Establishing a Value for the Ground Heat Exchanger as Storage

Presented Live at the NY-GEO 2023 Conference Albany, New York on April 26, 2023

Jens Ponikau / *Buffalo Geothermal*
Jared Rodriguez / *Emergent Urban Concepts*

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Geothermal:
The Ultimate Storage Solution

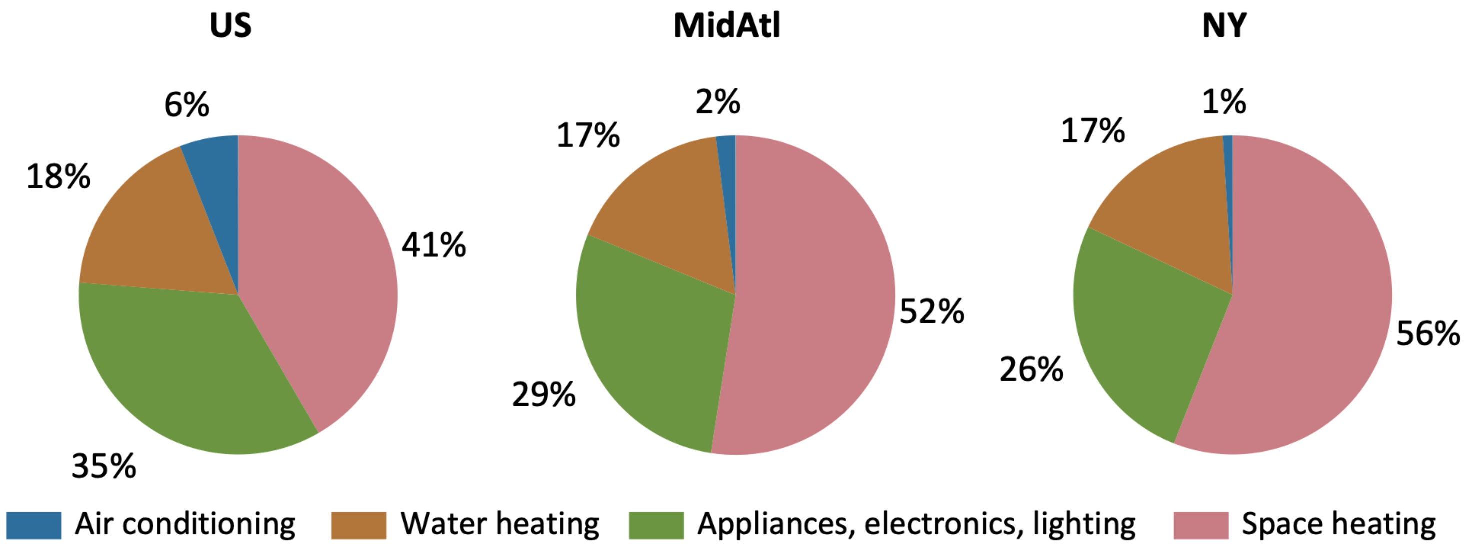
Jens Ponikau

President New York Geothermal Energy Organization

Buffalo Geothermal

Fossil fuels are used mainly for Heating/Hot Water (North Eastern 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

Significant different winter peak performance between technologies (Brattle Report Rhode Island)

COP ASHP = 1.3, GSHP (Geo) =3.6

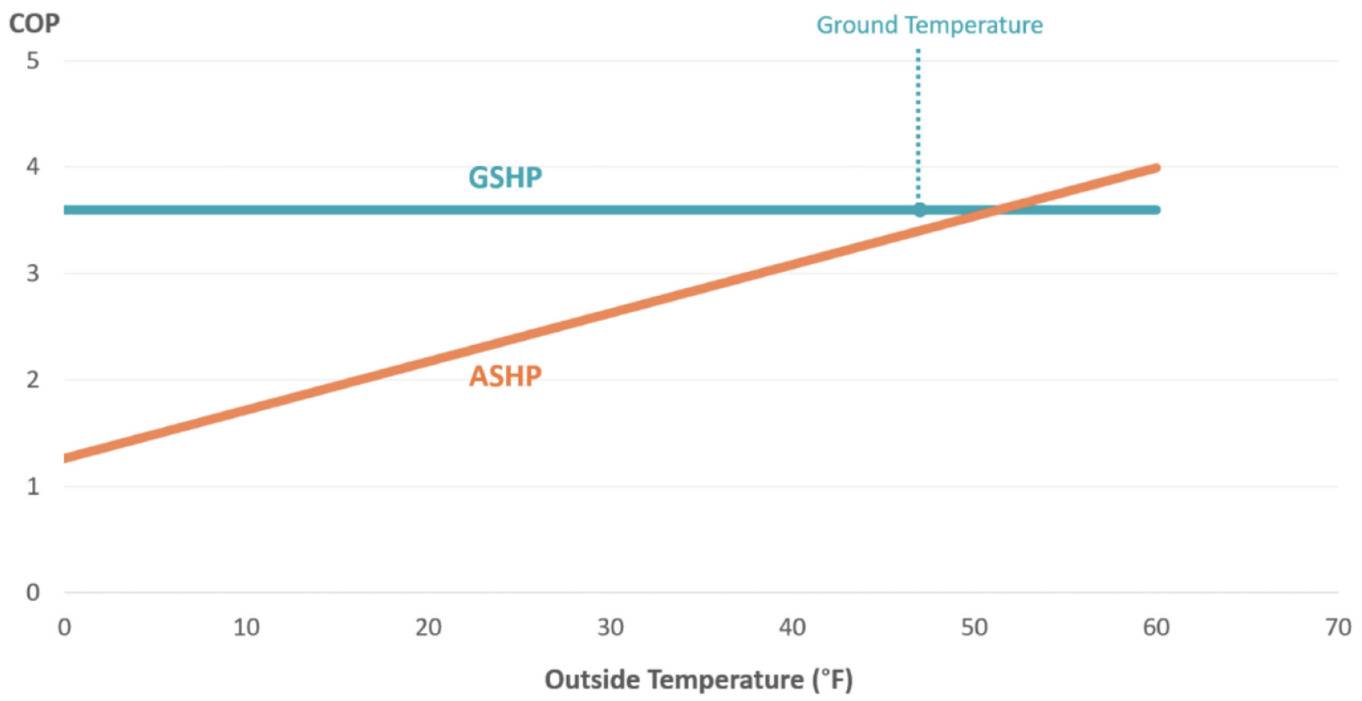


FIGURE 9: RELATIONSHIP BETWEEN OUTDOOR TEMPERATURE AND HEAT PUMP EFFICIENCY (COP)

New Efficiency: New York
Analysis of Residential Heat Pump Potential and Economics

Final Report | Report Number 18-44 | January 2019

Table 4-3. 2018 Statewide Residential and Commercial Thermal Load (Space Heating and Cooling)

End Use	Statewide Residential & Commercial Load (TBtu)
Space Heating	557
Space Cooling	221
Total	778

New Efficiency: New York

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

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

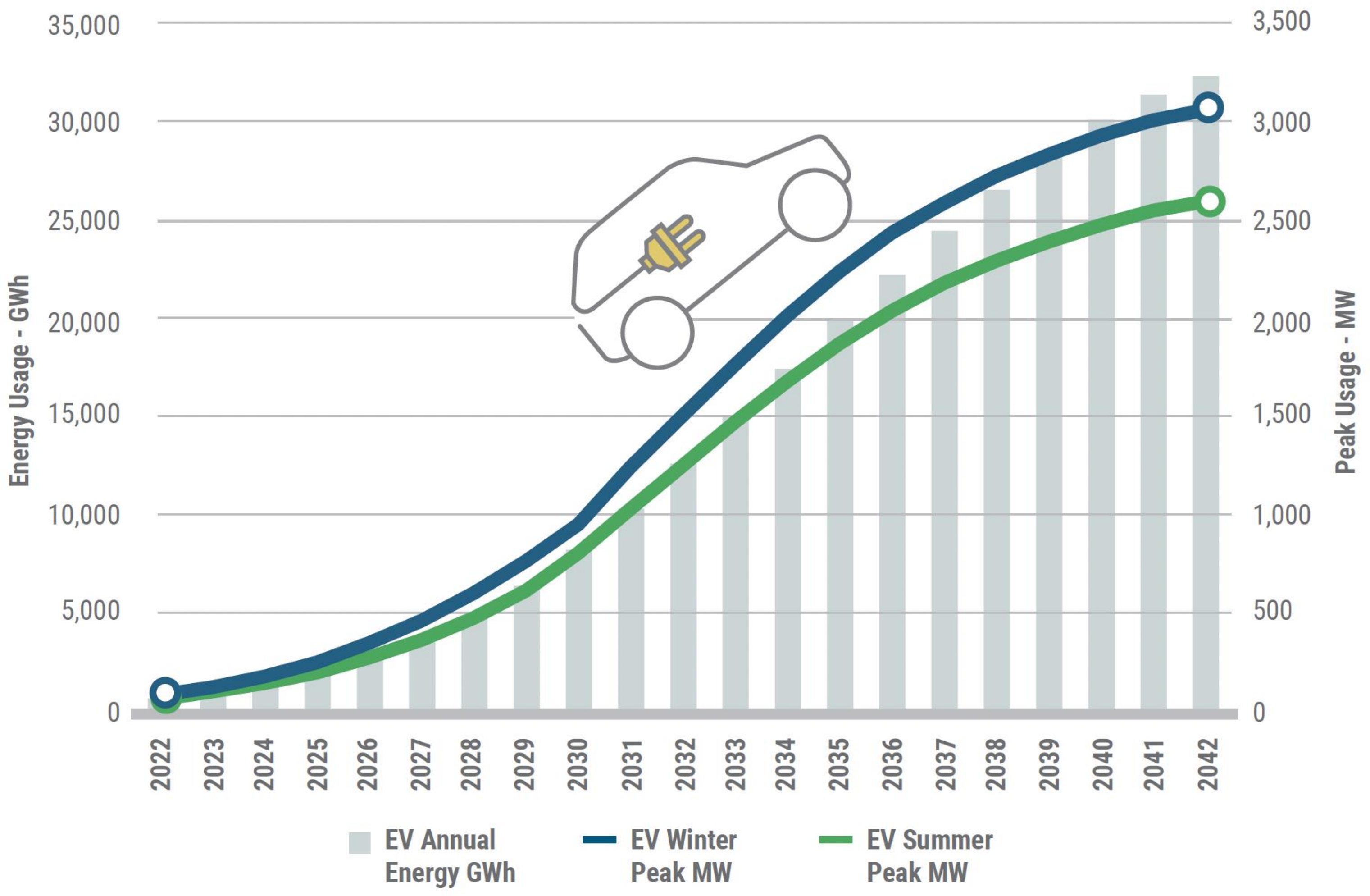
Peak Load = 557,000 Giga BTU/(3.412 x 1,321)

= 123.58 Giga Watt

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

Heating Peak Dwarfs Electric Vehicle Peak

Figure 8: **Electric Vehicle Energy and Peak Impacts - Baseline Forecast**



Current Plans for battery storage in NYS

- New York will deploy 3,000 MW of energy storage by 2025 and 6,000 MW (6 GW) by 2030
    - https://www.nyserda.ny.gov/All-Programs/energy-storage
- With a 100 GW peak load after electrifying buildings, will last….
    - 4 minutes !

NYSERDA Geothermal Heat Pump Study 2017
Peak Thermal Load Occurs Between 7 - 8 am

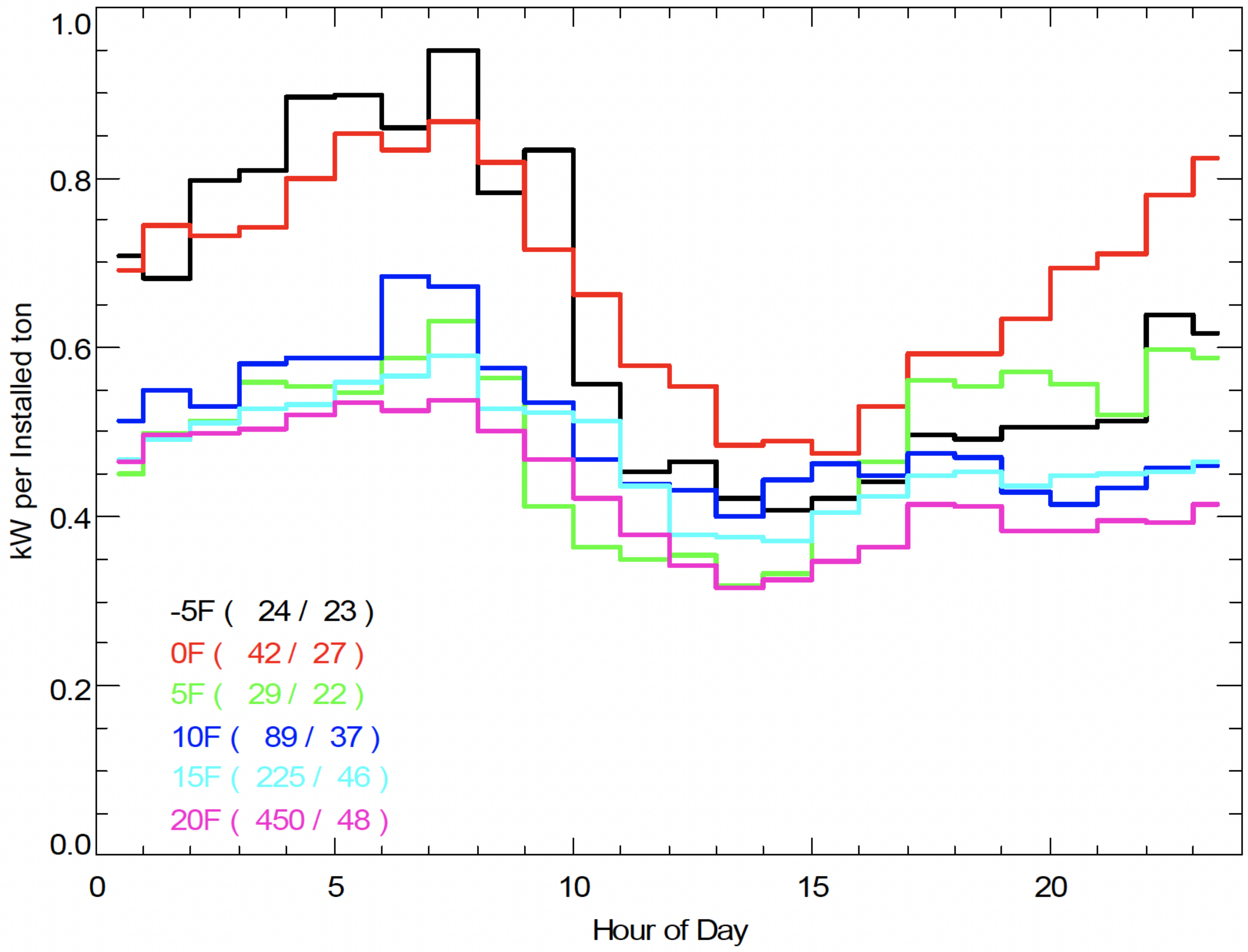
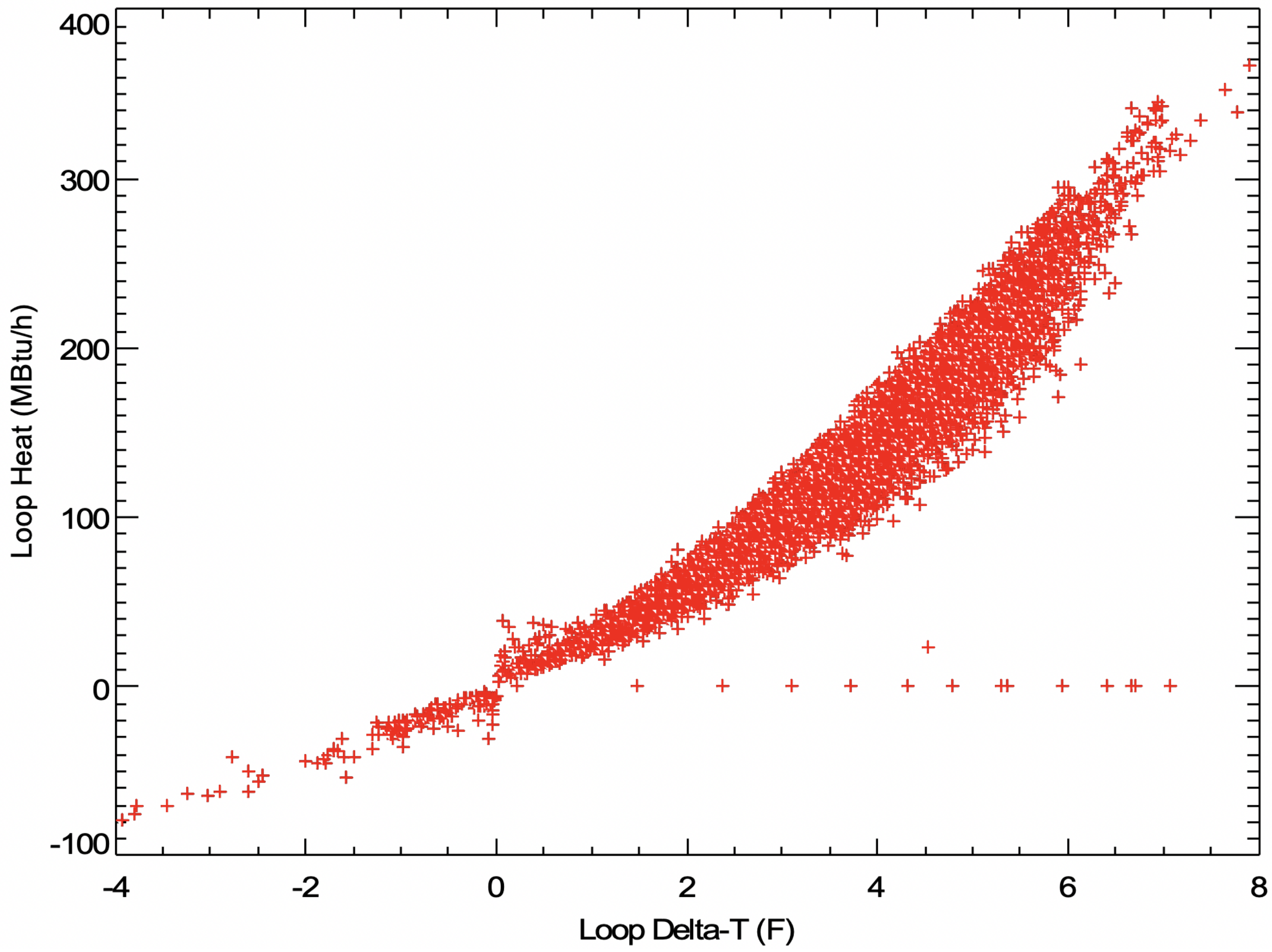


Figure 22. Average Winter Electric Demand Profiles at Various Outdoor Temperatures


AHEAD
ZerOPlace
New Paltz, NY

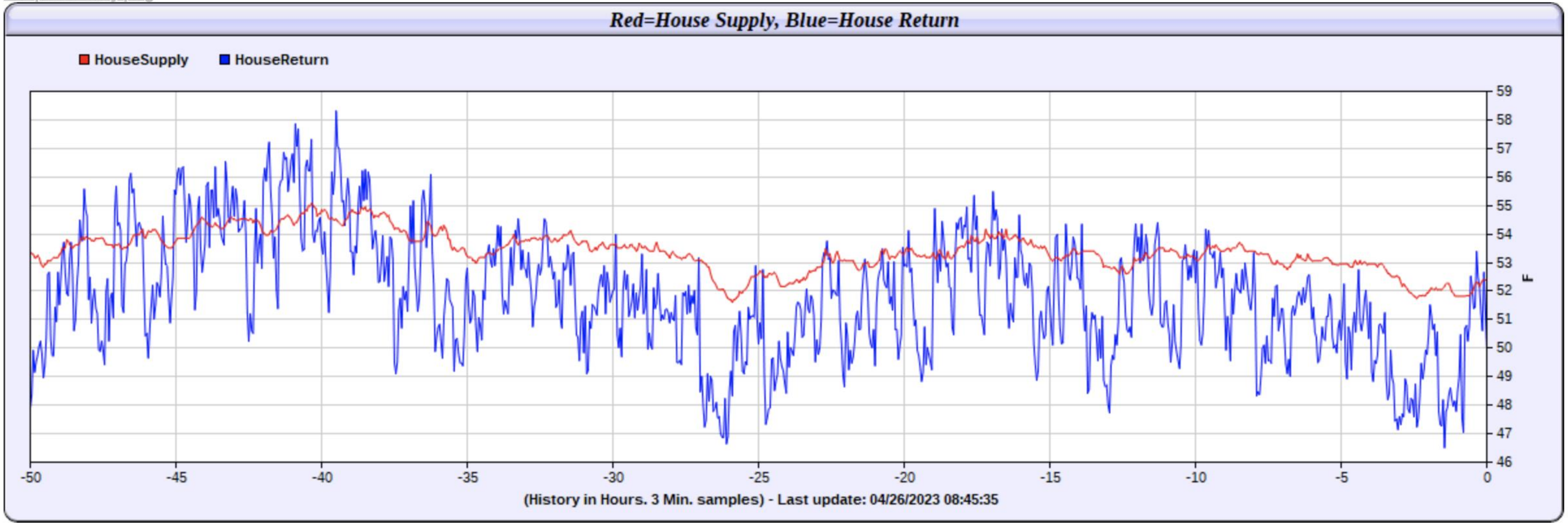

ZerOPlace

Hourly Heat Extraction ZeroPlace, New Paltz NY
Jan 11th –Feb 12th 2023



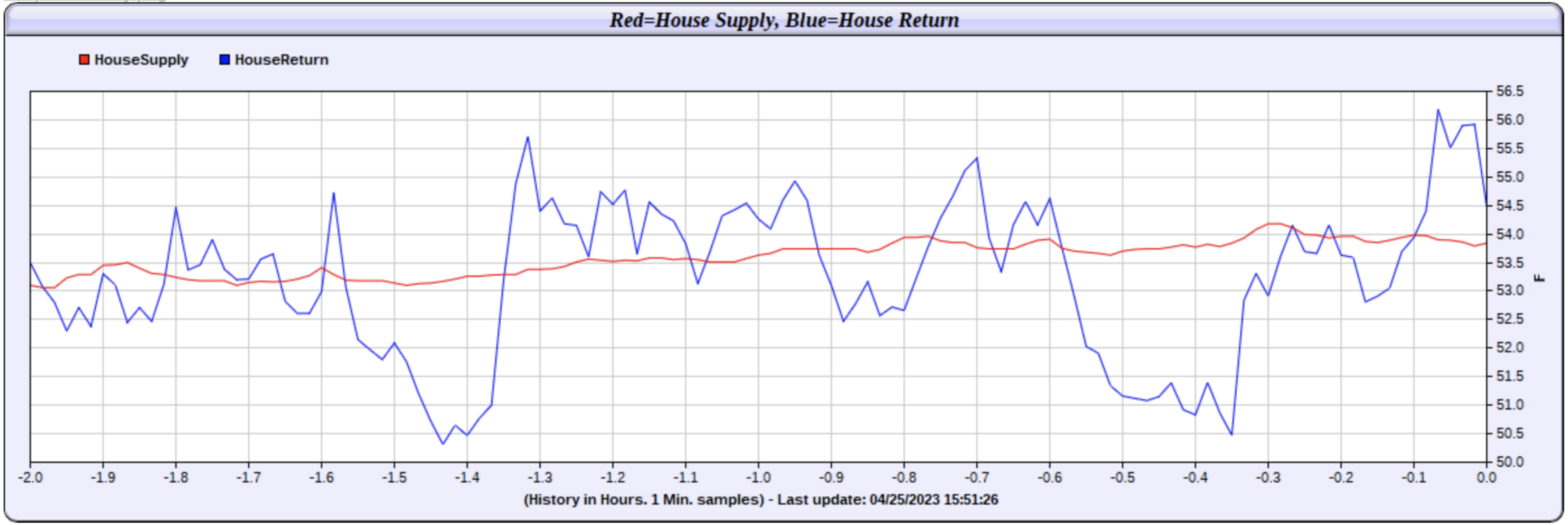
50 hour Loop Water Temperatures
Reacting immediately to energy input and output
Similar to an electric grid battery

LoopfieldDaily.png

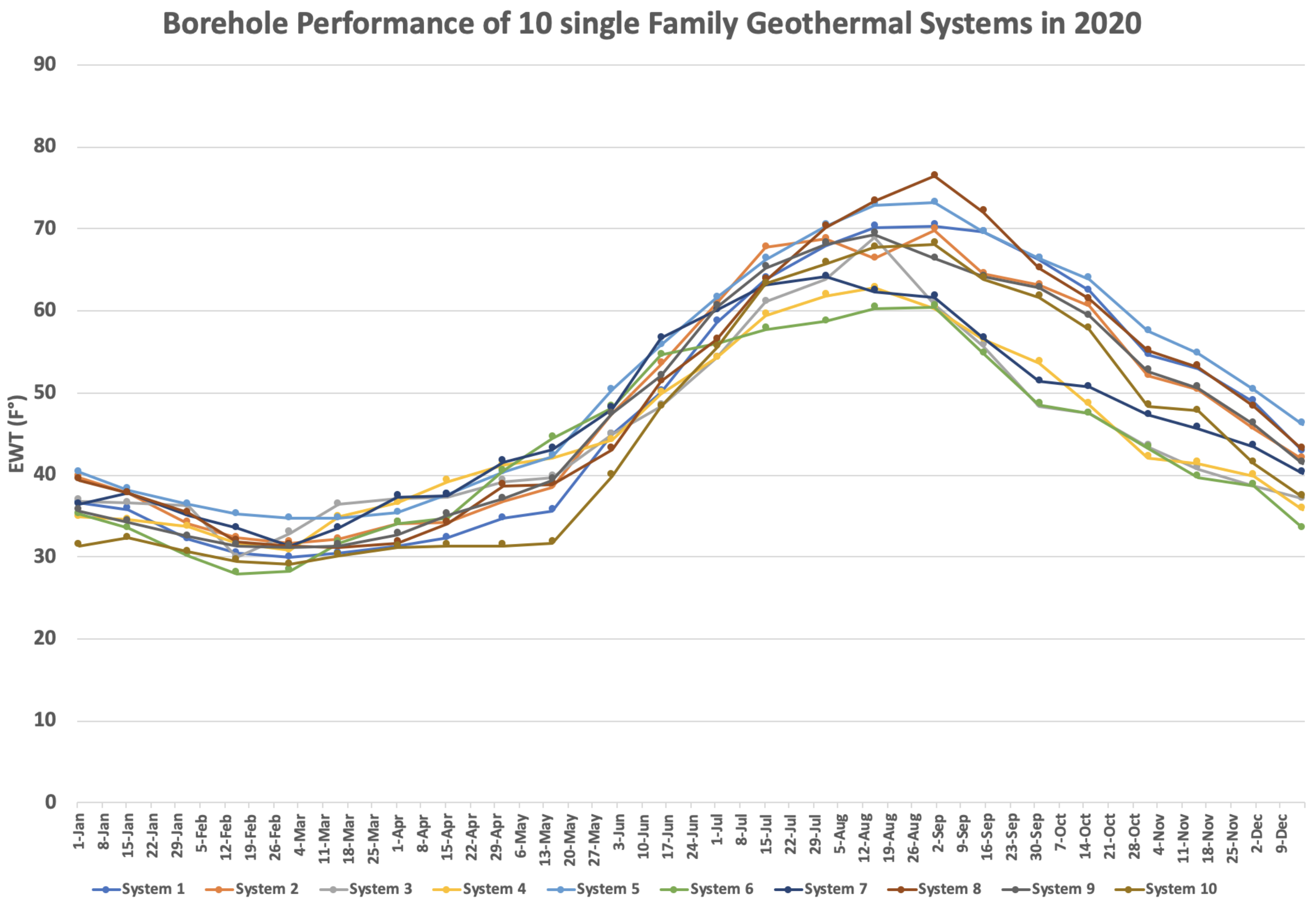


2 hour Loop Water Temperatures
Reacting immediately to energy input and output
Similar to an electric grid battery

LoopfieldHourly.png



Borehole Performance of 10 Single Family Geothermal Systems in 2020



NYSERDA Contract 174180

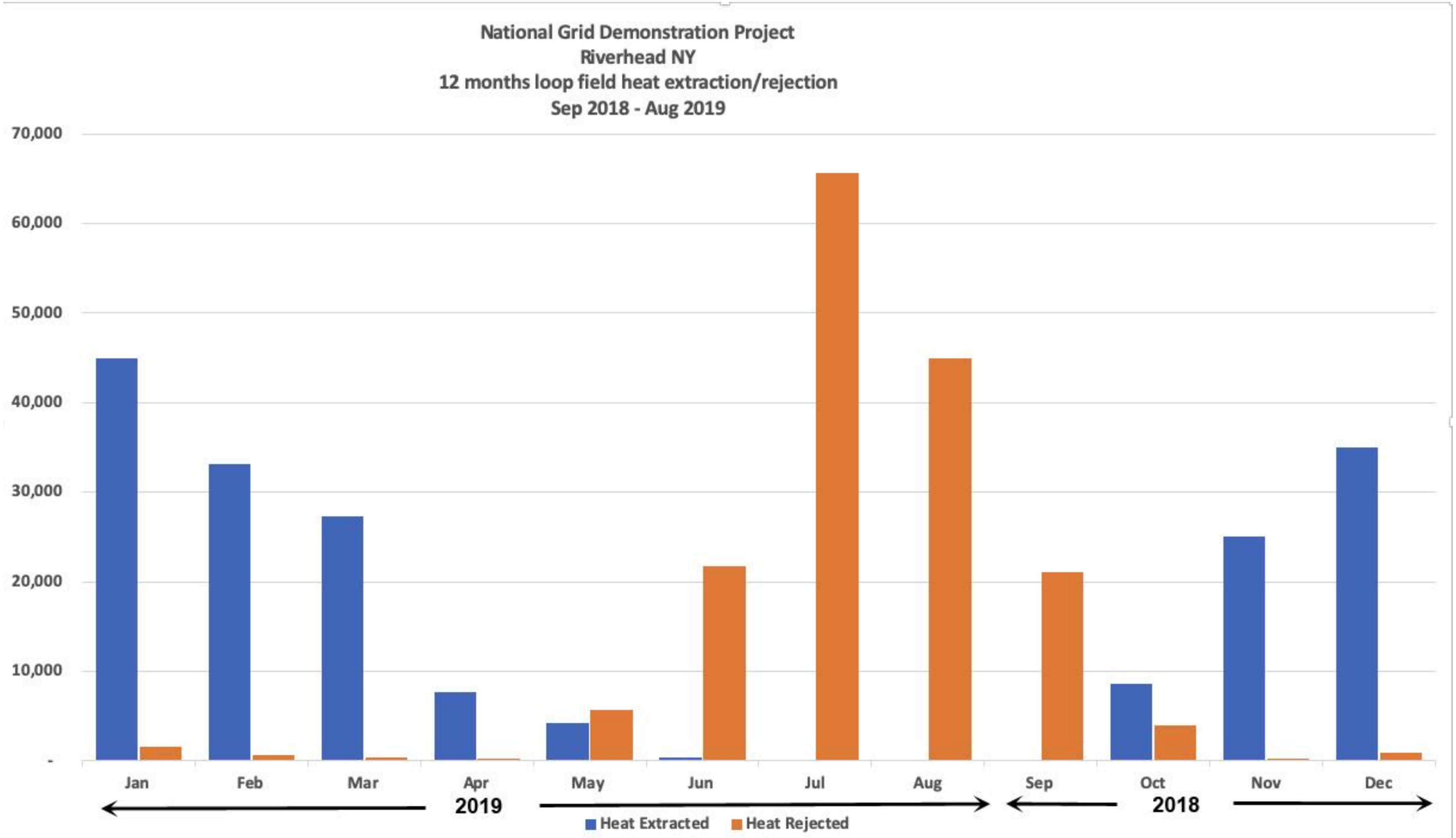
Draft Report – October 7, 2022

If we would have a battery which….

- Provides 75% energy for a home
- On a 6” footprint
- For a 6 month period (winter)
- Recharged by solar in the summer

- We would not have a grid anymore!

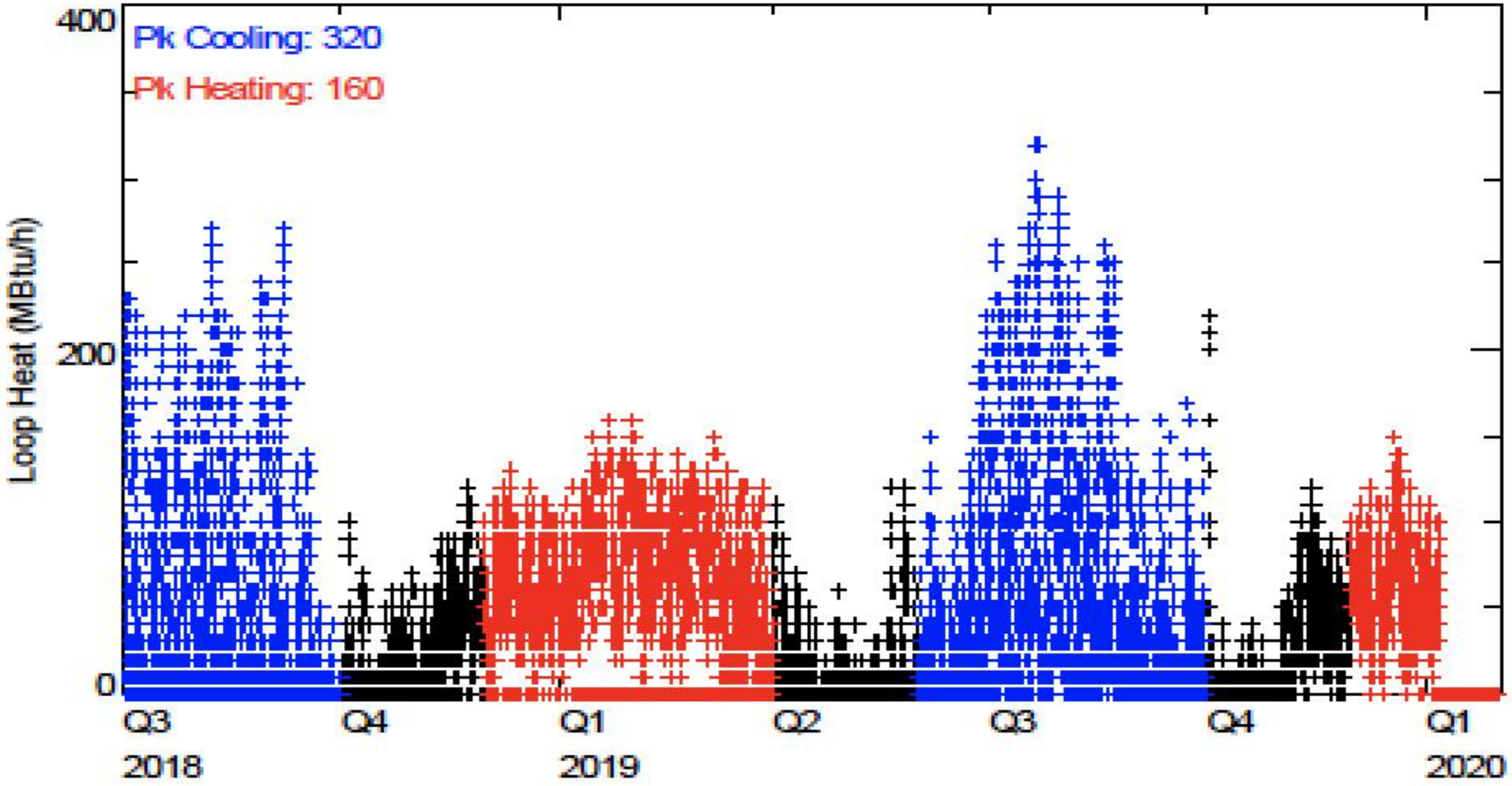
Loop Field Rejection/Extraction



Peak Loads Imposed on Ground Loop:

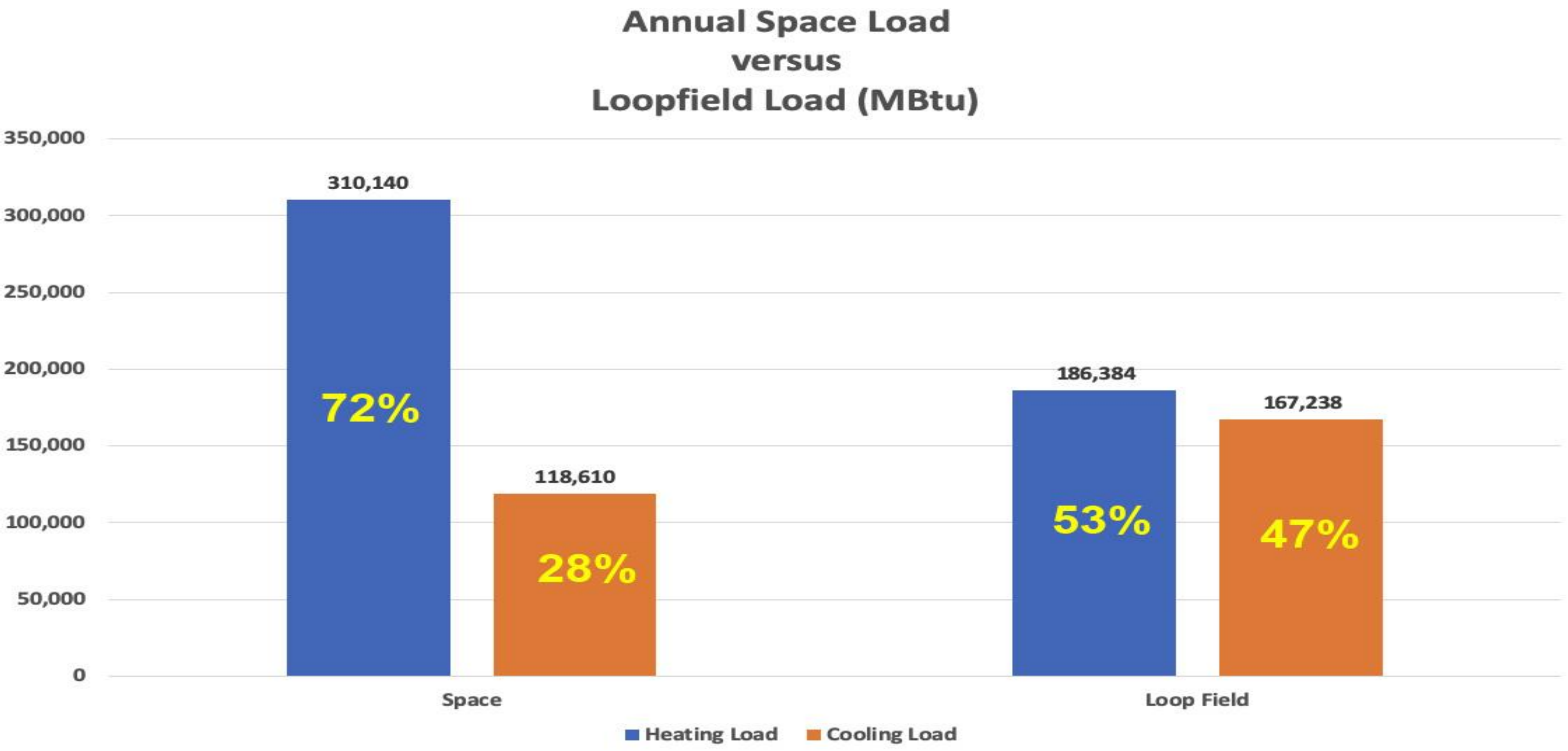
Twice as high in the summer as in the winter

Figure 15. Plot of Hourly Loads Imposed on the Ground Loop



Loop Field Performance

Space Load versus Loop Field Load

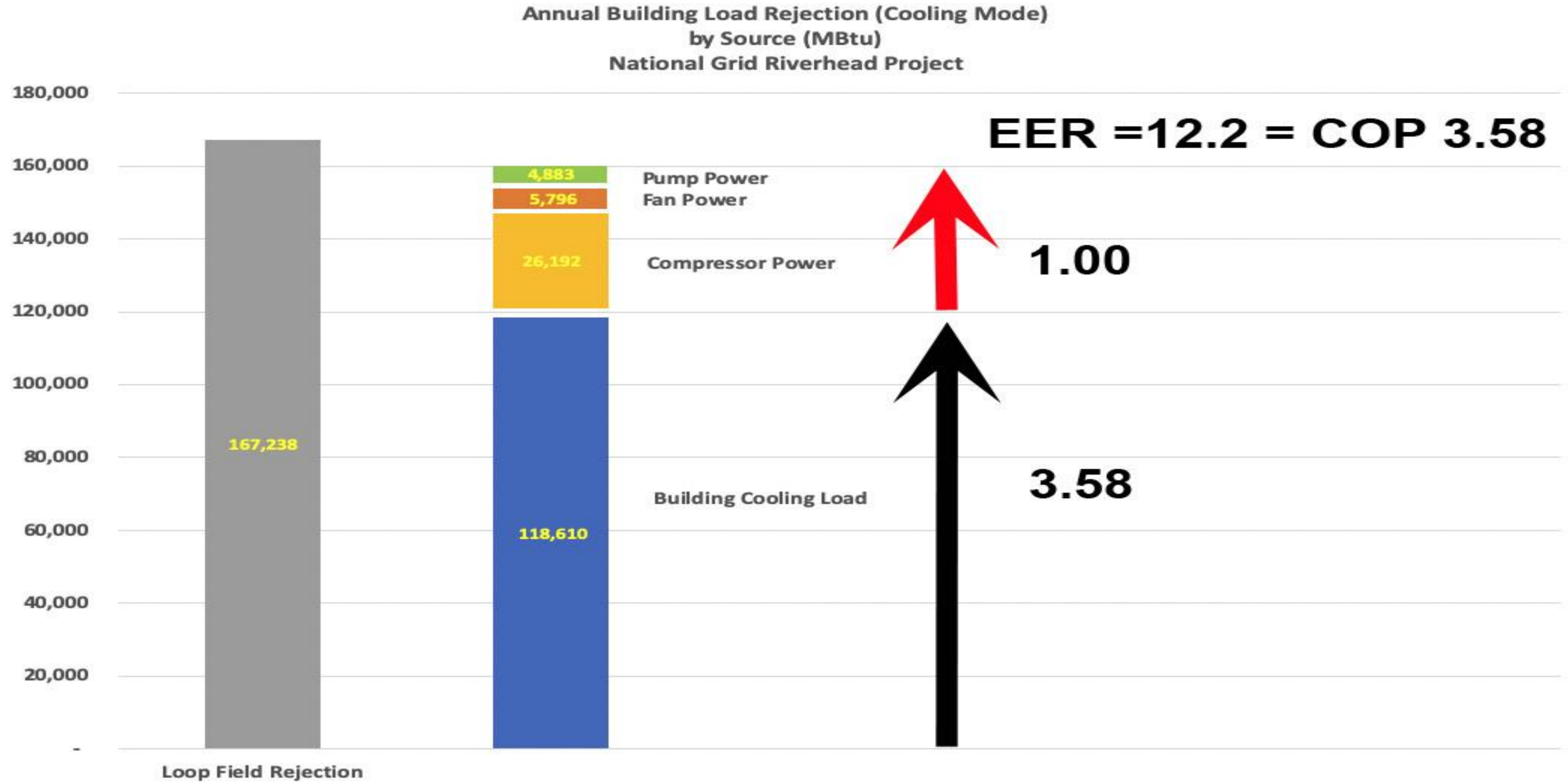


Source of Heat Delivered

In Heating Operation

Source of Heat Rejected

In Cooling Operation (simplified)

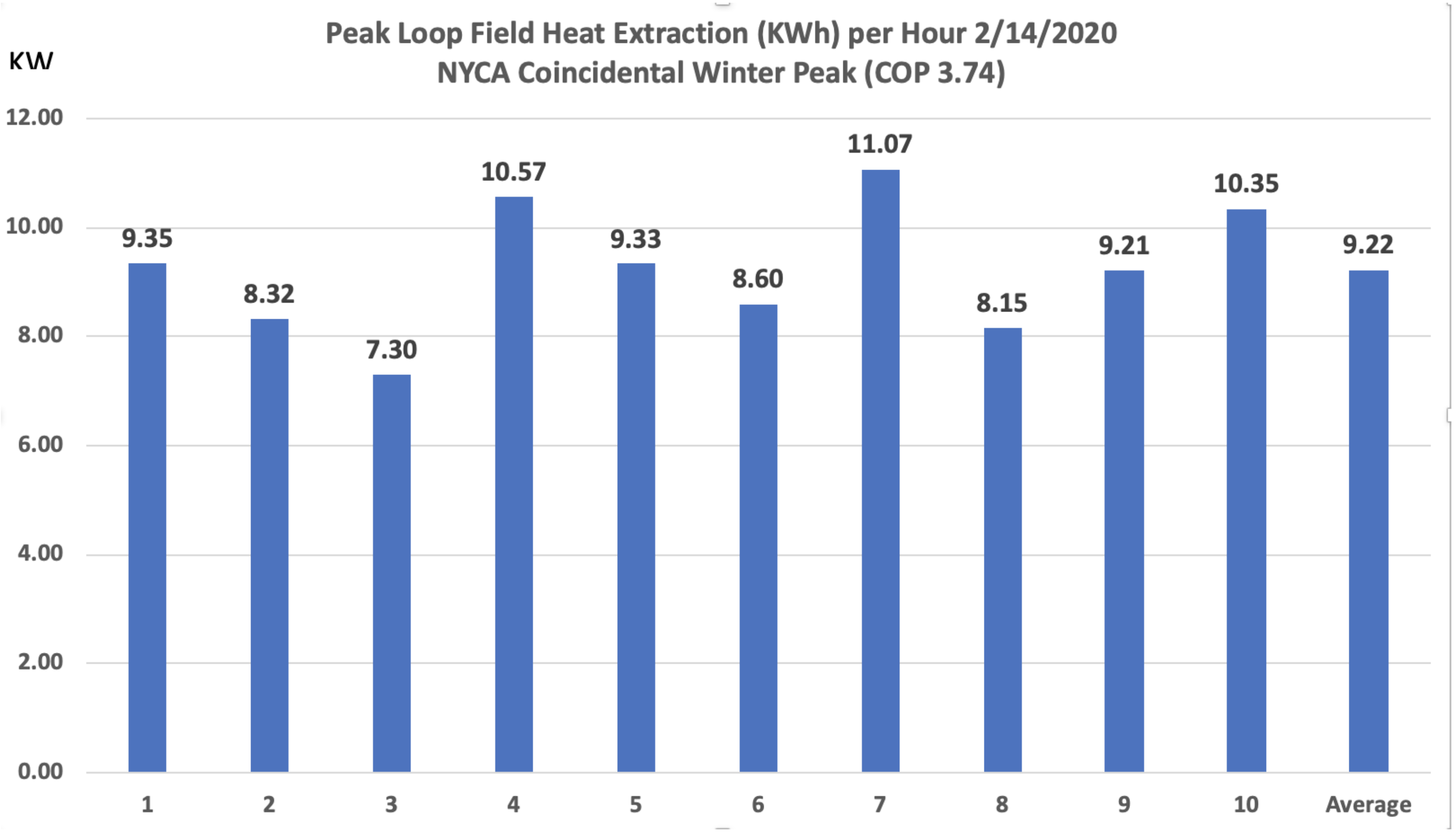


The ultimate thermal energy battery

- 1) The loop field stores all the thermal energy of the building in the boreholes for the whole year, enough to provide all the heating energy for the whole heating season.
- 2) It does not need to be connected to other buildings (no district), it makes all the energy it needs. The key is the storage.
- 3) It stabilizes below 30F and does not dip below, since it is making ice around the boreholes, which releases a large amount of heat due to the phase change. It is partly a phase change storage technology.
- 4) It reacts immediately to energy input and output.

Peak heat extraction of 10 residential systems in Buffalo NY

9.22 kW average



Average Residential Borehole Thermal Energy Extraction (n=10), Year 2020

Monetary Value

			@ $567/ kWh*
Peak Hour	9.22	kWh	$ 5,228
Peak Day (Feb 14)	173	kWh	$ 98,203
Monthly Thermal Energy	3.18	MWh	$ 1,803,060
Annual	13.05	MWh	$ 7,399,350

*"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


AHEAD
ZerOPlace
New Paltz, NY


ZerOPlace

ZeroPlace Loop Field Thermal Energy Delivery

Monetary Value

			@ $567/ kWh*
Monthly Thermal Energy (Jan 11 to Feb 10)	31.38	MWh	$ 17,792,460
Peak Day (Feb 4)	1,706.81	kWh	$ 967,762
Peak Hour	90.86	kWh	$ 51,518
Peak Interval (5-min)	106.98	KW	

*"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

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.

Additional benefits of geothermal geo storage

- No recharge needed for 6 months
  - Electricity generators to recharge are avoided
  - Solar capacity is very limited in the winter months
    - Peak to occur in the early morning hours
  - Wind is intermittent
    - 74 instances in 2020 when NYCA wind fleet output remained below 100 MW for more than 8 consecutive hours (NYISO Power Trends 2021)
  - Recharged automatically in the summer time
  - Capacity does not degrade (in contrast to electric storage)
    - 200+ year life expectancy

Key Points on Geo as a Storage Medium

1. The experience of European countries that have electrified their building sectors shows that peak demand shifts to around 7 AM before there is solar gain.

2. It is likely that NYS is underestimating the peak demand resulting from electrifying the economy (buildings and transportation) and potentially overestimating what solar and wind can supply.

3. Geothermal is the only renewable energy source with built-in storage capacity, which is essential for meeting CLCPA goals.

4. Meeting the enormous thermal peak requirement in NYS is only possible if 70% of the required energy come from a thermal storage reservoir onsite

Electric Capacity and Extreme Weather Events in the *High Electrification* Scenario

Jared Rodriguez

Emergent Urban Concepts

jared@emergentgroup.com

Recent Extreme Energy Events are Cold Weather Related:

Event	What Happened	Why	Consequences
The Blackout of 1965	Dropped 20 GW of load, 20 million lost power for 13 hours	Human Error set protective relay too low, led to cascading blackout	North American Electric Reliability Council Formed
NYC Blackout of 1977	All of New York City lost power for up to 26 hours	Lightning Strike, faulty transmission	Mass looting, New Mayor
Midwest Price Spike 1998	Prices went to $7,500 for June 25, 1998	Hot weather combined with planned maintenance and major Nuclear trip (Davis-Besse)	FERC Investigation, price caps instituted in Eastern Regions
California Energy Crisis 2000-2001	Rolling Blackouts	Poor market structure, failure to develop enough supply to meet growing demand	Direct Access suspended – never to return; $10billion in overpayment inflicted on ratepayers
Texas **February** 2011	Rolling Blackouts 2-8 hours	Fossil fuel plants weren't winterized	ERCoT report suggested Winterization
Northeast Polar Vortex **January** 2014	PJM hit a Record Winter Peak	Gas plants that pledged capacity did not have firm supply	Winter Reliability Program instituted by PJM, ISO-NE
New England **Winter** 2018	High Loads in ISO-NE caused dispatch of many oil-fired units	Extended Cold Snap and very high gas prices forced oil	Affirmation of Winter Reliabilty Program

Texas Power Crisis – Consequences

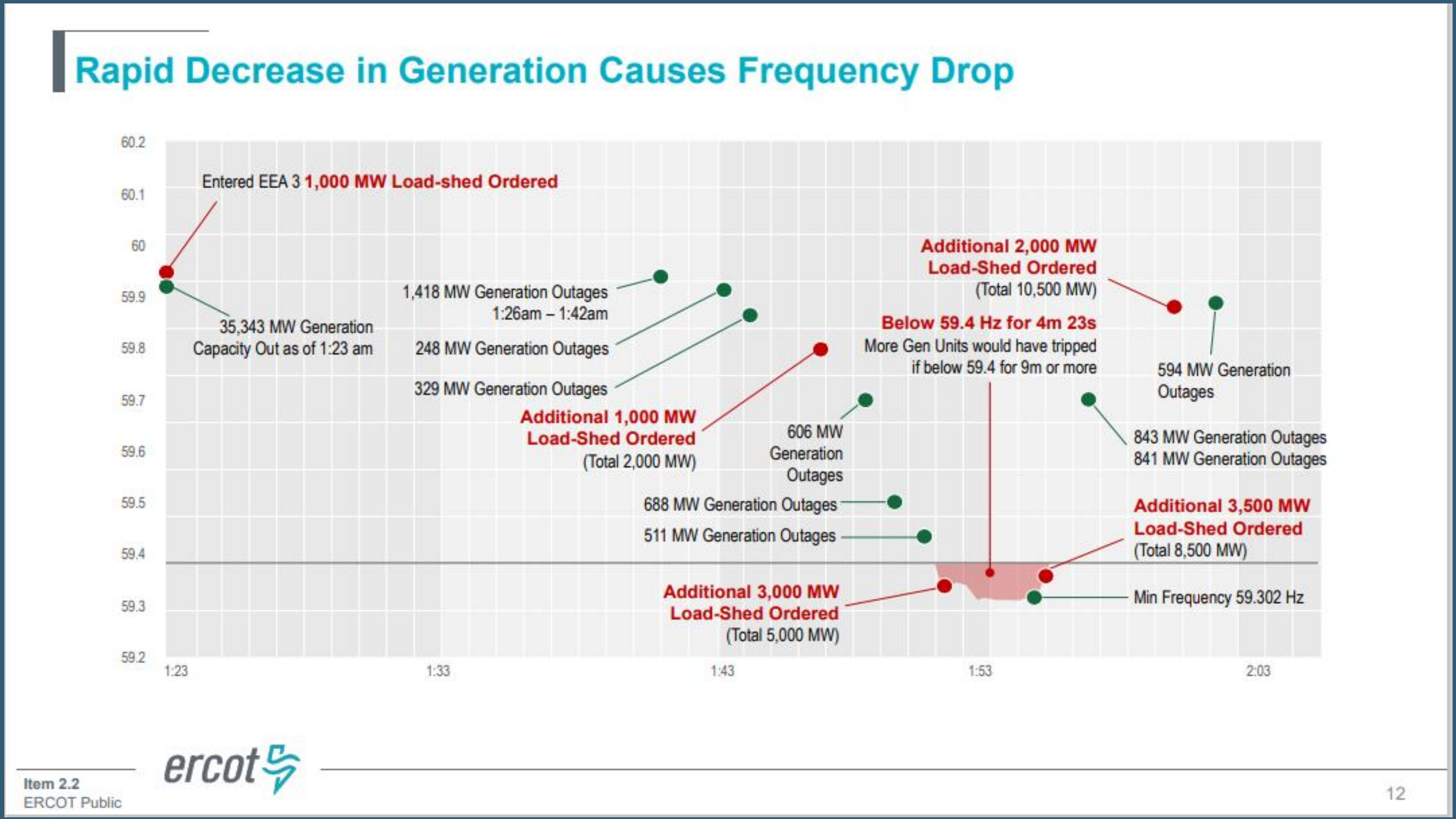
- 150+ Deaths
- $50,000,000,000 in electricity costs to be paid by parties for electricity for one 4-day period…
- Total financial impact of $150,000,000,000
- Hurricane Katrina - $161,000,000,000

Texas Power Crisis

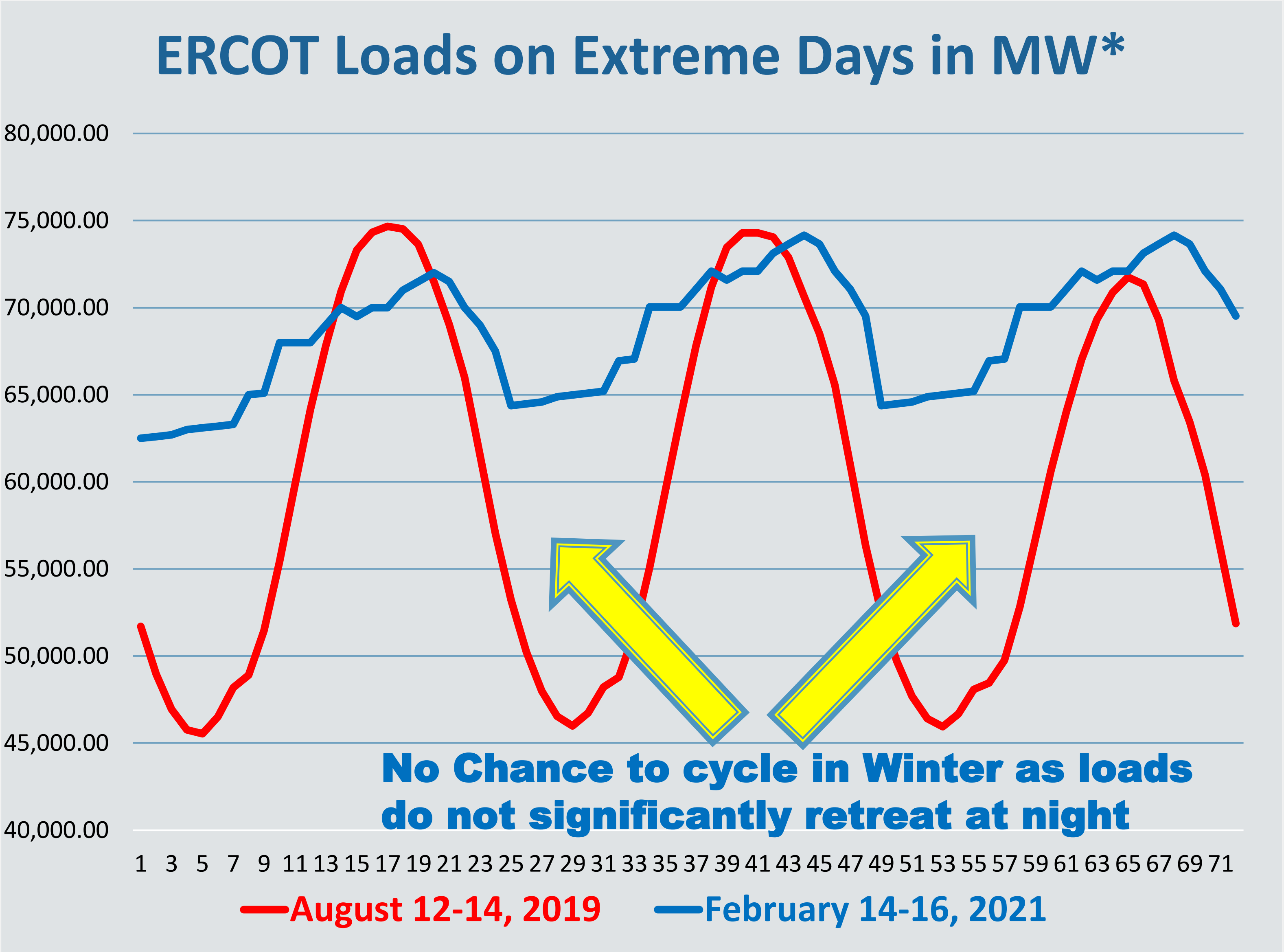
What happened?

- Unprecedented Cold Weather for Texas – 140 consecutive hours below freezing at DFW
- The Extreme Winter Peak Forecast was 67,206 MW per November Seasonal Assessment of Resource Adequacy (SARA)
- The Projected Peak Demand was more than 74,000 MW
- 35,000 MW out of 107,000 MW was already off-line →only 72,000 MW was available
- A new Winter Peak was hit at on Sunday, February 14 at 69,222 MW
- On February 15 at 01:23 the frequency started to droop below 59.9 Hz
- Over the next 30 minutes the frequency went as low as 59.302 Hz and over 10,500 MW of load were shed as 5,500 MW of generation tripped off-line
- At the worst point over 48% of ERCOT's peak generation capacity was out

Great Slide from ERCOT showing the timeline of events

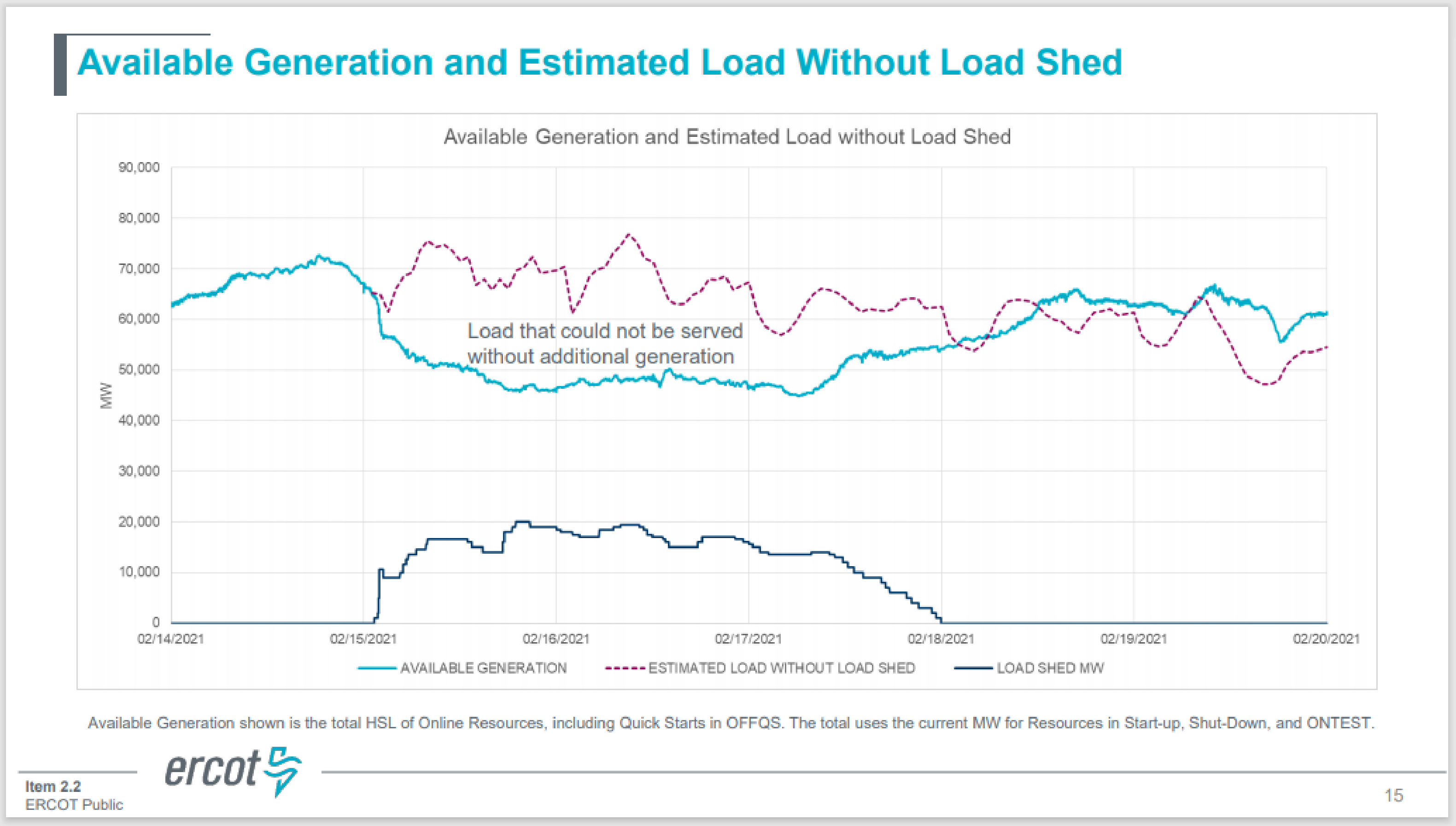


The Winter Peak Problem is a Thermal Storage Problem NOT an Electricity Storage Problem

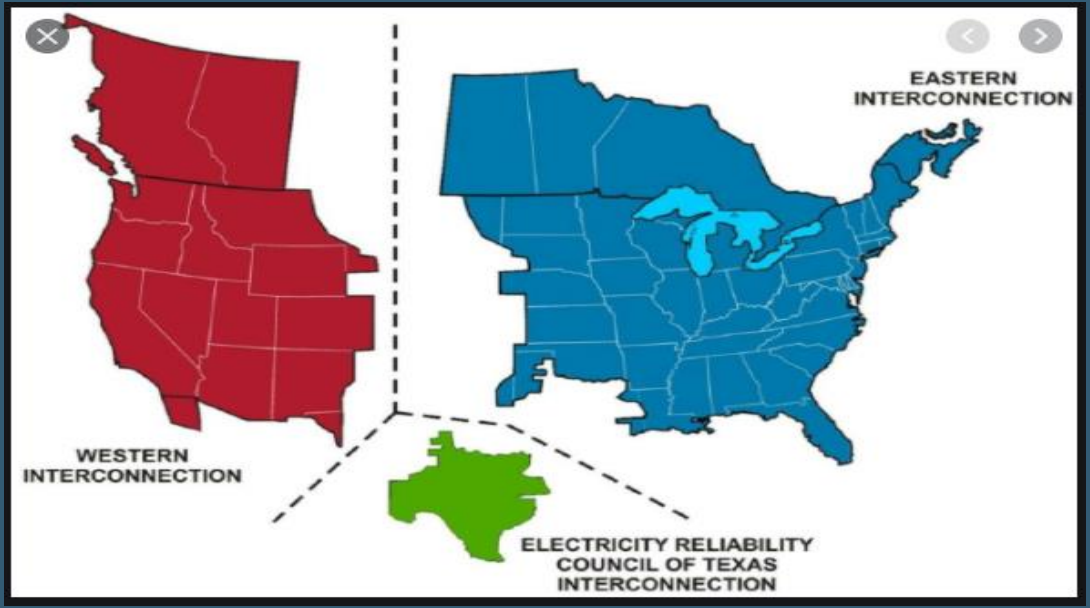


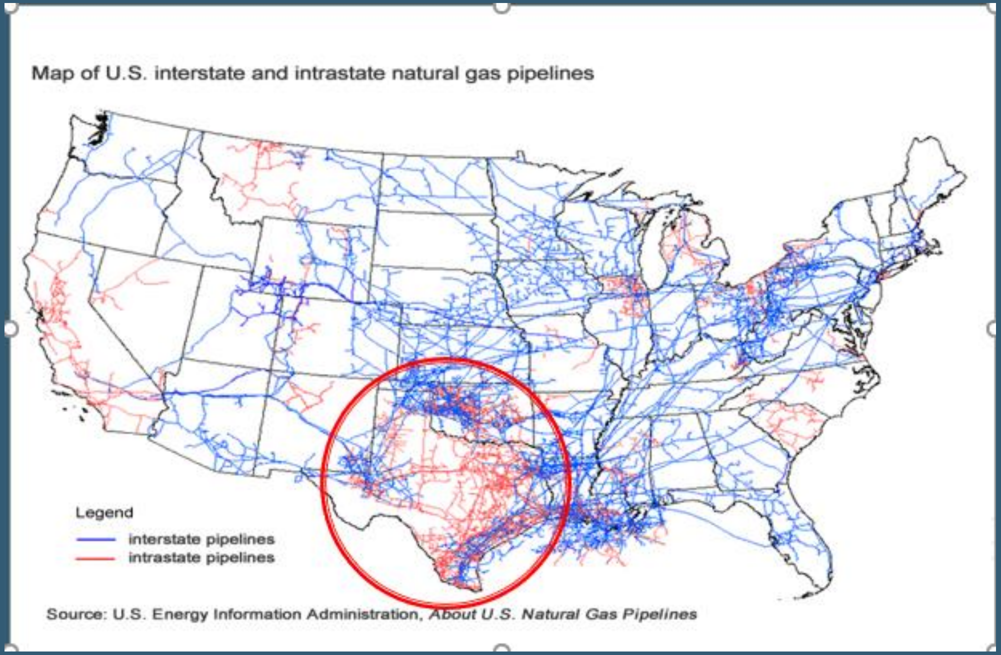
*Summer Data from ERCOT, Winter Data for Feb. 14 from ERCOT, 15 and 16 were projected as load was not met

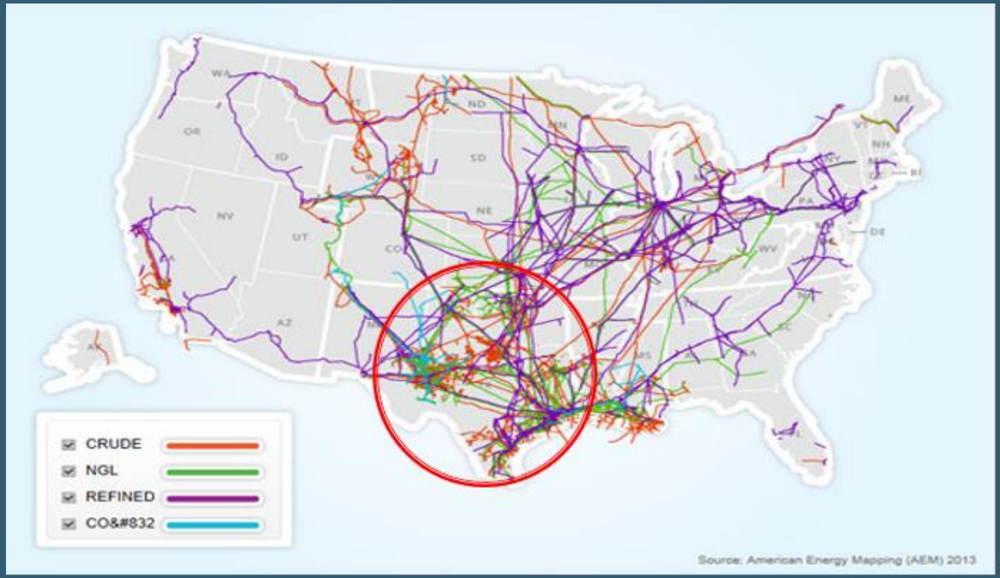
Important Point: There is no peak/off-peak split here – the purple line does not go up and down like it does diurnally during the Summer



ERCOT is not Las Vegas, What Happens there has Huge Implications:







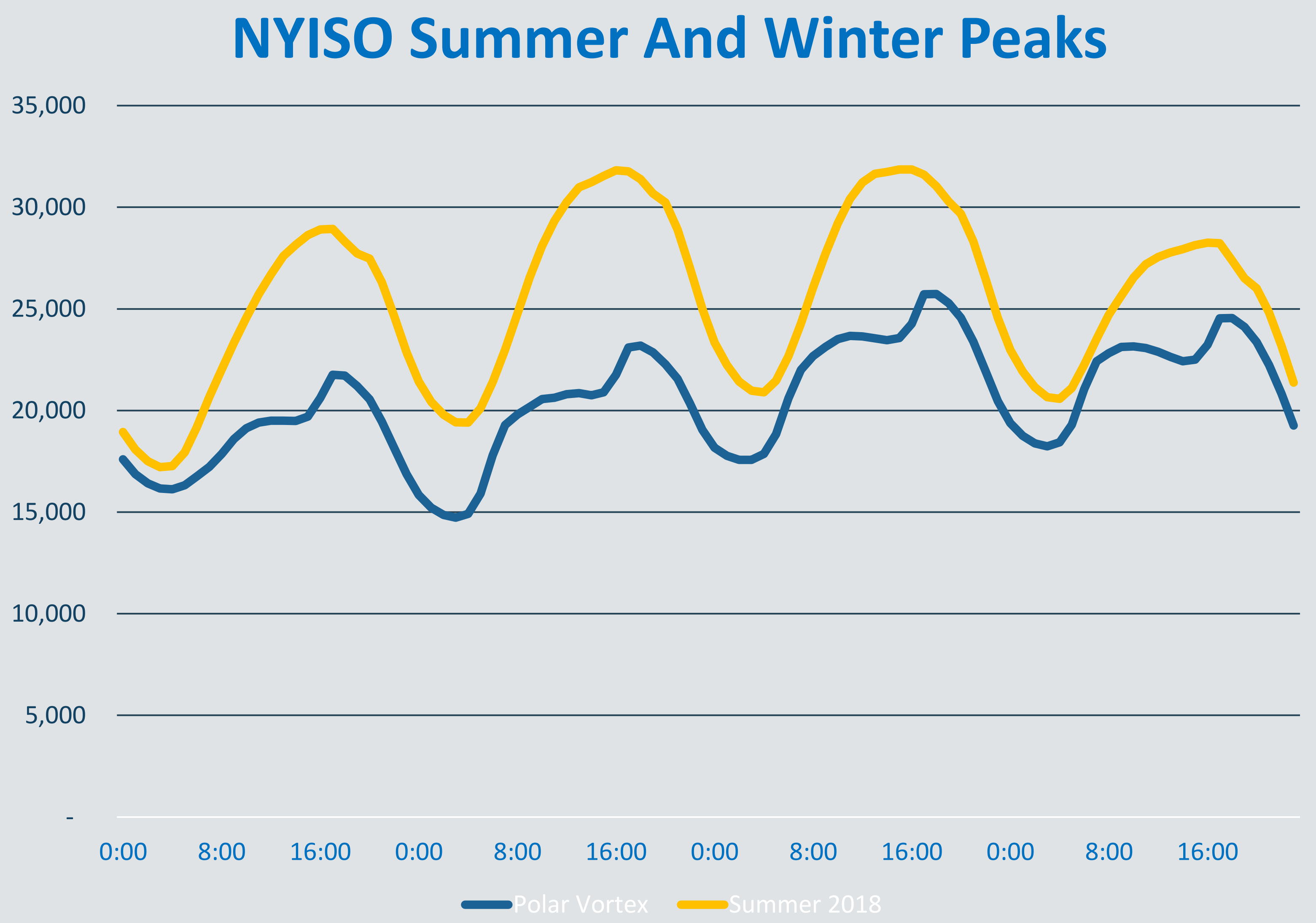
“Texas Freeze Triggers Global Plastics Shortage” – WSJ 3.17.2021

Area for this Study

The study looked at the Northeast as this is the most likely area to adopt beneficial electrification and experience significant Winter Peaks

We chose to examine New England, New York, Pennsylvania and New Jersey

A look at the Winter and Summer Peaks in one of the Regions under Study



* Data from NYISO for Augaust 27-30, 2018 and January 5-8, 2014

The High Electrification Scenario Shifts Constraints to January/February

DIVE BRIEF

NYISO: Transmission security margins sufficient for the state, but NYC faces reliability risks

Published April 17, 2023

Stephen Singer
Editor

Dive Brief:

- Statewide baseline transmission security margins for New York and margins for the lower Hudson Valley, New York City and Long Island are sufficient for 2023 to 2028, the state's grid operator said Friday.
- But the reliability of the New York City area faces the greatest risk due to limited generation and transmission to serve forecasted demand, New York ISO said in its first-quarter Short-Term Assessment of Reliability.
- Under expected summer weather, the grid is expected to be sufficient during the next five years, but has an "extremely narrow transmission security margin" in 2025 due to the planned unavailability of simple-cycle combustion turbines to reduce emissions during the ozone season from May through September and comply with the state's Peaker Rule, NYISO said.

This becomes a winter conversation.

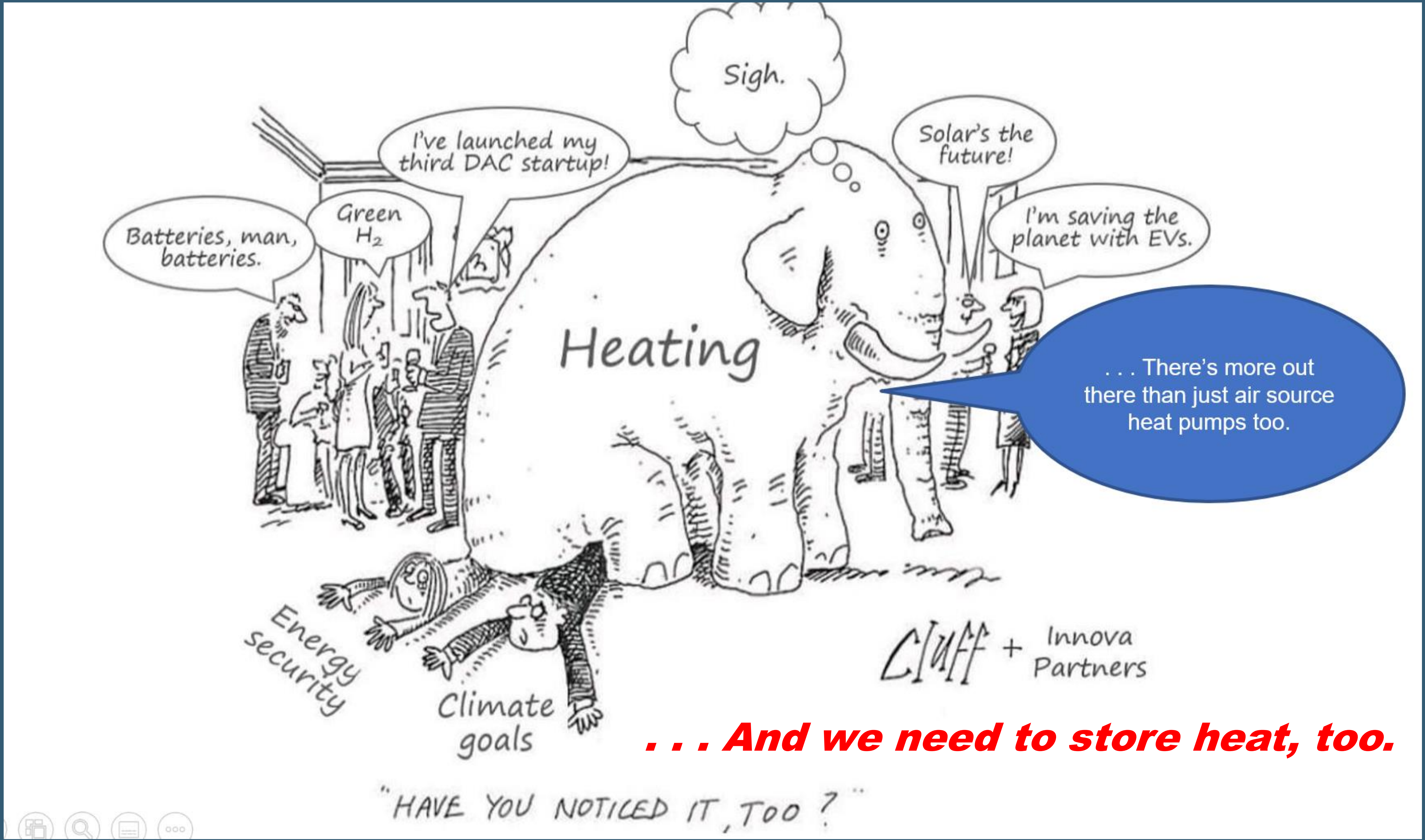
Methodology to Develop Peak Loads Under Beneficial Electrification

1. Identify peak winter electricity usage in the three ISOs under examination.

2. Develop relevant design day natural gas and heating oil space heating usage for each region.

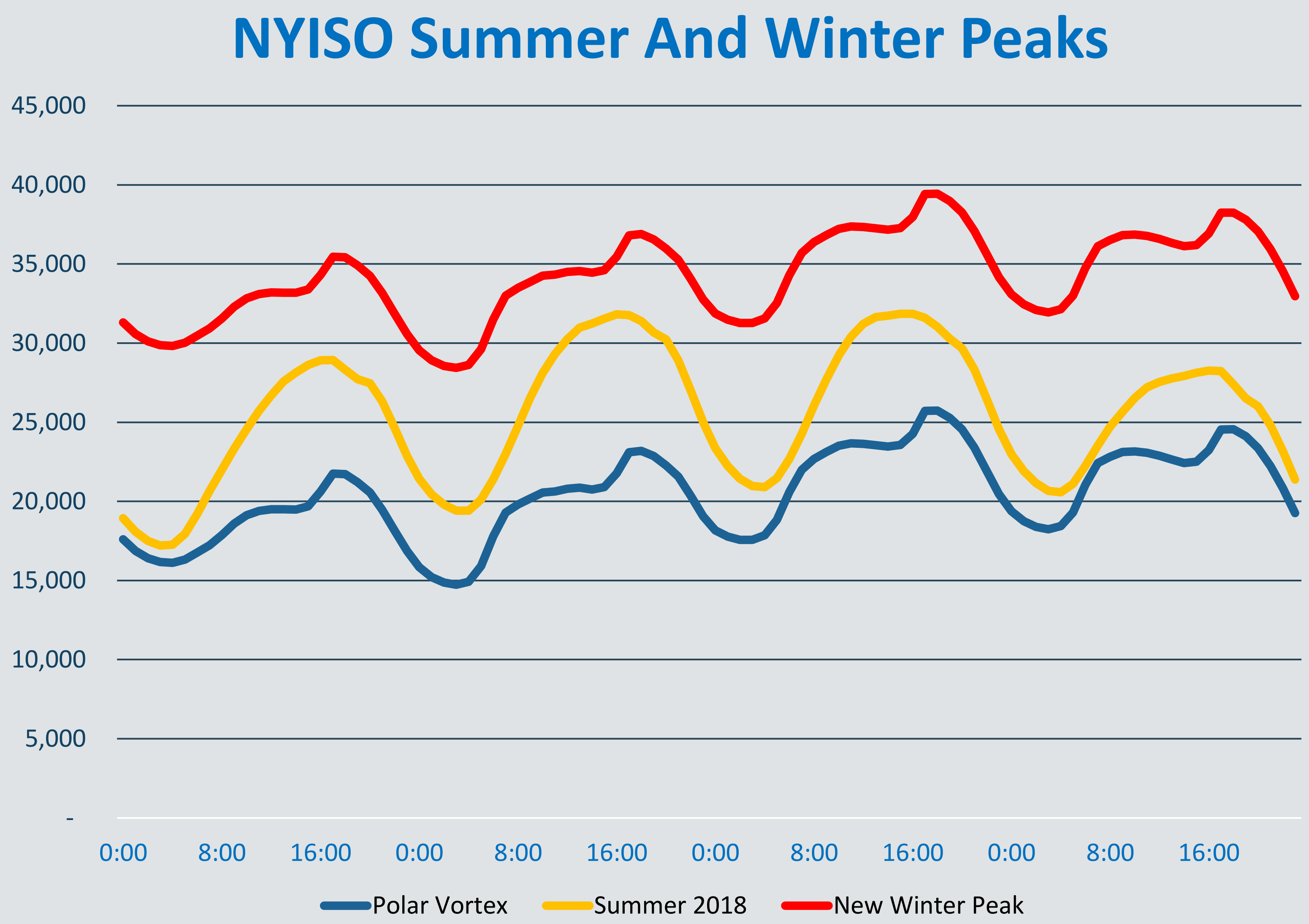
3. Convert the natural gas and heating oil space heating design day send out to kWh under projected Coefficients of Production (COP) for air source heat pumps.

4. Project new peaks for each region based on respective levels of air source heat pump incremental saturation.


Sigh.
I've launched my third DAC startup!
Solar's the future!
Batteries, man, batteries.
Green H_2
I'm saving the planet with EVs.
Heating
. . . There's more out there than just air source heat pumps too.
Energy security
Climate goals
Cluff + Innova Partners
. . . And we need to store heat, too.
"HAVE YOU NOTICED IT, TOO ?"

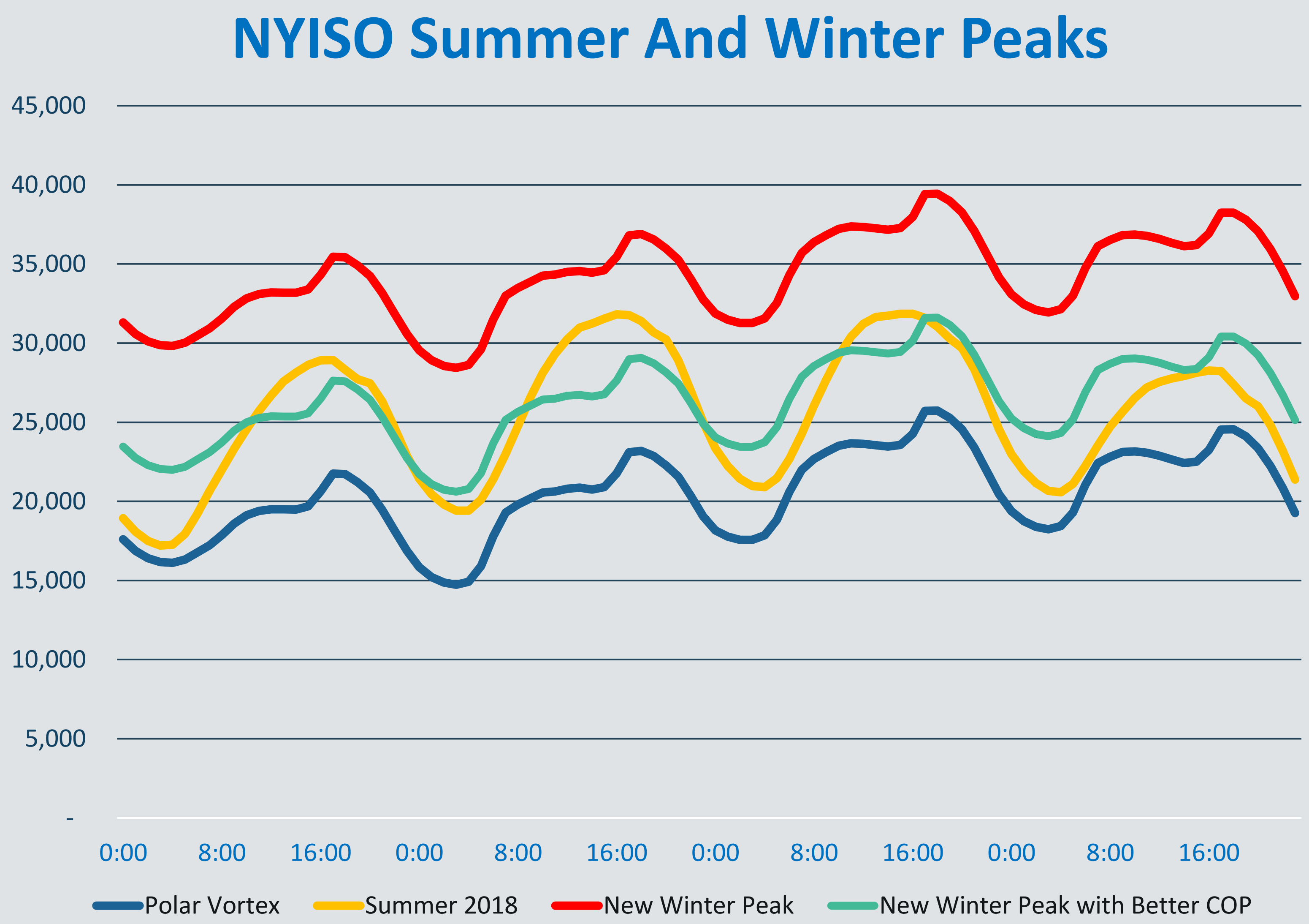
Assuming a Conversion rate of 20% of Natural Gas and 80% of Oil We get a New NYISO Peak of 39,000 MW at COP = 1.5

* Data from NYISO for August 27-30, 2018 and January 5-8, 2014

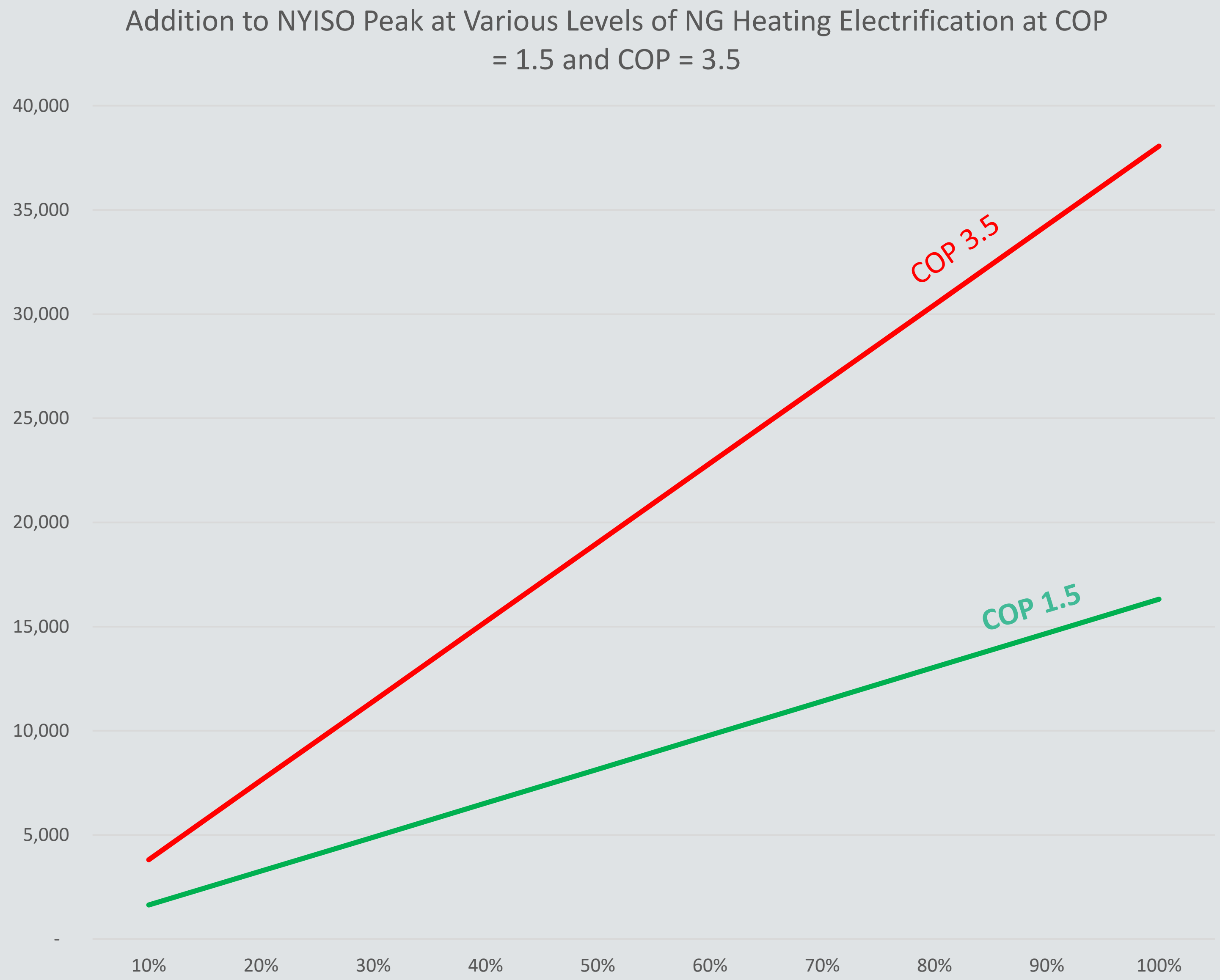


But…… Under the same conditions with a Higher COP of 3.5 we have a NYISO Peak similar to the current Summer Peak

* Data from NYISO for Augaust 27-30, 2018 and January 5-8, 2014



The Difference in Peak Increase at Differing COPs



New York as an Example of how important higher COPs are as we move to High Electrification

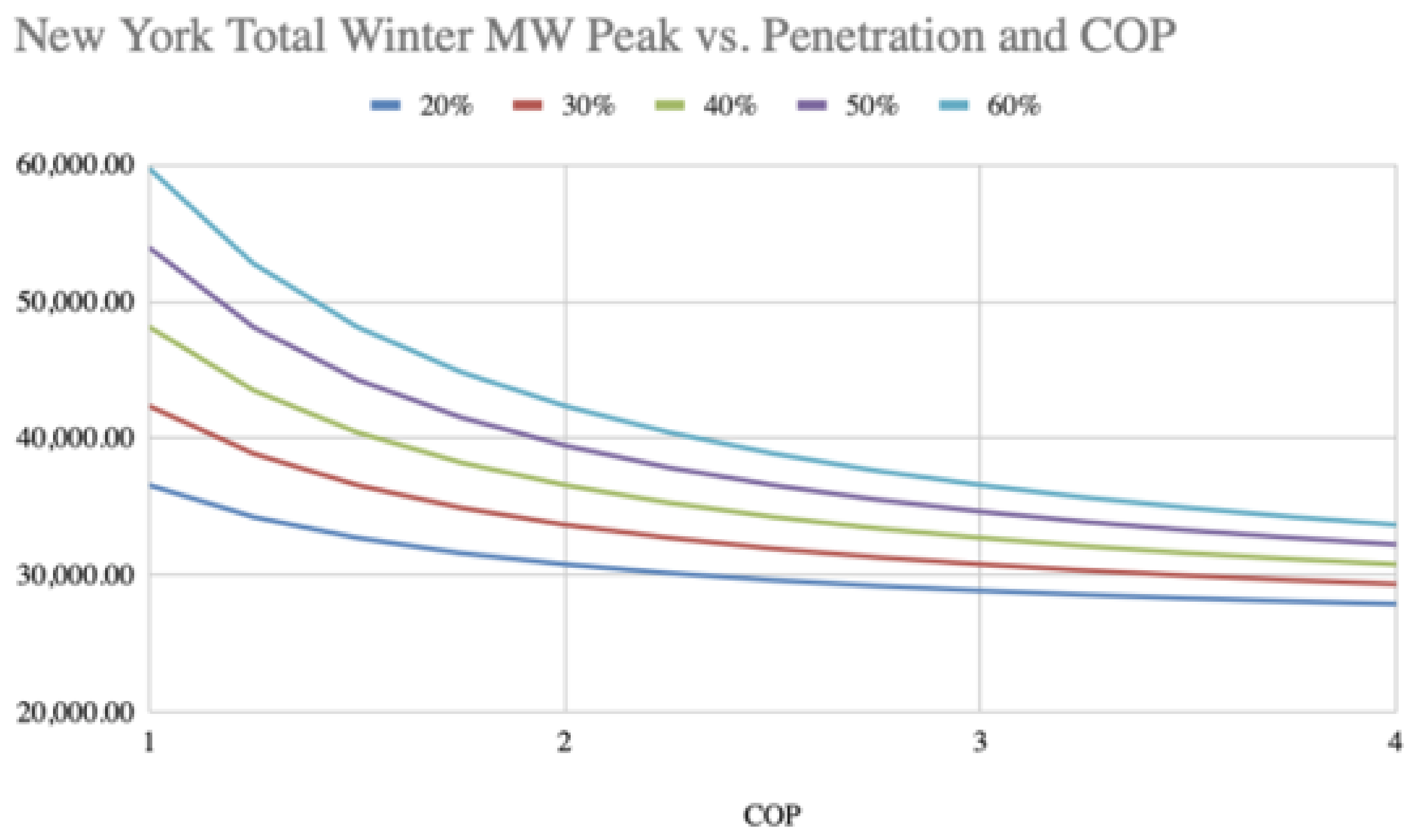
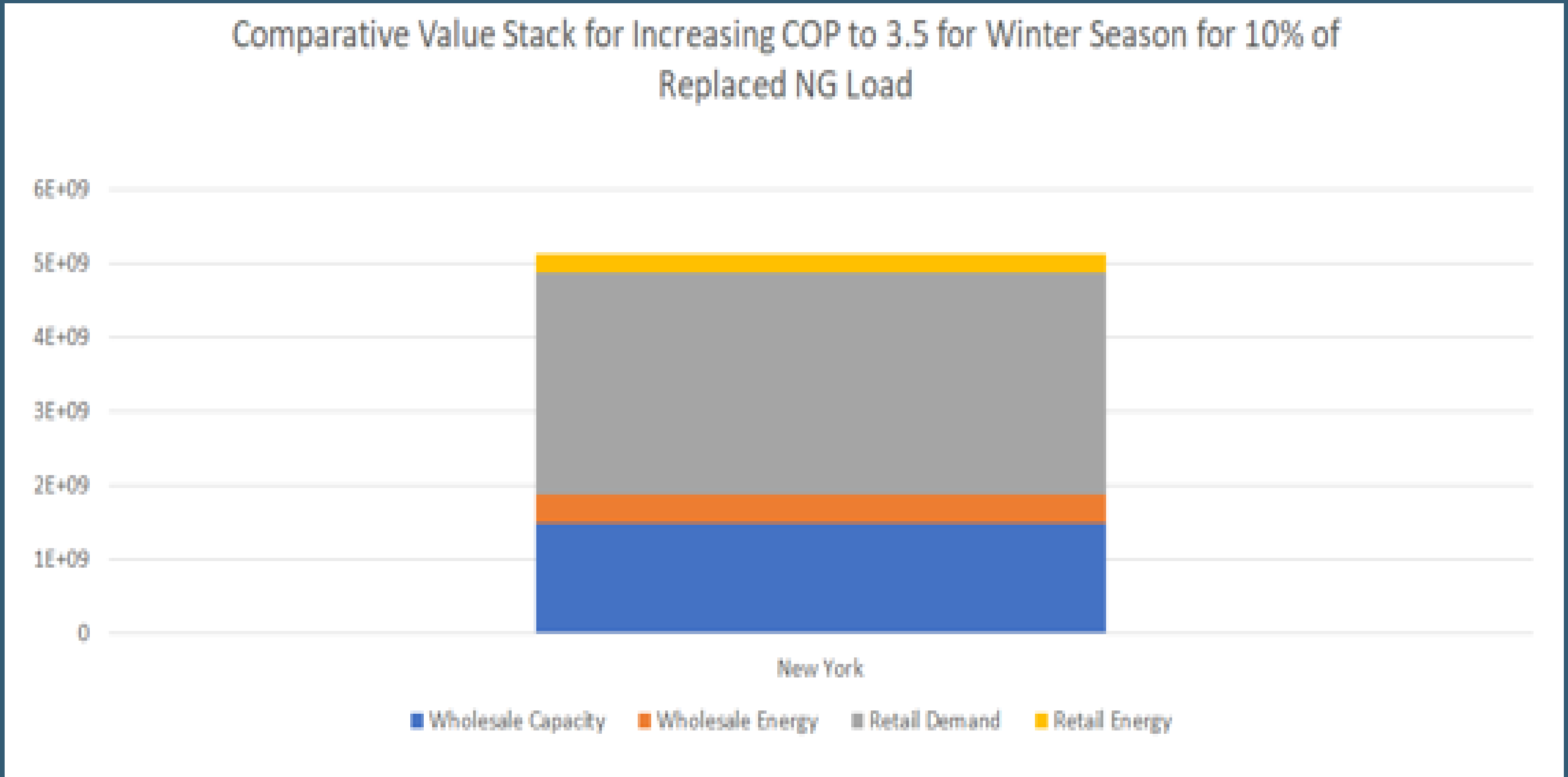


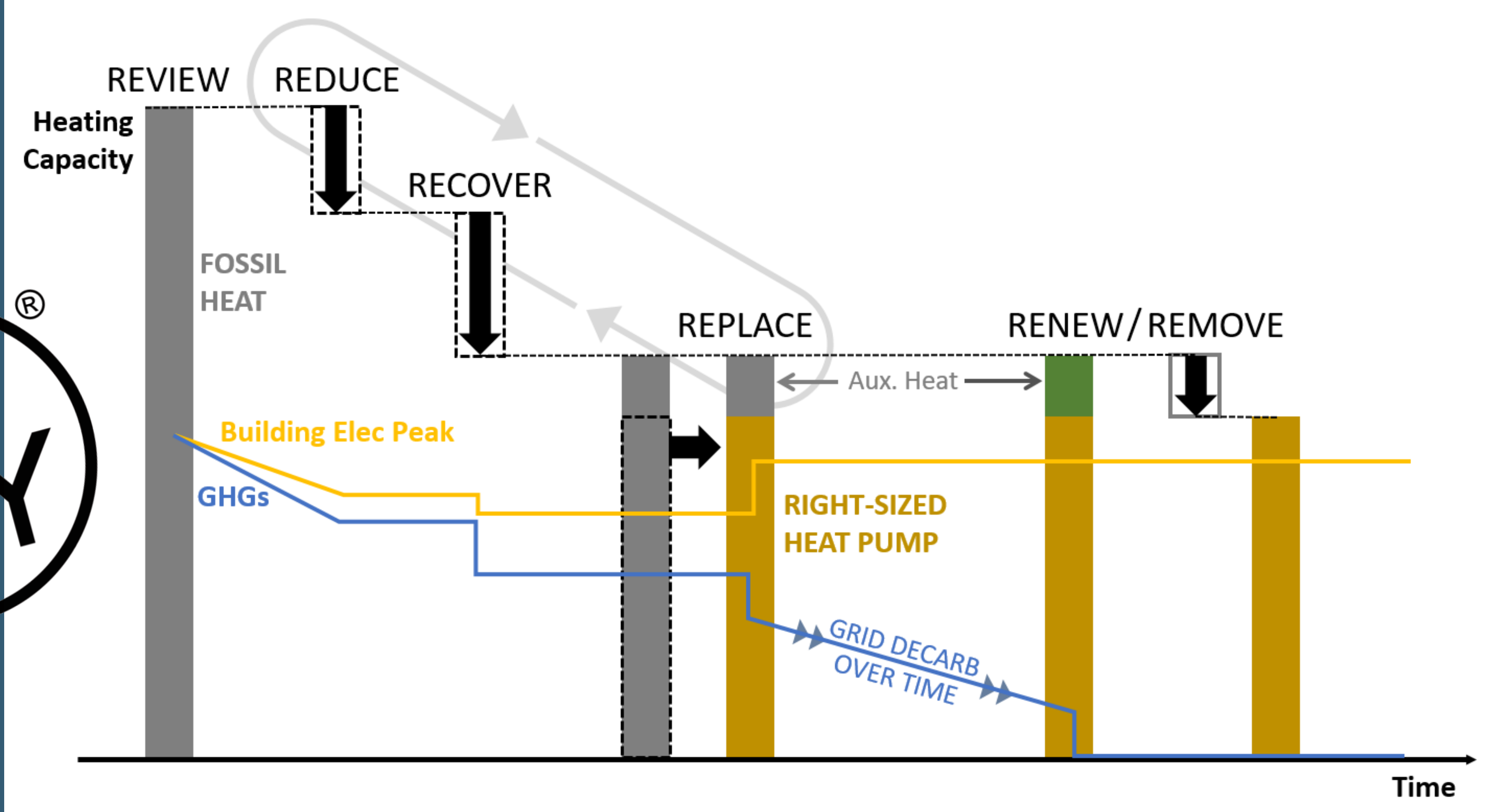
Figure 9. The total winter peak load in New York with various Coefficients of Performance and penetration levels.
Source: NYISO (https://www.nyiso.com)

The Value of Thermal Networks to the Electric Grid; rough estimate = $5 BILLION over 15 years

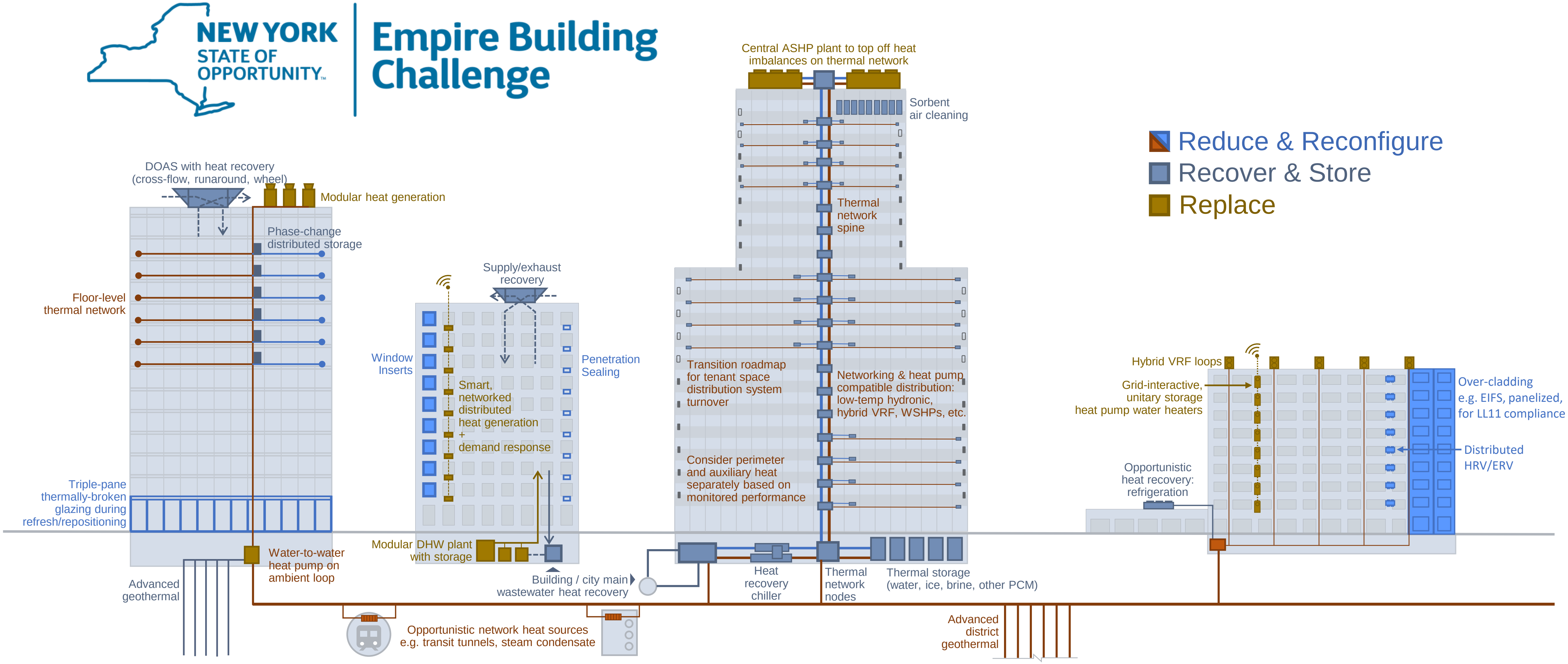


A Heuristic for Decarbonizing Buildings

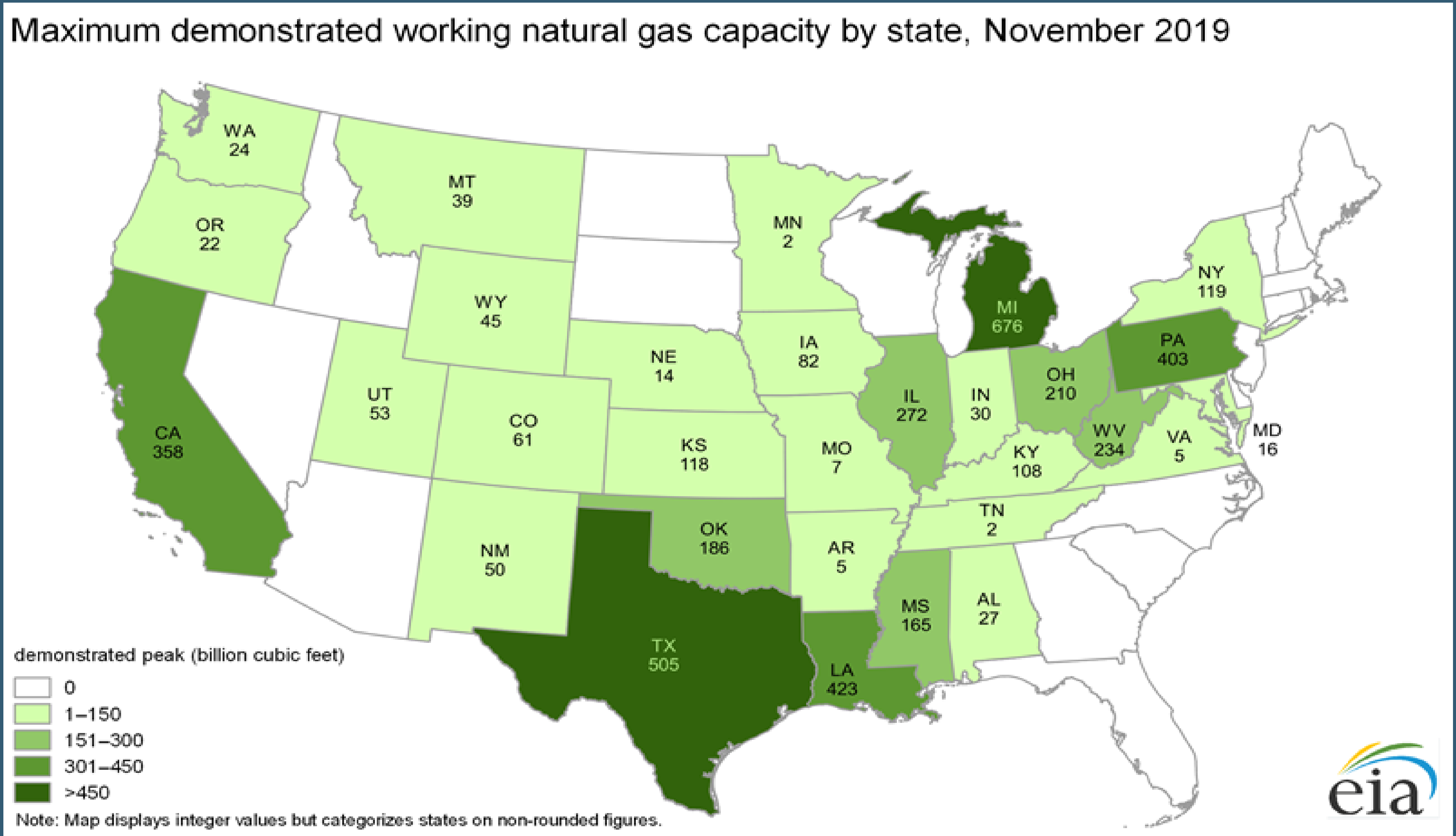
Resource Efficient Decarbonization (RED): an incremental methodology and integrated design process combined with strategic capital planning creates a path to efficient carbon neutral buildings.



Resource Efficient Decarbonization (RED) includes a whole-system, thermal network(ing) approach to decarbonizing cold-climate buildings.

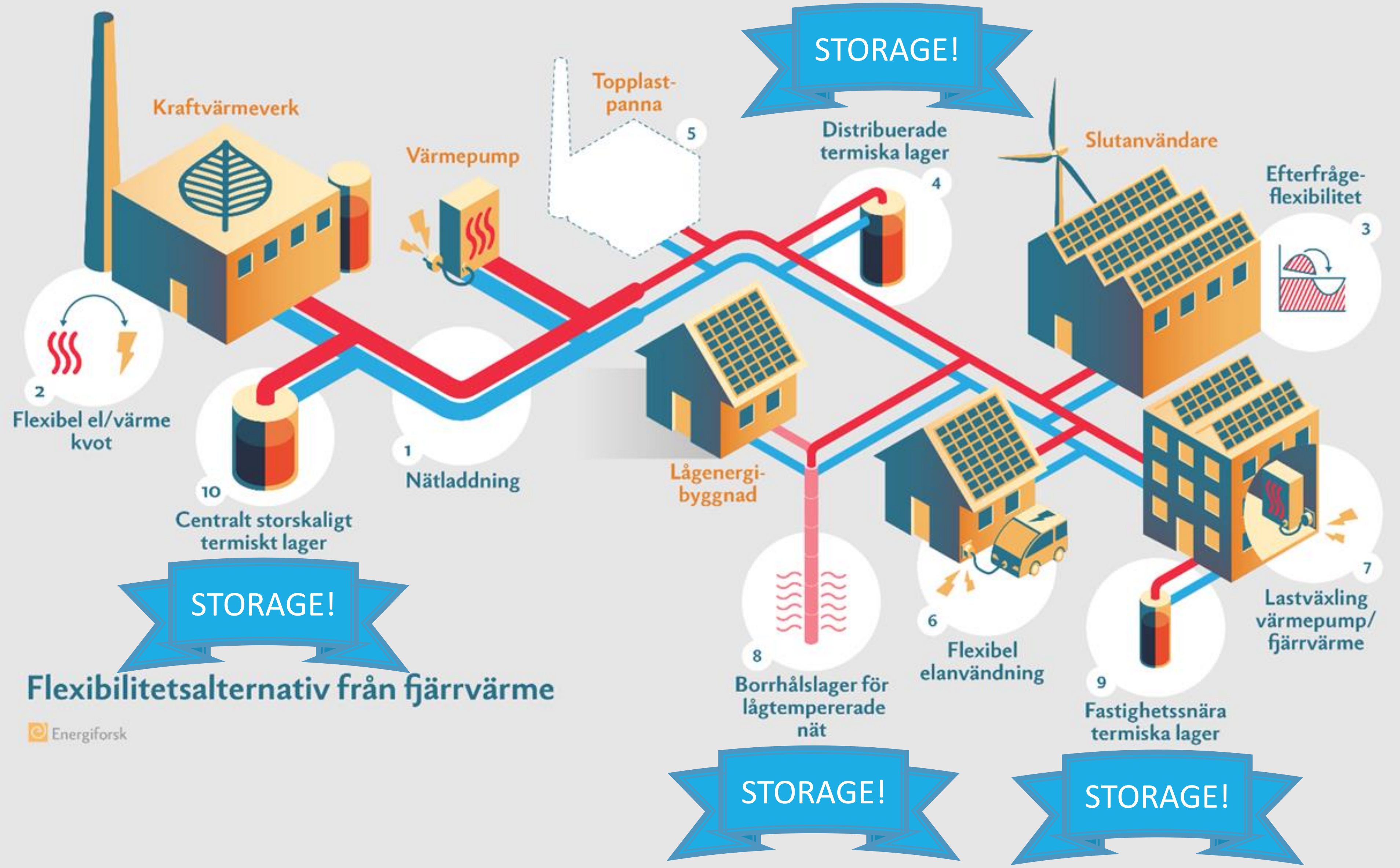


This is our current form of Thermal Storage:



Recommendations

- **More awareness of the value to the electric grid Thermal Networks and thermal storage represent. Thermal Networks are NOT just NPAs.**
- **Continue to Quantify Benefits and research impacts via the UTENs process and beyond.**
- **Advocate for allowing thermal networks to act as capacity resources at State Commissions, ISOs and at FERC.**
- **Urge the building industry to embrace Resource Efficient Decarbonization approaches versus BAU.**


STORAGE!
Kraftvärmeverk
Värmepump
Topplast-
panna
5
Distribuerade
termiska lager
4
Slutanvändare
Efterfråge-
flexibilitet
3
2
Flexibel el/värme
kvot
10
Centralt storskaligt
termiskt lager
1
Nätladdning
Lågenergi-
byggnad
STORAGE!
8
Borrhålslager för
lågtempererade
nät
6
Flexibel
elanvändning
7
Lastväxling
värmepump/
fjärrvärme
9
Fastighetsnära
termiska lager
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APPENDIX

To Convert 100% of Natural Gas Heating, NYISO will have an Increased Peak of 57,000 MW at COP =1

Heating Peak Day Natural Gas Sendout (Burner Tip) MMBtu	5,000,000
Assumed Efficiency of Heating	85%
Peak Day MMBtu needed for Heating	4,250,000
Convert to MWh/d	1,245,552
Convert to MWh/h	51,898
Scaling Factor	1.10
Peak Load (MW)	57,088

To Convert to 100% of No. 2 Oil Heating, NYISO will have an Increased Peak of 11,000 MW at COP =1

Heating Peak Day No. 2 Oil Burn (MMBtu)	1,000,000
Assumed Efficiency of Heating	85%
Peak Day MMBtu needed for Heating	850,000
Convert to MWh/d	249,110
Convert to MWh/h	10,380
Scaling Factor	1.10
Peak Load (MW)	11,418