

Valuing GHP Technologies as Grid Assets

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Lunch-N-Learn
October 13, 2026

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Abstract

- Geothermal heat pumps (GHPs) and other geo-exchange technologies have traditionally been viewed by utilities and regulators as primarily a building energy cost-reduction asset. And while “grid value” is acknowledged, it is rarely a significant factor in the decision to install geo-exchange technology. However, the value that GHPs deliver to electric ratepayer customers is far larger than the energy cost reduction to building owners/residents. This misalignment between the beneficiaries (ratepayers) and the investors (building owners) is the largest barrier to greater geo-exchange technology adoption. Interestingly this misalignment is exactly reversed for air-source heat pumps (ASHPs) in which the cost to ratepayers as a whole is far greater than the cost to the building owners/residents.
- How can GHPs be one way (ratepayers benefit) and ASHPs the other, when they are both heat pumps? The answer to that question lies in the impact of the two technologies on both winter AND summer peak demand.
- The presentation will cover the peak demand impact of GHPs and other geo-exchange technologies, and how it is different from ASHPs. The presentation will explore different methodologies to quantify that benefit and calculate the magnitude of the benefit that all ratepayers derive when large numbers (thousands) of GHPs are installed within a utility service territory. The value to ratepayers of the peaking value alone can be as much as \$20,000 per single family home that is converted to GHP for a summer peaking utility with a 4-ton air conditioning load, and even more if the utility is or will be a winter peaking utility.
- Some ideas are presented on options for implementing possible incentives and for the QA/QC that ensures that ratepayers get the grid benefits that they would be paying for. Differences between electric customers in IOUs versus vertically integrated utilities will be covered, as well as differences between Investor Owned Utilities (IOUs) and Public Utilities (Muni's, Co-Ops, etc).
- Key Grid Benefits & Value as an Asset
- Utility System Savings: Lower peak loads generate value for electric utilities across generation, transmission, and distribution levels.
- Decarbonization & Load Growth: By reducing overall energy consumption during both heating and cooling seasons, GHPs decrease power generation emissions, supporting grid decarbonization while enabling the integration of large, year-round data center loads.
- Enhanced Grid Asset: Beyond providing significant building-level efficiency and energy cost savings, these combined factors make GHPs exceptionally useful and valuable grid assets. However, measuring the exact scale of these grid benefits has historically posed a challenge.
- Presentation Scope & Methodology
- Quantification Frameworks: This presentation outlines three methodologies to quantify the grid value of GHPs and establish appropriate GHP incentive levels.
- Market Structures & QA/QC: It examines how different electricity market models—such as vertically integrated utilities (investor-owned or public) versus Independent System Operator (ISO) delivery regions—affect incentive frameworks and QA/QC processes designed to ensure value delivery.
- Universal Customer Benefits: The session demonstrates how GHP incentives yield long-term rate decreases for all electric customers, including those without a GHP.
- Case Studies: Analysis will include three sample sites spanning diverse climate zones and utility structures.

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Agenda

- ☐ Terminology, Technologies, BAU
- ☐ Evidence of Grid Value
- ☐ About Data Centers and the Grid
- ☐ Quantifying GHP Impact (3 methods)
- ☐ State Incentives
- ☐ Cold BTES & Data Centers

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Geothermal Heat Pumps Use Seasonally Stored Solar & Waste Heat Energy



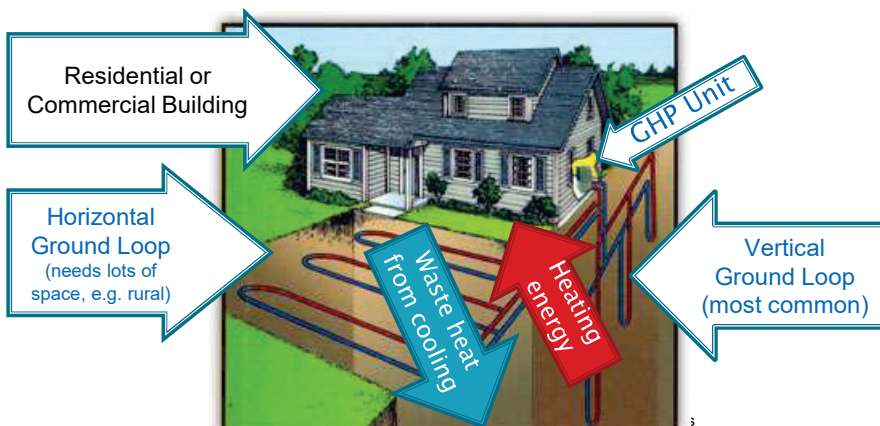
GHPs efficiently move energy between the building and the ground

Typically, only 25% of energy is from electricity (COP = 4)

Key Grid Benefits

Less energy – kWh/yr

Low peak demand (kW)
(at hottest & coldest air temperatures)



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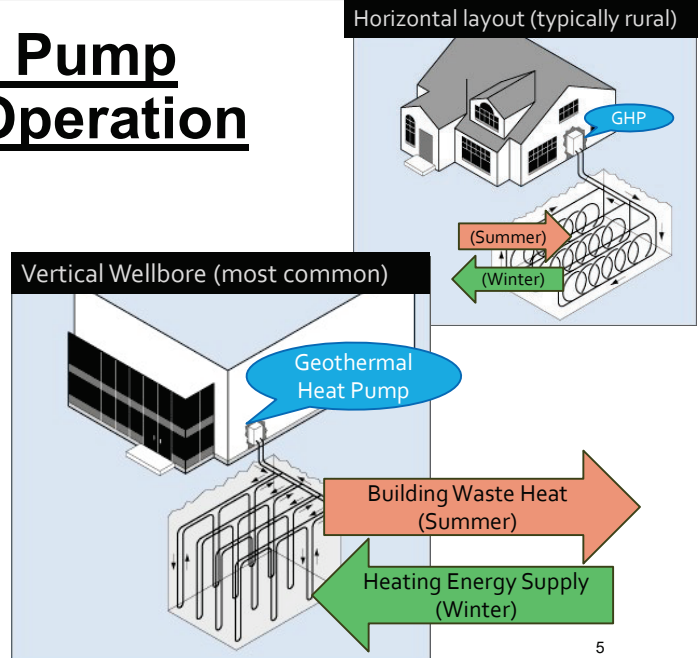
Geothermal Heat Pump Basic Design & Operation

• Heating:

- GHP pulls heat from the ground
- 25% electric → COP = 4

• Cooling:

- GHP rejects heat to the ground
- More efficient than air, especially when hot



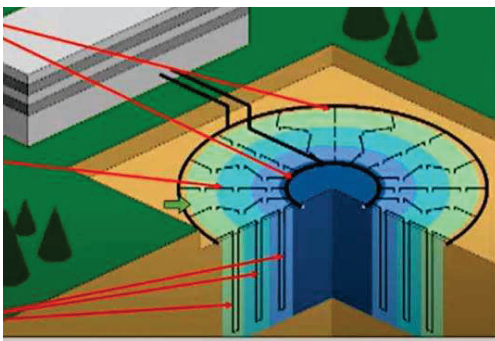
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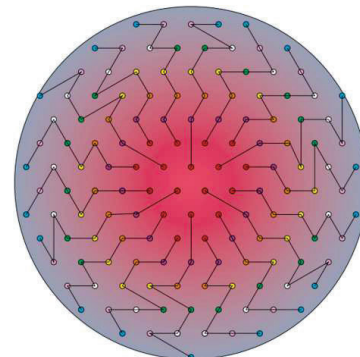
Borehole Thermal Energy Storage

a type of Underground Thermal Energy Storage (UTES)
Same as geo-exchange boreholes, but designed to accept and retain energy for long-duration storage

cool/cold BTES (Cold-UTES)



warm/hot BTES (Hot-UTES)

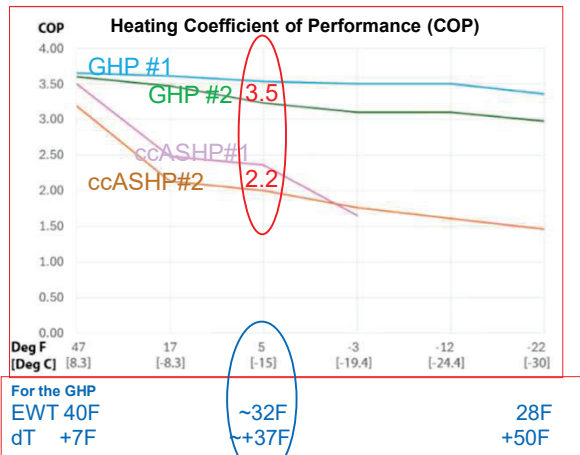


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Winter Performance of GHPs vs ccASHP

Performance Curves



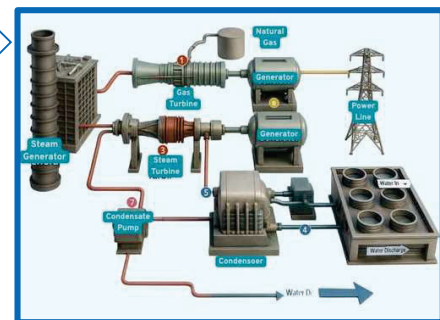
<https://igshpa.org/igshpa-blog/have-cold-eliminate-heat-pumps-caught-up-with-ground-source-performance/>

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Gas Turbine Overview

- **Simple Cycle Gas Turbine (SCCT)**
 - “simple” equipment
 - Mostly used for peaking
- **Combined Cycle Gas Turbine (CCCT)**
 - Much more complex & expensive
 - Increases output by 50%
 - Cuts emissions by 33%/MWh
 - More economical if many hours/year use
- **Grid planning uses both**



Images from:
<https://www.facebook.com/ismail.saad.18/posts/combined-cycle-power-plant-overview-a-combined-cycle-power-plant-ccpp-is-a-high/9776956862433638/>

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Capacity vs Energy

• **MW = Capacity or Power**

- Provided by the power plant rating (or load reduction)
 - Solar has zero capacity value in winter or near sunset.
 - A gas turbine has >100% rating in winter and ~90% for summer peak
- Peak capacity is the 1 – 10 hours/yr with the highest demand (MW)
 - it is ALWAYS a function of air temperature.
 - It is NOT an average value (across a day, month, or year)
- Transmission wires have a separate capacity/power rating

• **MWh = Energy**

- Summation of Power used over a time period (e.g. an hour).
- A hair dryer uses 1kW of power whenever it is running. If it runs for 60 minutes then it uses 1 kWh of energy. (or if it runs at 2kW for 30 minutes)

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Cost of Energy and Capacity (Gas Turbines)

Cost Inputs and Operating Assumptions Costs derived in 2024-2025

Supply-Side Resources	Nameplate (Plant Capacity) (MW)	Overnight Plant Capital (\$/kW)	Transmission/ Interconnection Capital (\$/kW)	Total Capital (\$/kW)	Fixed O&M (\$/kW-month)	Non-Fuel Variable O&M (\$/MWh)	Heat Rate (Btu/kWh)	Economic Life (years)
Combined Cycle Combustion Turbine (CCCT)	300	\$1,650	\$191	\$1,841	\$1.60	\$3.40	6,431	30
Simple Cycle Combustion Turbine (SCCT)	150	\$1,200	\$191	\$1,391	\$0.80	\$6.00	9,905	30
Reciprocating Gas Engine (Recip)	50	\$2,460	\$127	\$2,587	\$1.20	\$5.50	7,600	40
Hydrogen Combustion Turbine	150	\$1,470	\$191	\$1,661	\$0.80	\$6.00	9,905	30
Small Modular Reactor	100	\$10,310	\$191	\$10,501	\$14.60	\$3.40	9,180	60
Geothermal	30	\$0.450	\$127	\$0.577	\$18.50	—	—	30
Solar PV	—	—	—	—	—	—	—	—
Wind	—	—	—	—	—	—	—	—
Battery (4 hours)	—	—	—	—	—	—	—	—
Battery (4 hours)	—	—	—	—	—	—	—	—
Battery (4 hours)	—	—	—	—	—	—	—	—
Pumped Hydro (12 hour)	—	\$4,190	\$187	\$4,377	\$2.00	\$0.70	—	100
Iron Oxide Battery (100 hour)	50	\$3,000	\$127	\$3,127	\$1.70	—	—	15

Multiple Available Data Sources:

- **Idaho Power 2025 IRP – Appendix C Page 22**
 - <https://docs.idahopower.com/pdfs/AboutUs/PlanningForFuture/2025IRP/2025%20IRP%20Appendix%20C.pdf>
- **Lazard Levelized Cost of Energy 2026:**
 - https://www.lazard.com/media/kcfconhf/lazards-lcoeplus_vf.pdf

Delivery time = 5+ years
Plus installation & commissioning

2026 Lazard
Price increase >25%!!!!

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Gas Turbine Total Cost of Ownership (NPV)

- Create a 30-year Pro-Forma
- Calculate NPV of each
- Results

	Net Present Value (x%, 30 yrs)		
Discount Rate	4%	6%	8%
Metric	(\$/kW)	(\$/kW)	(\$/kW)
CCCT	\$6,721	\$5,372	\$4,410
SCCT	\$4,521	\$3,618	\$2,973

CCCT Combined Cycle					
Capital Payments (\$/MW-yr)	8.0%	\$203,504	\$203,504	\$203,504	\$203,504
Fixed O&M (\$/MW-yr)	0%	\$25,500	\$25,500	\$25,500	\$25,500
Variable O&M (\$/MW-yr)	0%	\$26,280	\$26,280	\$26,280	\$26,280
Fuel Cost (\$/MW/yr)	0%	\$146,314	\$146,314	\$146,314	\$146,314
1st 10 year capacity factor	60%	60%	60%	60%	60%
capacity factor thereafter	50%				
Hours per year		5,256	5,256	5,256	5,256
Fuel Cost	\$4.25	\$/MMBTU			
Total Cost/kw/Year		\$401,598	\$401,598	\$401,598	\$401,598

Net Present Value of New Capacity

- Analysis will use \$5k
- Upper range is >\$8k/kW (not shown)

Major Sensitivities

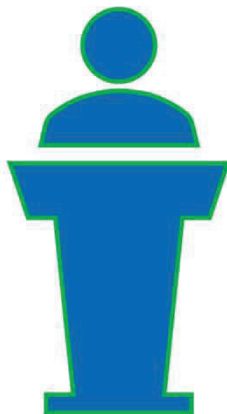
- 1) WACC
- 2) Discount Rate
- 3) Equipment Capex

\$6,700/kW of average load reduction

\$4,500/kW of peak load reduction

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- ☐ Cold BTES & Data Centers

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Why talk about GHP Technologies and the Grid?

What, Me Worry?



The Next 10 Years will be critical for the electric grid

Rapid growth in all hours

Bigger summer cooling loads

Mostly from AI Data Centers

The Grid is central to energy policy

Consumer Affordability

Emissions strategies

Enables AI expansion

GHPs are MOSTLY a Grid Asset

NOT (just) for building/facility energy cost reduction

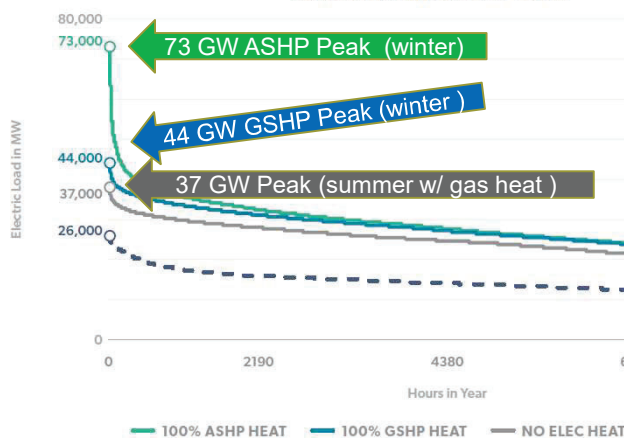
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Rhode Island Study of GSHP vs ASHP

New England Heating Electrification Projections

2050

Sorted Electric Load Hours



Performance & Economic Impact

- **GHPs Lower Peak Load by 29GW**
(73 – 44 = 29GW)
- **Value = ~ \$87 Billion**
At total cost of ownership ~\$3MM / MW
- **GHP to ASHP Differential is \$20k - \$30k**
Per retail meter w/ all grid and operating reductions

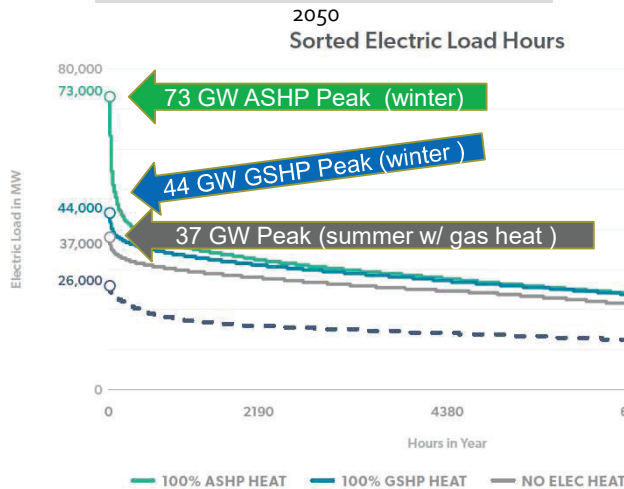
**GHPs lower cost for
for All Ratepayers**
[even those w/o GHPs (yet)]

<https://energy.ri.gov/sites/g/files/xkgbur741/files/documents/HST/RI-HST-Final-Pathways-Report-5-27-20.pdf>

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2019 Rhode Island Study of GSHP vs ASHP

New England Heating Electrification Projections



<https://energy.ri.gov/sites/g/files/xkgbur741/files/documents/HST/RI-HST-Final-Pathways-Report-5-27-20.pdf>

Performance & Economic Impact

- **ASHPs Increase Grid Peaking Cost by \$87 Billion**
 - Cost per retail meter \$11,600/meter
 - Excl. massive xmission & distribution EXPENSES
 - This is the ASHP cost, not the "grid cost"
- **GHP to ASHP Differential is \$20k - \$30k**
 - Incl. \$10k - \$20k of GHP Grid Peak Cost Reduction
 - w/ all grid capital and operating cost reductions

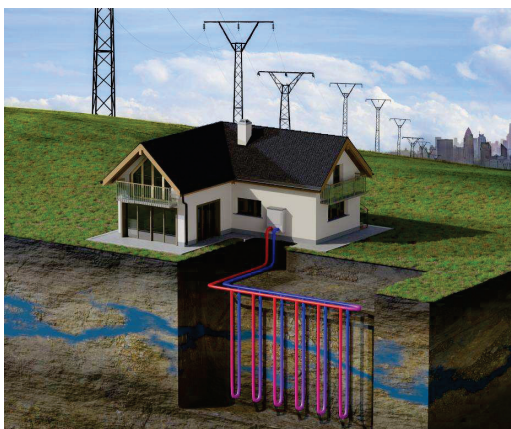
**GHPs are MUCH CHEAPER
for All Ratepayers
[even those w/o GHPs (yet)]**

- **ASHP Calculation: Winter Peak is Expensive**
 - $73 - 44 = 29\text{GW} * \$3\text{MM/MW} = \$87\text{B}$
 - 7.5MM retail meters (serving 15MM people)
 - \$3MM/MW Total Cost of Ownership for simple cycle turbine
 - $87\text{B} / 7.5\text{MM} = \$11,600$ per meter

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2023 DOE/NREL Study: Grid Cost Reduction via Mass Deployment of GHPs



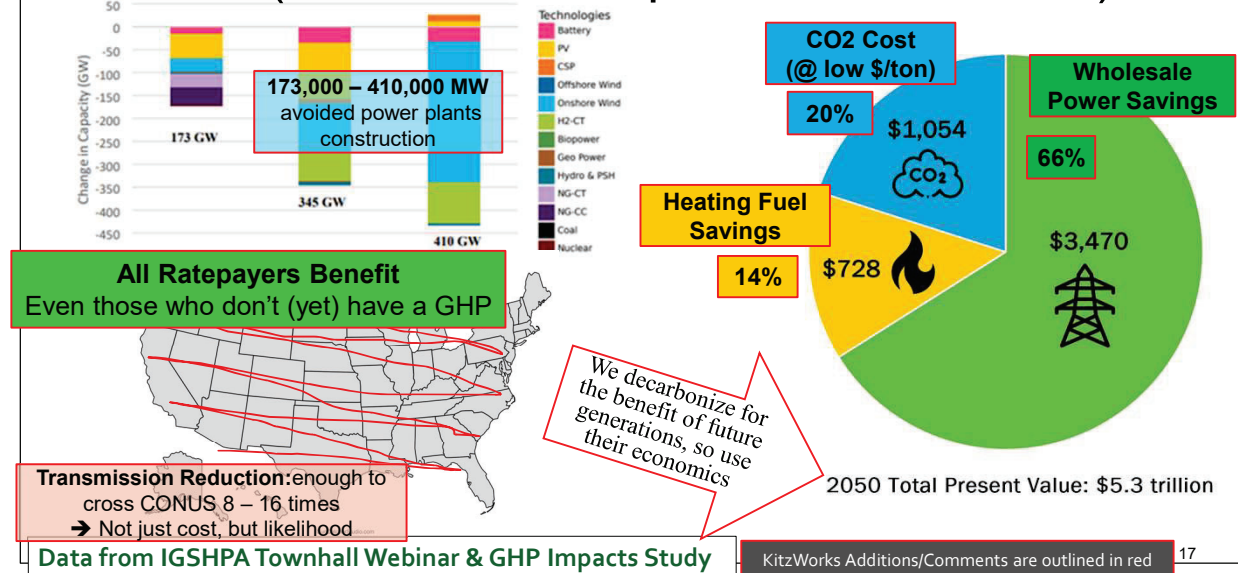
Links to Study

<https://info.ornl.gov/sites/publications/Files/Pub196793.pdf>



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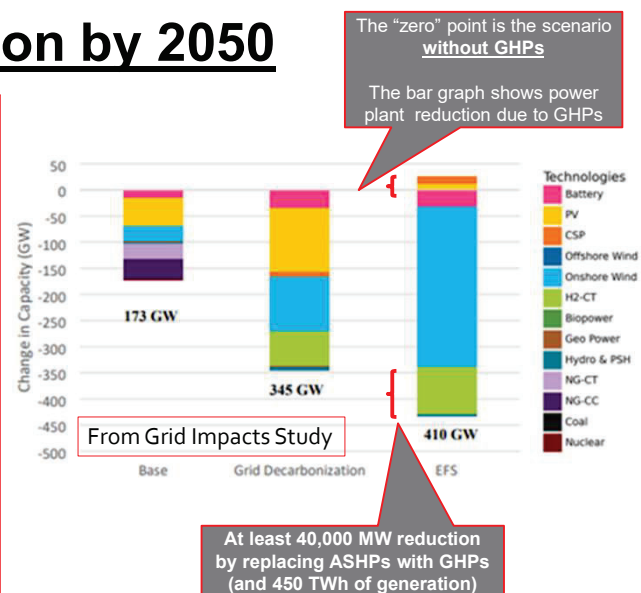
“The Grid” is the Biggest Value Driver for GHPs (i.e. the most important “Customer”)



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Power Plant Reduction by 2050

- **GHPs electrify heating and still reduce power plant construction**
 - How is that possible?
- **The BAU grid was built for ASHP summer peak**
 - GHPs need less peak power in summer
 - GHPs need less peak power in winter
- **Cool water is more efficient than**
 - Hot air in summer
 - Cold air in winter
 - Thermodynamics, not technology
- **May be Conservative**
 - Model assumes an idealized grid

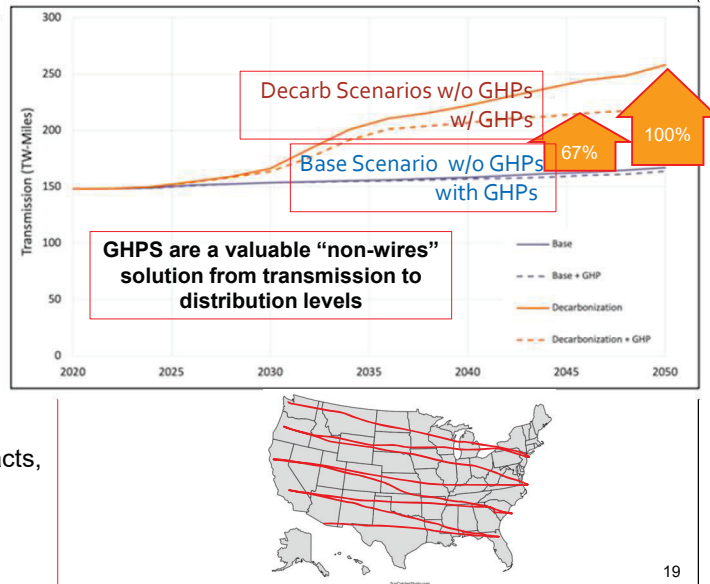


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Transmission Reduction Through 2050

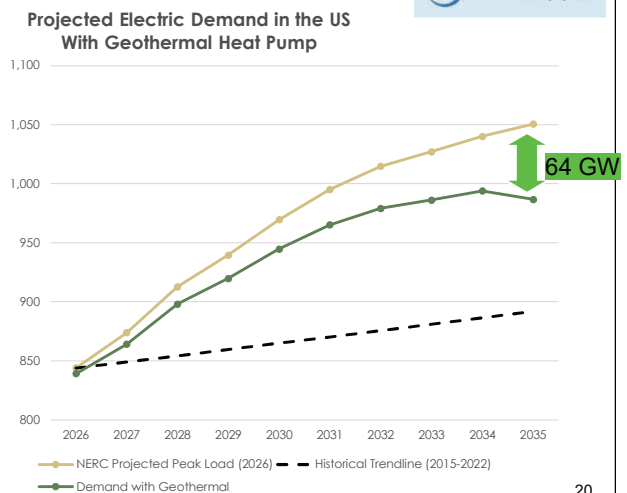
- **Base + GHP Scenario**
 - Heating is electrified AND
 - There is a reduction in transmission!
- **Grid Decarb + GHP Scenario**
 - 33% reduction in new transmission!
 - Roughly 24,000 mile reduction
 - Enough to cross the US eight (8) times
- **EFS + GHP Scenario (not shown)**
 - >20% reduction in transmission
 - Roughly 43,500 mile reduction
 - Enough to cross the US almost 16 times
- **May be Conservative**
 - No Subtransmission or Distribution Impacts, which will be large for ASHP
 - Assumes perfect foresight and 100% success on T-line construction



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MissionGeo Analysis (by AnnDyl)

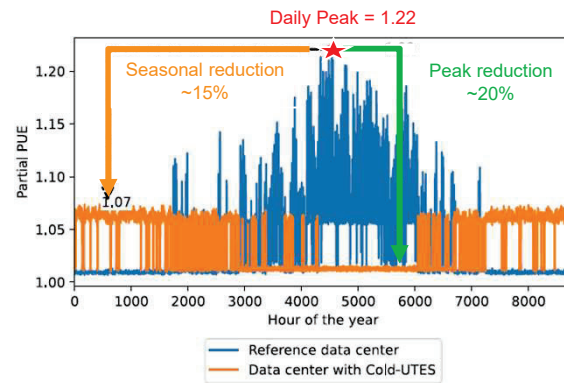
- **Reach 10% GHP use in US residential & commercial buildings by 2037**
 - 20% of all retrofits per year
- **Analyze with ComStock & ResStock data sets from DOE/NLR**
- **Assumptions in analysis (varies by state)**
 - 2-stage GHP + envelope improvement
 - Capacity value: usually \$50/kW-yr
 - Transmission value: usually \$10/kW-yr
 - Distribution value: usually \$10/kW-yr
 - Financial: usually WACC = 7%, 2.5% inflation
 - Single weather year is 2018 (GHP value will be underestimated)
 - Fuel cost from EIA embedded in data sets, so no periodic fuel price upsets



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June 2026 NLR/DOE Study: Cold UTES for Data Center Cooling

- Study included BTES
- Results
 - Peak Hour Reduction = 20%
 - Seasonal Peak Reduction = 15%
 - Increase off-peak winter load
- Applicable to any large cooling load
- Mechanism
 - Pre-cool the ground from Fall thru Spring
 - Absorb data center heat during peak hours
 - Use dry coolers, but NOT chillers



(a) Virginia

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Geo Heat Pumps: Building Value vs. Grid Value



Building Energy Savings
from a particular GHP

Assume \$300 - \$500 per
year savings
7-year value = \$2k - \$4k



Grid Infrastructure Avoided
Cost from the same GHP

Net Pres. Value = \$4k - \$20k



Total GHP Value

Building + Grid = \$6k - \$24k
Value Increase = 3X - 6X

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What does GHP “Grid Value” Mean

Three important metrics

- GHPs lowers the future costs to grow and operate the grid
- **ALL RATEPAYERS** benefit (not just the building owner)
- Benefits occur over 30+ years (and grow)

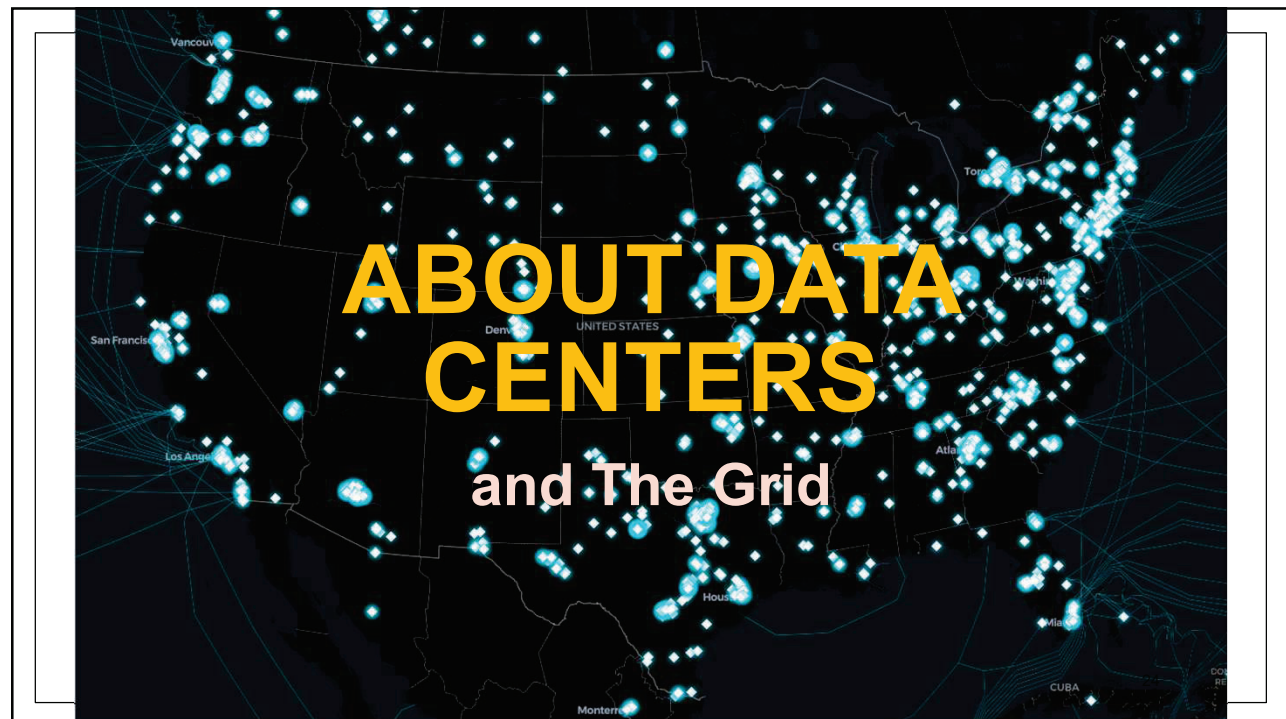
Drives three key grid policies

- Provides the basis for GHP installation incentives
- Justifies ratepayers funding the incentive
- Ratebase of the incentive means future ratepayers pay their fair share

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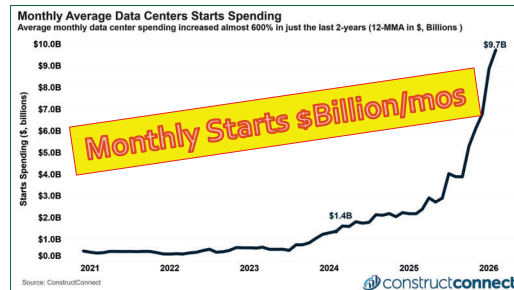
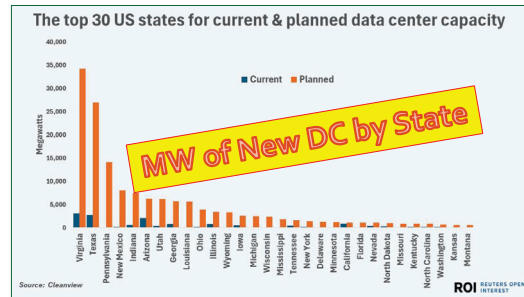
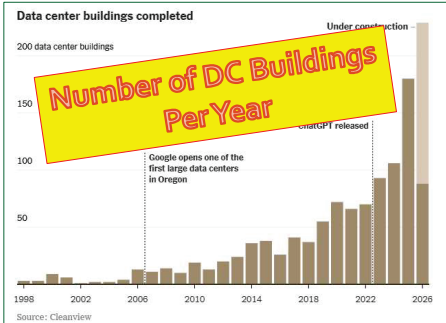
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Data Center Growth

- **100,000+ MW New DC “Planned” – top 10 states**
 - Not possible from supply chain alone
 - Whatever happens, it will be massive
- **Construction “Starts” \$10B per MONTH**
- **Exponential Growth – Number of DC Buildings**



<https://www.reuters.com/business/energy/charting-data-center-development-roadmap-key-us-states-2026-01-22/>
<https://news.constructconnect.com/april-2026-data-center-report-extraordinary-growth-continues>
<https://www.nytimes.com/interactive/2026/10/05/upshot/data-center-scale.html>

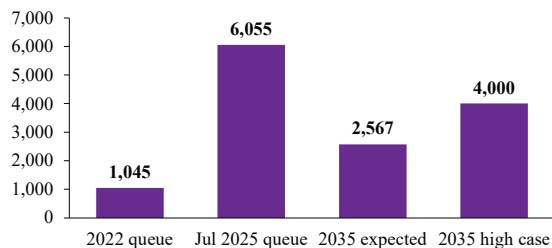
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Data Center Growth Over Time

- **2010 - 2021: No separate data center load**
 - NYISO did not track data centers as a distinct load class; statewide peak demand actually declined from its 2013 record of 33,956 MW
- **2022 - 2025: Large loads enter the queue**
 - Interconnection requests grew from 6 projects / 1,045 MW in 2022 to 29 projects / 6,055 MW by July 2025
- **To 2035: 2,500 - 4,000 MW expected on system**
 - The 2025 Gold Book forecasts 2,567 MW of large-load demand added by 2035; NYISO publishes no data center forecast to 2040
- **Why it matters for the grid**
 - NYISO's 2024 RNA assumes ~1,200 MW of large load can be reduced at peak - flexibility, not new peakers, is the reliability lever



NYISO large-load (data center / chip fab) demand, MW



Sources: NYISO, "Energy-intensive Projects in NYISO's Interconnection Queue," Aug 26, 2025 (queue MW); NYISO Power Trends 2025 / 2025 Gold Book (2,567 MW expected by 2035; 2,500-4,000 MW range). NYISO does not publish a separate data center load series before 2022 or a data center forecast to 2040.

(MS Copilot AI generated slide)

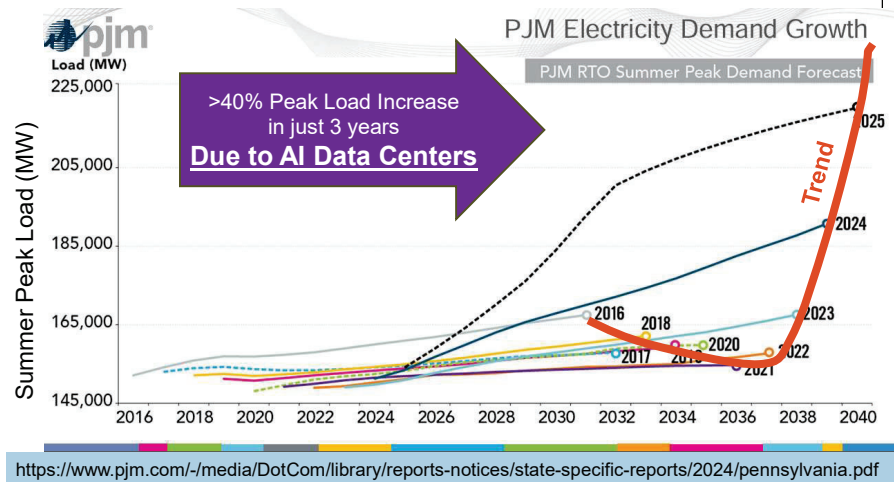
Prompt: a slide about data center growth with time and include images

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Peak Demand (MW) is Skyrocketing

Grid Challenge:

- Serving AI Data Centers
 - 25% - 35% peak demand for relatively few hours per year
 - Poor load factor ($= \text{hrs of peak} / 8760$)



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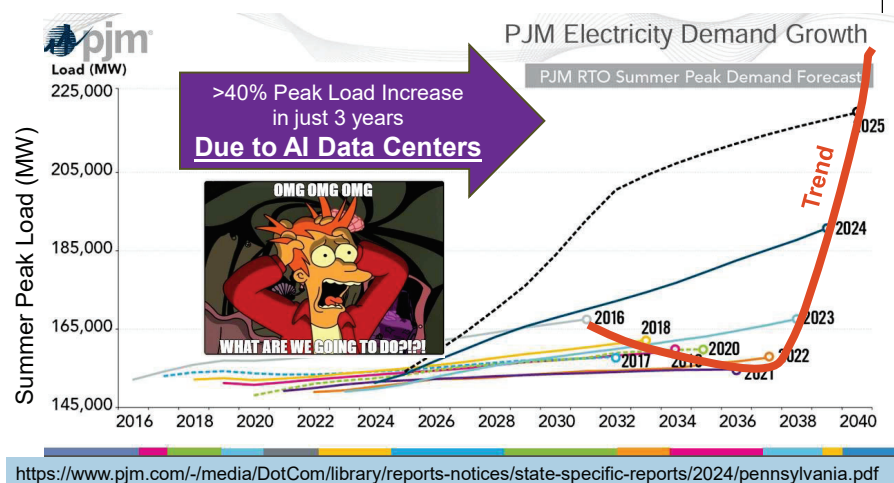
Data Centers are causing demand to skyrocket

Grid Challenge:

- Serving AI Data Centers
 - 25% - 35% peak demand for relatively few hours per year
 - Poor load factor ($= \text{hrs of peak} / 8760$)

Grid Solution:

- GHP Technologies
 - Cut peak load
 - Avoid peaking plants
 - enable more AI D-C AND
- **lower ratepayer energy costs**
- Store off-peak power



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Annual Energy Use is Skyrocketing

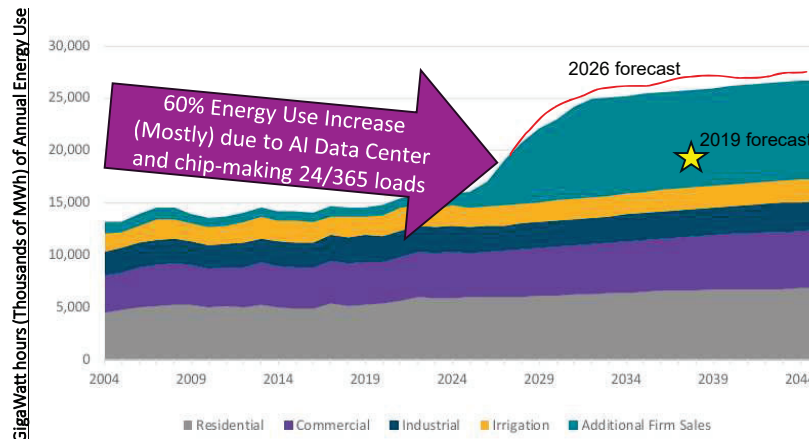


Figure 3. Composition of system company electricity sales (thousands of MWh)

<https://www.idahopower.com/energy-environment/energy/planning-and-electrical-projects/our-twenty-year-plan/>

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Data Centers and GHP Technology

AI Problems/Challenges

- Massive Growth in demand and energy for AI Data Centers
- Long wait for new sources of either capacity (MW) generation (MWh)
- Transmission is also an issue
- Few jobs created by AI

GHP Technology Counterpoint

- Potential for massive cut in grid demand and energy use
- Allows existing capacity and generation to be re-allocated
- GHPs are a “non-wires” solution
- Enormous local and domestic job creation

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GHP Analysis Methods

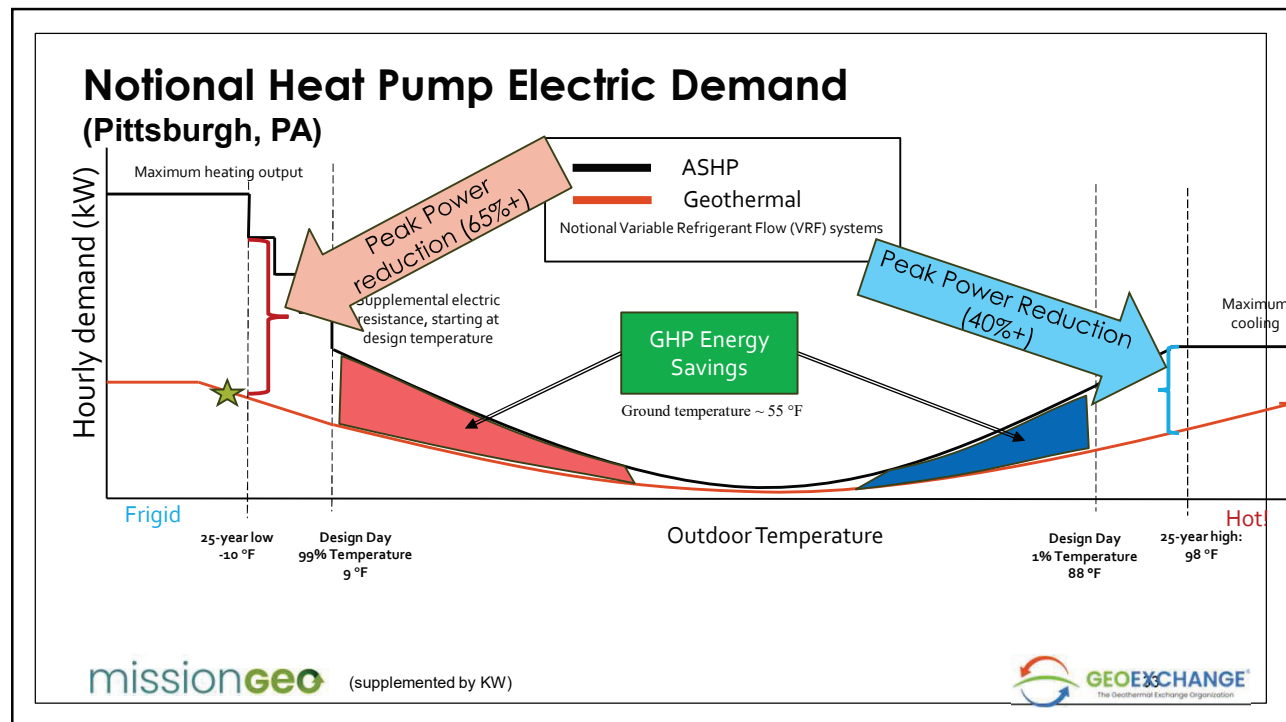
Direct Grid Benefits

1. **Physics**
 - Compare Machine Performance
 - Apply to a Mass Deployment Scenario
 - Back Calculate from Published Data
2. **Building Energy Modeling**
 - Use published aggregate data
 - Build up from a specific mix of buildings
3. **Grid Capacity Expansion Modeling (CEM)**
 - Refine with Production Cost Modeling (PCM)

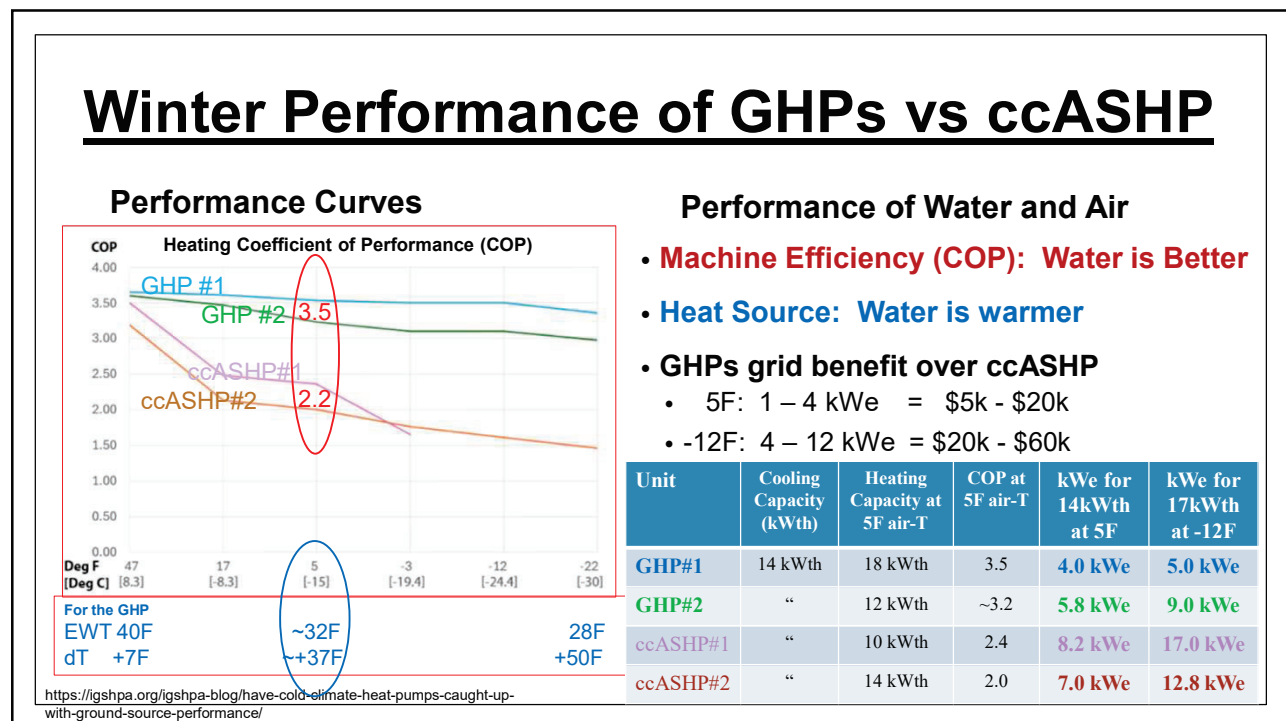
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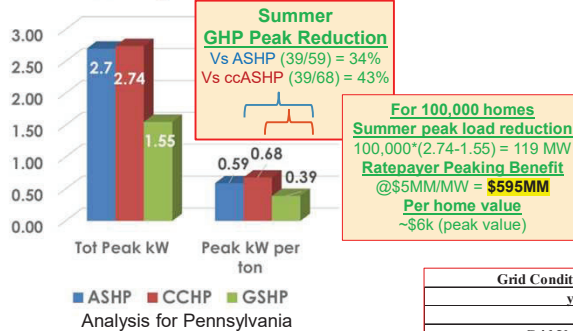
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GHP Peaking Grid Value = \$13,000/home

from machine performance characteristics (physics)

Summer Performance: 95F OAT

Cooling Demand [4 ton cooling load]



Winter Performance: 5F & -15F OAT

Winter GHP Peak Reduction
Vs ASHP (27/60) = 55%
Vs ccASHP (27/51) = 48%

For 100,000 homes
Winter peak load reduction vs ccASHP
At 5F = $100,000 * (5.09 - 2.7) = 320 \text{ MW}$
At -15F = 790 MW
Ratepayer Peaking Benefit
@\$5MM/MW = **\$1.6 to \$4.0 Billion**
Per home value ~\$12k to \$40k

	HP Peak kW 5 degF	Total Peak kW 5 degF	HP Peak COP 5 degF	Total Peak COP 5 degF	HP Peak kW -15 degF	Total Peak kW -15 degF	HP Peak COP -15 degF	Total Peak COP -15 degF
ASHP	3.44	6.04	2.16	1.87	3.24	14.4	1.0	1.0
CCHP	5.07	5.09	2.12	2.08	2.85	11.9	1.85	1.21
GSHP	2.70	2.70	3.89	3.89	3.76	4.01	3.78	3.59

Grid Condition	Summer peaking (current)							Winter peaking (future)			
year	1	2	3	4	5	6	7	8	9	10	11
2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	
Grid Value	\$6,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$14,000	\$0	
Present Value (8%)	\$13,003	per home									
Present Value (4%)	\$15,836	per home									

Bob Brown, Water Furnace presentation
NYGeo Saratoga Springs 2025
https://www.ny-geo.org/assets/pdf/1.+Peak+Demand+Comparison_FINAL/

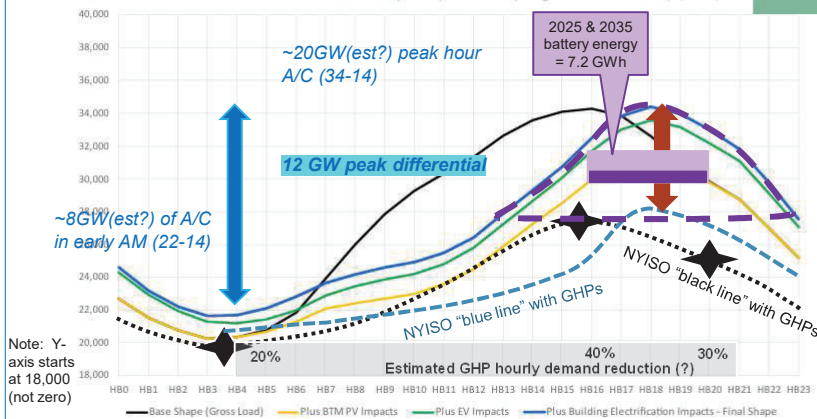
Additional by
KitzWorks

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2035 Summer Load Shape Impacts

NYCA 2035 Summer Load Shape Impacts - July High Load Weekday (MW)



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2035 Light load hour = 15GW
assume 1 GW AC (?) → 14 GW non-AC

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<https://www.nyiso.com/documents/20142/51579307/03%20Forecasts%20for%20Reliability%20Planning%20Studies.pdf/cbc909b9-184d-e8a2-a0b5-ec89aed2c693>

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Impact of Mass GHP Deployment (using device physics)

NYISO graph

Black line shows projected base load shape (gross load).
Yellow line shows base load shape plus BTM solar reductions.
Green line shows base load shape plus BTM solar reductions and EV charging impacts.
Blue line shows final projected load shape - base shape plus BTM PV, EV, and building electrification impacts.

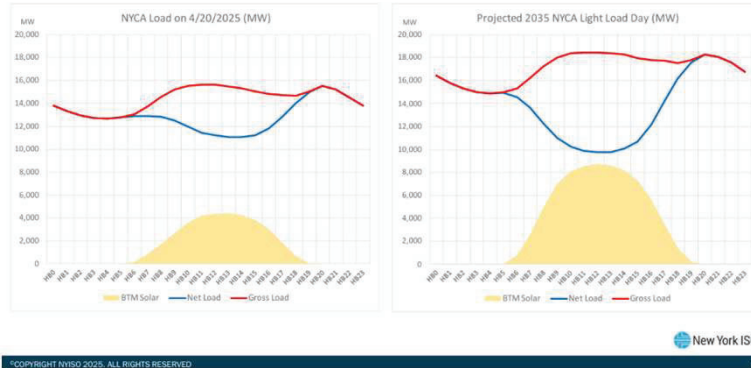
Peak demand ~36 GWh in dashed area
6GW peak
TCO of SCCT = \$5MM/MW (min)
Total = \$30B
Bloomberg 2035 (low): \$225/kWh * 7.2GWh = \$1.62B without the cost of power to charge them
7 years daily charge at \$50/MWh = \$0.9B
Total Cost of Ownership = \$4B++
Still need a LOT of SCCT

New York ISO

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Very little variation across day on light load days. There will still be some 24/7 cooling loads from industry, data centers, etc

NYCA Light Load Day Shapes



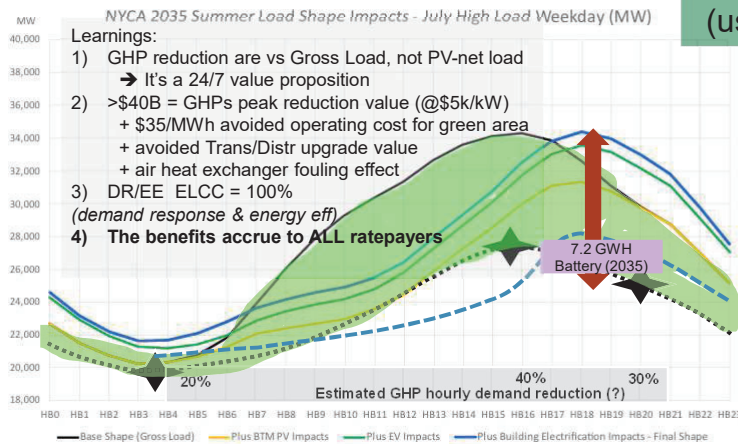
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<https://www.nyiso.com/documents/20142/51579307/03%20Forecasts%20for%20Reliability%20Planning%20Studies.pdf/cbc909b9-184d-e8a2-a0b5-ec89aed2c693>

37

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2035 Summer Load Shape Impacts

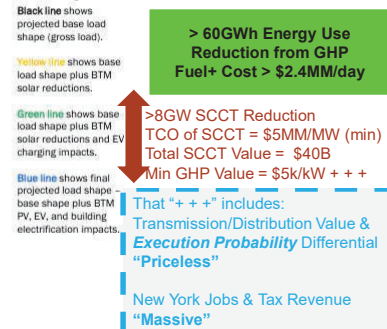


Learnings:

- 4) GHPs make BESS & BTM PV more valuable
- 5) Lower demand lowers market clearing price
- 6) Massive job & tax revenue increase
- 7) Use the approach, not the values ("swag-gy")

Impact of Mass GHP Deployment (using device physics)

NYISO graph



New York ISO

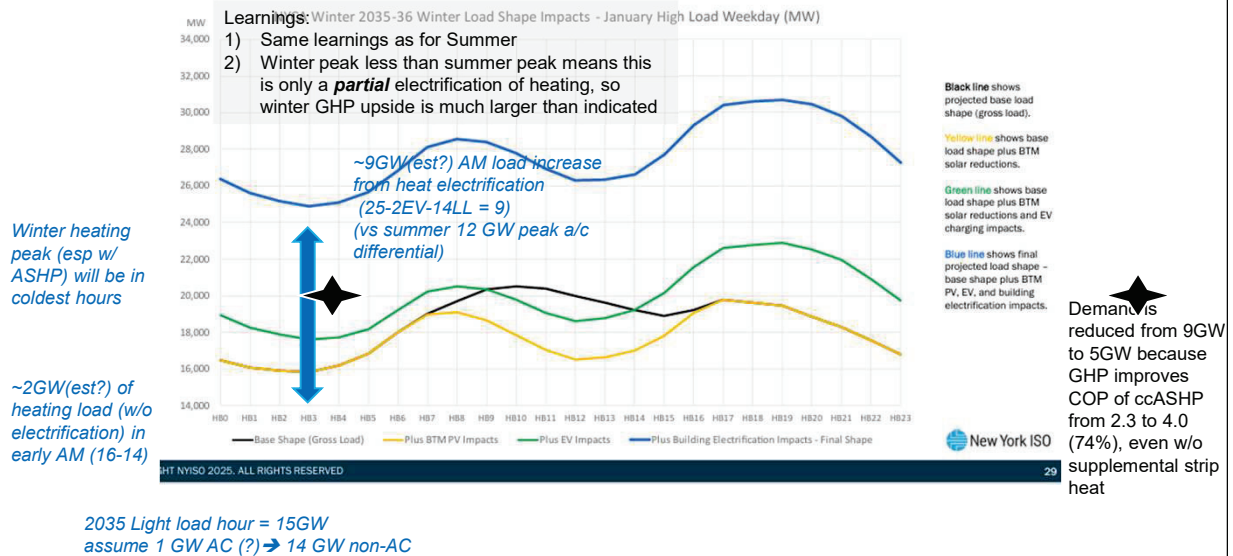
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2035-36 Winter Load Shape Impacts

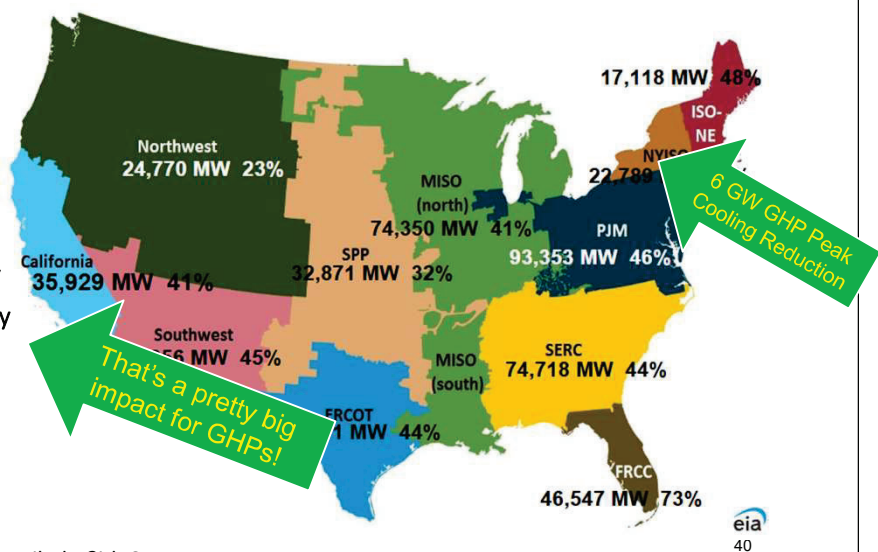


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US Natural Gas Generation Installed Capacity (2022)

A 6 GW reduction in cooling peak capacity =

- ~30% of NYISOs gas capacity
- ~1.5% of nationwide capacity

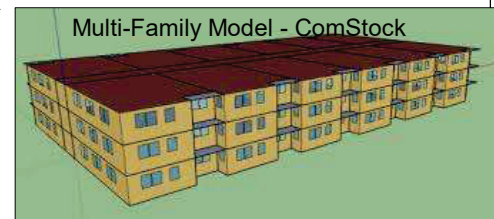


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<https://www.eia.gov/todayinenergy/detail.php?id=61444>

40

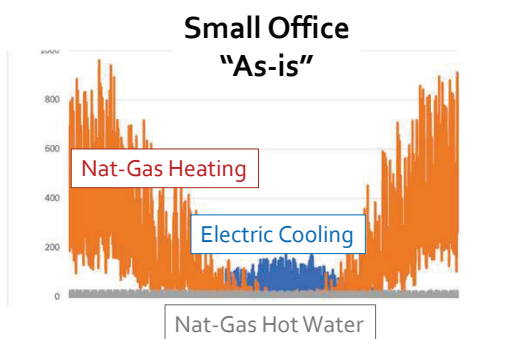
Building Modeling

- Construct Custom 3D models
 - Predict building energy requirements
 - Calibrate with data
 - Include Energy Conservation Measures (ECMs)
- Generic Building Models from ResStock & ComStock
 - Model provides energy use data for different systems



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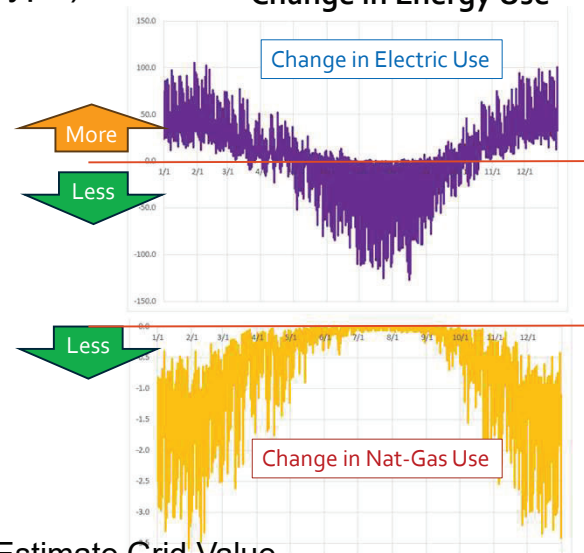
Annual Hourly Energy Use (model for each of building type)



Conversion Process

- Start w/ As-Is
- Adjust for new COPs
- Predict New Electric Use Profile
- Use Capacity & Energy Values to Estimate Grid Value

Small Office w/ GHP Change in Energy Use



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GHP Grid Value: Building Model Approach

Deployment assumptions:

GHPs installed in 1% of buildings/yr

- 20% of annual HVAC systems replacements

Analysis:

Uses the NLR* model ResStock and ComStock

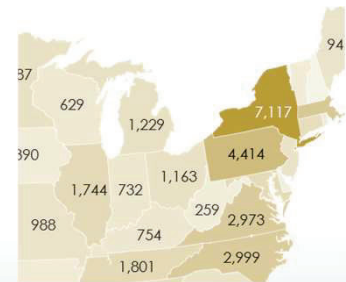
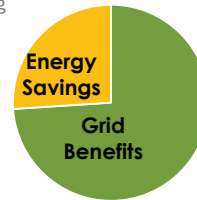
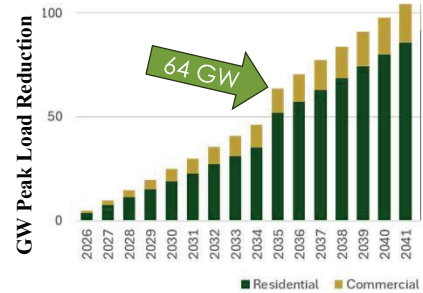
- All U.S. regions and utility systems
- 650,000 residential and commercial buildings
- Quantifies peak demand & energy use
- Inputs include: local utility peak conditions, weather, building stock, and projected growth

Grid Present Value Savings for 2025 – 2035

- SFH = \$7.5k - \$19k
- Multi-family unit = \$2.8k - \$7k
- 10k sq-ft commercial = \$27k - \$73k
- 14.1 million households and 7.7 billion sqft of commercial space
- \$94 - \$240 billion of grid benefits
- \$78 - 85 billion of fuel/energy savings (present value)

(*NLR = National Lab of the Rockies, formerly NREL)

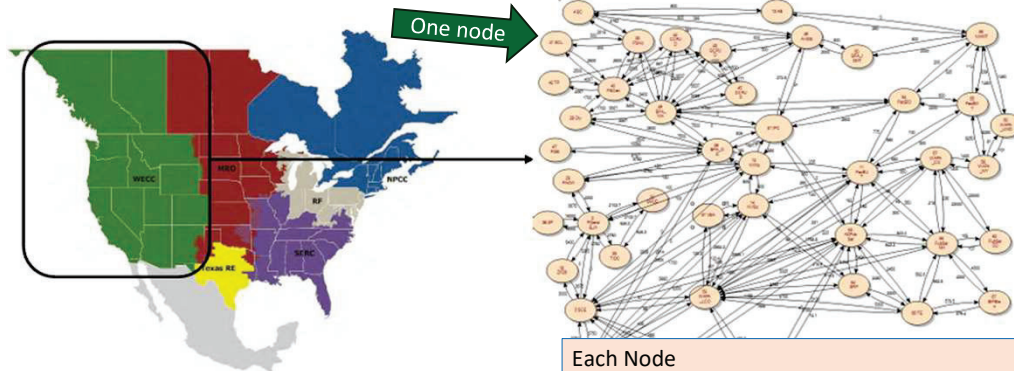
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missiongeo

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GHP Grid Value: Capacity Expansion Modeling: Create a Numerical Model of a Grid Region



Each Node

- Is a Utility Area
- Contains Load profiles vs hours & years
- Contains Load Assets (current, retiring, planned)

https://docs.idahopower.com/pdfs/AboutUs/PlanningForFuture/irp/AURORA_Overview.pdf

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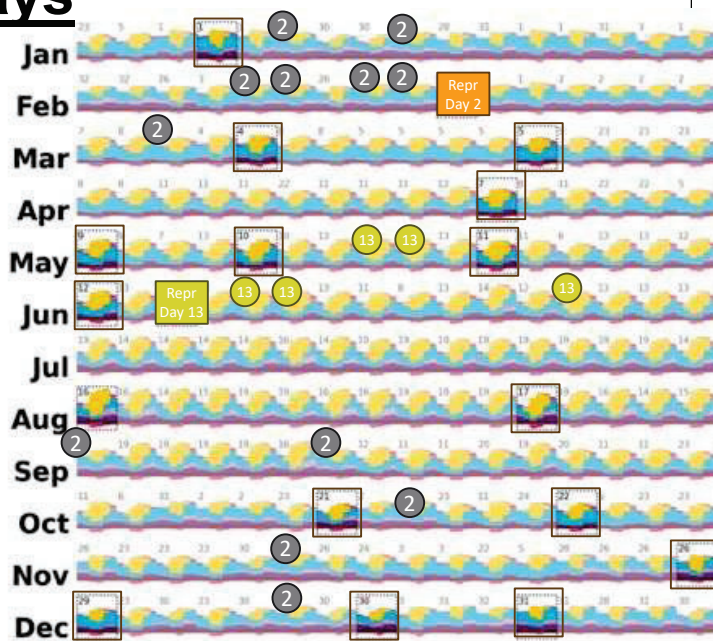
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Representative Days

- **Each Day with a box around it is a representative day**
 - Usually 25 - 30 days
 - Only a few hours/day is modeled
- **Each month is comprised of various representative days**

Examples:

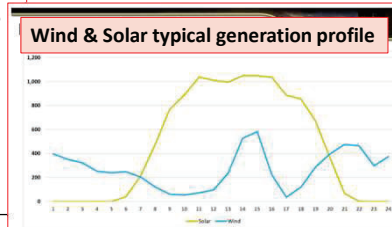
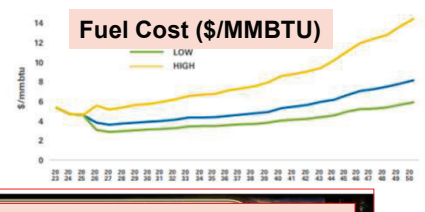
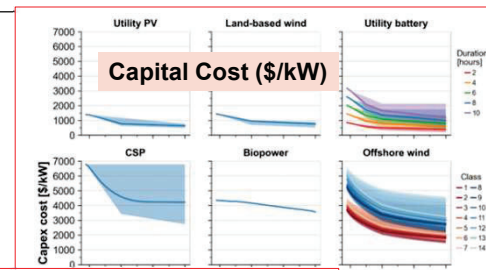
 - Day#2 is used from Sept – Feb
 - Day 13 is used in May – June



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Cost and Performance Inputs

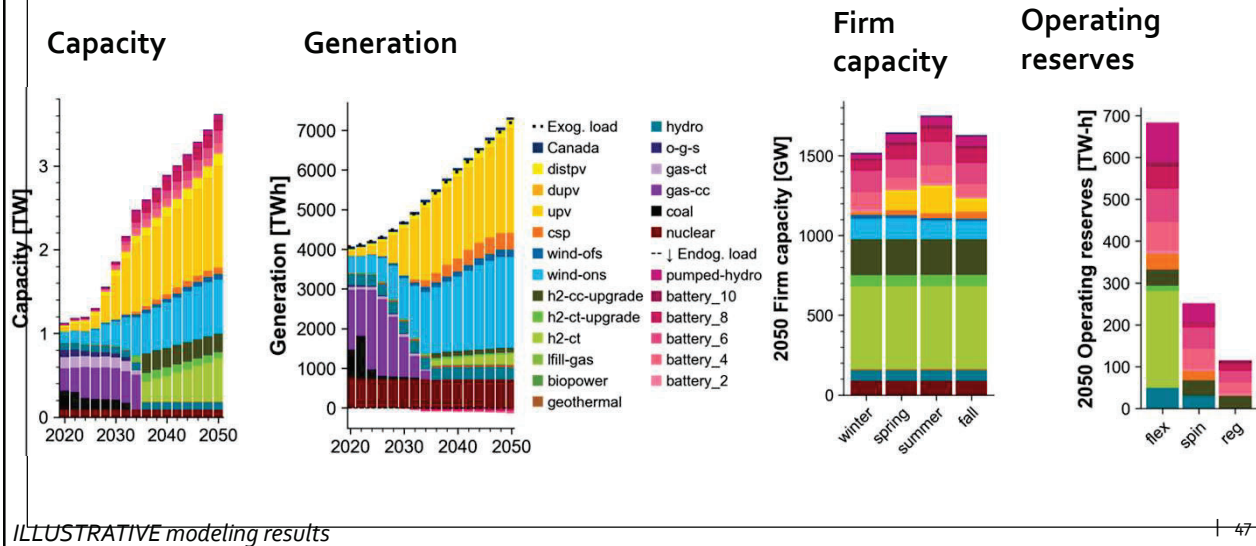
- **Cost of future power plants**
- **Cost projections for natural gas fuel**
 - Scientific Wild Ass Guesses (SWAG)
- **Operating costs (e.g. staffing cost & repairs)**
- **Performance characteristics of plants**
 - E.g. no power from PV after sunset
 - It takes 1 hour for a gas turbine to startup
- **Etc.**



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Key Outputs: Capacity and Generation

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OF THE ROCKIES



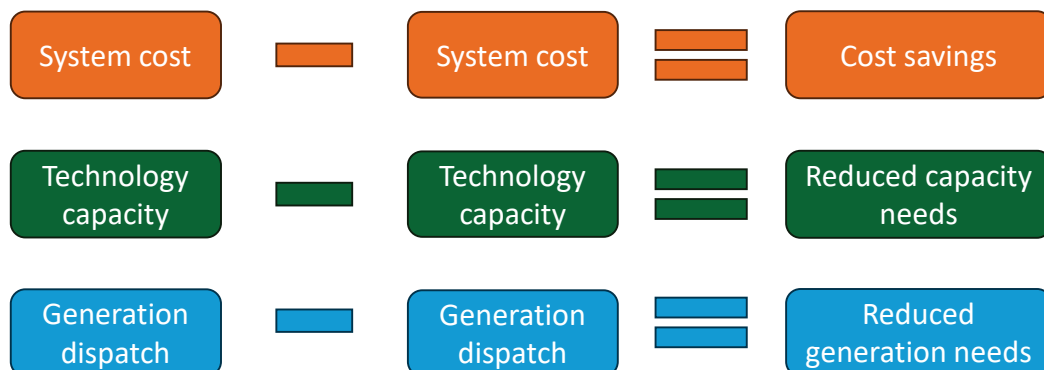
47

Estimate impact of GHPs by comparing least-cost power systems with and without it

System **without** GHPs

System **with** GHPs

Difference



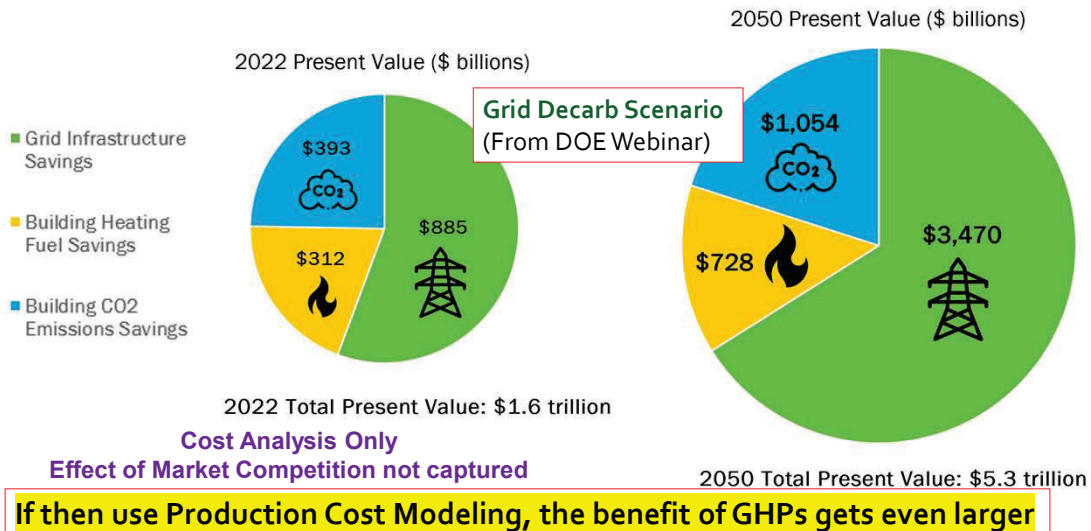
Modified from slide by

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LABORATORY
OF THE ROCKIES

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Mass-Deployed GHPs are a Grid Cost Reduction Technology



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Summary: GHP Grid Impact Methodologies

- **Physics & Building Modeling – Value Buildup**
 - Peaking Value: \$5k per avoided kW
 - Avoided Fuel and O&M: \$0.04 /kWh
 - CO2 Reduction: ~.8 Ton/MWh (1.6lb / kWh)
- **Grid Modeling**
 - Compare GHP to conventional for all-in value
- **Other Factors for GHP**
 - T&D avoided cost
 - Local jobs & tax revenue

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Summary: GHP Grid Impact Methodologies

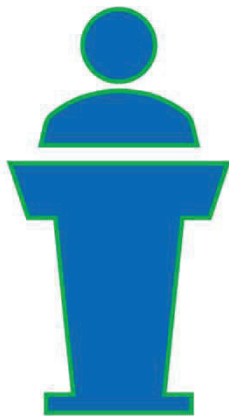
Savings Method Type Described	Grid Peak Capacity Reduction	Grid Energy Savings	Grid Xmission Savings	Distribution Savings	Value of Lower Emission	Building Energy Savings
Avoided Resource Calc	\$3k - \$8k per avoided kW	Possible <i>(not shown)</i>	Possible <i>(not shown)</i>	Only Indirect <i>(difficult & variable)</i>	Possible <i>(not shown)</i>	n/a
Equipment Performance	Yes <i>(w/ above)</i>	Yes <i>(w/ above)</i>	Possible <i>(if above)</i>	<i>ditto</i>	Possible <i>(if above)</i>	Possible
Back Calculate Grid Forecasts	<i>ditto</i>	<i>ditto</i>	<i>ditto</i>	<i>ditto</i>	<i>ditto</i>	<i>ditto</i>
Building Modeling	Yes \$3k - \$19k / SFH residential \$3k - \$7k / apartment or 1kft ² com'cl	Yes	<i>For some models</i>	<i>ditto</i>	Yes	Yes
CEM (Capacity Expansion)	Yes	Yes	Yes	<i>ditto</i>	Yes	Yes
PCM (Prod Cost Model)	Improves CEM	Improves CEM	Improves CEM	<i>ditto</i>	Improves CEM	<i>No change from CEM</i>

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Agenda



- ☒ Terminology, Technologies, BAU
- ☒ Evidence of Grid Value
- ☒ About Data Centers and the Grid
- ☒ Quantifying GHP Impact ^{Six} (3 methods)
- ☐ State Incentives
- ☐ Cold BTES & Data Centers

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New York Incentives (Clean Heat Program) (Single Family Homes shown)

Category 2b - ccASHP Full Load Heating with Decommissioning

Clean Heat
Emissions Value
= \$7k ?

	Non-DAC Single Family		
	Current	Base	Wx Tier
Con Edison	\$8,000	\$7,000	\$10,000
National Grid	\$10,000	\$7,000	\$12,000
NYSEG/RG&E	\$10,000	\$7,000	\$12,000
Central Hudson	\$8,000	\$7,000	\$12,000
O&R	\$9,000	\$7,000	\$12,000

Category 3 - GSHP Full Load Heating (Retrofit)

Extreme T&D Value
= \$7k - \$10k ?

	Non-DAC Single Family		
	Current	Base	Wx Tier
Con Edison	\$30,000	\$25,000	\$30,000
National Grid	\$20,000	\$18,000	\$23,000
NYSEG/RG&E	\$17,000	\$15,000	\$20,000
Central Hudson	\$18,000	\$15,000	\$20,000
O&R	\$14,000	\$18,000	\$23,000

GHP vs ccASHP
Grid Incremental Value ?

Retrofit = \$8k - \$11k ?

New Build = \$8k - \$14k ?

Machine performance basis = \$14k+
Bigger homes even more
(still benefits all ratepayers)

Category 3 - GSHP Full Load Heating (New Construction)

	Non-DAC Single Family		
	Current	Wx Tier	C
Con Edison	N/A	\$15,000	
National Grid	\$14,000	\$14,000	
NYSEG/RG&E	\$10,000	\$10,000	
Central Hudson	\$8,000	\$8,000	
O&R	\$7,000	\$14,000	

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GHP Incentives are Easy

- **GHPs, regardless of where they are installed,**
 - benefit accrue to all ratepayers
 - Reduces future grid spending
 - Displaces natural gas power (least expensive resource)
 - Other resources at higher cost savings
- **So why do they vary by**
 - State, distribution company, Grid power mix, etc
- **Locations that justify higher incentives**
 - extreme high or low air-T
 - Severe T&D congestion

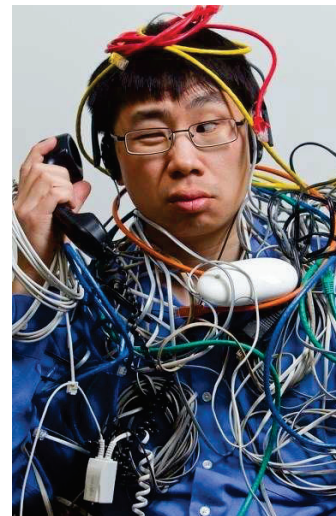


Image:
<https://www.stalbertgazette.com/local-news/what-a-tangled-mess-1288712>

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GHP Utility Incentives for Single Family Homes

Table summarized from Google AI search:
What are the electric utility incentives for GSHP or GHP for 10 large utilities around the US

Utility Company	State	Amount	GHP Incentive Program
Various	NY	\$8k - \$14k	NYS Clean Heat Program (GHP portion)
National Grid & Eversource	MA	Up to \$14k	Mass Save
Pacific Gas & Electric (PG&E)	CA	\$3k	Utility & Local Programs
Commonwealth Edison (ComEd)	IL	\$1k- \$2k	Home Energy Savings
Duke Energy	Carolinas & Midwest	\$300 - \$1k	Smart Saver program
Xcel Energy	CO / MN / TX	\$400 - \$2.5k	Misc Programs
Georgia Power	GA	\$1k - \$2k	Home Energy Improvement
Rocky Mountain Power	UT / ID / WY	\$1.5k - \$2k	Misc Program
Idaho Power	ID	\$0 - \$3k	Only homes w/o nat-gas
Full Cost Accounting	All US	\$10k - \$20k+	Value to ratepayers

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Program and Policy Thoughts

Put Incentives in the Ratebase

- 30+ year asset
- Benefits all Ratepayers
 - Those who benefit should pay
 - Amortization lowers annual cost
- Use "Utility Cost Test" to determine incentive
 - Not "Participant Cost or Total Resource Tests"

Planning

- They have an ELCC of 100%
 - Peak hour reliability
- Need accurate load shapes
 - Can get them from existing GHPs

Ratemaking

- More total kWh/yr
- Means lower rates for everyone
 - Another reason to Ratebase incentives

Mass Deployment to reduce cost

- Don't need new technology
- Need economy of scale
- Incentivize contractors to deliver >1,000 installations per year
 - For a few years per contractor.

Require Guaranteed Performance

- Ratepayer Value correlates with water temperature
- Require a 2nd year end-of-summer max T (or min winter T)
- Contractor is liable for liquidated damages to utility & building owner

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Agenda

- ✓ Terminology, Technologies, BAU
- ✓ Evidence of Grid Value
- ✓ About Data Centers and the Grid
- ✓ Quantifying GHP Impact (3 methods)
- ✓ State Incentives
- ☐ Cold BTES & Data Centers

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<https://www.vietjetair.com/en/destinations/experience/5-most-beautiful-new-years-fireworks-locations-in-the-world>

Summary

- **Three methods to estimate grid value**
 - Physics
 - Building modeling
 - Grid Modeling
- **GHPs are a Grid Asset**
 - Avoided peak value > \$5k/kW
 - The value is Universal
- **Incentives**
 - Ratebase is justified
 - Most utilities severely underestimate grid value
- **Look to the subsurface**
 - Many ways to create grid value
 - Address some of challenges with AI-DC load growth

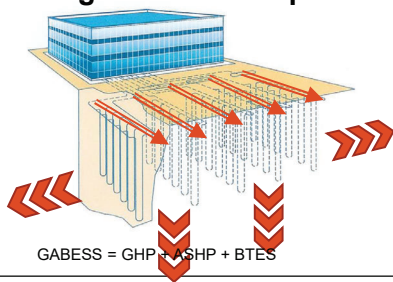
58

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“GHP Technologies”

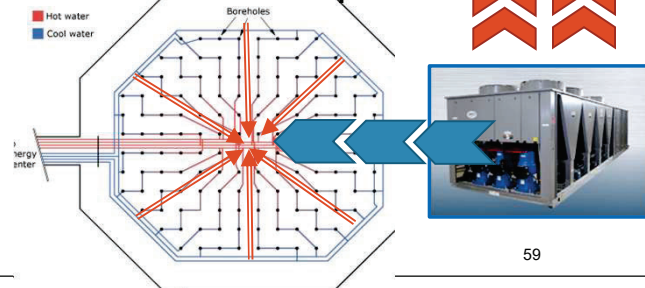
Traditional GHP Array

- Parallel Flow
- All external heat xfer via ground conduction
- Poor for extreme climates & unbalanced loads
- Large surface footprint



Borehole TES Array

- Radial or Parallel Flow
- All external heat xfer via electric ASHPs or chillers or dry coolers
- Effective in all climates and excels at unbalanced loads
- Smaller surface footprint

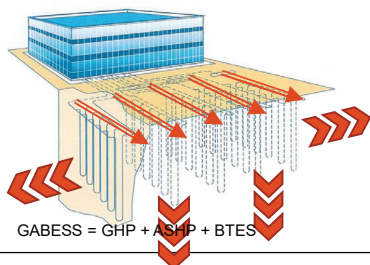


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Value Comparison

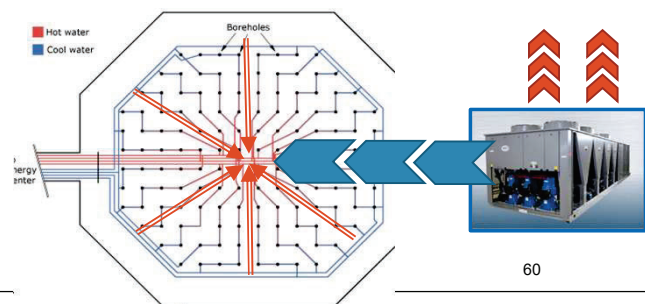
Traditional GHP Array

- Many Boreholes → Large CAPEX
- Grid Benefit when HVAC runs by reducing demand
- The bigger it is, the worse it does



GABESS BTES Array

- 40% to 50% reduction in CAPEX
- Same, AND grid benefit when charging off-peak energy into BTES
- The bigger the better



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Cold-BTES provides grid value (esp for large industrial & cooling loads)

Peak Hour Capacity Value (MW)

- Reduces Peak Power Requirement
- Negawatts = Megawatts
 - An avoided Megawatt is a "Negawatt"

Generation Asset Value (MWh)

- Enables new load with existing power plants
- Reduces need for new power & 4-hr batteries
- Ultra-long duration storage of green grid power

Transmission Capacity Value (MW)

- Enables new load on existing conductors (avoids new construction)

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Summary: Cold-BTES and the Grid

Data Centers are Changing the Grid

- Massive build-out is planned
- Power WILL get more expensive

Grid value of Cold-BTES has INCREASED

- Better ratepayer affordability
- Improved grid resiliency and reliability

Cold-UTES is an underutilized GRID asset

- Let's FIX THAT!

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Using Cold Geo-Thermos

For Data Center Cooling

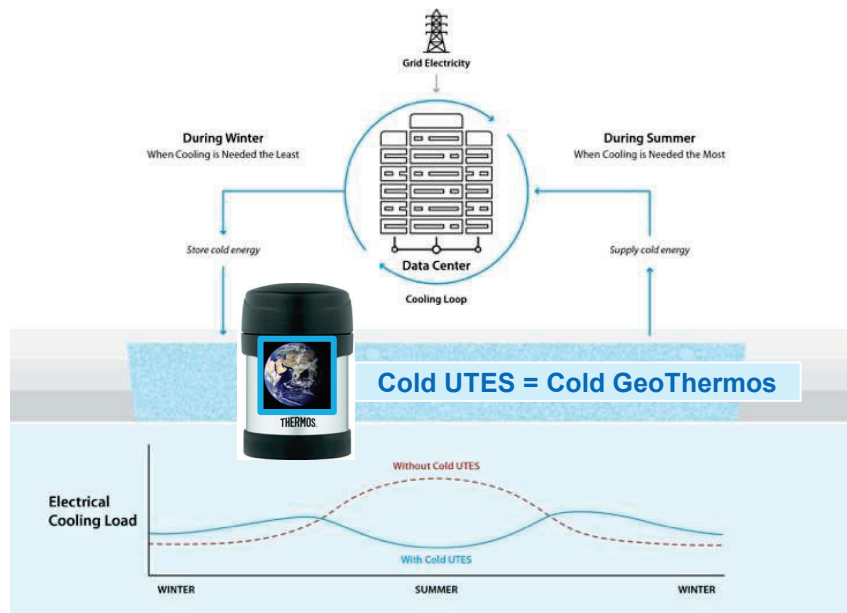
Term used by researchers in Norway to describe the ability of a BTES to hold energy for long periods

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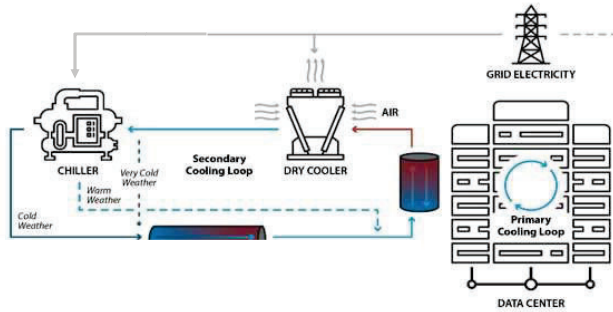
Cold GeoThermos Using Cold UTES to Reduce Peak Cooling Load



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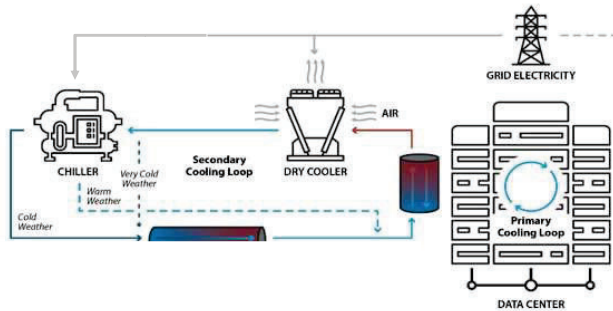
64

How to Cool a Data Center without Cold GeoThermos



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How to Cool a Data Center without Cold GeoThermos

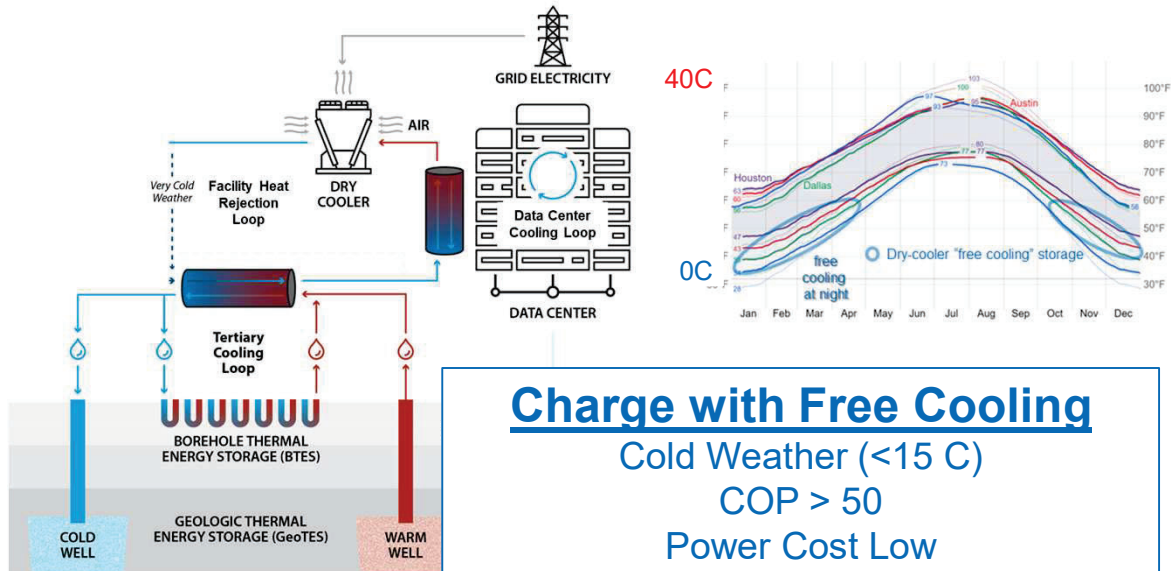


Primary Loop
Operating Temperature
Case 1: 30C / 40C
Case 2: 40C / 50C

Future:
Nvidia is targeting 45C / 55C

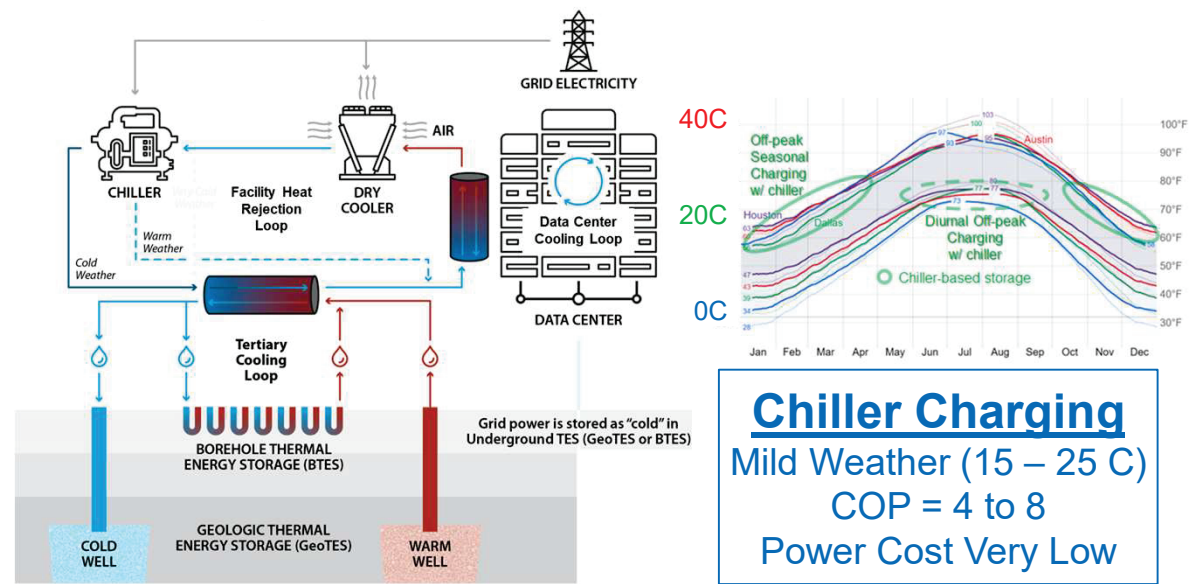
66

Charge the Geo-Thermos with Dry Coolers

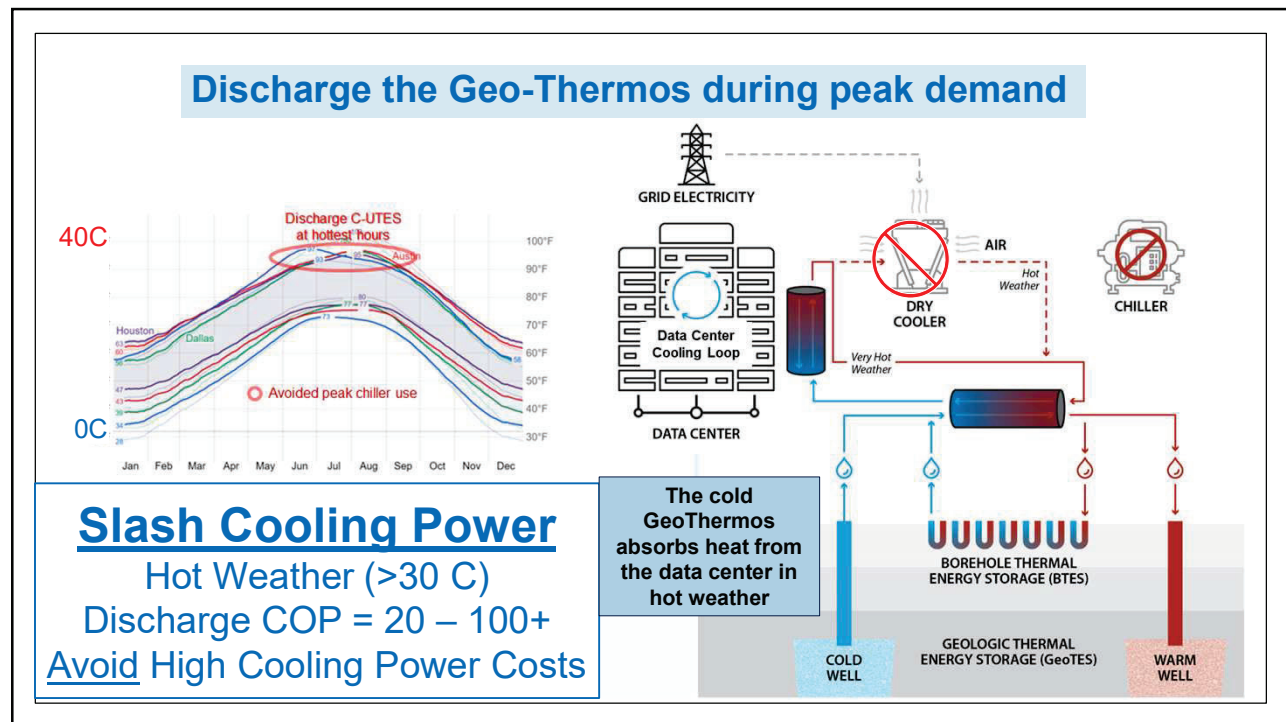


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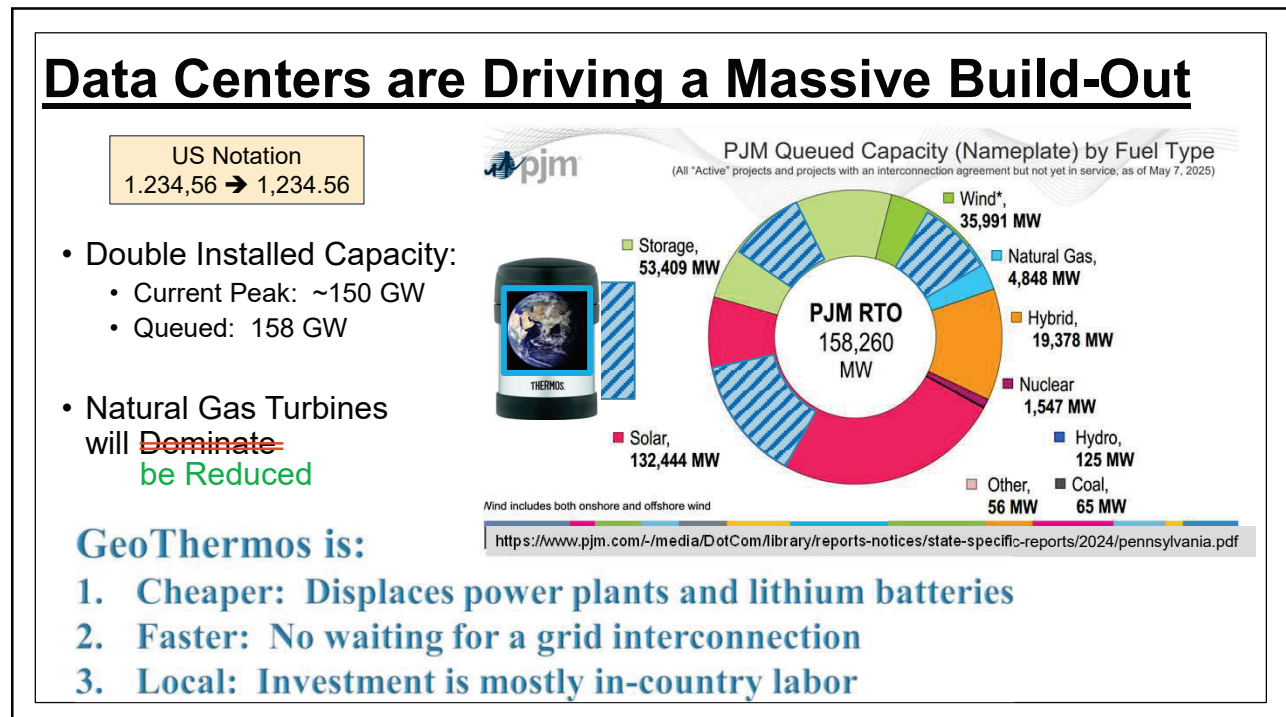
Charge the Geo-Thermos with Chillers



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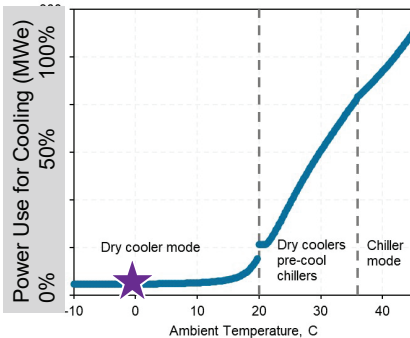
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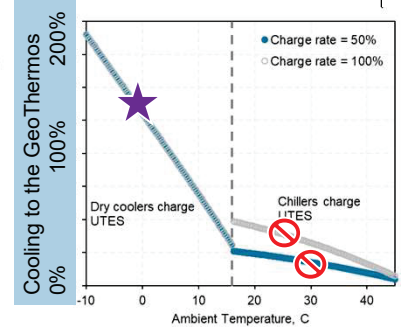
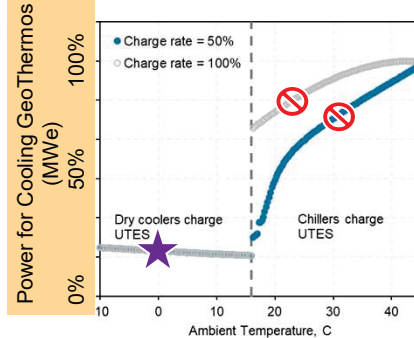
70

Unused cooling system capacity “fills” the Cold GeoThermos

Normal Data Center Cooling Power vs Air-T



Cold GeoThermos Performance Incremental Power & Stored Thermal Energy



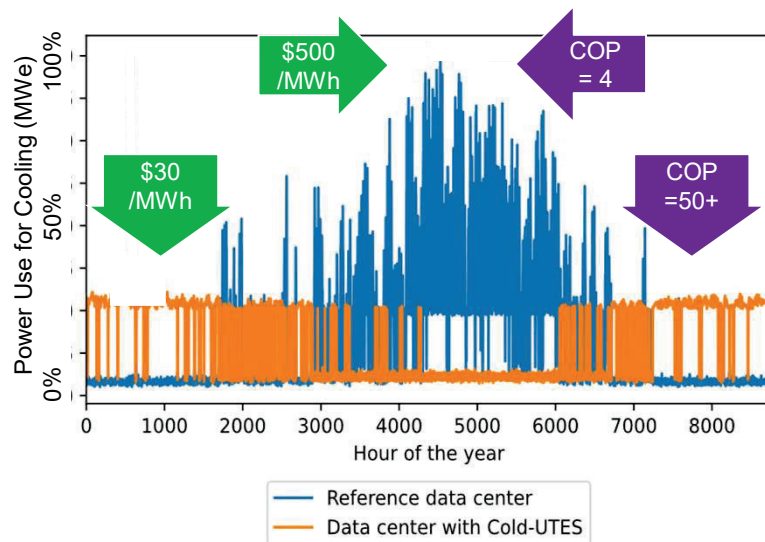
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Cold GeoThermos Cuts Cooling Power Peak Use (Using Ultra Long Duration Grid Energy Storage)

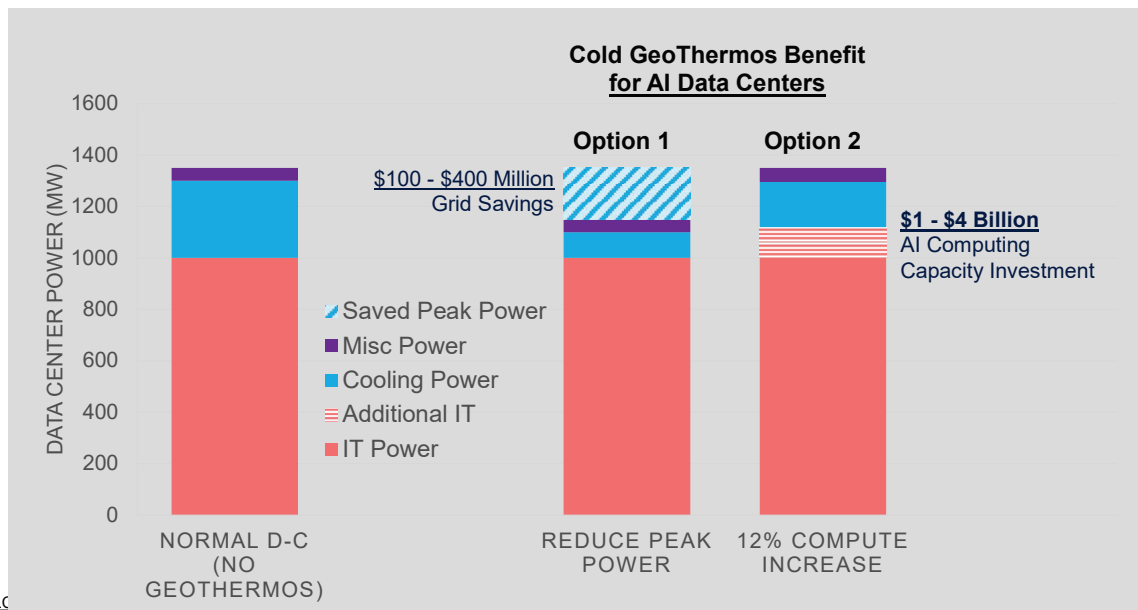
Double Arbitrage

- **\$30 Power Replaces \$500 Power**
 - >10X Benefit
- **COP = 50+ Replaces COP = 4**
 - >10X Benefit



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Data Centers with 1350 MW Interconnection limit



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Thank you.

Questions?

Kevin Kitz, P.E.

Kevin@KitzWorks.com

208-761-3442

Supported by:



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