Impact of Geothermal on Grid Planning

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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)

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
Current Peak Electrical Demand on Peak Winter Day in NYS

<table>
<thead>
<tr>
<th>Type of Building</th>
<th>Number of sites</th>
<th>Peak Load BTU/Hr</th>
<th>Total Peak Heating MMBTU/Hr</th>
<th>Peak Demand in GW</th>
</tr>
</thead>
<tbody>
<tr>
<td>RES SF</td>
<td>2,890,000.00</td>
<td>40,606.00</td>
<td>117,351.34</td>
<td>34.39</td>
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<tr>
<td>Small MF</td>
<td>400,000.00</td>
<td>82,662.00</td>
<td>33,064.80</td>
<td>9.69</td>
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<tr>
<td>Medium MF</td>
<td>100,000.00</td>
<td>222,608.00</td>
<td>22,260.80</td>
<td>6.52</td>
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<tr>
<td>Large MF</td>
<td>43,000.00</td>
<td>1,516,926.00</td>
<td>65,227.82</td>
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<tr>
<td>Large Comm</td>
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<td>1,516,926.00</td>
<td>72,812.45</td>
<td>21.34</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>3,655,000.00</strong></td>
<td><strong>3,684,998.00</strong></td>
<td><strong>331,258.02</strong></td>
<td><strong>97.09</strong></td>
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</table>
Table 4-3. 2018 Statewide Residential and Commercial Thermal Load (Space Heating and Cooling)

<table>
<thead>
<tr>
<th>End Use</th>
<th>Statewide Residential &amp; Commercial Load (TBtu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Heating</td>
<td>557</td>
</tr>
<tr>
<td>Space Cooling</td>
<td>221</td>
</tr>
<tr>
<td>Total</td>
<td>778</td>
</tr>
</tbody>
</table>

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

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
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
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

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

Winter
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
Peak Hour Energy Use in KW

- Thermal Battery Supply: 84.1 kW
- Thermal Grid Supply: 35.7 kW
- Grid Supply for other Electricity Demands: 13.4 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

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

Total Energy Demand (Heating, Hot Water, Electrical Demand)
ZeroPlace, Peak Heating Day in kW (Feb 4, 2023 - 6 Degree F at 7:30 am)
29 kW Geo Electric Demand, 33.3 kW Non-Geo Electric Demand, 62.3 kW Total Electric 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
Took NYSERDA along to monitor and verify
Multifamily Passive House: Connecting Performance to Financing

- **Pre-2003**: 1,633 NYC properties
- **Post-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 Autumn Garden
Total Site KWHs Before (Blue) and After (Red) Geothermal Conversion
40.7% Total Site Energy Savings
Lockport Housing Authority
Demand Reduction

Total Site Demand Reduction in KW by Geothermal Conversion from Electric Resistance Heat
Lockport Housing Autumn Garden's 72 Apartments

- June 2014-May 2015
- Demand June 2016-May 2017
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
  • 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).

• 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

• 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
- 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
  - 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
  - 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

Long Island Single-Family Residential Incentives - Block 2

- Allocated Budget: $3,000,000
- Committed Budget: $1,547,375
- Available Budget: $1,452,625
- Current Incentive: $250/kWh

New York City Commercial Storage Incentives

- Block 3
  - Block Size: $15,600,000.00
  - Rate: $240.00/kwh
  - Opened: 07/02/2020
  - Closed: 10/29/2020
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](https://www.nyserda.ny.gov/All-Programs/energy-storage)

• 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

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly Thermal Energy</td>
<td>31.38   MWh</td>
</tr>
<tr>
<td>Peak Day (Feb 4)</td>
<td>1,706.81 kWh</td>
</tr>
<tr>
<td>Peak Hour</td>
<td>90.86   kWh</td>
</tr>
<tr>
<td>Peak Interval (5-min)</td>
<td>106.98  KW</td>
</tr>
</tbody>
</table>

*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.

Peak heat extraction of 10 residential systems in Buffalo NY
9.22 kW average
<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Peak Hour</strong></td>
<td>9.22</td>
<td>kWh</td>
<td>$5,228</td>
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<tr>
<td><strong>Peak Day (Feb 14)</strong></td>
<td>173</td>
<td>kWh</td>
<td>$98,203</td>
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<td><strong>Monthly Thermal Energy</strong></td>
<td>3.18</td>
<td>MWh</td>
<td>$1,803,060</td>
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<tr>
<td><strong>Annual</strong></td>
<td>13.05</td>
<td>MWh</td>
<td>$7,399,350</td>
</tr>
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</table>

*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.

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.”

• 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.
  • 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 reliably 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