6th Thermal-Mechanical-Chemical Energy Storage Workshop
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THE POWER MARKET LANDSCAPE

STRATEGIC ASSESSMENT: WHERE COULD LONGER-TERM DURATION STORAGE PLAY A BIGGER AND MEANINGFUL ROLE?

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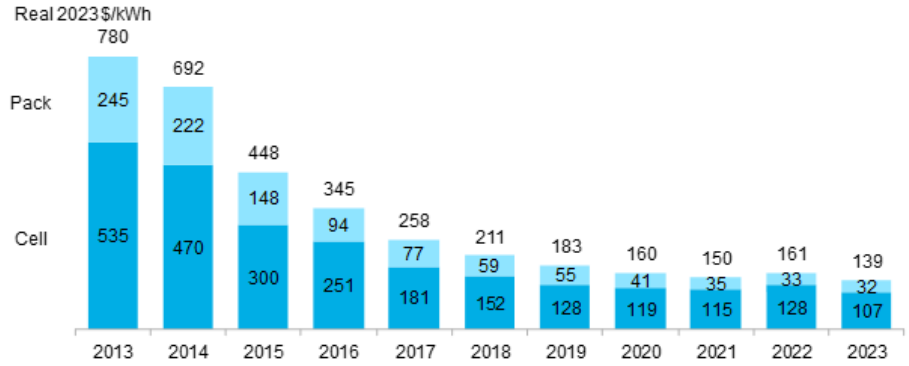
The cost keep falling…

- Last year's presentation explored the crucial role of utilization in storage economics.
- We observed that longer-term storage typically translates to lower utilization.
- Consequently, cost-effectiveness is paramount for long-term storage solutions.
- Additionally, we identified a potential need for a regulatory revenue line item in the long-term storage market, as the spot market may not be able to sustain it independently.
- This year, we shift our focus to the increasingly competitive landscape.
- The benchmark for cost-effectiveness is constantly evolving.
- As the market scales, Li-ion batteries are likely to see continued cost reductions over time.
- Similar to the solar industry, actual battery deployments will likely be greater than forecasts for several years.

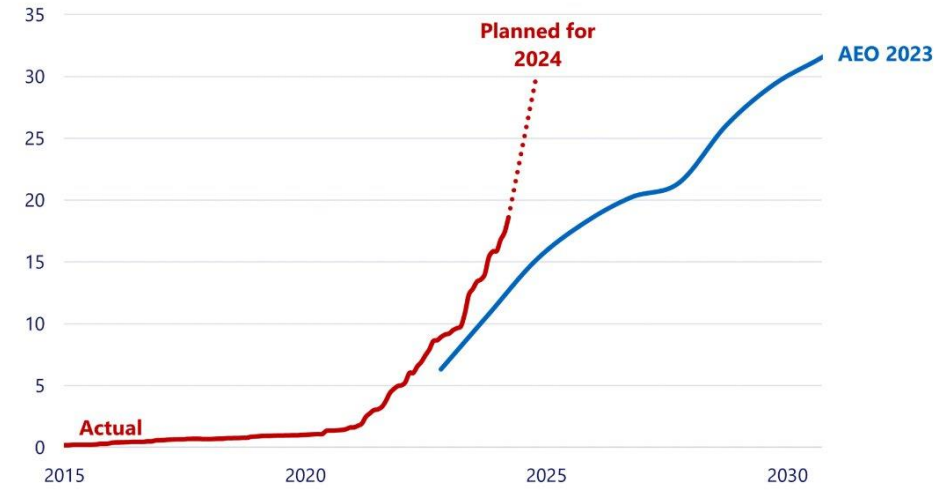
Figure 1: Volume-weighted average lithium-ion battery pack and cell price split, 2013-2023



Source: BloombergNEF. Historical prices have been updated to reflect real 2023 dollars. Weighted average survey value includes 303 data points from passenger cars, buses, commercial vehicles, and stationary storage.

Figure 7. Grid-Scale Storage Continues to Advance Ahead of Projections

Gigawatts

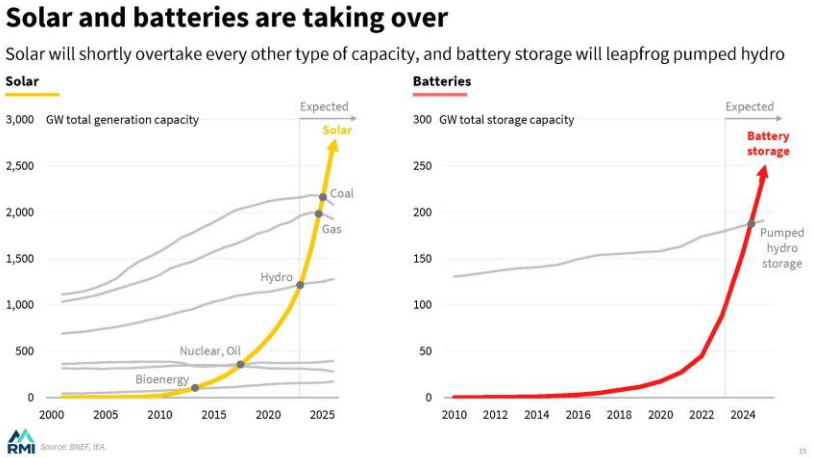


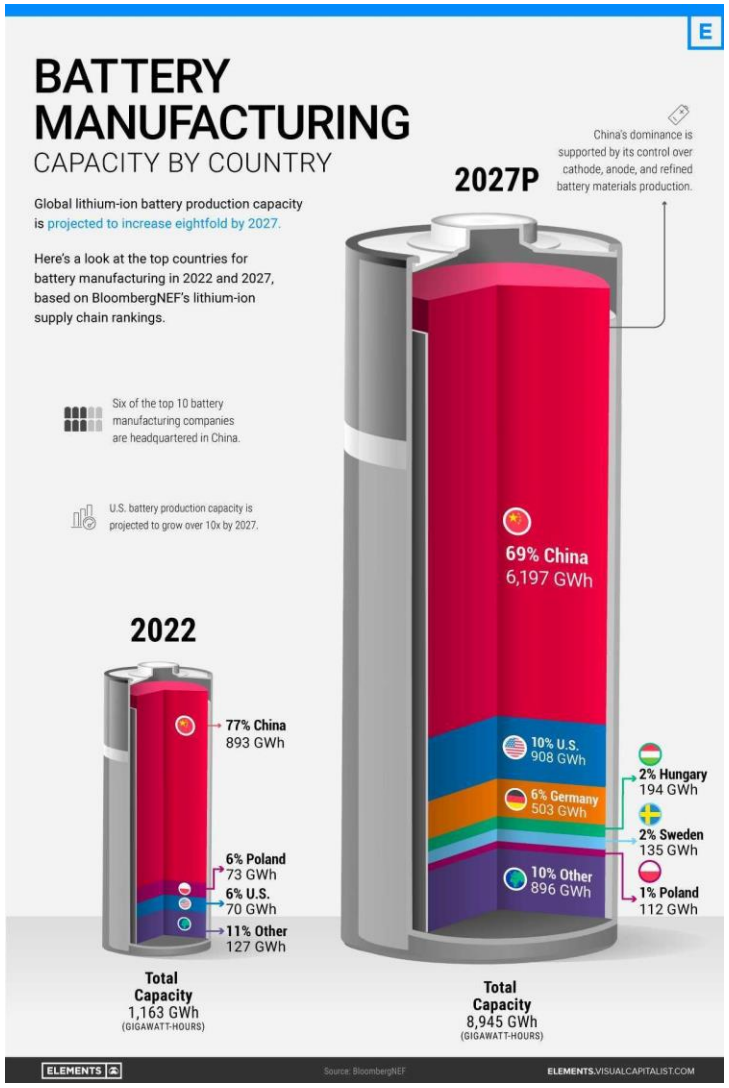
Source: U.S. Energy Information Administration.
Note: Projections from EIA Annual Energy Outlook. Actuals from EIA Monthly Energy Review. Planned from EIA Form 860M.
As of June 27, 2024 at 12:00pm.

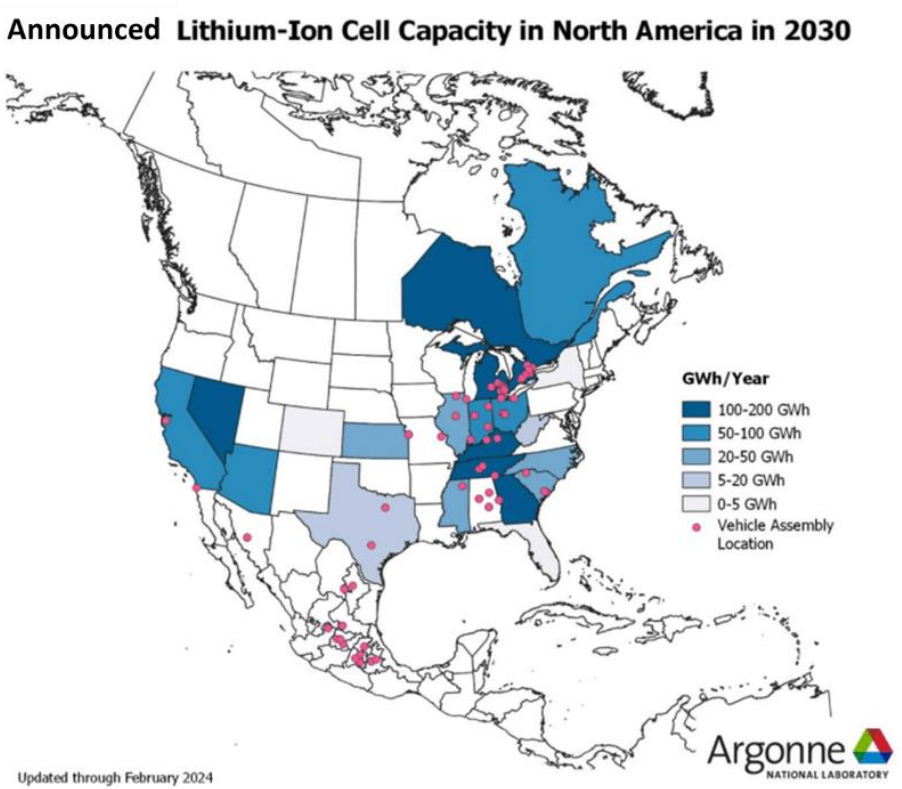
Manufacturing is key

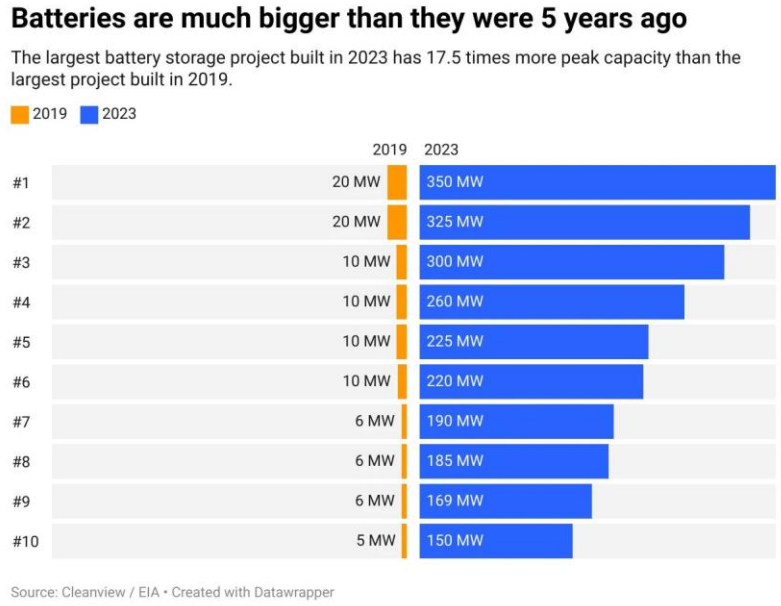
The significant expansion of lithium-ion battery manufacturing capacity is transforming the entire value chain.

Are your supply chains competitve?









More Competition?

Other Storage:

Stanford Unveils Game-Changing Liquid Fuel Technology for Grid Energy Storage (scitechdaily.com)
Liquid Fuel Technology - liquid organic hydrogen carriers (LOHCs)
https://www.yahoo.com/tech/scientists-crucial-discovery-could-revolutionize-090000448.html
Supercapacitors
https://cleantechnica.com/2024/05/30/energy-storage-pumped-hydro-texas-startup-investor/
Pump Storage but with storage reservoir in underground rock formations

With a potential 10 GW of load across the US, Bitcoin mining can significantly contribute to grid stability. Bitcoin mining is uniquely positioned to respond quickly to changes in power prices due to its economic incentives and technical capability to ramp up or down within the hour.

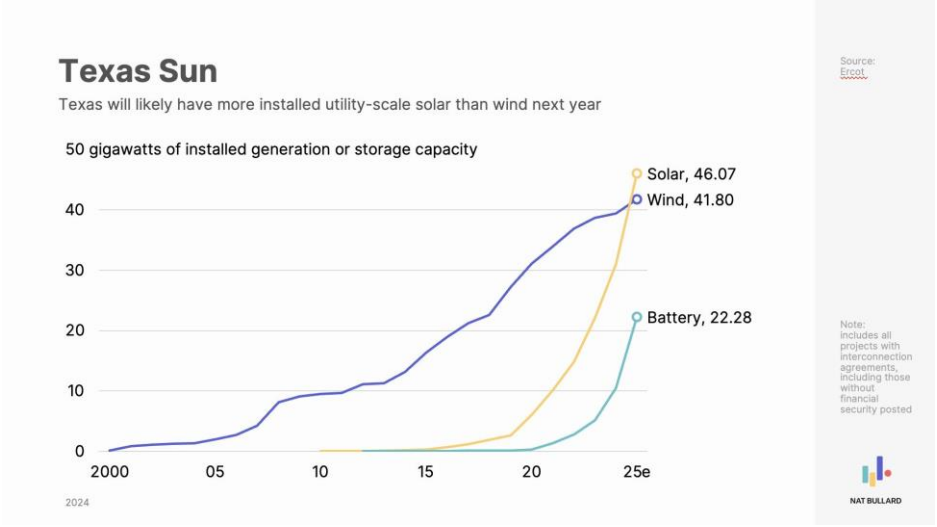
Datacenter loads: While some datacenter loads, specifically those used for training and high-latency applications, can be adjusted, current economics make this impractical. Disconnecting these loads would only be economically viable when electricity prices exceed $3,000/MWh, unlike Bitcoin mining which remains profitable below $200/MWh.

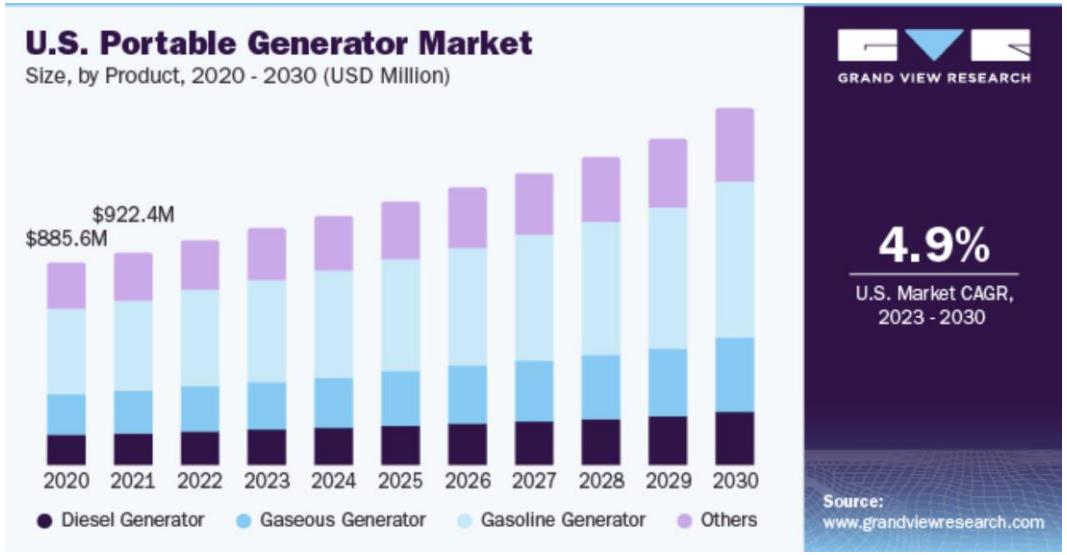
Reliability Societal or Individual

Should we invest in a level of reliability that exceeds the needs of the general public but caters to a select group who require absolute uptime?

The recent situations in ERCOT highlights the concern that the grid may not be fully equipped to handle the increasing integration of wind, solar, and battery storage. Long-term issues could lead to extended outages.

The absence of capacity markets in ERCOT has resulted in the creation of several alternative markets, effectively replicating a capacity market structure. These include ancillary services markets, Energy Emergency Response Services (ECRS), and Operating Reserves Demand Curve (ORDC), all of which contribute to the overall cost of ensuring grid reliability.





Who pays for all this – the rate payers?
Who truly benefits from this increased reliability?
Loss of load expectation (LOLE) set reliability targets, often aiming for no more than one outage day in 10 years – this is 2.4 Hours a year. Distribution system also has their own loss of load targets System Average Interruption Duration Index (SAIDI) System Average Interruption Frequency Index (SAIFI) Customer Average Interruption Duration Index (CAIDI)

Reliability Societal or Individual

- Finding the optimal balance between high reserve margins and their associated costs remains a critical challenge.
- Consumers illustrate this trade-off with their own backup power solutions.
    - Residential options range from portable generators and solar battery systems (priced between $5,000 and $50,000) to full-home protection.
    - Even in affluent areas, not everyone chooses complete backup.
    - For some, financial resources allow alternative solutions like temporary relocation during outages.
- Businesses mirror this cost-benefit analysis with their backup power choices.
    - Options range from no backup to portable generators to large, fixed installations costing millions, as seen in hospitals, grocery stores, and data centers.
- Evaluating the cost of designing a system to handle "routine" rolling blackouts compared to maintaining high reserve margins is crucial.
- If policymakers (RTOs and PUCs) acknowledge an acceptable level of outages, a market can emerge for scalable technologies that cater to those willing to pay for increased reliability.

Datacenter

Tier 1 – 28.8 Hours Downtime per year

Tier 2 – 22 Hours Downtime per year

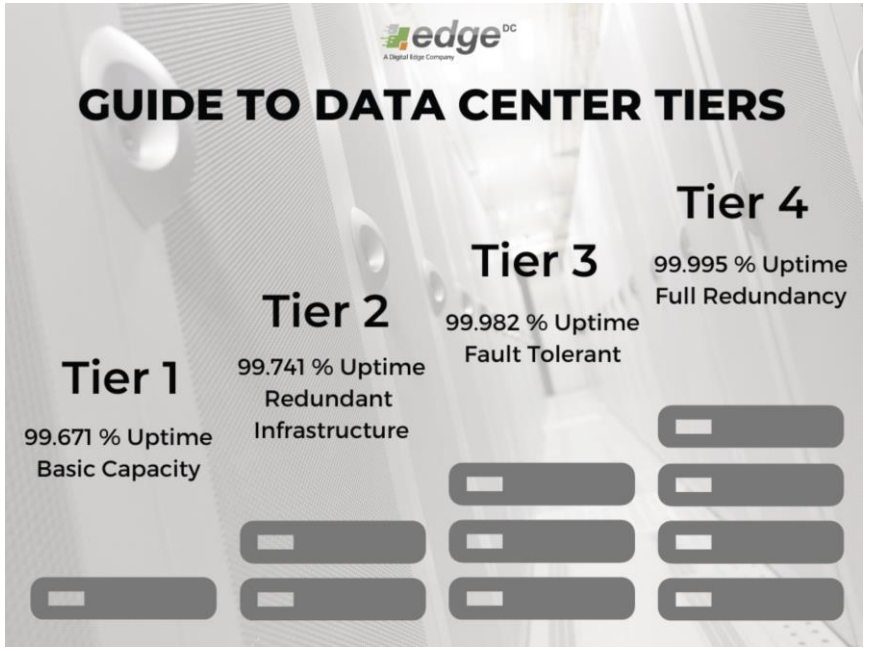
Tier 3 – 1.6 Hours Downtime per year

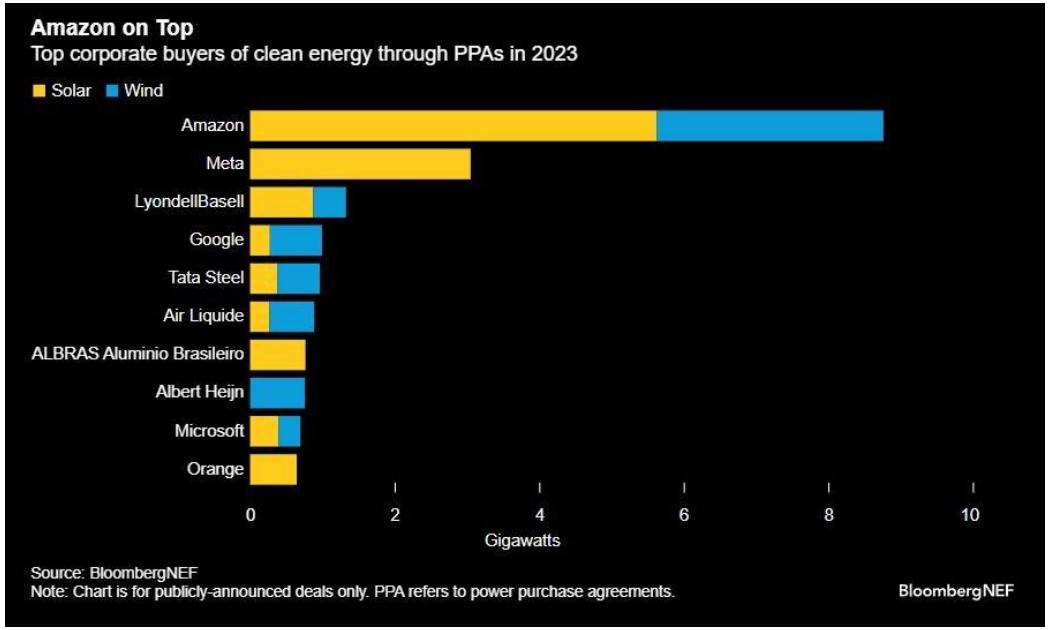
Tier 4 – 26.3 Minutes Dowtime per year

Lead times for backup diesel generators 18mth+

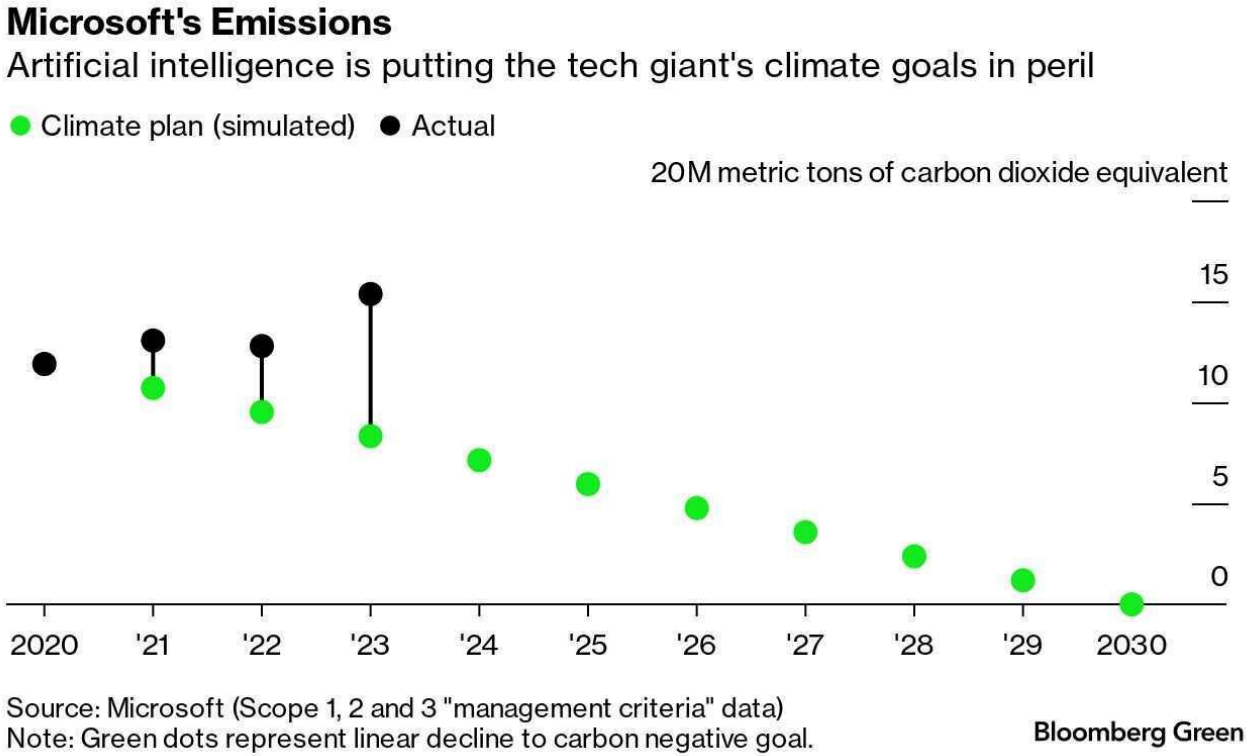
Economics of Datacenter is not that complicated and yes it can be very lucrative .

10 MW Build				
Datacenter Build	$ 360,000,000			
H100	7840	Unit		
Utilization of Datacenter	75%			
Power Price Cases $/MWh	100	1000	2000	3000
Cost of Power	$ 9,385,714	$ 93,857,143	$187,714,286	$ 281,571,429
H100 Rental	5	$/Hr		
Potential Annual Revenue	$ 257,544,000			
Power % of Revenue	4%	36%	73%	109%





Datacenters want to be green AND want ATC reliability



Google Sustainability Report

ENERGY		2023		
Energy consumption	**Unit**	**Renewable sources**	**Non-renewable sources**	**Total**
Fuel	MWh	68,300	232,900	301,200
Purchased electricity[7]	MWh	15,672,000	9,580,600	25,252,600
Purchased heat[8]	MWh	0	278,500	278,500
Purchased steam	MWh	0	14,500	14,500
Purchased cooling	MWh	0	53,000	53,000
On-site renewable electricity	MWh	10,700	0	10,700
Total energy consumption	**MWh**	**15,750,900**	**10,159,600**	**25,910,500**

Is it possible to develop a cost-effective long-duration energy storage system that can address both short-term and long-term energy needs?

Such a system could be a game-changer if enabling facilities to achieve sustainability goals while simultaneously providing backup power capabilities.

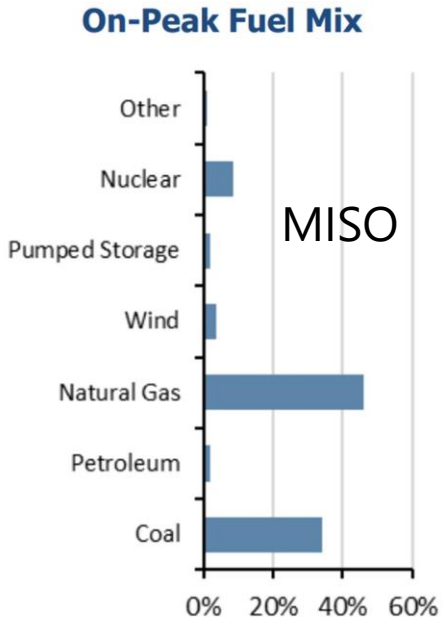
Being Green Requires More Work

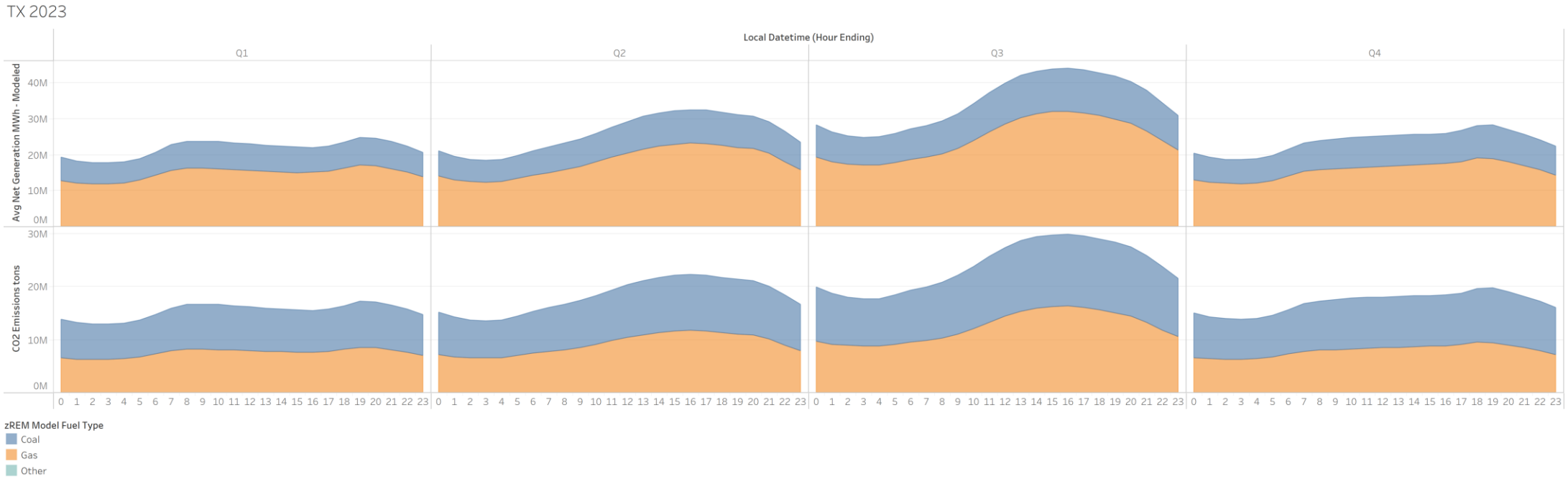
Energy storage can play a crucial role in minimizing CO2 emissions from data centers.

Data centers connected to the grid can utilize on-site storage to significantly reduce their carbon footprint and contribute to a cleaner grid.

For facilities prioritizing CO2 reduction, strategically deploying battery storage with a capacity of approximately 12 hours a day can minimize carbon emissions.

In this scenario, the primary driver for storage adoption is not cost reduction, but rather CO2 emissions reduction.





Conclusion

- Long-duration energy storage inherently comes at a higher cost and may see less utilization compared to shorter-duration options. However, it offers significant benefits in terms of increased uptime during disruptions.
- Lithium-ion battery costs continue to decline and this trend is expected to persist with the global expansion of manufacturing facilities.
- The increasing integration of renewable energy sources necessitates greater grid reliability, making storage a key driver.
- A critical question arises: Should the responsibility for high reliability shift towards consumer discretion, or will the grid continue to prioritize a level of reliability exceeding what society is willing to pay for?
- Data centers experiencing significant load growth and require a highly reliable, clean energy source.
- Developing long-duration thermal-mechanical energy storage solutions specifically designed for data centers could be an ideal solution.
- Data centers possess the capability and willingness to invest in premium products that deliver superior reliability and environmental benefits.