – In the Matter of Energy Storage Deployment Program.
New York’s 6 GW Energy Storage Roadmap Policy Options for Continued Growth in Energy Storage.pdf

Lockport Housing Authority, New York

GEOTHERMAL HEAT PUMP CASE STUDY:

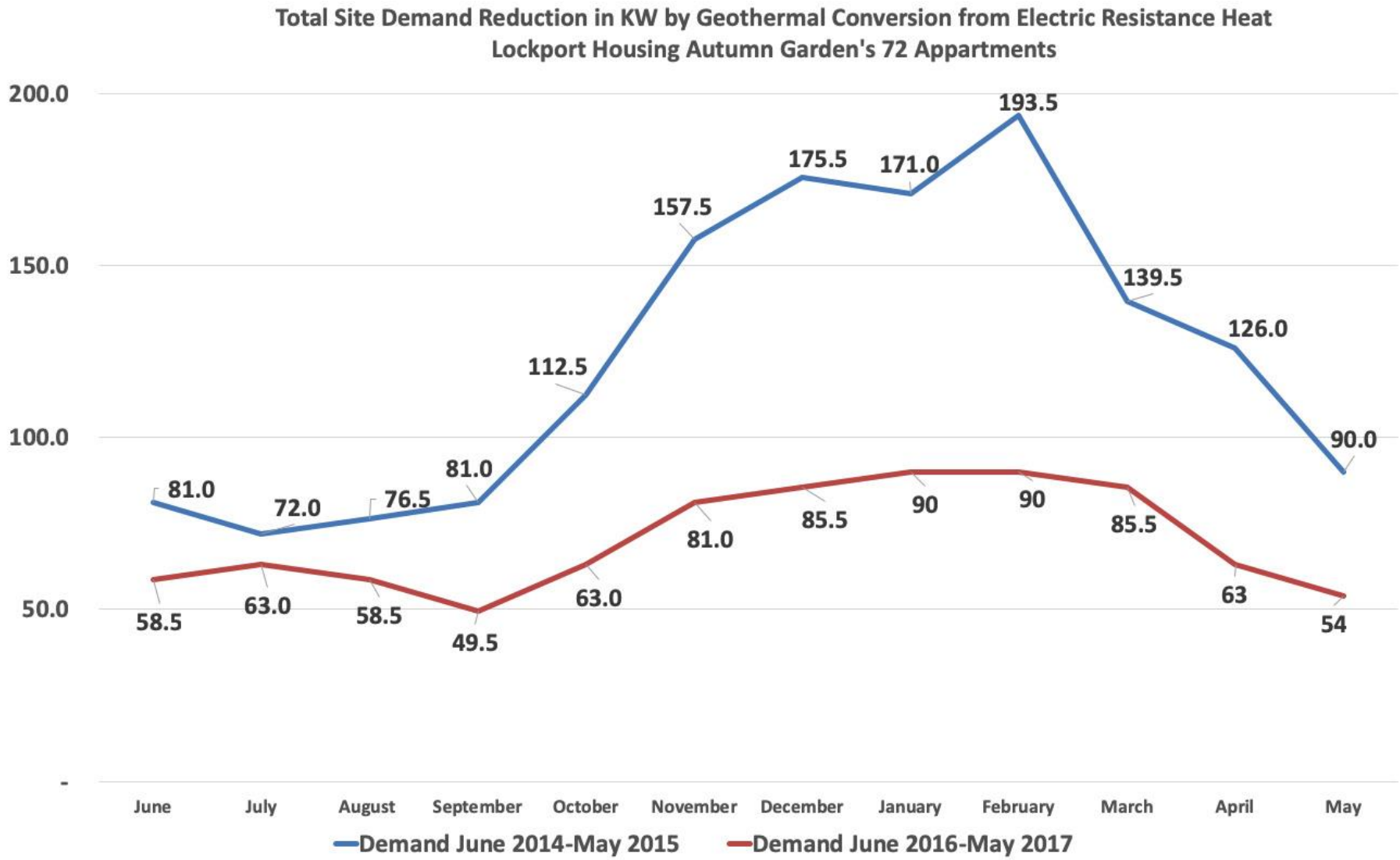
Autumn Gardens Apartment Complex

U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

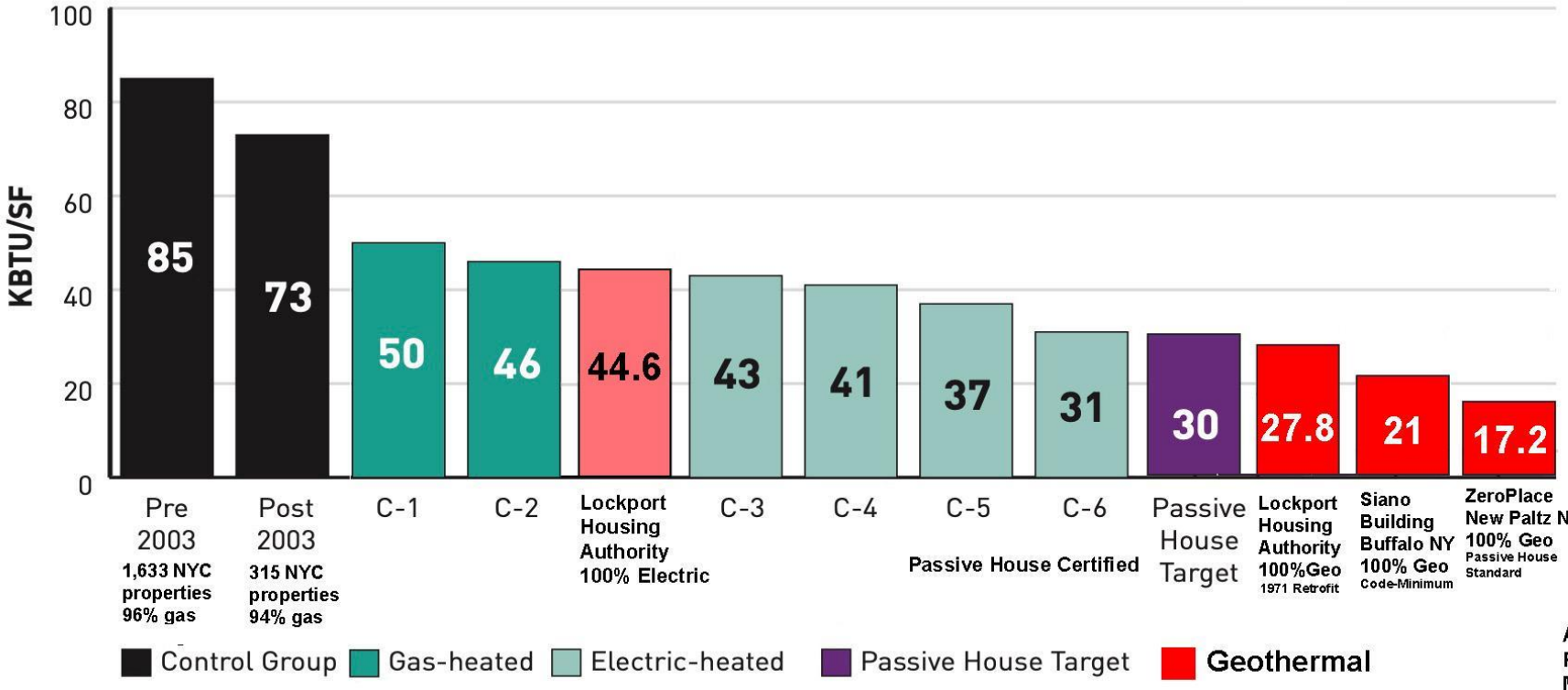
GEOTHERMAL TECHNOLOGIES OFFICE

Lockport Housing Authority

Demand Reduction



New York City Department of Housing Preservation and Development (NYC HPD)



Energy Use Intensity (EUI)

Passive House case study buildings C1-C6 consume signifcantly less energy than the buildings in the post-2003, conventionally-built control group. Electrically heated Cerified Passive House Buildings with gas domestic hot water consume the least energy, but still do not reach the Passive House Target.

All Geothermal heated (incl geo DHW) exceed Passive House Target, whether retrofits without envolope upgrades (Lockport), 2014 code minumum new built (Siano), or passive house new built 2017 (ZeroPlace).

Adapted from:
Passive House: Connecting Performance to Financing
March 2021

ASHPs versus Geothermal with storage

- Clean Heat Programs are incentivizing all kind of heat pumps based on energy savings and fossil fuel reduction for the ratepayer.
  - Only Geothermal heat pumps provide thermal storage energy service to the grid.
  - The NYISO projection in winter peak growth are driven by ASHP, which do not store thermal energy.
  - Nonetheless, the electrical peak was still in the summer, even after electrifying the heating, due to appliance load.
  - It is meeting the demand with a non-emitting technology, which otherwise does not exist.
    - **"…commercially available technologies to provide dispatchable, non-emitting supply do not exist at scale at this time. " (NYISO 2023 Power Trends)**

Conclusion

- The ground is capable of supplying 70% of the needed generating capacity, over 123 GW in NYS
- Geo system installation can achieve immediate passive house standard
  - Even in retrofit installations without significantly improving the envelope
- Geo is the only choice we have to reliable deliver sufficient energy for Heating (at any cost) to meet the CLCPA goals, no other technology is available onsite.
  - Automatically dispatched emission free thermal energy

Thank You!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GEO

Value of Geothermal Heat Pumps Beyond Energy Savings

Moderator: **Joseph Hitt / *NYS Department of Public Service***

Panel: **Jennifer Livermore / *U.S. Department of Energy***
Akhilesh Ramakrishnan / *The Brattle Group*
Robert Greig / *Consolidated Edison Company of New York*
Jens Ponikau / *Buffalo Geothermal & NY-GEO Board*