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What will the mission for critical power equipment look like in 2030, and why?

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2025 – 2030 Megatrends

Frequent power interruptions &

Skyrocketing costs for electricity:

A “perfect storm”

- Huge increments of new electric load
  - Data centers
  - Electrification of everything: cooking, heating, transportation
  - Reshoring
- Mass retirement of dispatchable generation
- Increased failures of aged grid equipment

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The Perfect Storm: 2025 – 2030 Megatrends

Reshoring

Datacenter Growth

Electrification of Everything
Cooking, heating, transportation

Mass retirement of dispatchable generation

Huge increments of new electric load

Increased failures of aged grid equipment

Quotations from the DOE Report July 2025

Retirements Plus Load Growth **Increase Risk of Power Outages by 100x** in 2030

Planned Supply Falls Short, Reliability is at Risk

… the model shows a significant decline in all reliability metrics between the current system scenario and the 2030 Plant Closures scenario. Most notably, there is a **hundredfold increase** in annual LOLH from 8.1 hours per year in the current case **to 817 hours per year in the 2030** Plant Closures. In the worst weather year assessed, the total lost load hours increase from 50 hours to 1,316 hours.

Source: Department of Energy, "Resource Adequacy Report: Evaluating the Reliability and Security of the United States Electric Grid", July 2025

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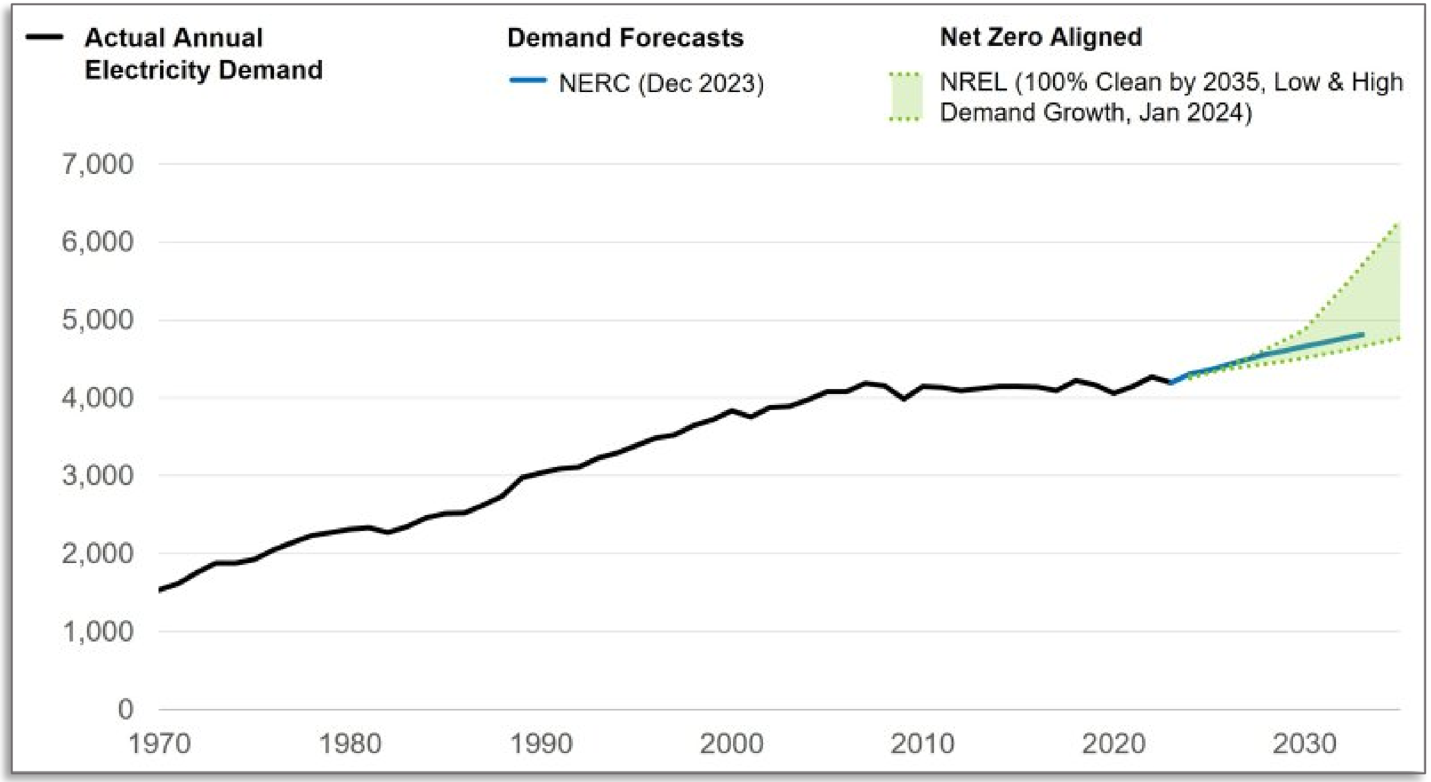
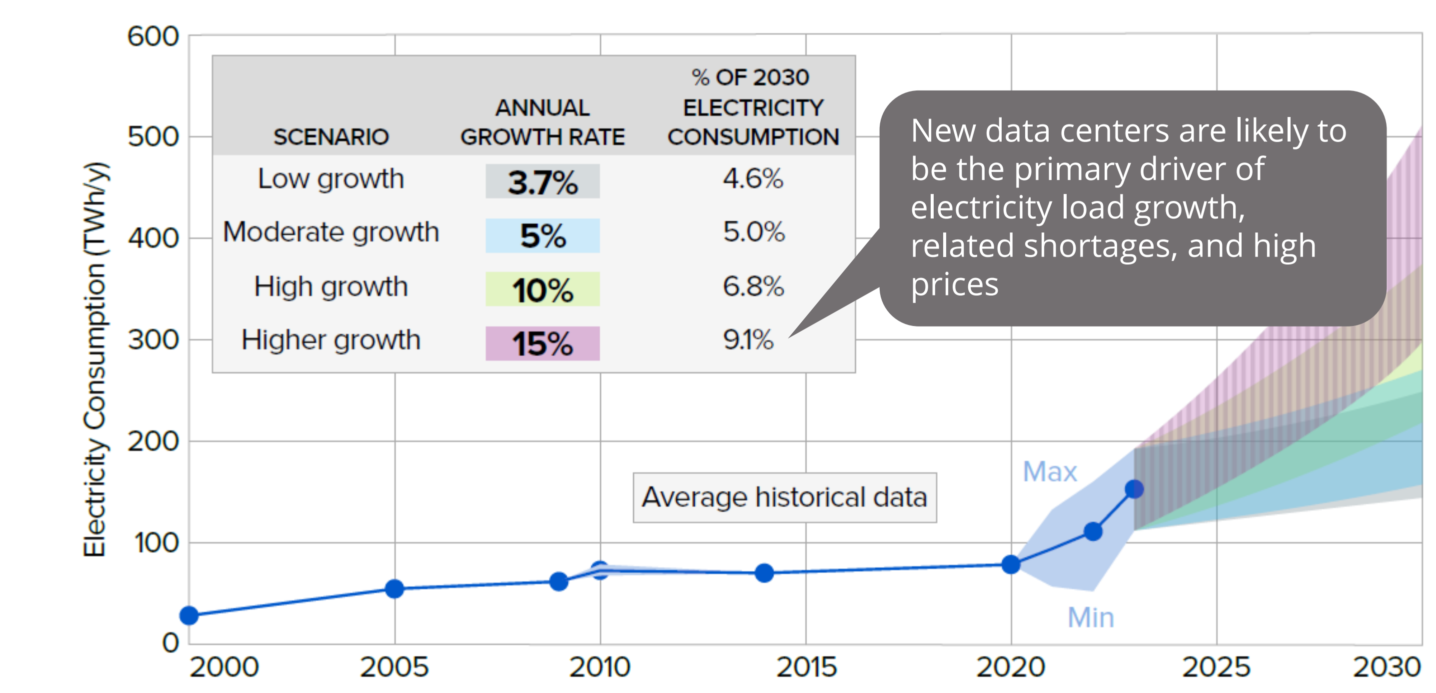
Flat demand replaced by high growth

U.S. Actual and Forecasted Electricity Demand — 1970-2035



Source: Department of Energy, "Clean Energy Resources to Meet Data Center Electricity Demand"

Projections of Potential Electricity Consumption by U.S. Data Centers: 2023 - 2030



SCENARIO	ANNUAL GROWTH RATE	% OF 2030 ELECTRICITY CONSUMPTION
Low growth	3.7%	4.6%
Moderate growth	5%	5.0%
High growth	10%	6.8%
Higher growth	15%	9.1%

Figure ES-1. *Projections of potential electricity consumption by U.S. data centers: 2023–2030 . % of 2030 electricity consumption projections assume that all other (non-data center) load increases at 1% annually.*

Source: EPRI Report, "Powering Intelligence," May 2024

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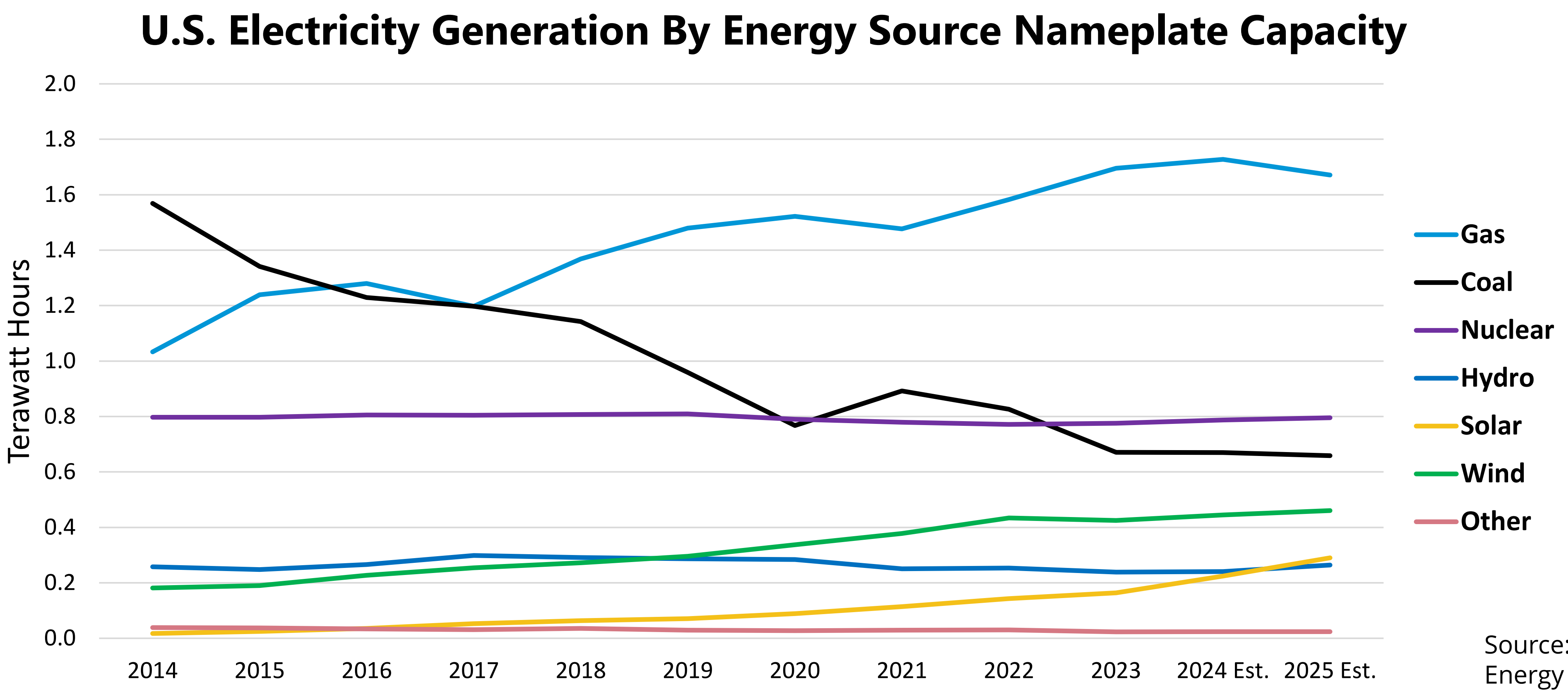
Retirement of Dispatchable Generation



Source: U.S. EIA Short-Term Energy Outlook, August 2024

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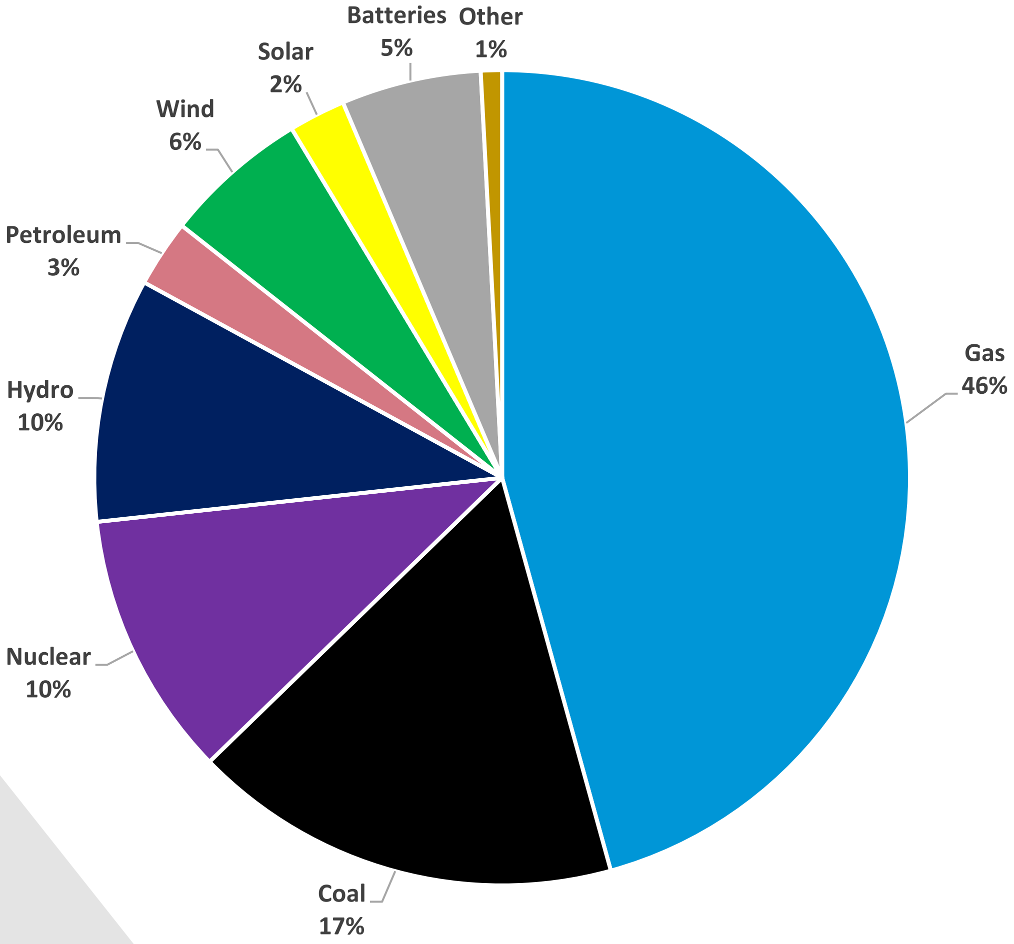
Retirement of Dispatchable Generation

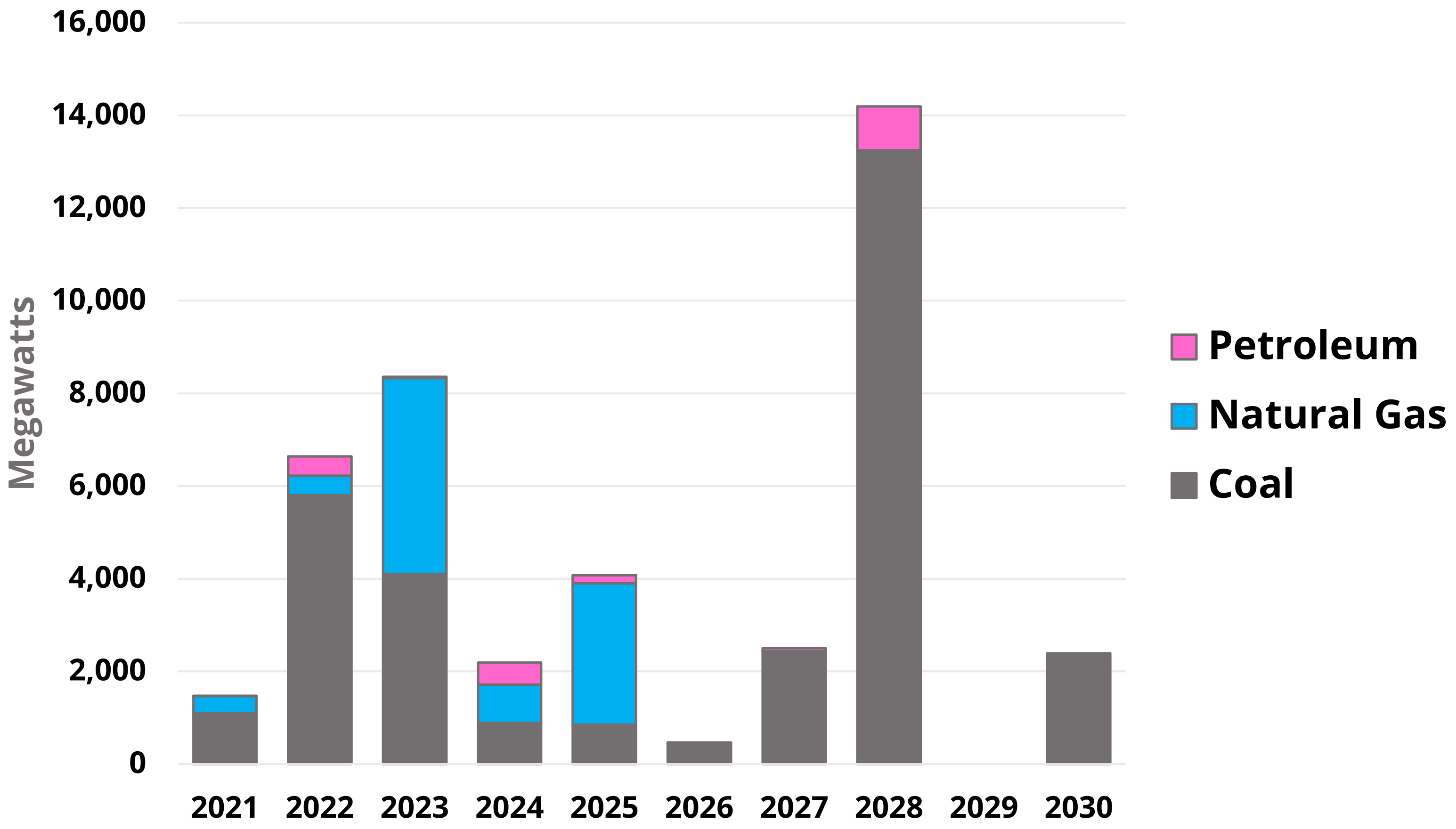
- Coal plants still account for large proportion of U.S. generating capacity
- EPA regulations will cause retirement of many coal plants by 2030
- Derated solar and wind generators cannot replace dispatchable coal generation
    - Solar at **21%** of Nominal Capacity
    - Wind at **33%** of Nominal Capacity
- When coal plants are gone, today's reserve margins of 15% will be far less for many areas
- Without dispatchable capacity, rolling blackouts will be likely during hot and cold spells

2023 Derated U.S. Generating Capacity—843 GW



Source: U.S. EIA Short-Term Energy Outlook, August 2024; NERC Generator Availability Data System (GADS); Foundation for Resilient Societies analysis

PJM Past & Expected Retirements



Sources: U.S. EIA Form 860-M, Integrated Resource Plans submitted to state PUC, Court-approved settlements, Trade press, Public statements by company officials, SEC reporting, Foundation for Resilient Societies analysis

PJM 4 R's Report Predicts Power Shortage

- ▶ Retirements, Low New Entry, and Load Growth likely cause Reserve Margins to dip below Prudent Level of 15%

Source: "Energy Transition in PJM: Resource Retirements, Replacements & Risks," February 24, 2023 (annotated)

Balance Sheet Summary (2022–2030)				
Retirements	**New Entry Wind/Solar**[6]	**New Entry Standalone Storage**	**New Entry Thermal**	**Load Growth**
40 GW **60% Coal** **30% Natural Gas** **10% Other**	**Low =** 48 GW-nameplate / 8 GW-capacity **High =** 94 GW-nameplate / 17 GW-capacity	**Low =** 3 GW **High =** 4 GW	**Low =** 4 GW **High =** 9 GW	**2023 Forecast =** 11 GW **Electrification Forecast =** 13 GW

Table 1. Reserve Margin Projections Under Study Scenarios

Reserve Margin	2023	2024	2025	2026	2027	2028	2029	2030
Low New Entry								
2023 Load Forecast	23%	19%	17%	15%	11%	8%	8%	5%
Electrification	22%	18%	16%	13%	10%	7%	6%	3%
High New Entry								
2023 Load Forecast	26%	23%	21%	19%	17%	16%	17%	15%
Electrification	25%	22%	20%	18%	15%	14%	14%	12%

Why Electricity Prices Could Quadruple

Two-thirds of U.S. electric grid has electricity markets

- ERCOT, SPP, PJM, MISO, NYISO, CAISO, ISO-New England

Market price is determined by **supply and demand**

During most days and hours, electricity supply responds to demand to set reasonable prices

With **3-8 years to replace retired plants**, the maximum supply of electricity (capacity) cannot be expanded in the short-term to meet unusual demand conditions

During "scarcity" (e.g., near-blackout conditions), all electricity markets have price caps – up to 100x "normal"

Extended operation at price caps could increase average prices significantly – by factors of 2, 3, 4, or more!

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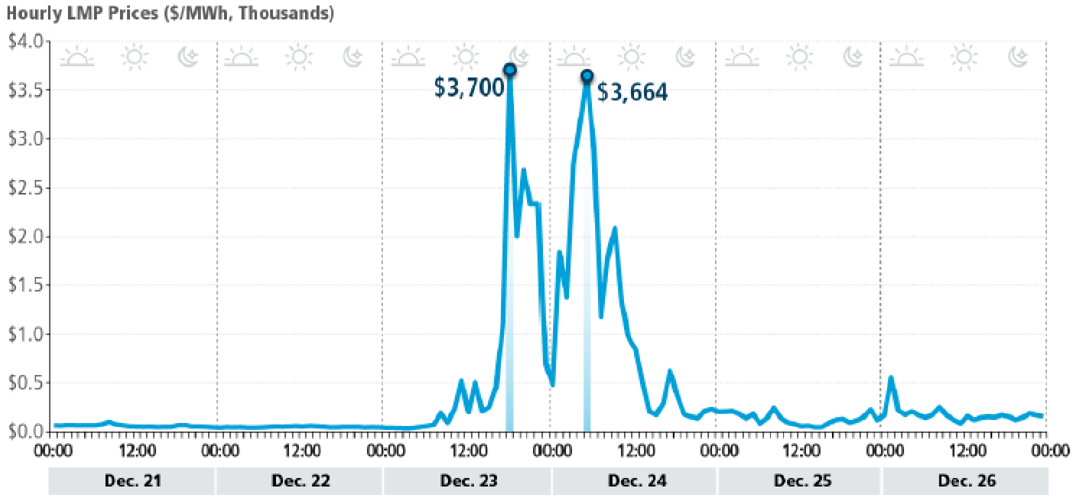
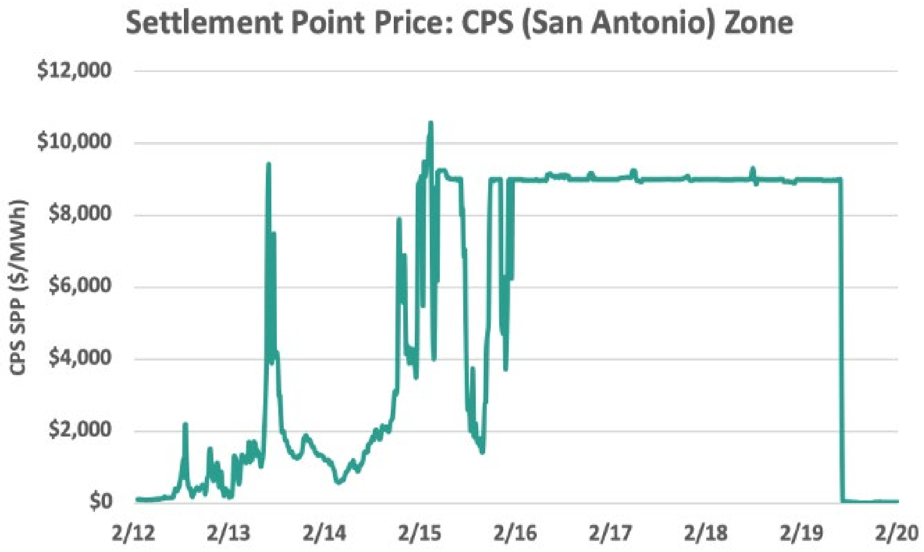
Examples

ERCOT Winter Storm: Peak Price 200x Norm



Source: The Timeline and Events of the February 2021 Texas Electric Grid Blackouts

PJM Winter Storm: Peak Price 86x Norm



ERCOT real-time wholesale electricity prices during February 12-19 in the San Antonio Zone of ERCOT

Source: Winter Storm Elliott: Event Analysis and Recommendation Report

4x Price W'Sale Price Operating at Rate Cap

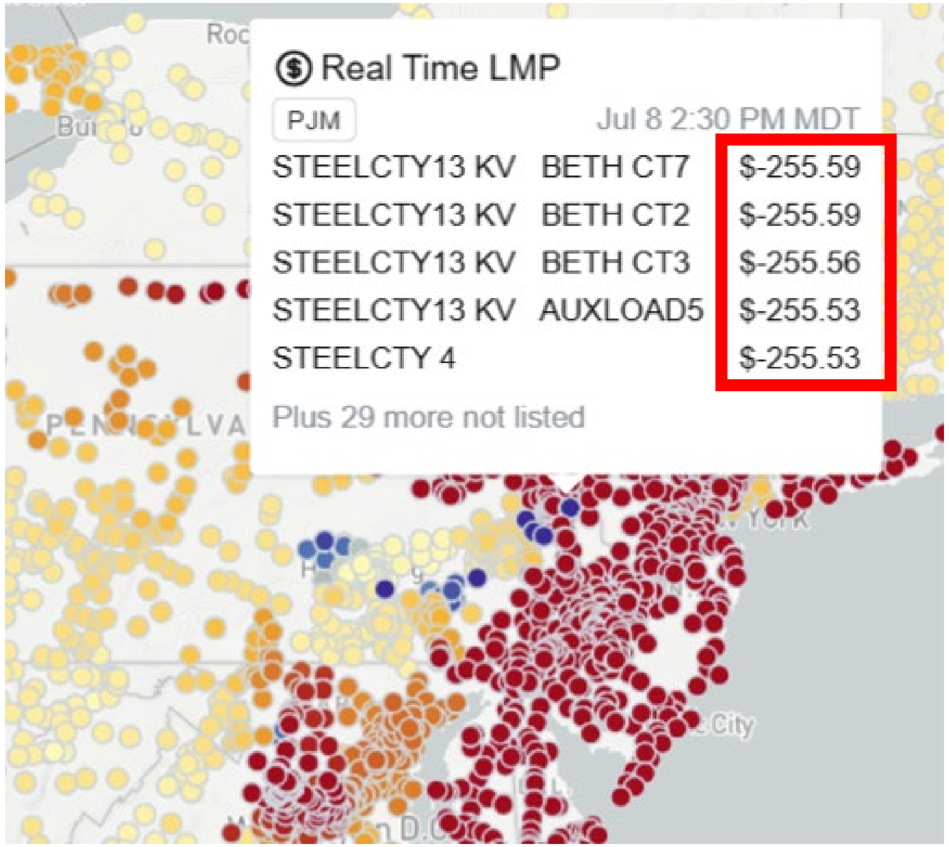
Electricity Market	Price Cap	Average Annual Wholesale Price ($/MWh)	4X Prices	Annual Cap Hours for 4X Prices	Cap Hours Percent of Year	Average Wholesale Price
ERCOT	$5,000	$45	$180	239	2,7%	$180
Southwest Power Pool	$6,500	$36	$144	146	1.7%	$144
PJM	$3,700	$43	$172	308	3.5%	$172
Mid-Continent ISO	$3,500	$36	$144	272	3.1%	$144
ISO-New England	$3,000	$47	$188	418	4.8%	$188
New York ISO	$2,000	$41	$164	550	6.3%	$164
California ISO	$2,000	$30	$120	400	4.6%	$120
ERCOT–2021 Storm Uri Scenario	**$9,000**	**$45**	**$180**	**90**	**1.0%**	**$137**
ERCOT–2021 Actual Performance						**$168**

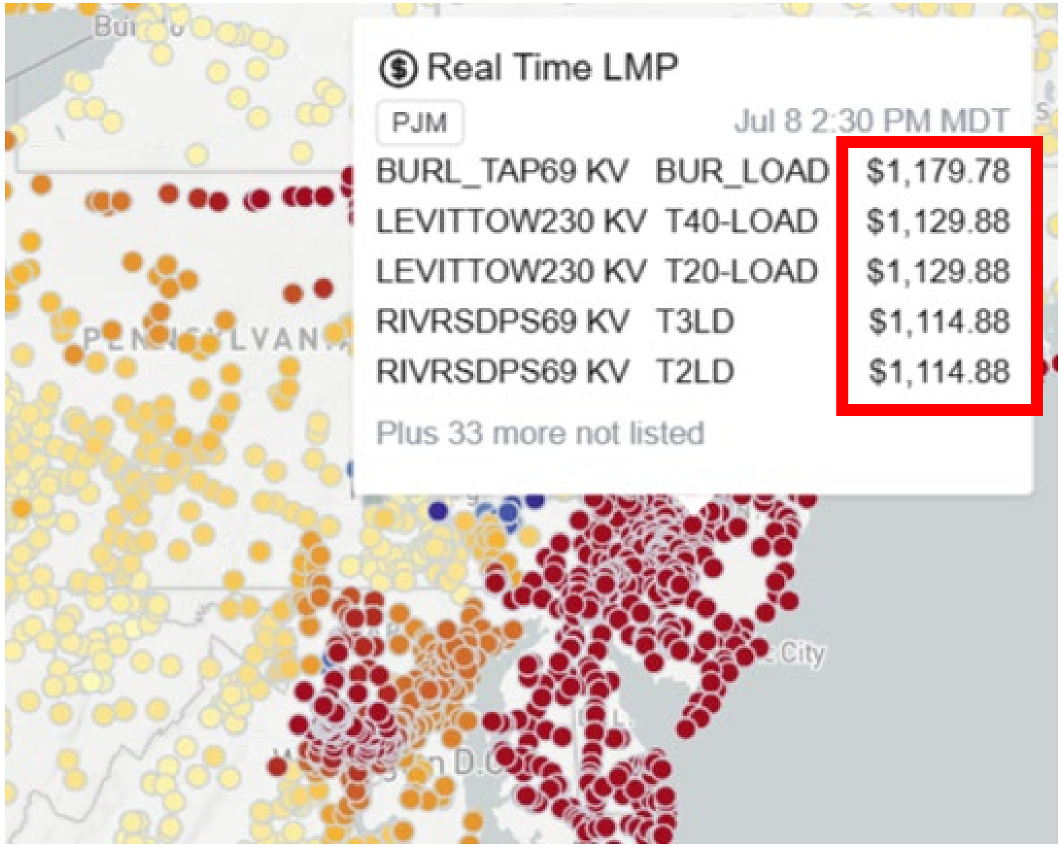
What would a 4x power bill mean?

AT&T $1.6 bn/year electric bill. Price Δ = $4.8 bn, is 39% of net income	Google est. $2 bn/year US electric bill. Price Δ = $6 bn, is 6% of net income	Estimated financial institution (JP Morgan, Morgan Stanley, etc.) electric bill is "low hundreds of billions". MS net income for 2024 was $12.8 bn. Assuming $250 bn expense now, price Δ of $750M would be a 6% reduction in net income	These higher costs would recur *every year*

- Key Point: 6% to 39% are enough of a profit hit to incentivize capital spending. Electric cost increase could trigger billions of dollars to be spent on bigger batteries, new power electronics & other equipment (e.g. switchgear for gensets to operate in parallel with grid)

7/8/25: Average Day in PJM. Who is making money?





Near-Term Solution

On-Site Energy Assets

Minimize consumption when power is most expensive

Maximize consumption when it is cheap

Get paid to keep the grid from collapsing

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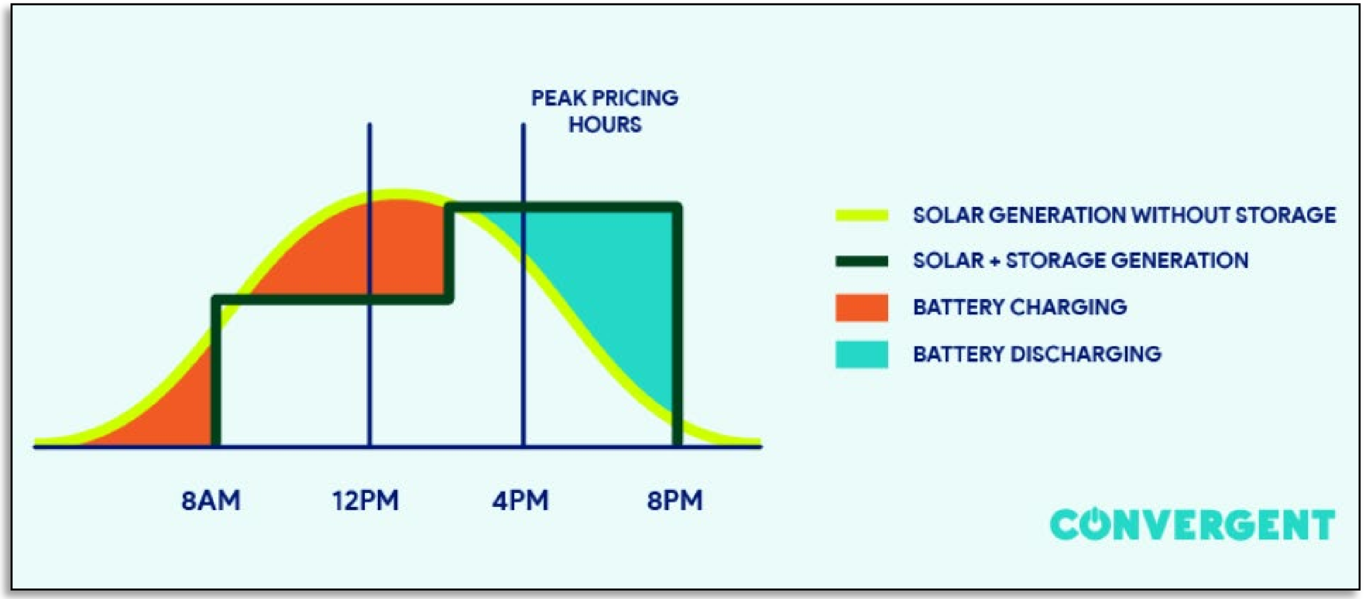
Mitigation 1: Cut T.O.U. Charges



Shift time of power consumption

Consume from battery instead of grid during high-cost hours

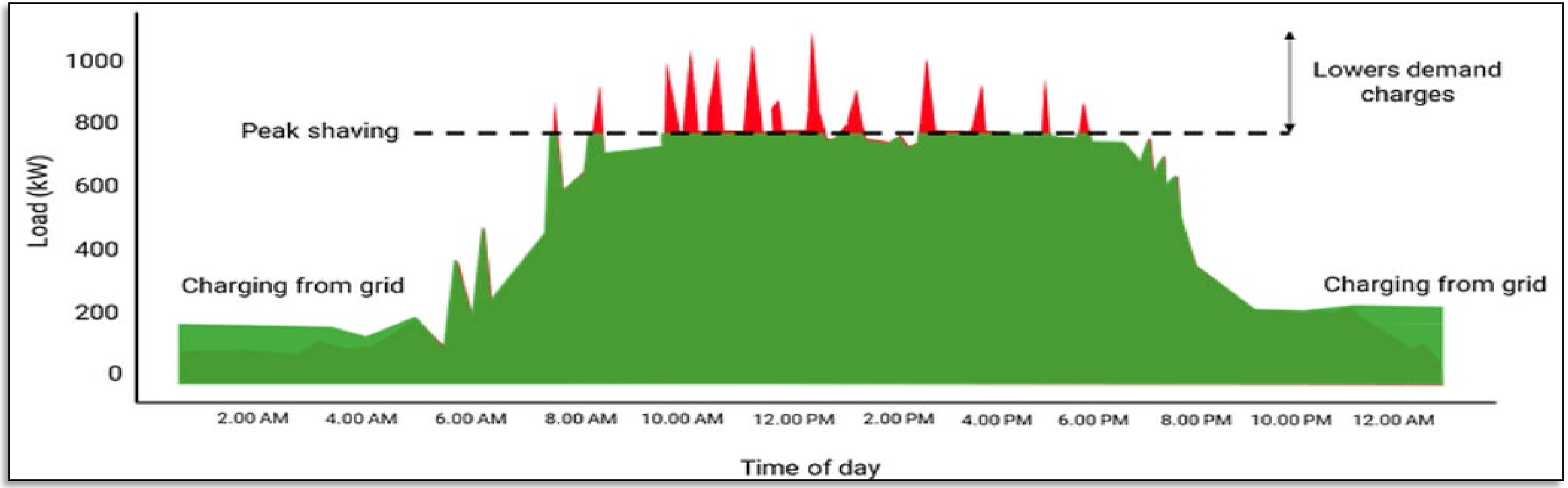
Recharge when power is cheap

Mitigation 2: Reduce Demand Charges

Utilities charge industrial customers based on highest 15-min consumption period

Strategy: dispatch battery when meter detects highest usage

- Shave off short demand peaks that would otherwise multiply facility electric costs
- Side benefit: when enough firms peak shave, risk of utility blackouts is reduced



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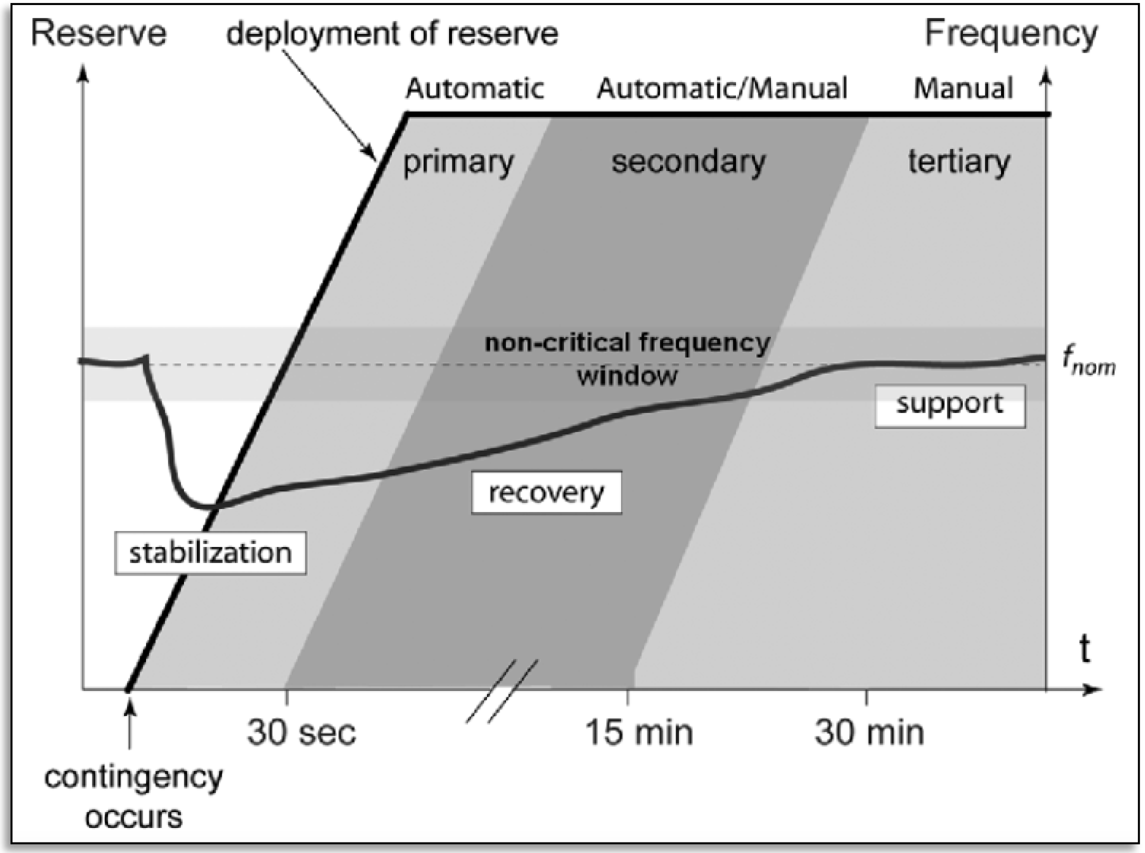
Mitigation 3: Get paid for P.F. Response



Renewables-based grids offer no "spinning reserve"

Failure to provide fast-acting frequency support leads to grid instability and eventual collapse

New Role for Critical Power Batteries

Stack the revenue application atop the critical power application

- Big benefit of regular plant exercise
- Skilled staff in short supply. Retask existing skilled staff with expanded mission

Upsize batteries and power electronics to handle revenue application

Leave designated reserve for "mission critical" loads

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Battery Requirements

Criteria	
Much higher capacity than today's critical power batteries (10X?)	• Size driven by required blackout duration • Financial expectations for energy arbitrage
20-year calendar life	
5,000 + cycles	(200 full cycles / year X 20 years, plus more partial cycles)
Full compliance w/national safety standards	
Fast charging capability: need to recharge before next price event	
More inherently fire safe than utility scale BESS units. Customer premise location	
Updated training & safety procedures & training	

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Power Conversion Requirements

Bi-directional operation

- Note: very little cost premium vs. charger or inverter only

Even bigger boost in size than battery – to enable fast charging

- Example: **30 times** more power (5X battery size, 6X charging speed)

UL 1741 listed

High DC voltage (800 V nominal) to reduce conductor size

Separate DC-DC converters to run lower voltage systems (48, 125 volt)

Also: updated procedures & training for safety: higher voltages, arc flash, etc.

What's the alternative?

What if, despite the financial incentive, you don't deploy batteries?

On-site power generation is another alternative

~100 GW of gensets sitting idle in the US	~45% of these are in data centers

But, EPA emission regulations prevent most gensets from being run >50 hours/year

Summary

How is your organization preparing for this future?

Blackouts will increase in many regions

Power will become much more costly

Solution is more private storage, conversion & generating assets to minimize impact of extreme costs and blackouts

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About the author

William Kaewert is CEO of Colorado-based Stored Energy Systems LLC (SENS), an industry leading supplier of non-stop DC power systems that are an essential part of the nation's critical infrastructure. SENS products provide non-stop power that enable 24/7 operation of the power grid, energy production, data centers, health care facilities, the financial system and other services that sustain modern life. Mr. Kaewert received his AB in history from Dartmouth College and MBA from Boston University.

He has served on the board of directors of several economic development organizations and the Electrical Generation Systems Association (EGSA). He is an active member of InfraGard, a public/private partnership of private industry and the FBI to protect United States critical infrastructures from deliberate attack.

Bill co-founded Resilient Utilities Now, a non-profit working to improve US resilience against long-duration electric system failures. Bill has in the past served in other roles related to power system resilience, including director and Chairman of the Board for the Foundation for Resilient Societies a NH-based non-profit.