Impact of Geothermal on Grid Planning

Jens Ponikau CGD

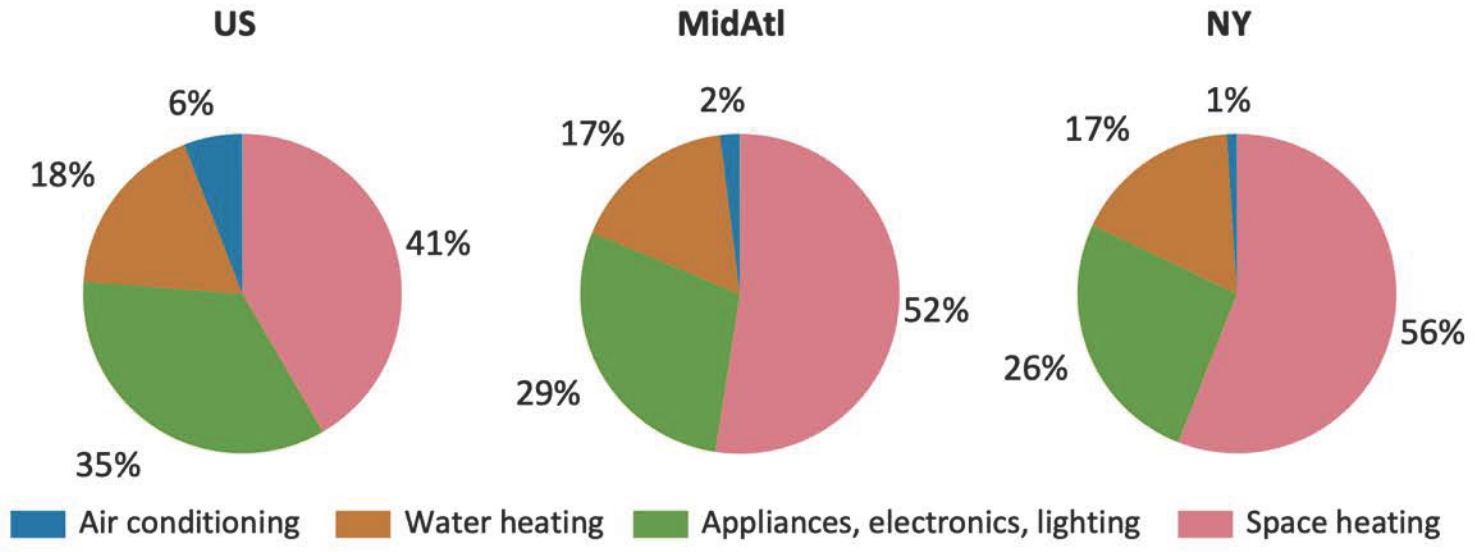
President, New York Geothermal Energy Organization

Buffalo Geothermal LLC

RGE and NESEG grid planning

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

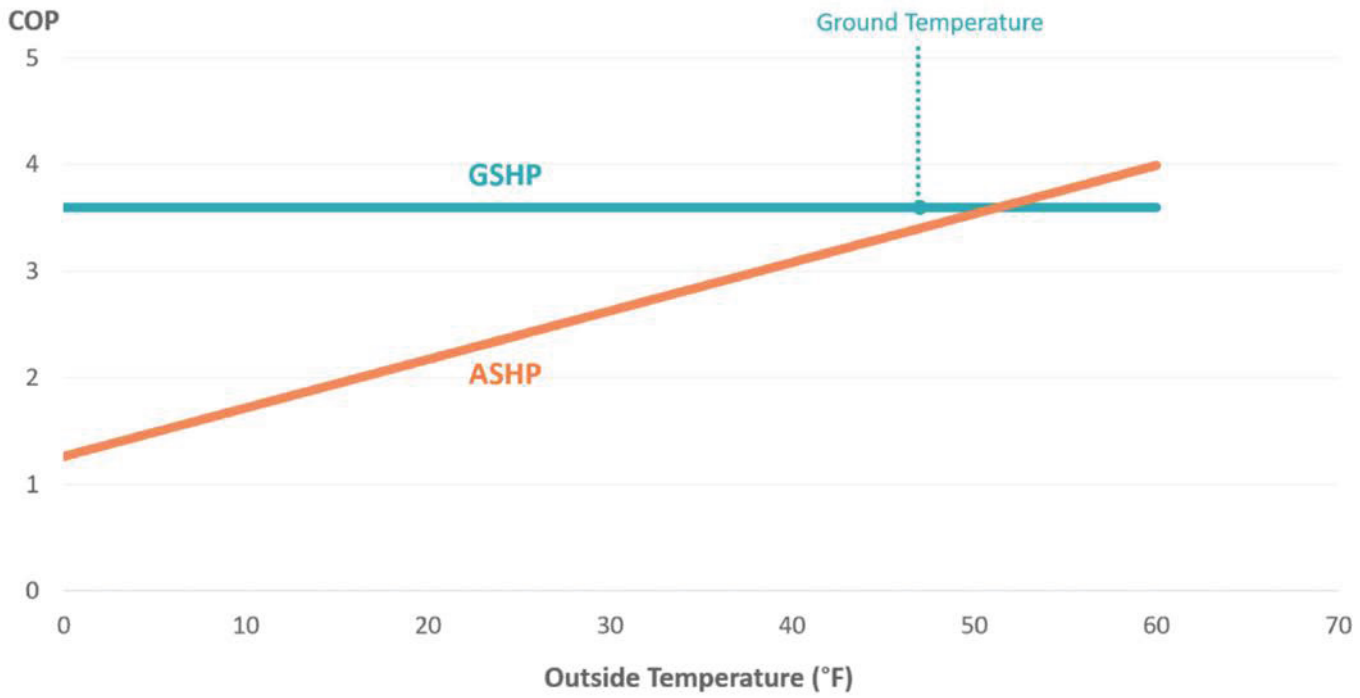
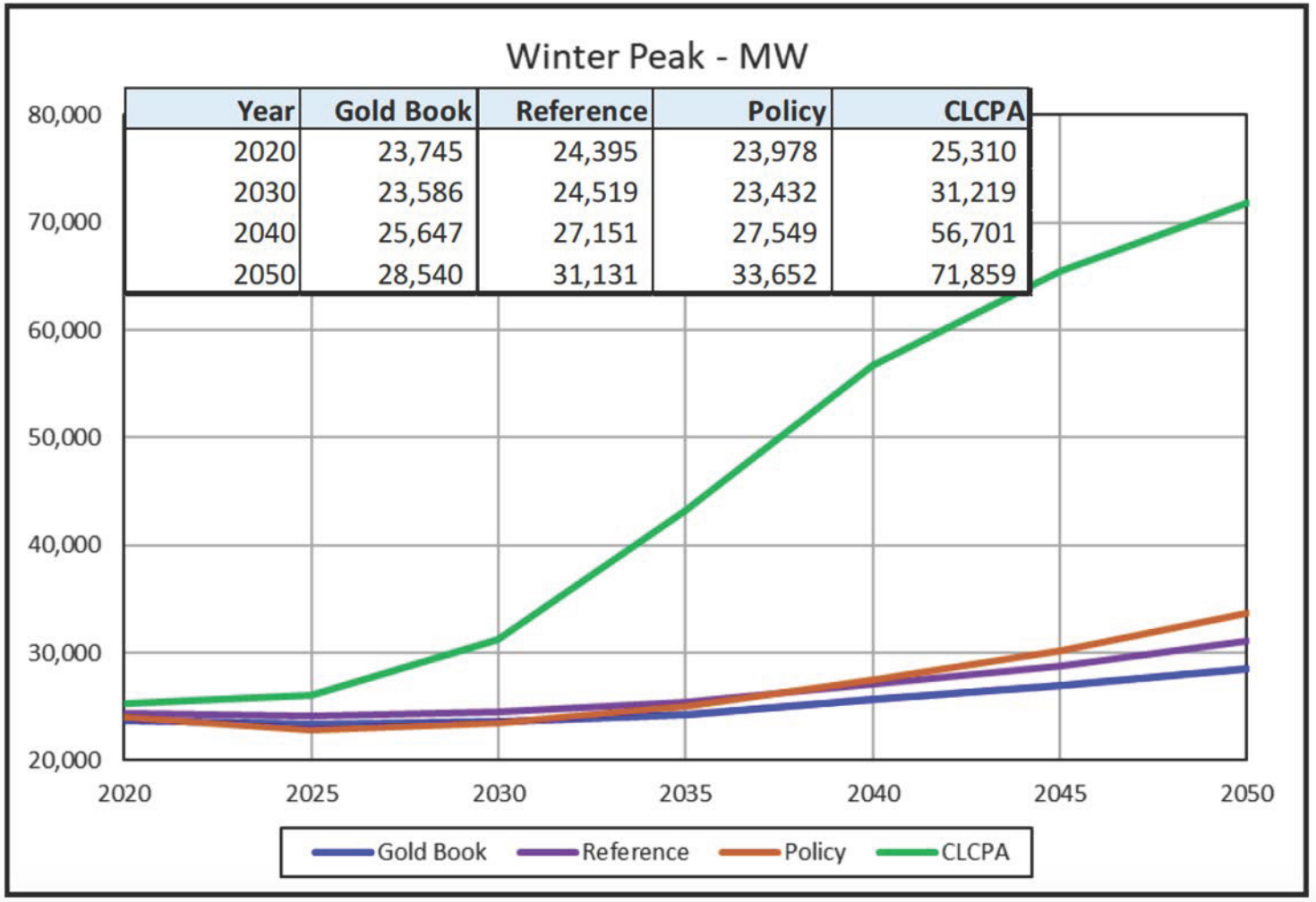


FIGURE 9: RELATIONSHIP BETWEEN OUTDOOR TEMPERATURE AND HEAT PUMP EFFICIENCY (COP)

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

Current Peak Electrical Demand on Peak Winter Day in NYS

NYSERDA Baseline Data				
Type of Building	Number of sites	Peak Load BTU/Hr	Total Peak Heating MMBTU/Hr	Peak Demand in GW
RES SF	2,890,000.00	40,606.00	117,351.34	34.39
Small MF	400,000.00	82,662.00	33,064.80	9.69
Medium MF	100,000.00	222,608.00	22,260.80	6.52
Large MF	43,000.00	1,516,926.00	65,227.82	19.12
Small Comm	130,000.00	82,662.00	10,746.06	3.15
Medium Comm	44,000.00	222,608.00	9,794.75	2.87
Large Comm	48,000.00	1,516,926.00	72,812.45	21.34
Total	3,655,000.00	3,684,998.00	331,258.02	97.09

MEISTER CONSULTANTS GROUP

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

Note: Based on an estimate of the portion of building primary energy use associated with thermal end uses (derived from RECS and CBECS), applied to an estimate of primary energy consumption for residential and commercial buildings available from NYSERDA's *Patterns and Trends* report (2014 data). Excludes hot water heating and process heating. Excludes new build after 2018.

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

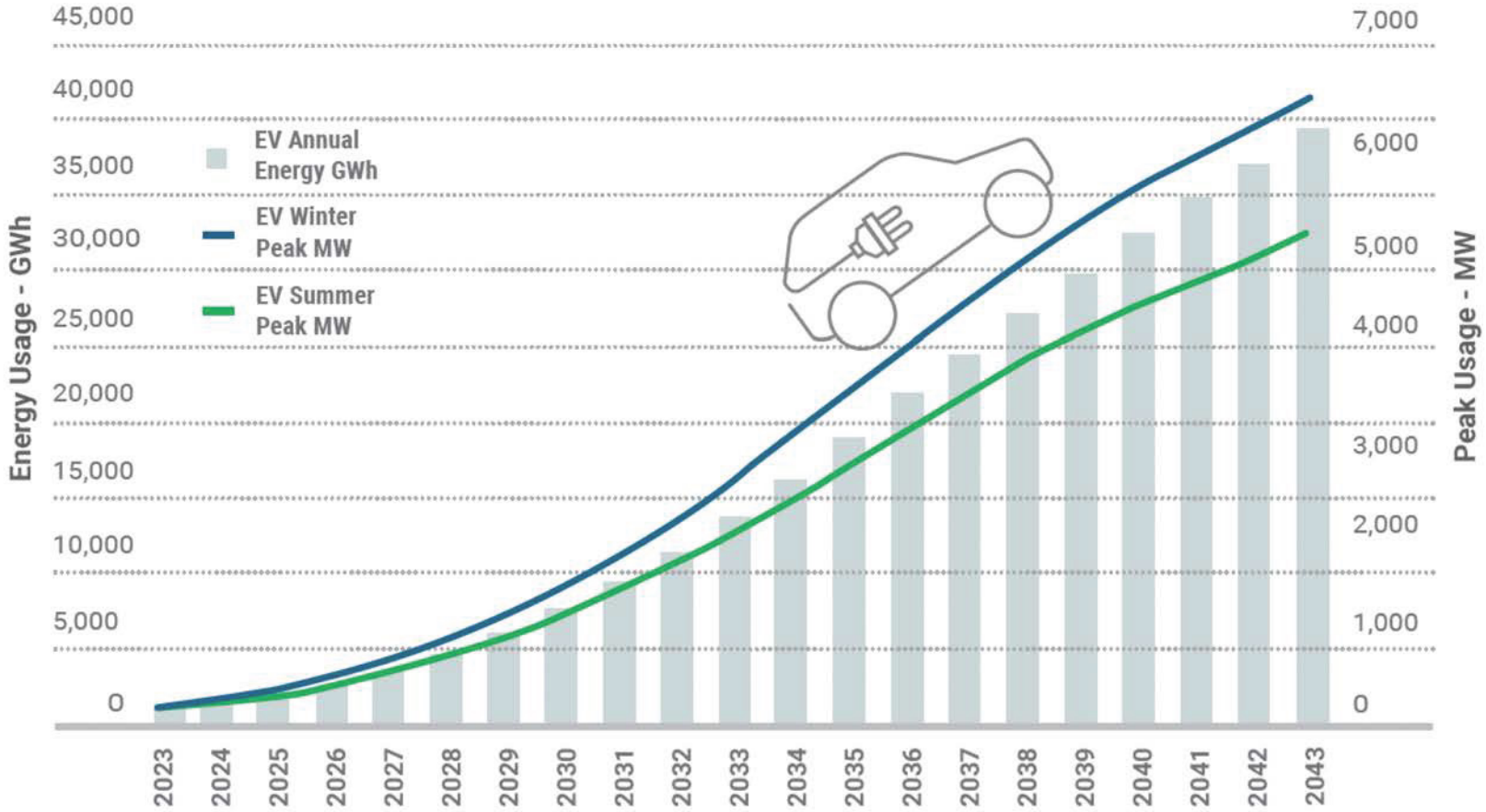
- Without the hot water load
- Without Process heat
- Without EV charging

NYISO issued the *2021 – 2040 System & Resource Outlook*

- *"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

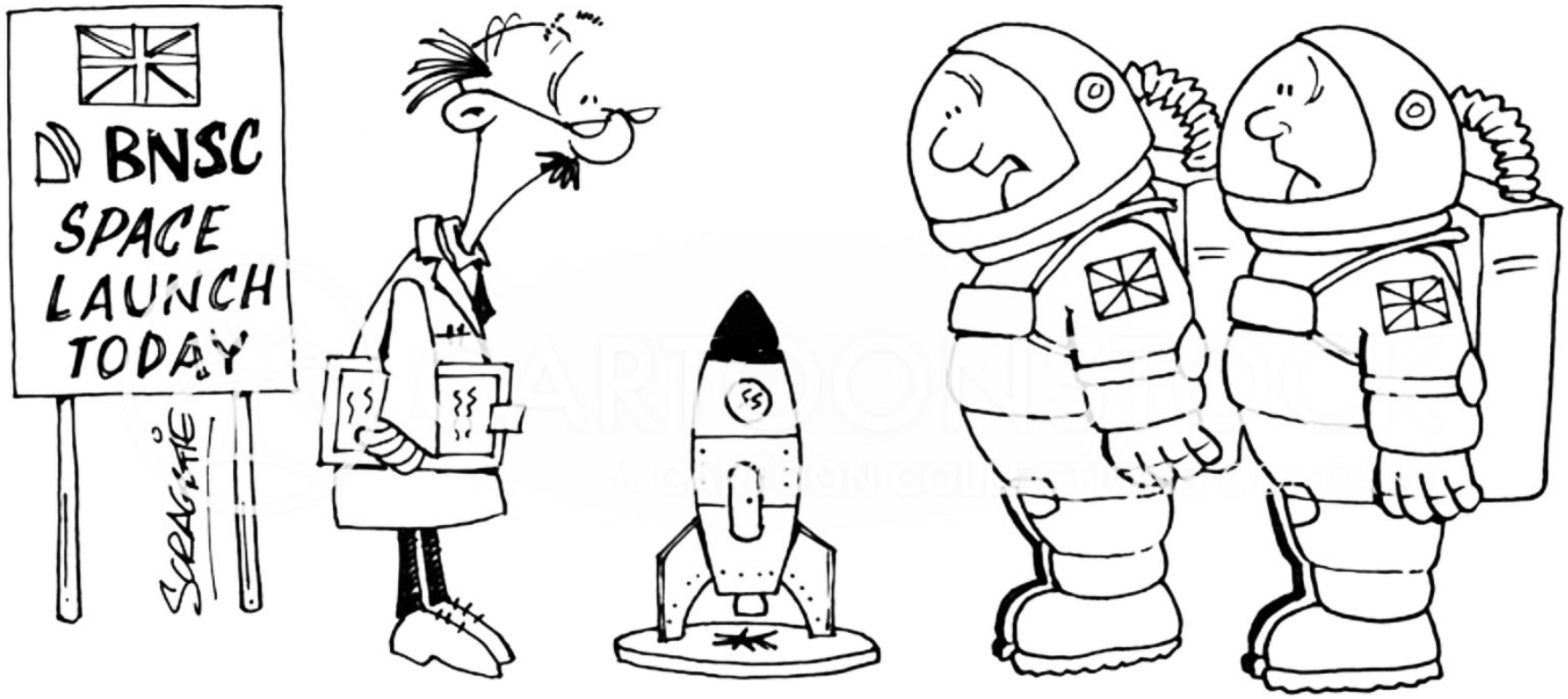
FIGURE 15: **ELECTRIC VEHICLE ENERGY & PEAK IMPACTS: 2023-2043**



Requirements for Future Heating System

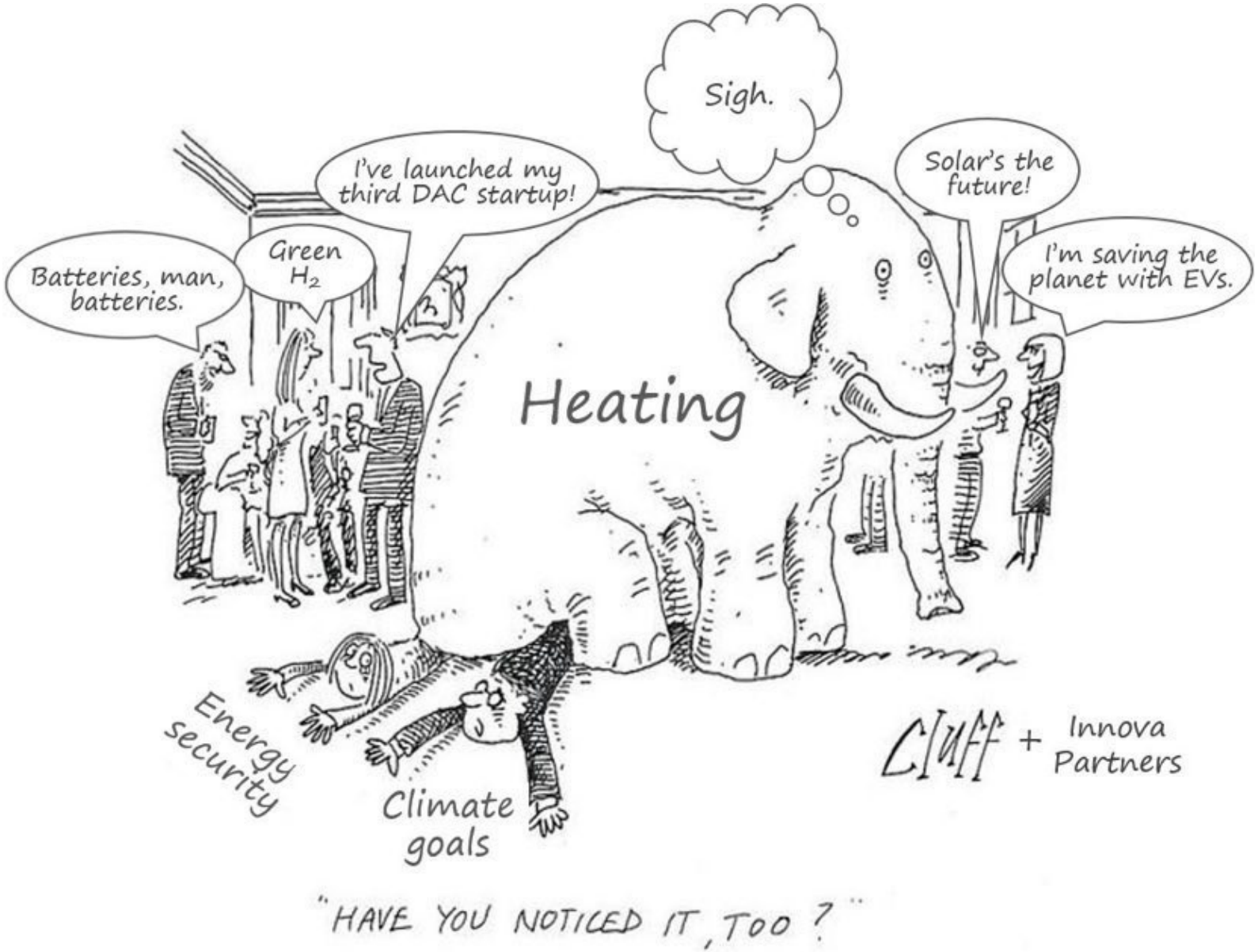
- 1) The heating system's efficiency and capacity must operate independent of the outside temperature
- 2) It must cover the full load without supplement resistance heat.
- 3) It must not only reduce the heating but also the significantly the cooling load.
- 4) It must make all the domestic hot water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

Flying to the moon….



"Do you have one in a larger size?"

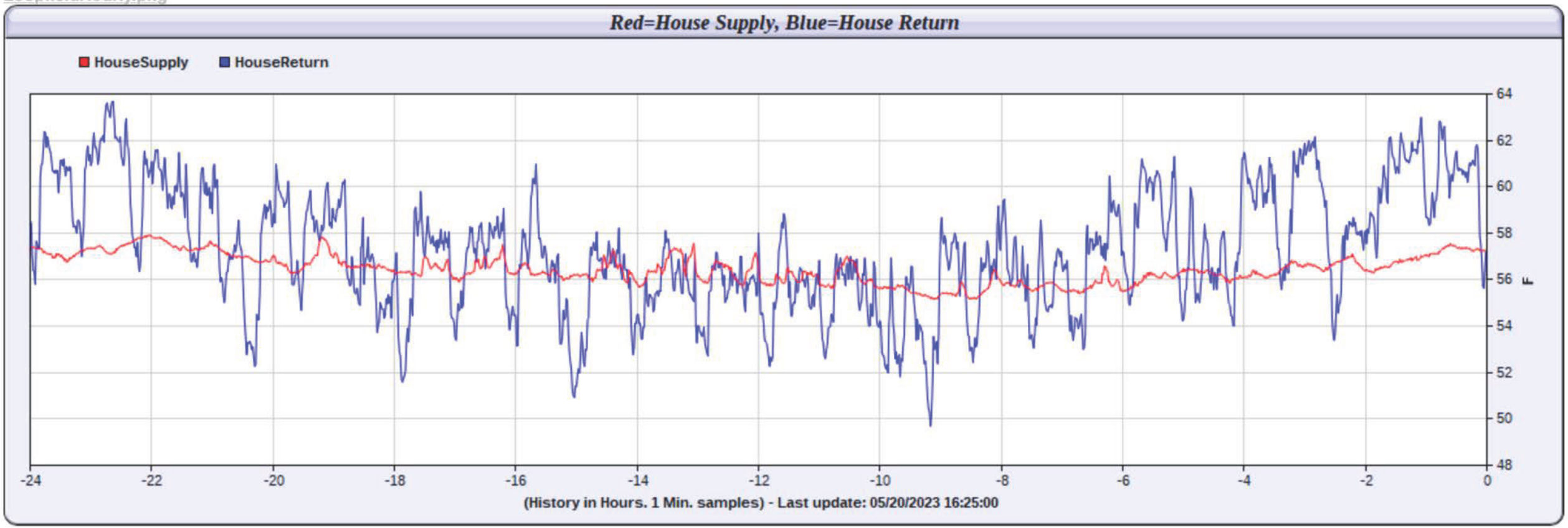
The giant elephant in the room…..



Cooling Tower and Heating Plant operating at the same time

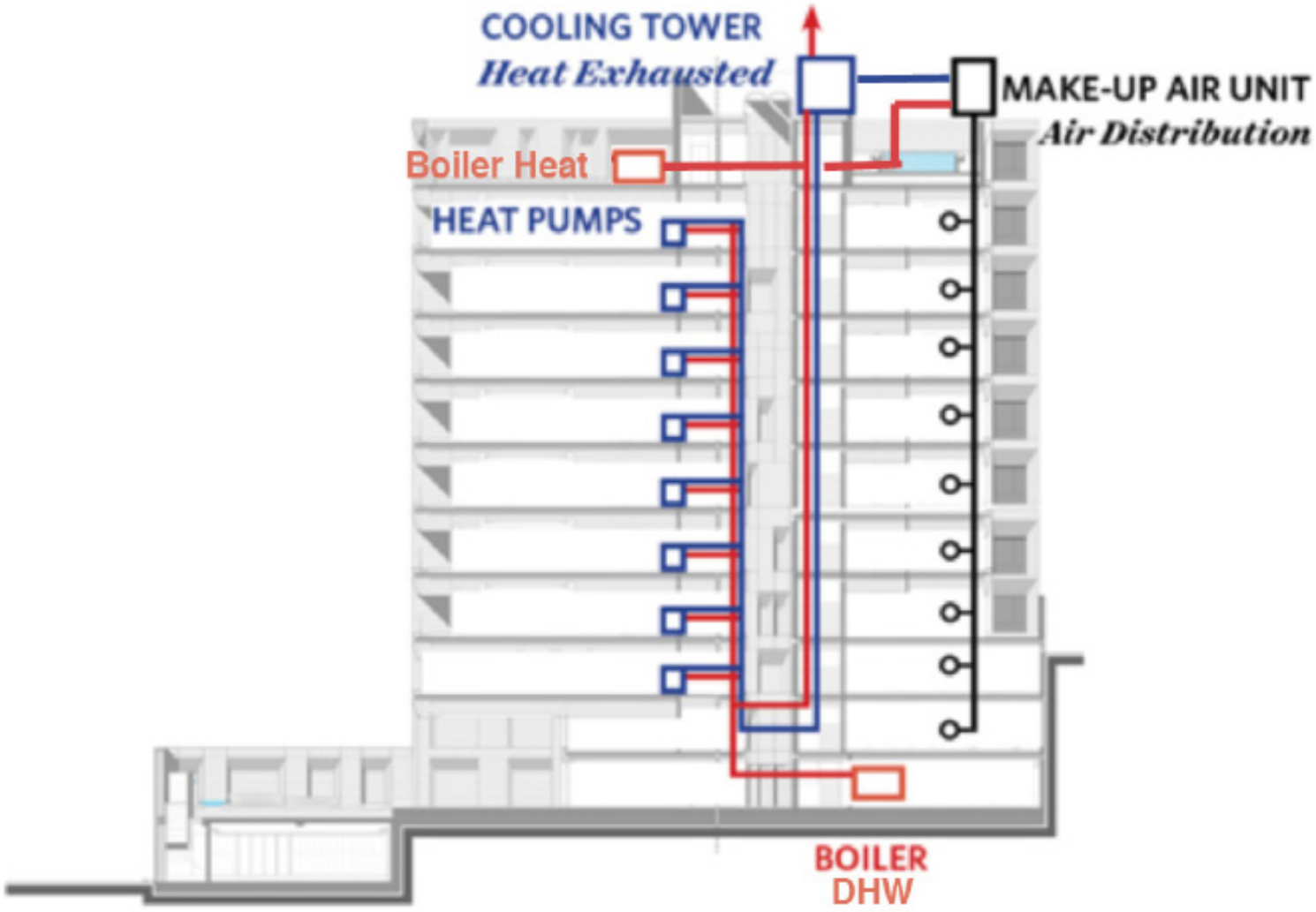
Ground Thermal battery reacting to input/output by changing Delta T

LoopfieldHourly.png

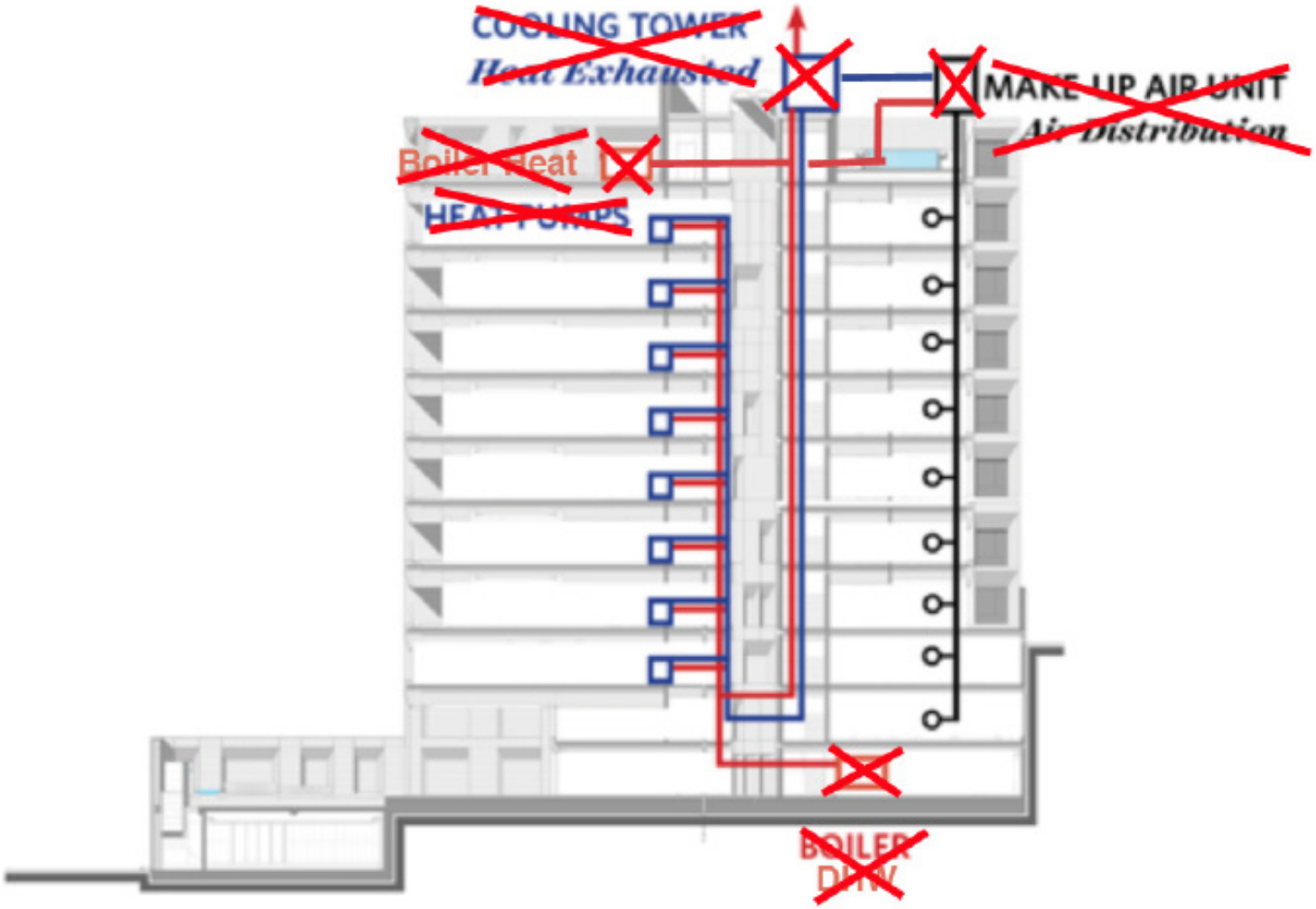


Conventional high rise design

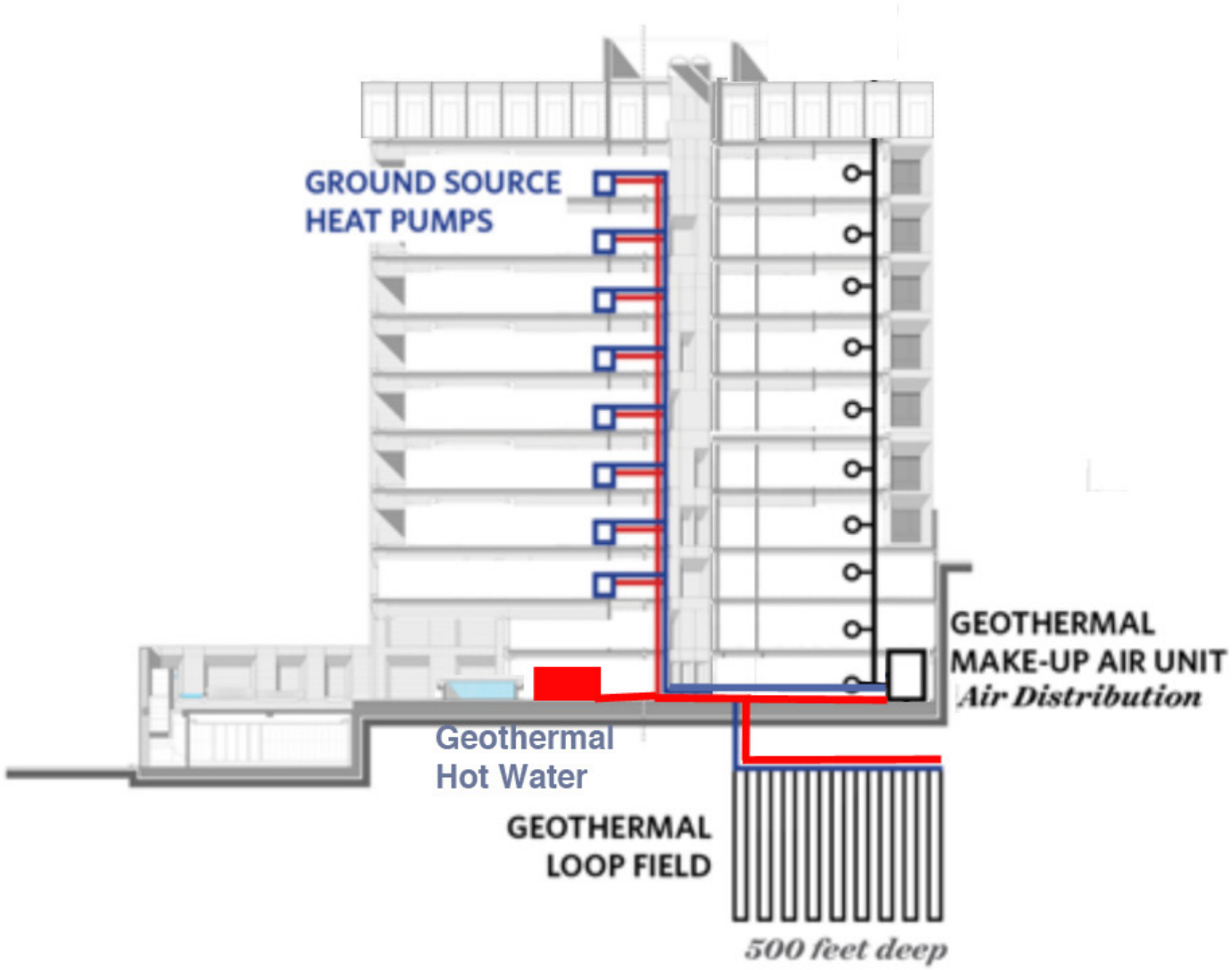
70 F – 110F building loop



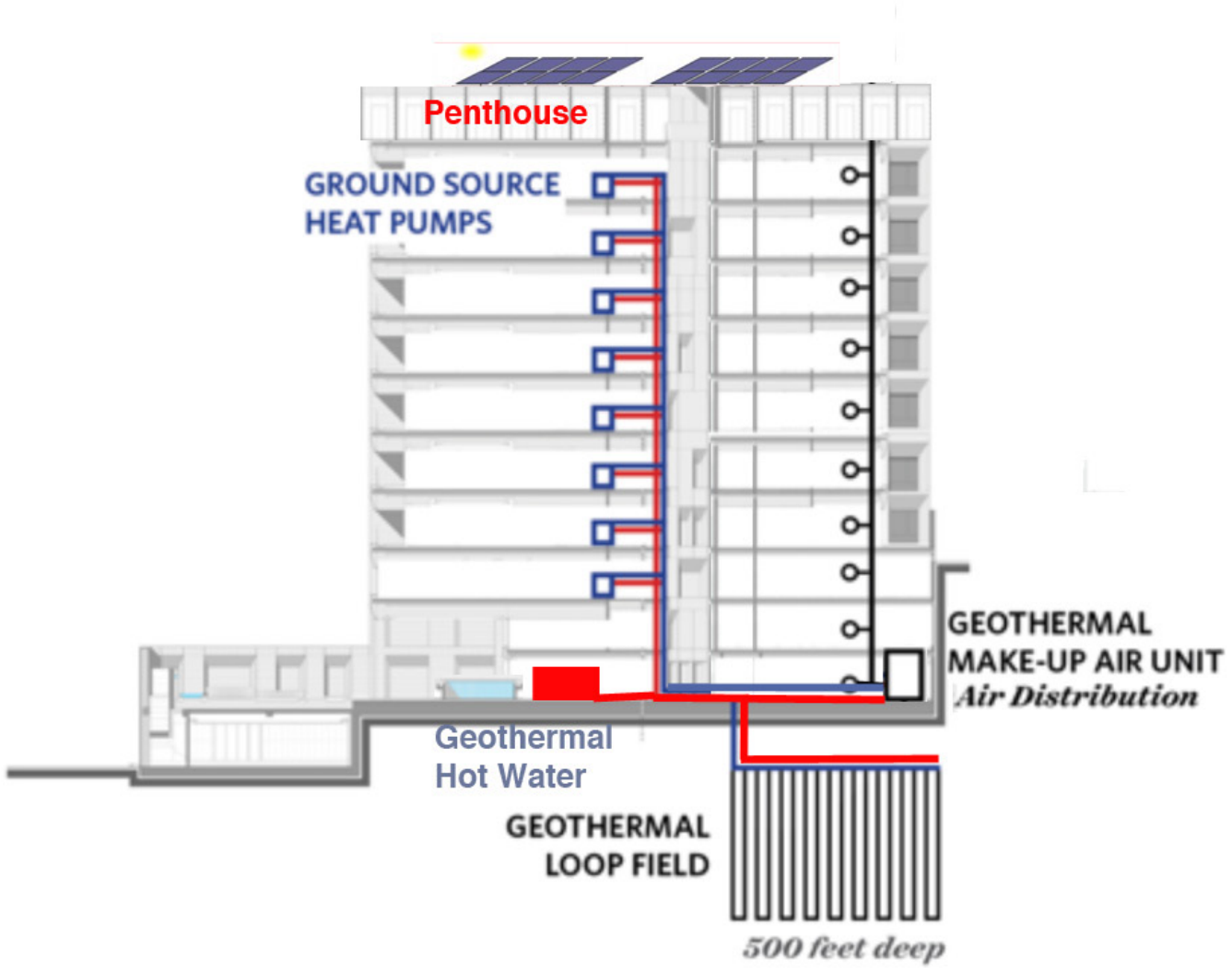
30F-90F extended range heat pumps



Addition of loop field



Space for additional Floor + Solar



What is needed?

- Apartment heat pumps extended range
- Geothermal make up air units
- Energy Recovery Ventilation (ERV)
- Hot water generation via geothermal • Provides load balancing
- Loop field (under building), optional next to building

ZerOPlace

Tesla electric grid battery

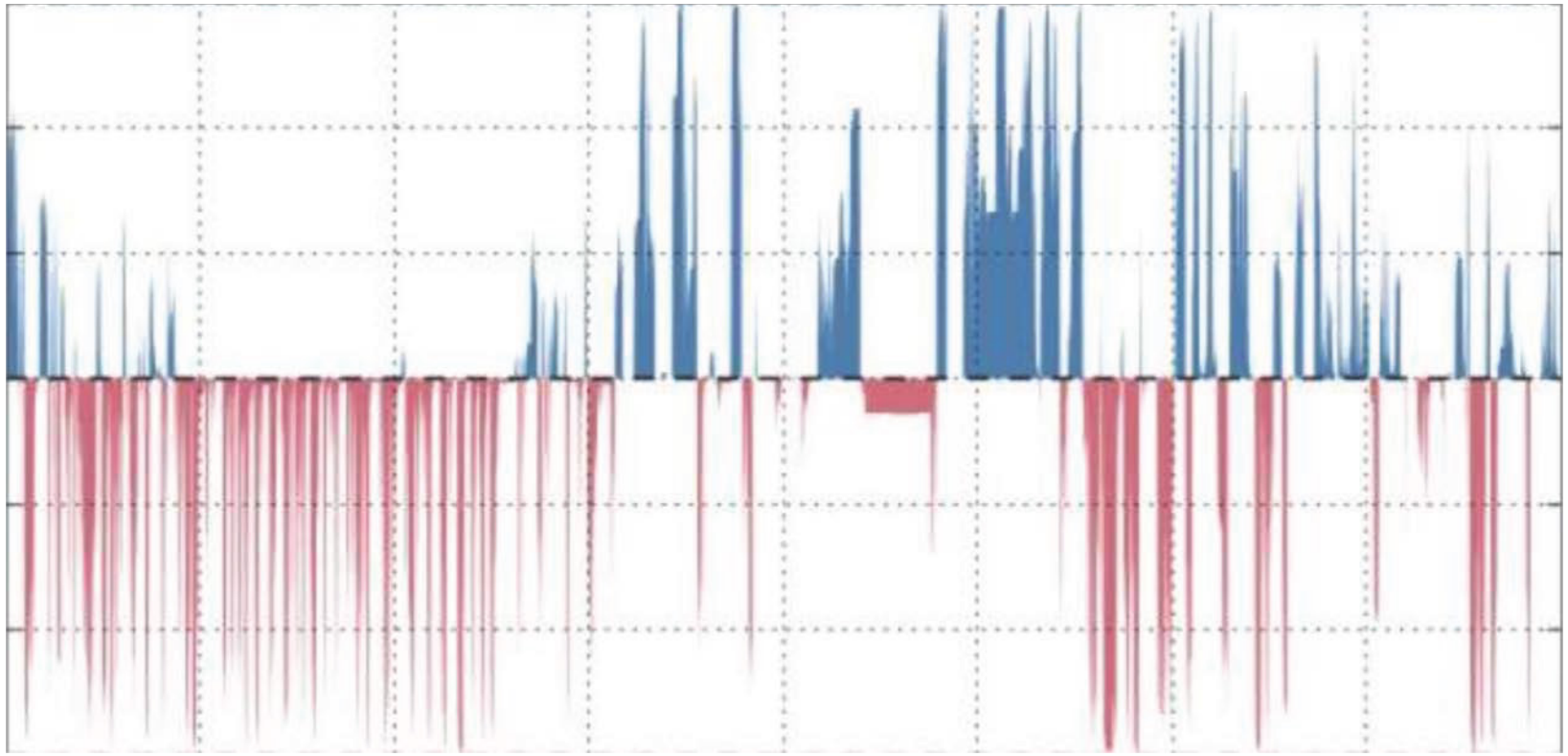
South Australia's Tesla big battery saves $40 million in grid stabilization costs

A new report analyzing the world's largest lithium-ion battery's performance in the first year of operation shows the Hornsdale Power Reserve has delivered on high expectations of its performance and market impact. It has helped stabilize the grid, avoid outages and reduce system costs, as well as triggered a surge in uptake of similar fast response systems across Australia.

DECEMBER 5, 2018 MARIJA MAISCH

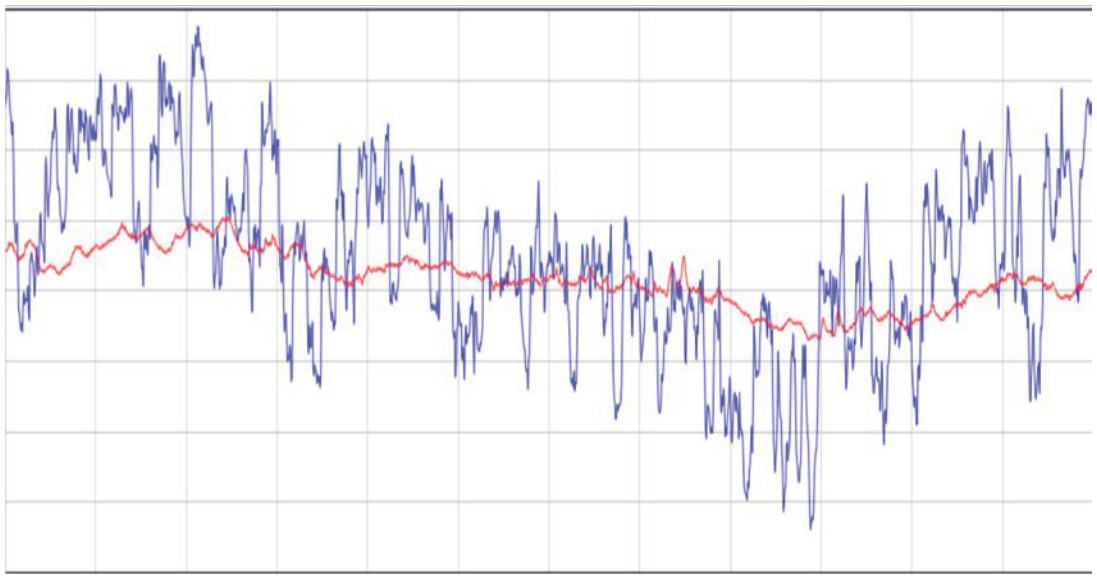
ENERGY STORAGE | HIGHLIGHTS | UTILITY SCALE STORAGE | AUSTRALIA

The Tesla big battery has responded rapidly to system outages.

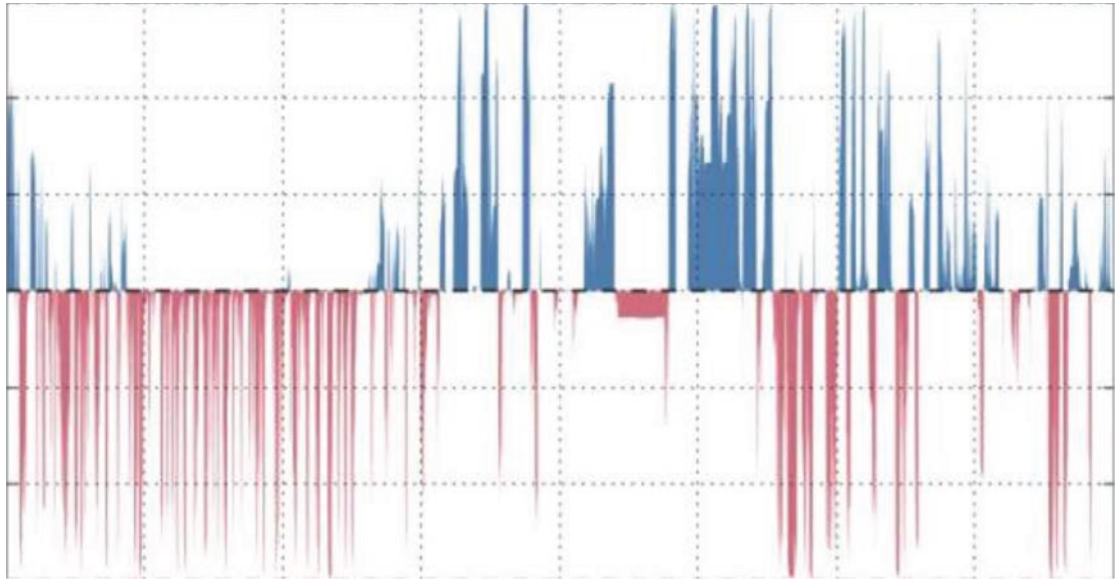


Thermal Battery versus Electric Battery

Thermal Ground Battery ZeroPlace
New Paltz NY

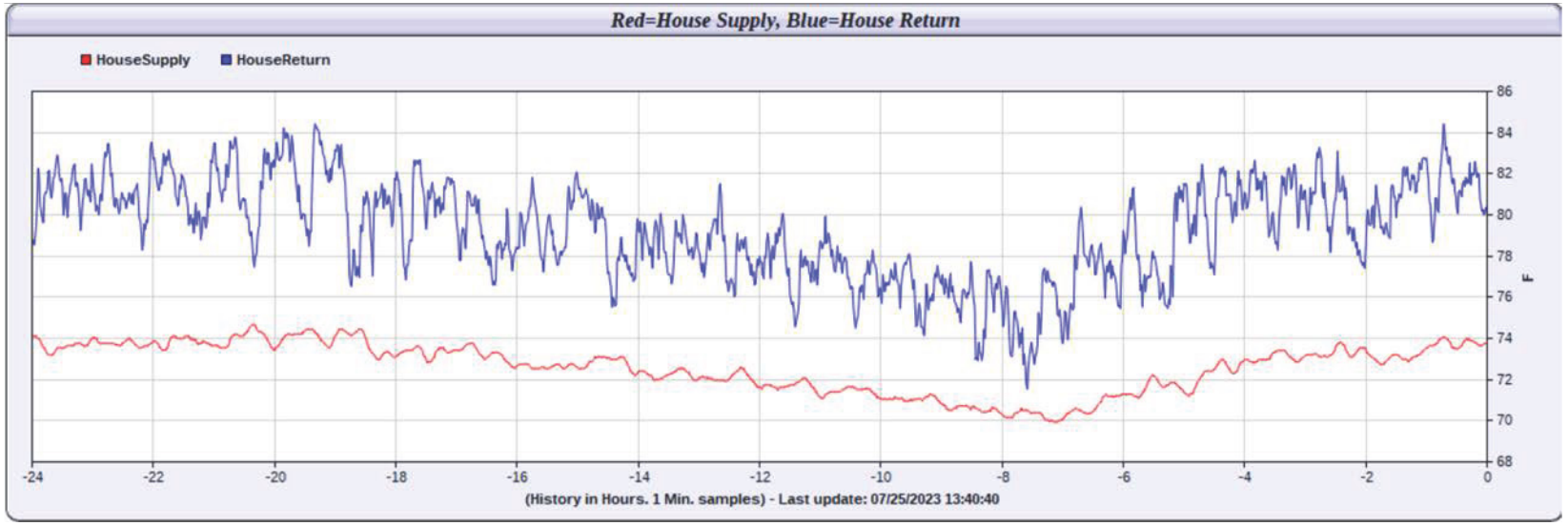


Hornsdale Power Reserve
Hornsdale, Australia



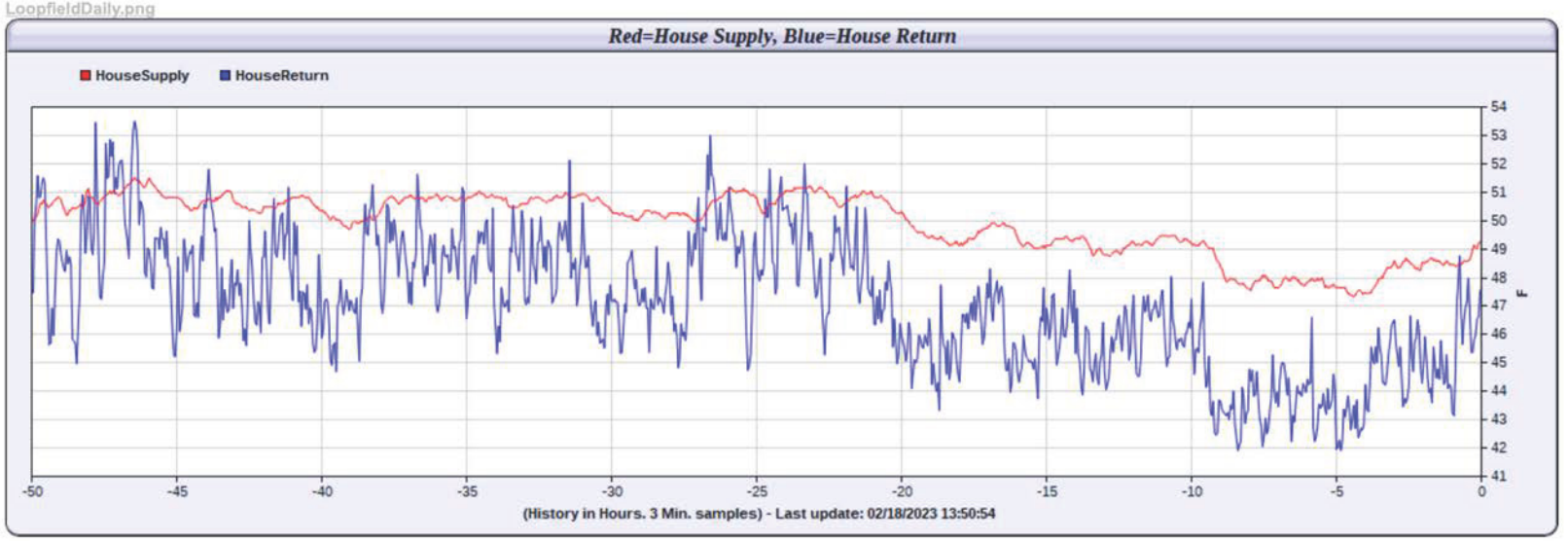
Summer versus Winter Ground loop

Heat Rejection versus Heat Extraction



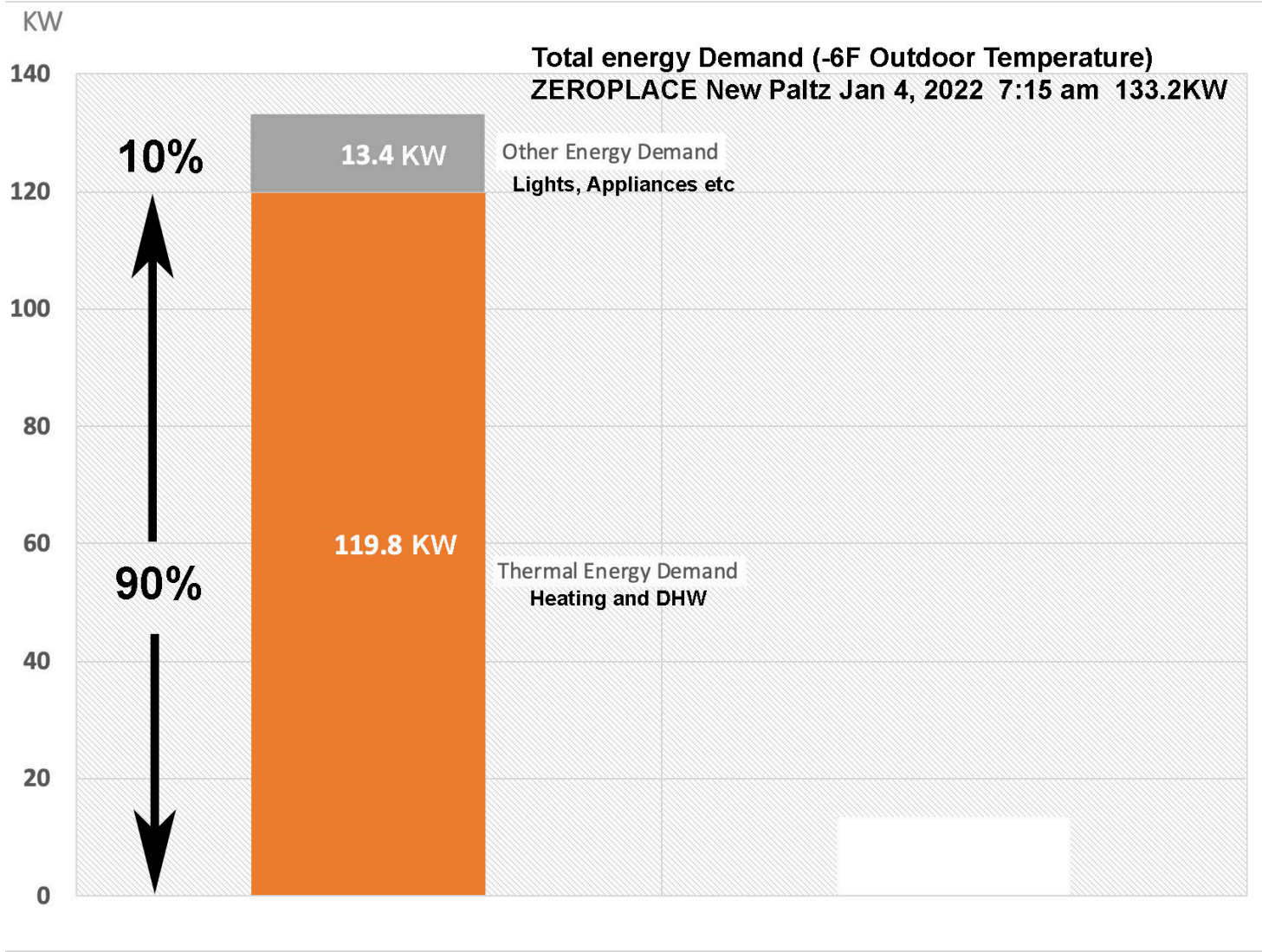
Summer

LoopfieldDaily.png

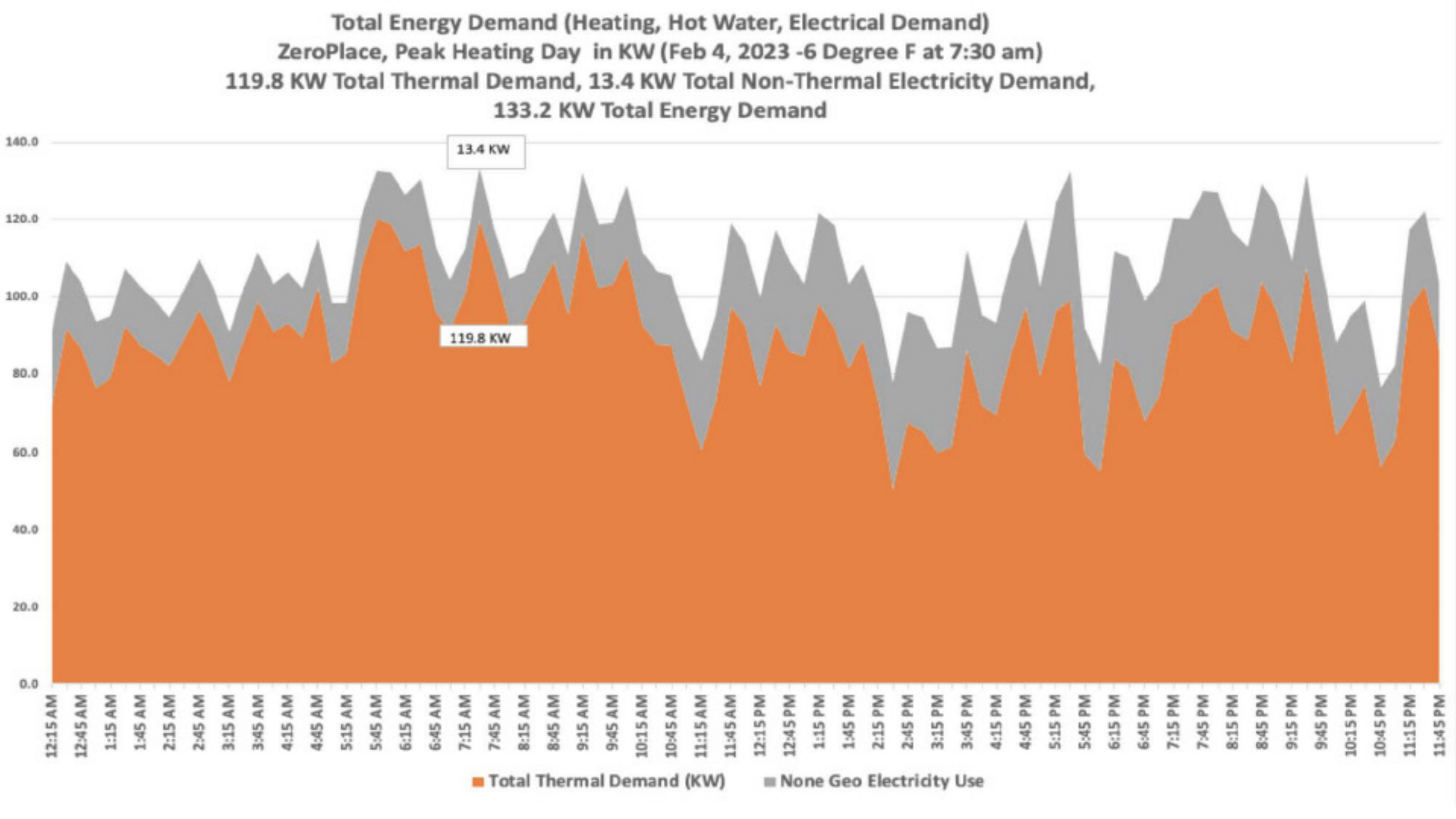


Winter

Peak Hour Energy Use



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


Total Energy Demand (Heating, Hot Water, Electrical Demand)
ZeroPlace, Peak Heating Day in KW (Feb 4, 2023 -6 Degree F at 7:30 am)
119.8 KW Total Thermal Demand, 13.4 KW Total Non-Thermal Electricity Demand,
133.2 KW Total Energy Demand
13.4 KW
119.8 KW
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
12:15 AM
12:45 AM
1:15 AM
1:45 AM
2:15 AM
2:45 AM
3:15 AM
3:45 AM
4:15 AM
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5:15 AM
5:45 AM
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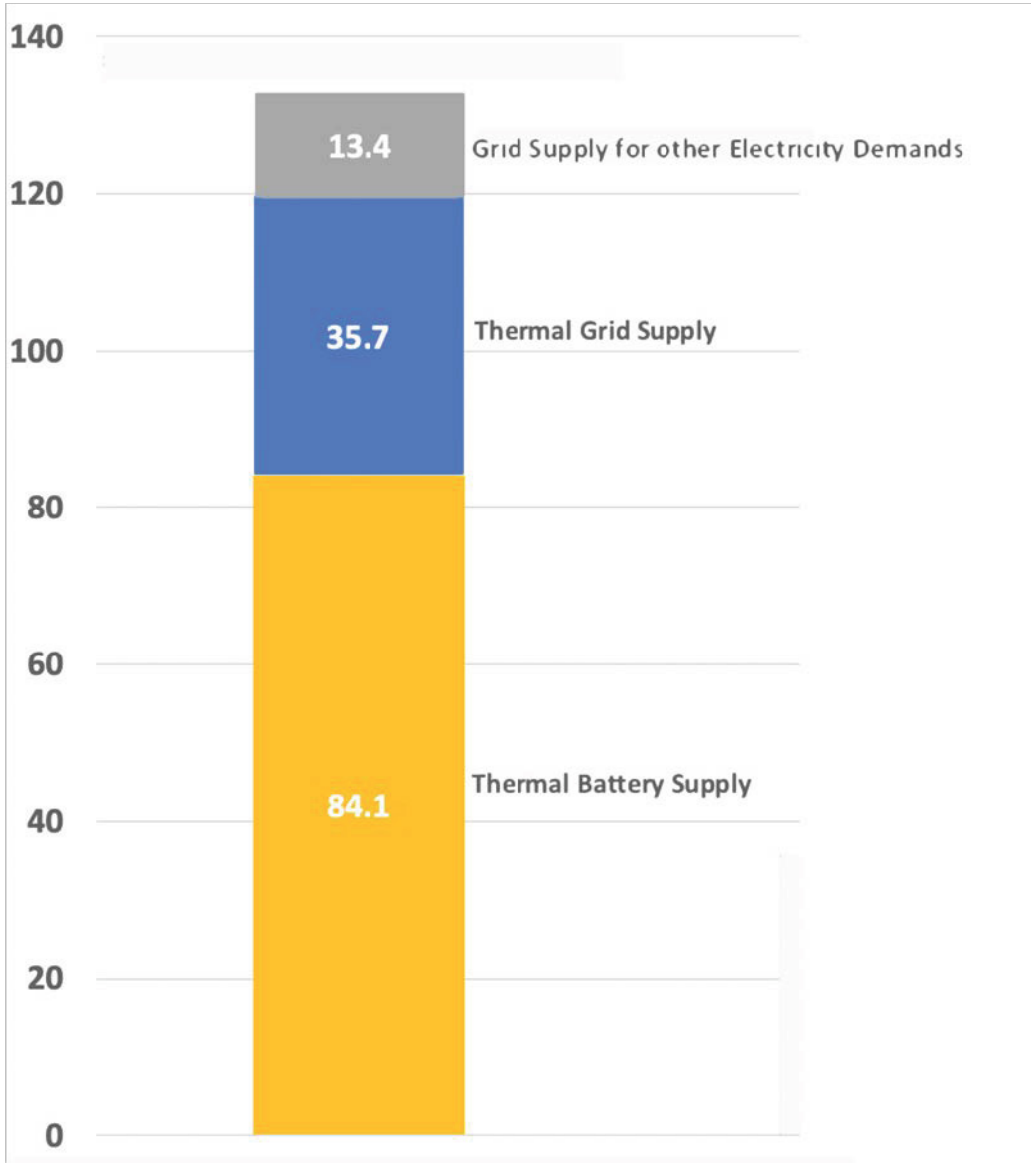
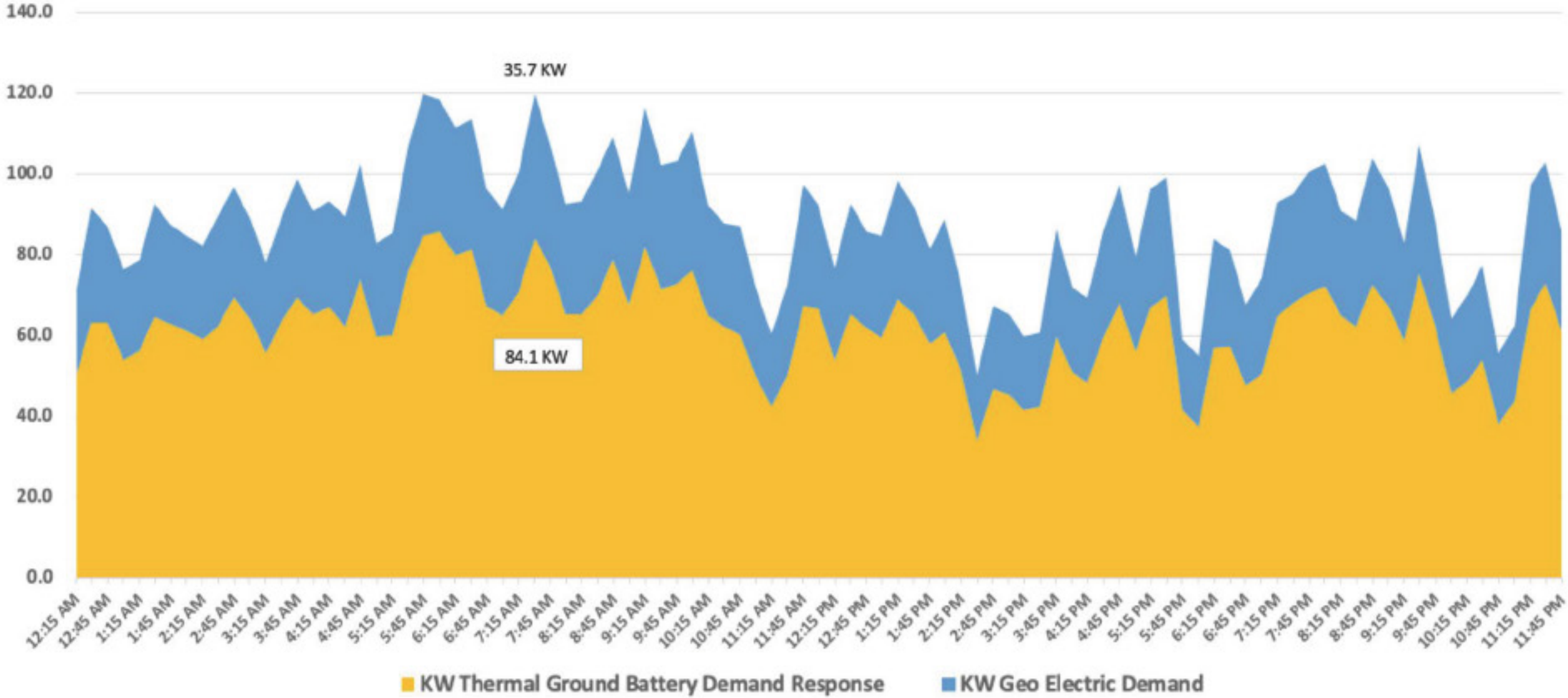
Total Thermal Demand (KW)
None Geo Electricity Use

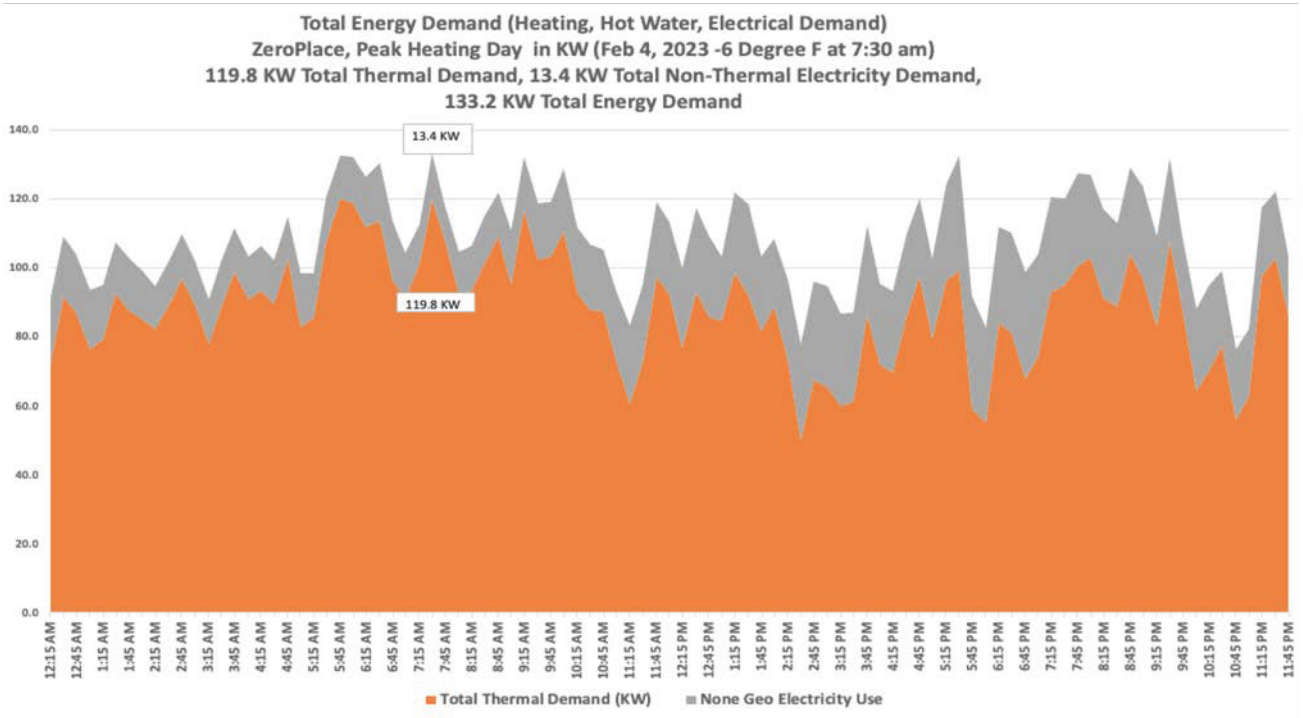
Peak Hour Energy Use in KW

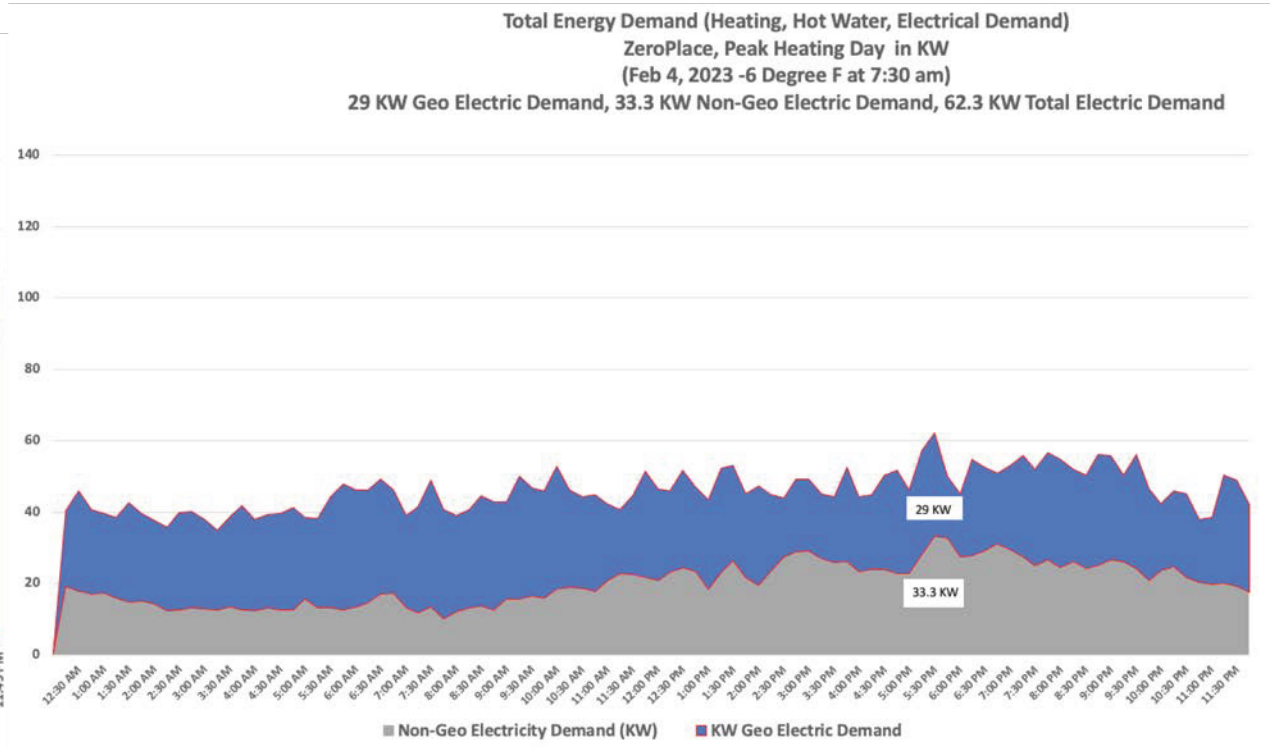


Total Thermal Energy Demand (Heating + DHW)
Peak Heating Day in KW
(Feb 4, 2023 -6 Degree F at 5:30 am)
84.1 KW Ground Battery, 35.7 KW Geo Electric Demand, 119.8 KW Total Heating Demand



Total Energy Demand versus Total Grid Demand





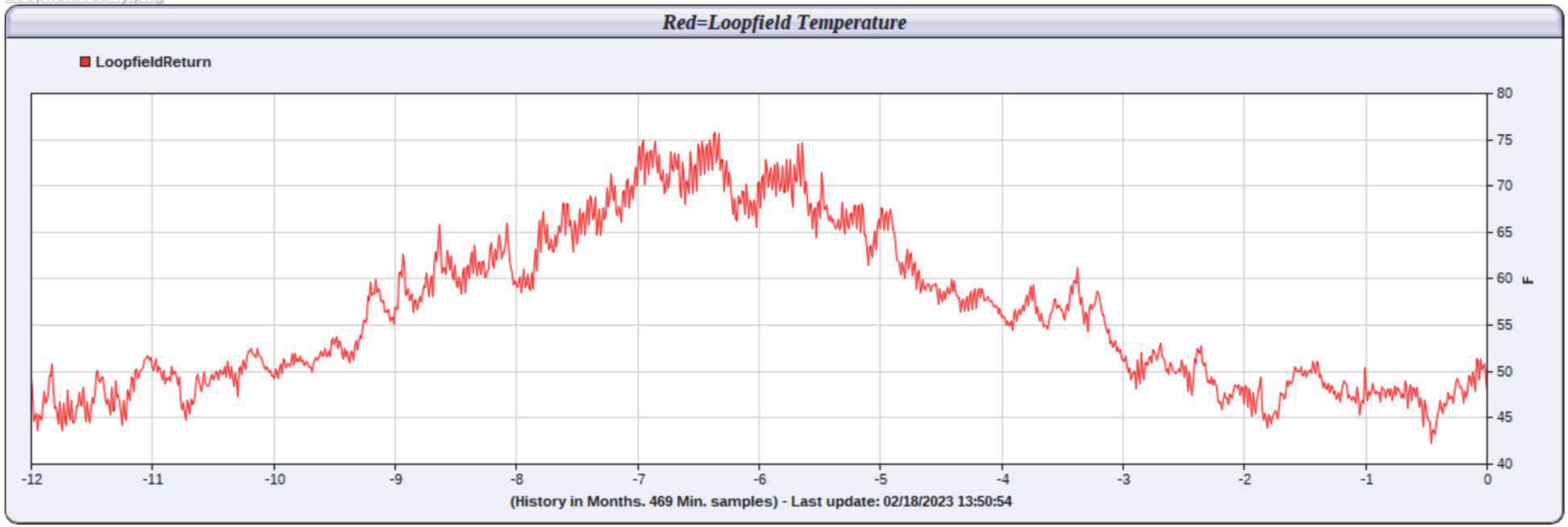
Thermal storage battery reduced thermal load on the grid by 70%

- Given that the total cost of the geo system (entire HVAC and DHW system) in 2017 was $890,000 (Geo Ground Battery was about $350,000)
  - It literally paid for itself in terms of grid capacity avoidance in one single day.

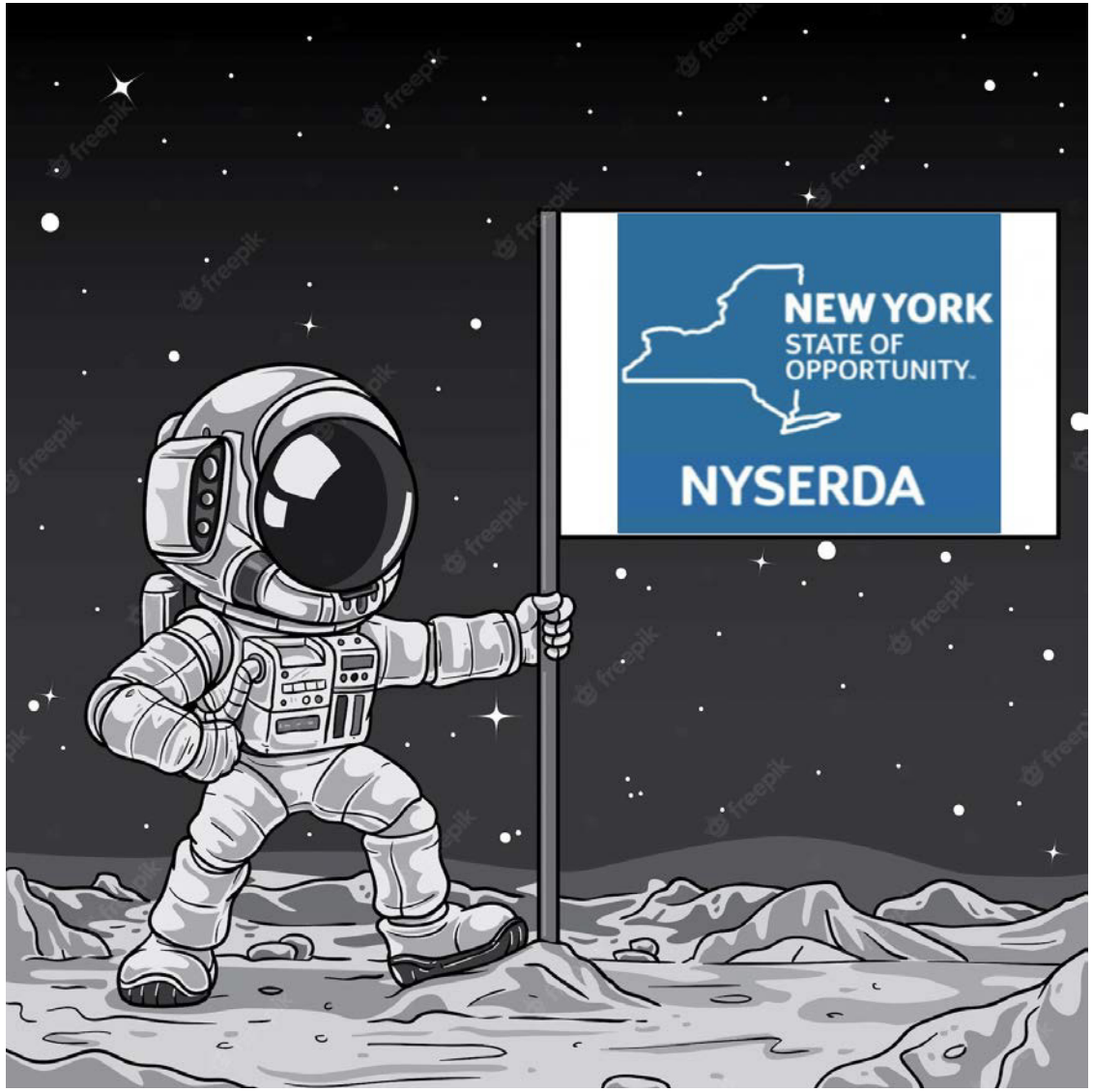
- 2024 scenario:
  - $1,190,000 total costs
  - 40% tax credit = $476,000

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

LoopfieldYearly.png

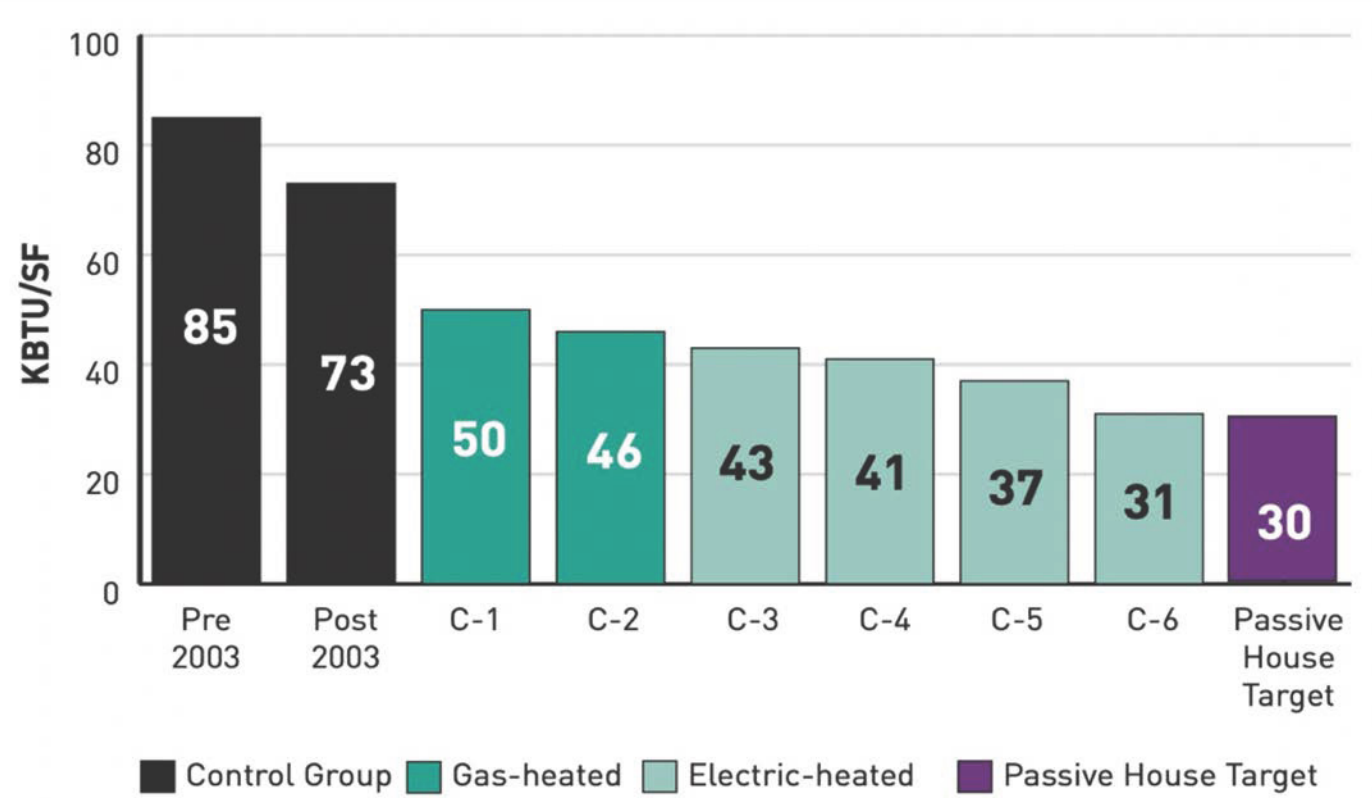


Took NYSERDA along to monitor and verify



Multifamily Passive House: Connecting Performance to Financing

- **Pre-2003:** 1,633 NYC properties
- **Poest-2003:** 315 NYC properties
- **A gas-heated group** that includes two very early projects with gas hydronic heating and window unit air conditioners with custom covers (C-1 and C-2). Neither project is certified.
- **An electric-heated group** that includes
  - two certified projects (C-5 and C-6),
  - a project pursuing certification (C-4)
    - “Passive House like" building that implemented Passive House design principles but did not certify (C-3).
- All projects across the two Passive House sub-groups use gas to heat domestic hot water.



Lockport Housing Authority

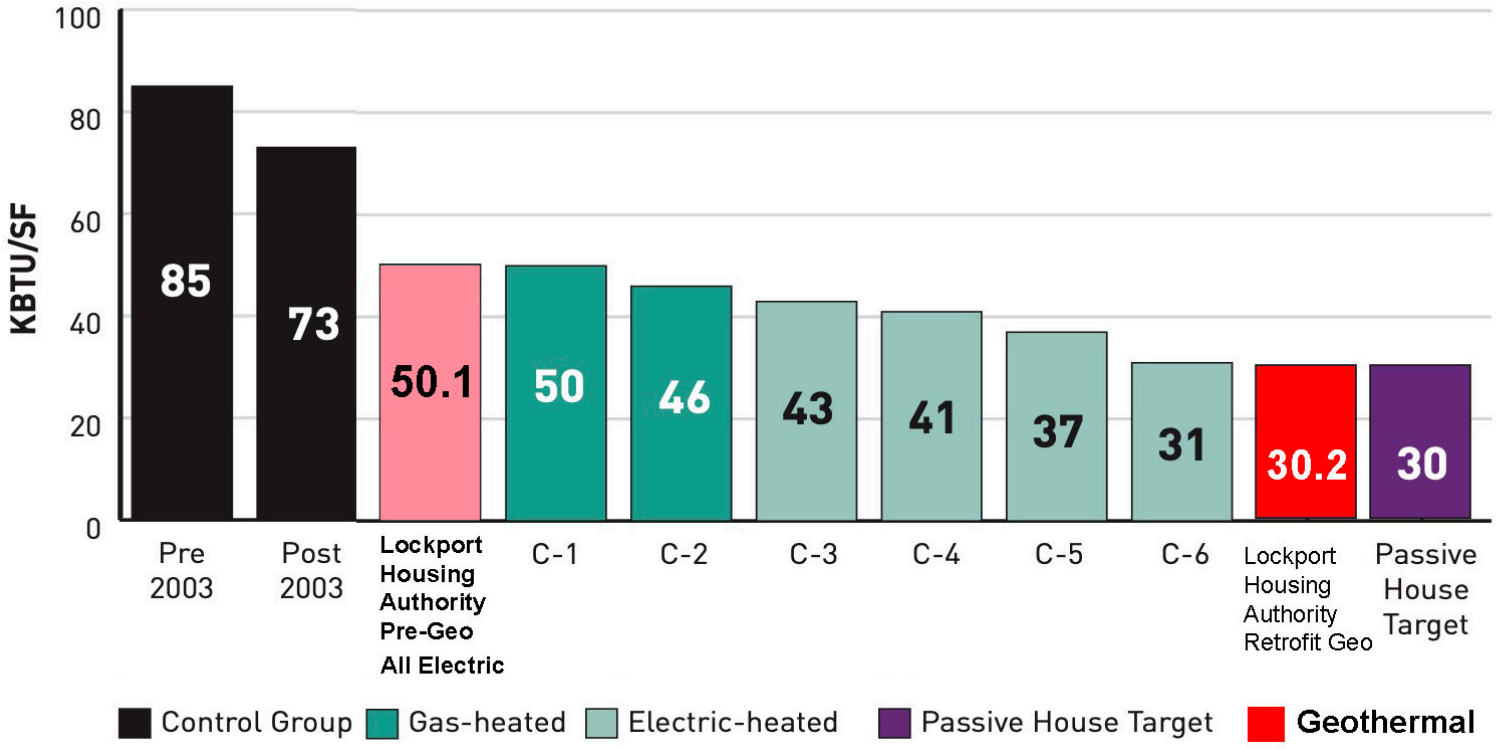
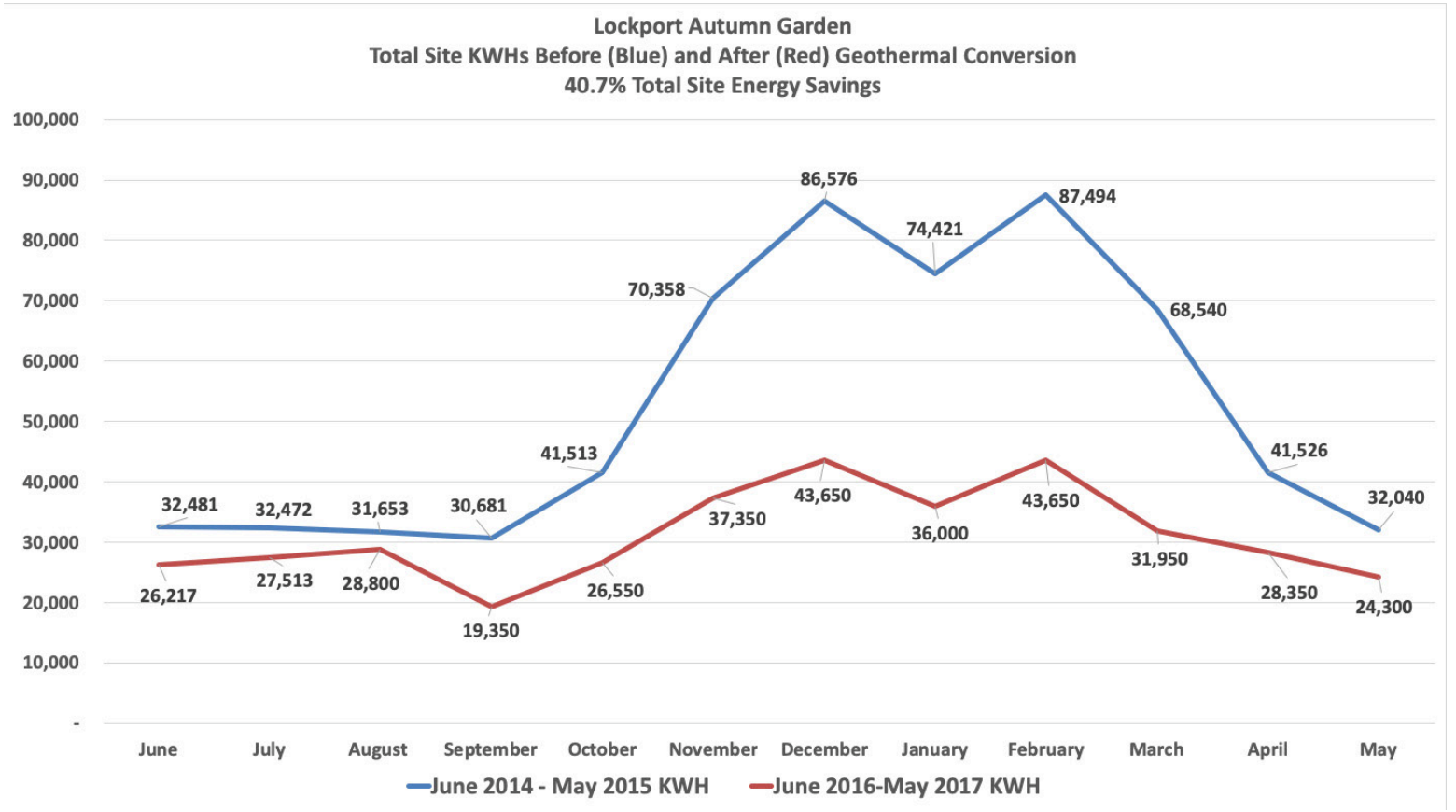


Figure B. Looking at Energy Use Intensity (EUI), the Passive House case study buildings consume 32-58% less energy than the buildings in the post-2003, conventionally-built control group.[5]

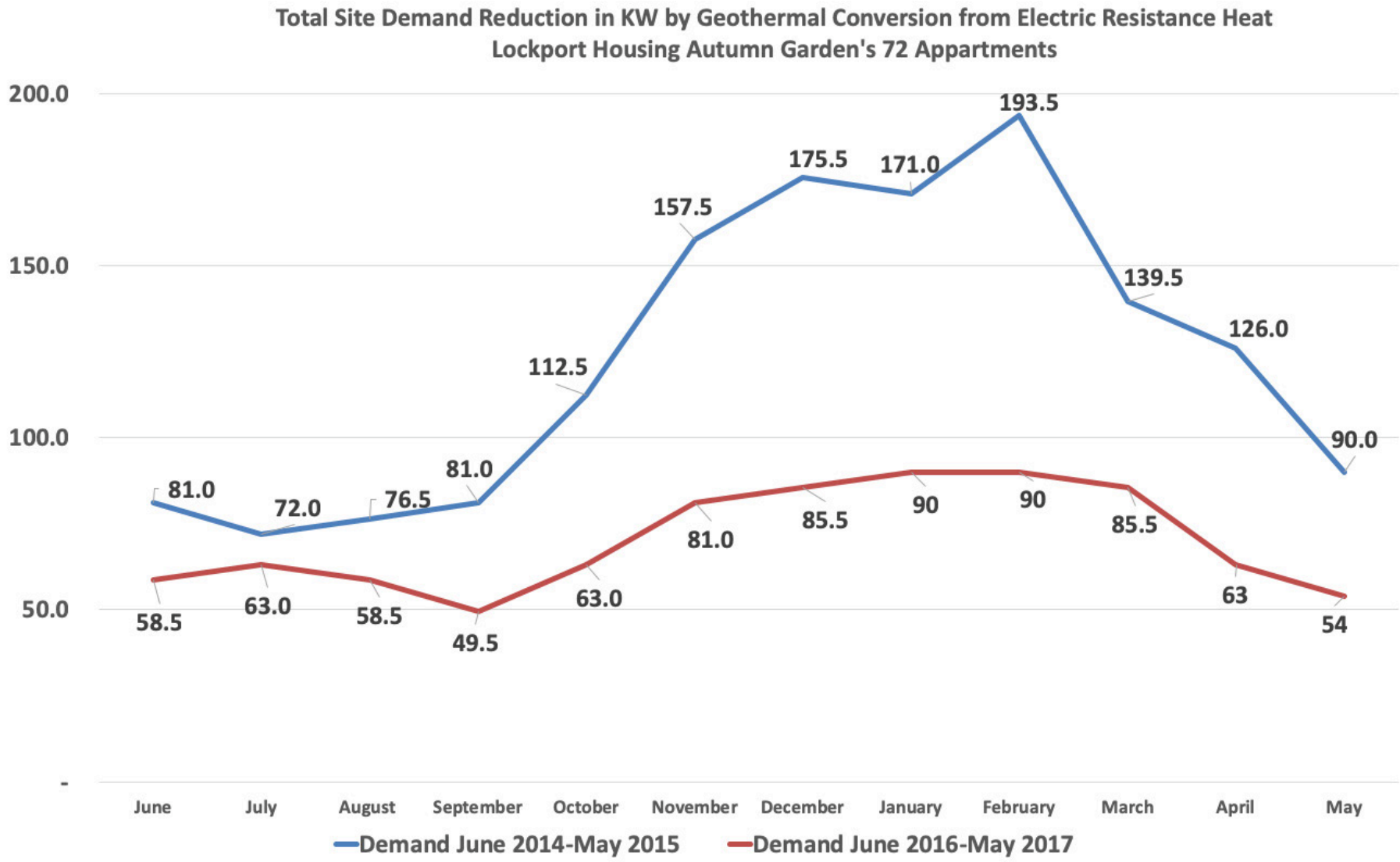
Lockport Housing Authority

Total Site KWh Usage



Lockport Housing Authority

Demand Reduction



Siano Building Buffalo NY

New Build 2017

Passive House Target

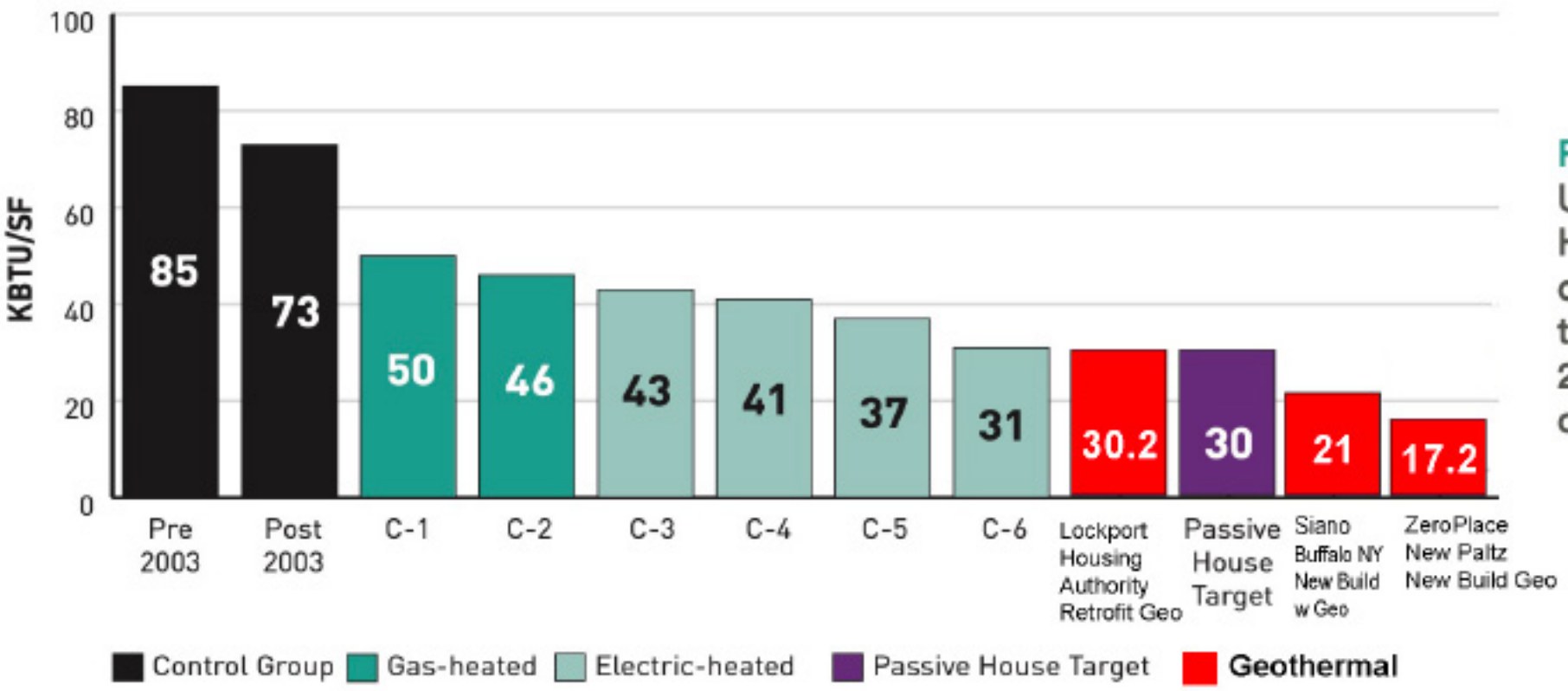


Figure B. Looking at Energy Use Intensity (EUI), the Passive House case study buildings consume 32-58% less energy than the buildings in the post-2003, conventionally-built control group.[5]

On an average single family home, the loop field stores

- 75% of the thermal energy for a home
  - 98 Million BTU annually 39
  - 28 MWH of thermal energy storage
- For a 6 month period (winter)
- Recharged by solar in the summer

- The upfront cost of geothermal systems is more expensive to install than ASHP, but the value of the energy storage to the grid more than compensates from a system perspective.

The ultimate thermal energy battery

- 1) The geothermal loop field stores all the thermal energy of the building 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 stores all the energy it needs (DER). 40
- 3) It stabilizes below 30F, since
  - It is making ice around the boreholes, which releases a large amount of heat due to the phase change.
  - It is a phase change storage technology.
- 4) It reacts instantaneously to energy input and output.

Grid of the future

- No solar capacity at 7 am in the winter morning
  - Need storage 41
- Wind generator (supply) capacity at $1.2B/GW
  - 74 instances in 2020 when NYCA wind fleet output remained below 100 MW for more than 8 consecutive hours (NYISO Power Trends 2021)
- Delivery capacity at $2.4B/GW (2 times the supply rate)
- 80% ASHP/20% GSHP vs 20% ASHP/80% GSHP = 20 GW = $52 Billion
- Reducing 30% of the 2030 load reduction mandate means 30 GW of load shift to electrification
  - 8 GW difference between current summer and winter peak

For now geo (thermal energy storage)

- Results in minimal impact on the capacity of the electric grid
- increases the load factor significantly 42
- reduce the cost of electricity to all ratepayer

- Geo should **not** be evaluated by MMBTU savings or Carbon savings alone
- **Significant value as energy storage avoiding grid capacity (cost)!**
- **Transition to electrified heating in NYS requires a technology which gets 70% of thermal peak demand from a DER (loop field)**

Costs (baseline “Chevy” version)

- Residential system:
  - $40,000 Dual stage single heat pump, usually up to 4,000 sqf house, horizontal loop field, advanced controls
  - Provides (100% heating and Air conditioning), 100% more efficient in cooling
    - 6,000 sqf if new built and well insulated)

- $8,000 Clean Heat rebate
- $9,600 Federal Tax Credit
- $5,000 NYS Tax Credit (in legislature to be increased to $10,000)
- Cost to Homeowner $17,400
- Cost avoidance A/C system $10,000
- Out of pocket costs $7,400

Cash Flow positive from day 1 in new builds (cost avoidance)

Retrofit 3-8 years payback depending fuel source Twice the

life expectancy

Costs (upgraded “Mercedes” version)

- Residential system:
  - $65,000 Variable speed single heat pump, usually up to 4,000 sqf house, horizontal loop field 44
  - Provides (100% heating and Air conditioning, plus 100% of dedicated DHW), advanced controls
    - 6,000 sqf if new built and well insulated)
    - 30% higher efficiency for Heating cooling compared to dual stage)
    - 300% higher efficiency compared to electric hot water

- $9,000 Clean Heat rebate
- $16,800 Federal Tax Credit
- $5,000 NYS Tax Credit ((in legislature to be increased to $10,000)
- Cost avoidance incl. DHW ($15,000)
- Cost to Homeowner $19,800

Cash Flow positive from day 1

Retrofit 4-9 years depending fuel source

Twice the life expectancy

95% of customers choose “Mercedes”

Costs (upgraded “Mercedes” version)

- $20,000 financing
  - 30 year mortgage 45
  - 2% against principal
  - 6% interest (4% after taxes)
  - 6% total cost annually = $1,200
  - $100 higher monthly payment, but….
  - No gas bills
  - Electric: Higher winter bills, lower summer bills, lower hot water bills, different rate structure. Average customer saves $60/month on utility bills (new built)

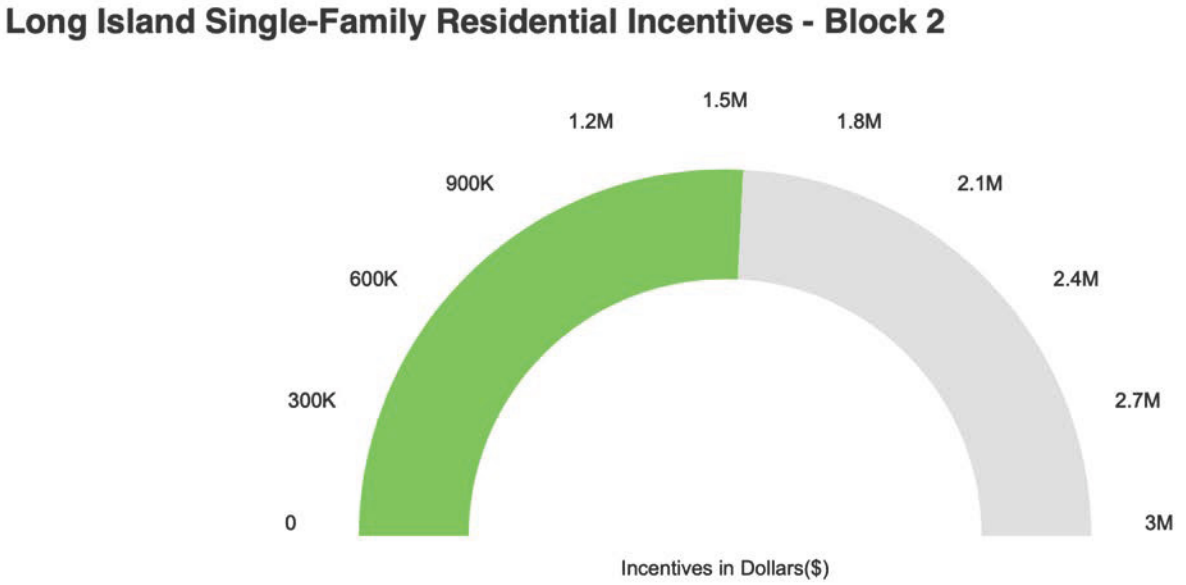
On an average single family home (4 ton) the loop field, during peak time the borehole delivers around

- 30,000 BTUs/hour of the thermal energy
  - 540,000 BTUs/day
  - 158 KWh/day
- Electric storage is currently $800/kwh installed
  - Tesla Battery currently $7,500/14 kwh plus installation
  - Grid storage is currently $576/KWh
- Value of 24 hour storage capacity $91,000 (158 KWh x $576/KWh)
- Current incentive level for battery storage around $250/kwh
  - Would avoid same amount of electric storage capacity
- For a 6 month period (winter)
- Recharged by solar in the summer

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!

Current Battery Storage Incentives

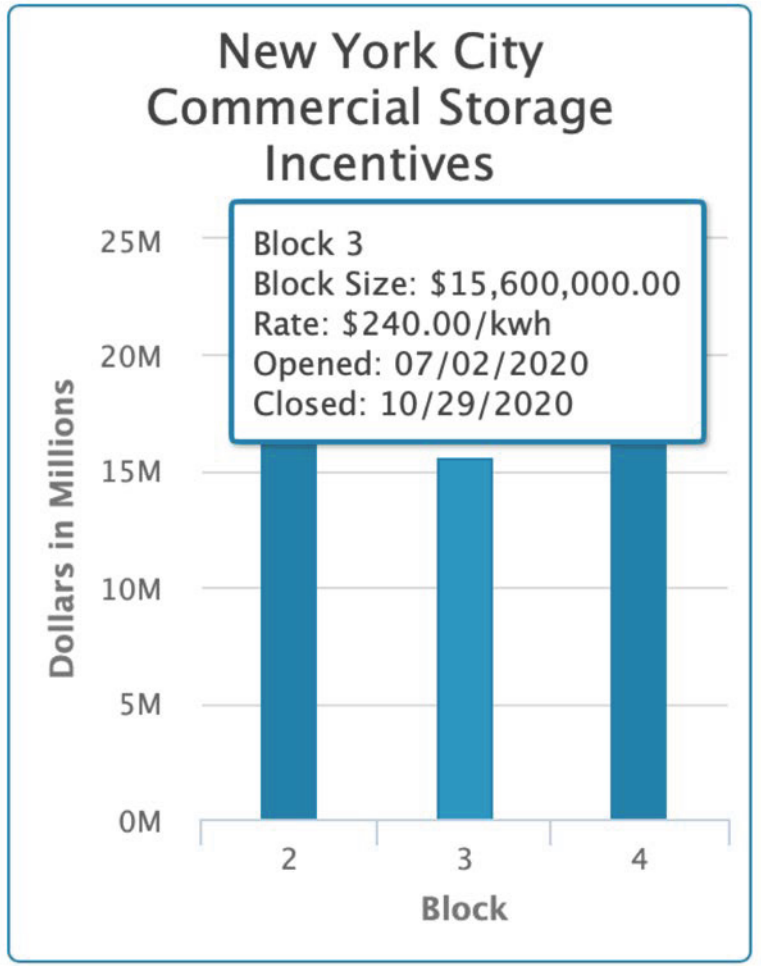


Allocated Budget: $3,000,000

Committed Budget: $1,547,375

Available Budget: $1,452,625

Current Incentive : $250/kWh



Grid of the future

- No solar capacity at 7 am in the winter morning
  - Need storage
- Wind generator (supply) capacity at $1.2B/GW (x3 needed for resilience)
- Delivery capacity at $3.6B/GW (3 times the supply rate)
- $250/KWh x 158 KWh = $39,500 per household

Current Plans for battery storage in NYS

- New York will deploy 3,000 MW of energy storage by 2025 and 3,000 MW (6 GW) by 2030
    - https://www.nyserda.ny.gov/All-Programs/energy-storage 50
- With a 100 GW peak load after electrifying buildings, will last….
    - 4 minutes !

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

Thermal energy storage

- would eliminate the gas distribution system
- have minimal impact on the capacity of the electric grid
- increase the load factor significantly
- reduce the cost of electricity to all ratepayer
- **Significant value as energy storage avoiding grid capacity (cost)!**

ZeroPlace Loop Field Thermal Energy Delivery

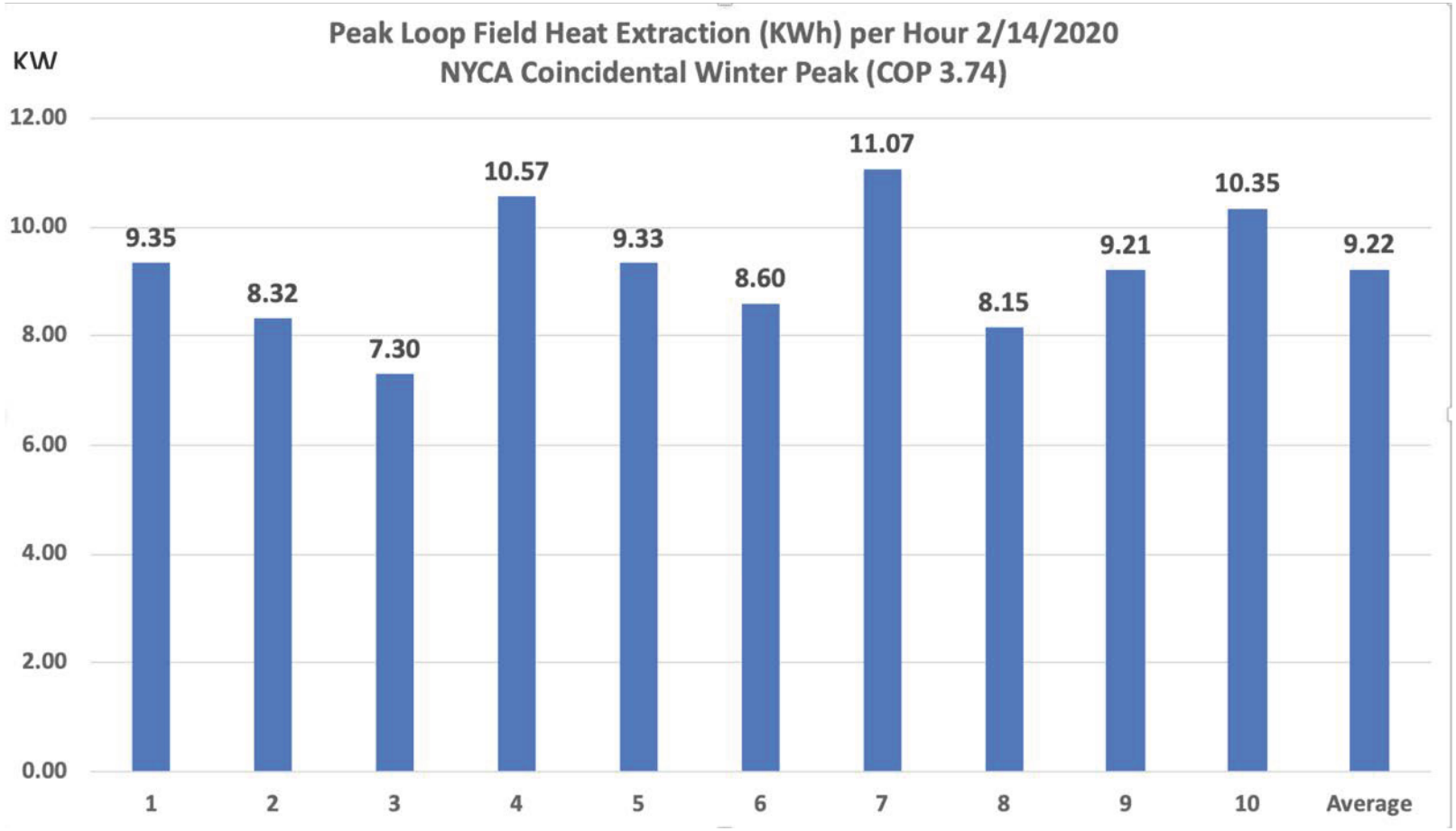
Monetary Value

			@ $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 average $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

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 average $567/kWh for installations occurring in 2022 and 2023" Case 18-E-0130 – In the Matter of Energy Storage Deployment Program.

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Costly?

- To put it further in perspective, NYS is currently paying $6 Billion for a 1.2 GW transmission line from Quebec to NYC, that is $ 5,000/KW transmission capacity to get peak capacity for the summer to NYC.
  - That is without paying for the actual power during peak time, and that
    - Contract is only for the summer, since Quebec needs it for the winter heating themselves.

- Again, this is without the cost of any generators, since "…non-emitting resources which can be dispatched like fossil fuel generators do not exist as of today." 56

- Wind energy currently runs at $1,200/KW name plate capacity, but is intermittent.

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 storage energy service to the grid. 57
  - The NYISO projection in winter peak growth are driven by ASHP, which do not store thermal energy.
  - As expected, at ZeroPlace, the geothermal system had significantly reduced summer demand.
  - Nonetheless, the electrical peak was still in the summer, even after electrifying the heating, the hot water system, the stoves and the cloth dryers.
  - 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)**

Financials Multifamily NYC

- Assumption 10 story tower, 236 apartments
  - $160 Million construction cost (including soft costs)
  - $8 million HVAC and DHW
  - Building Loop with boiler/cooling tower

Cost assumption

- Loop Field including engineering costs $2M
- Upgrade of existing apartment heat pumps for geothermal use $400,000
- Makeup air units (with energy wheels) $200,000
- Domestic hot water geothermal pumps and storage tanks (each floor) $500,000

Geothermal premium **$3.1M**

Incentives

- Using current cost estimates, the following incentives will be available:
  - Coned Rebate
    $1.1M
  - Federal Tax Credit
    $8M x 40% = $3.2M
  - Federal Accelerated Depreciation tax benefit in 2025 $3.5M

- ***total incentives*** **$7.8M**

Cost Avoidance

- Gas boilers for heating
- Cooling tower
- Gas boilers for domestic hot water
- Entire building gas infrastructure
- $3.5 Million cost avoidance

Annual Operating Cost Avoidance

- Gas to run boilers
  - 110,000 therms @ $1.26 / therm $ 138,600
- Gas to run makeup air units
  - 27,000 therms @ $1.26 / therm $ 34,000
- Electricity to run cooling tower
  - estimated $ 75,000
- Gas to run domestic hot water
  - 260,000 gallons hot water per month $ 82,000
- Maintenance of boilers & cooling tower
  - estimated $ 34,000
- Annual water cost avoidance for cooling tower $ 32,000

Total Annual Savings **$ 395,600**

Developer Financial

- Upfront capital cost
  - $3.5 million cost avoidance (boilers, gas infrastructure)
  - $1.1 million ConEd Rebate
  - $7.8 million total to geothermal company
  - Total $12.4 geothermal incentives
  - Versus geothermal costs premium $3.1M
- Operating costs
  - Annual costs operational costs savings geo system = $395,600

Geo is

- Cheaper to install (after incentives)
- Cheaper to operate and maintain

Compared to a conventional gas and A/C system

- If done right

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