London Economics International LLC

Reliable and affordable electricity: the fuel for economic growth

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Julia Frayer
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Reliable and affordable electric service is a necessary ingredient to securing sustainable economic growth

1. **Treat reliability as non-negotiable**

   Reliable electricity creates the foundation for investment, productivity, and participation in modern supply chains

2. **Recognize role of demand-side participation in wholesale market design**

   Markets should reflect not only the cost of producing electricity, but also the true value of reliable and flexible electricity to electricity customers

3. **Electricity sector should be built around the "customer"**

   Market design, planning should enable the industries, technologies, and economic activities that the power system is expected to support

4. **Make reliability and flexibility a focal point of market design, planning rules**

   Capability, ancillary services, resilience, and power quality are fundamental components of dependable electricity service, but typically overshadowed by energy

5. **Create durable arrangements that can withstand political pressure**

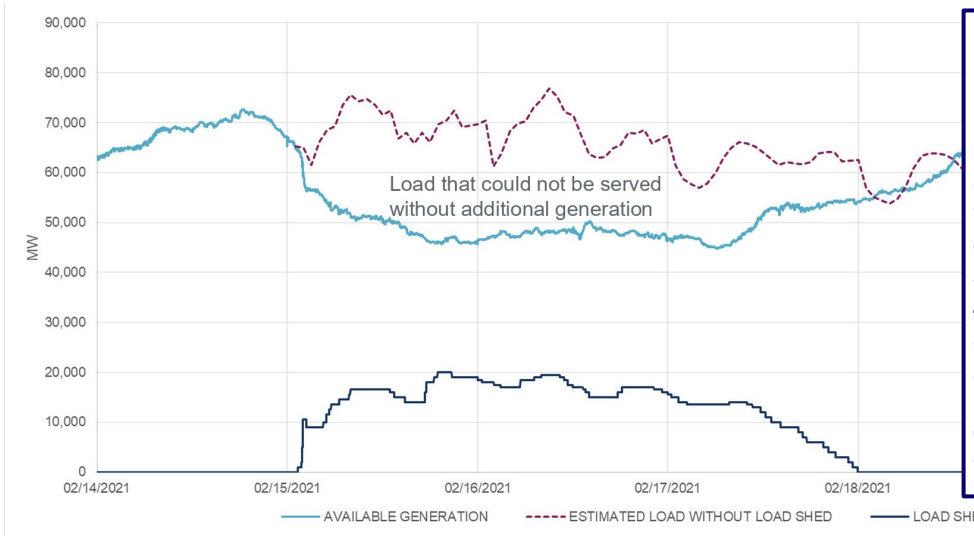
   Realistically, we cannot eliminate political intervention – so how do have credible and investable commercial arrangements that are not destabilized?

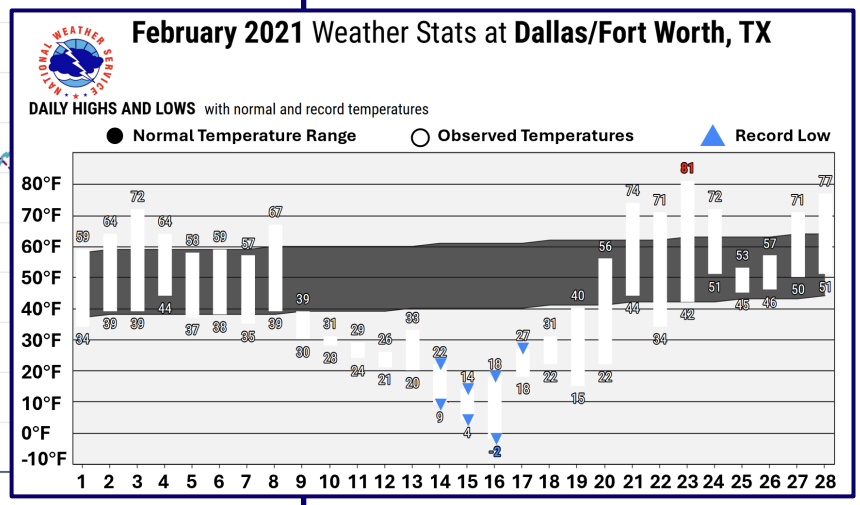
6. **Ensure that electric power systems improve outcomes for all customers**

   Well-designed investment can spur demand growth, which in turn improves grid economics, affordability, and reliability for households and small businesses

What happens when reliability of the electric system falls short? Economic activity is interrupted, lives and livelihoods are negatively impacted

ERCOT's generation and load shed during Storm Uri





Severe Generation Outage

- **52,277 MW** of forced generation outages at the peak (49% of total installed capacity)
- **70.5 hours** of load shed

Extreme price spike

- With a cap of $9,000/MWh, official real time energy price averaged **$6,500/MWh** from Feb 14-19
- Average hub prices in ERCOT were ~$21/MWh in Jan 2021 and ~$19/MWh in Mar 2021

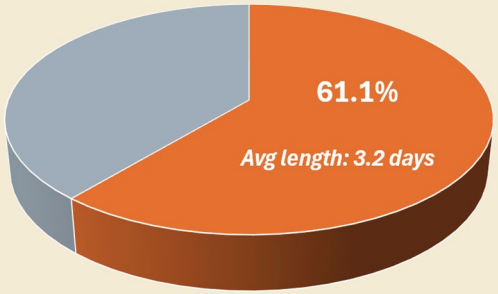
- Nearly 70% of Texans lost power during Uri, which was associated with 246 storm-related deaths
- Retail electricity providers, a G&T cooperative and generators filed for bankruptcy following Uri, with claims and unpaid obligations running into billions of dollar
- Uri sparked years of disputes over retroactive repricing affecting around $5 billion in ERCOT settlements

Sources: Electric Reliability Council Of Texas ("ERCOT"), National Weather Service, Stretto, Texas Department of State Health Services, ERCOT Independent Market Monitor ("IMM").

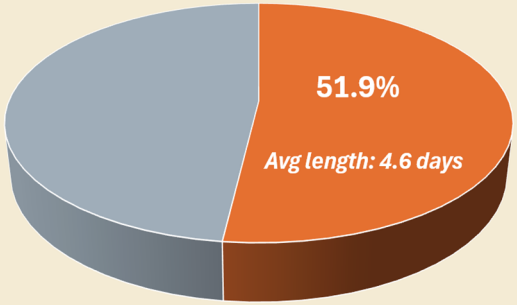
Unreliable power raises the real cost of doing business - in Texas, the Federal Reserve Bank of Dallas estimated economic losses totaling billions from Storm Uri outages

Lost economic output in Texas due to Storm Uri (February 2021)

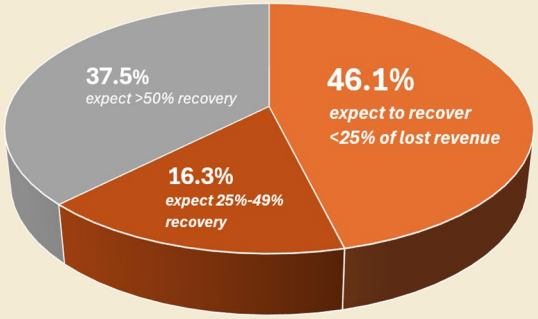
- Firms reported losing an average of **13.6%** of their February revenue as a result of Storm Uri
- Manufacturing was hit hardest: **83.3%** of firms shut down for an average of **5.1 days,** losing **20.5%** of February revenue



Share of Firms Experiencing Power Loss



Share of Firms Experiencing a Complete Shutdown



Lost Revenue Expected to Be Recovered Within 4 Weeks

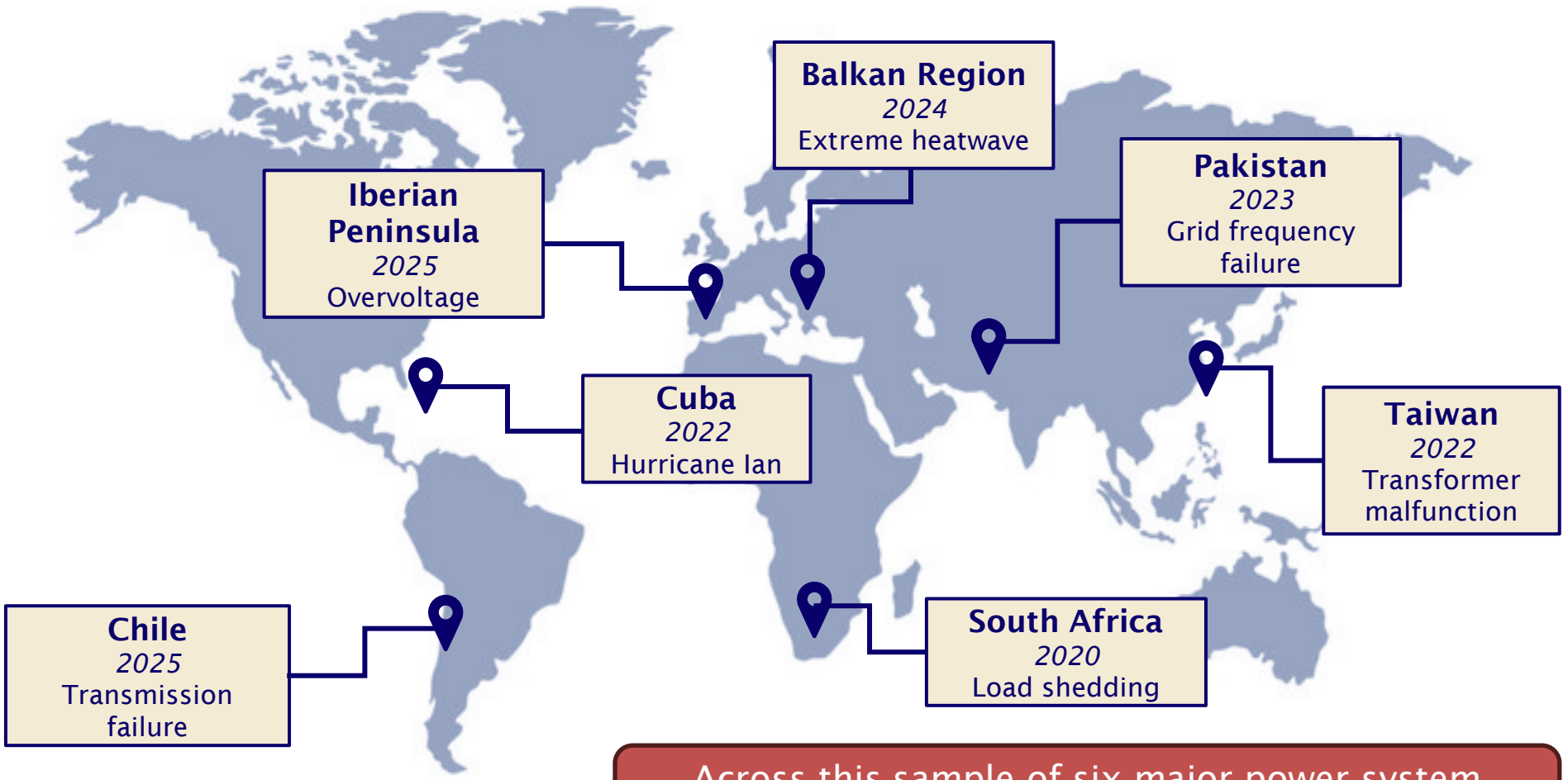
Notes: Data are based on a March 2021 Federal Reserve Bank of Dallas survey of 385 Texas business executives on Storm Uri's impact on their businesses.

Various estimates of losses caused by the freeze and outages during Storm Uri across different studies:

- Texas Department of Insurance data indicated **approximately $11.5 billion in ultimate insured losses**
- An estimate acknowledged by the Dallas Fed and the Texas Comptroller placed **direct and indirect losses to the Texas economy at $80–$130 billion** – equivalent to 4-6% of the state's 2021 GDP
- An economic research firm estimated **$197–$296 billion in total expenditure impacts after accounting for multiplier effects, including $86–$129 billion in long-term losses in gross product**

Sources: Federal Reserve Bank of Dallas (March 2021), Federal Reserve Bank of Dallas (April 2021), Texas Department of Insurance (2022), FRED, LEI analysis.

Power grid disruptions are a worldwide phenomenon and not limited to specific economic, technical or demographic conditions



Across this sample of six major power system disruption events, over 375 million people affected

Sources: Al Jazeera, France 24, CNN, The Citizen, Business Insider, ABC News, The Associated Press.

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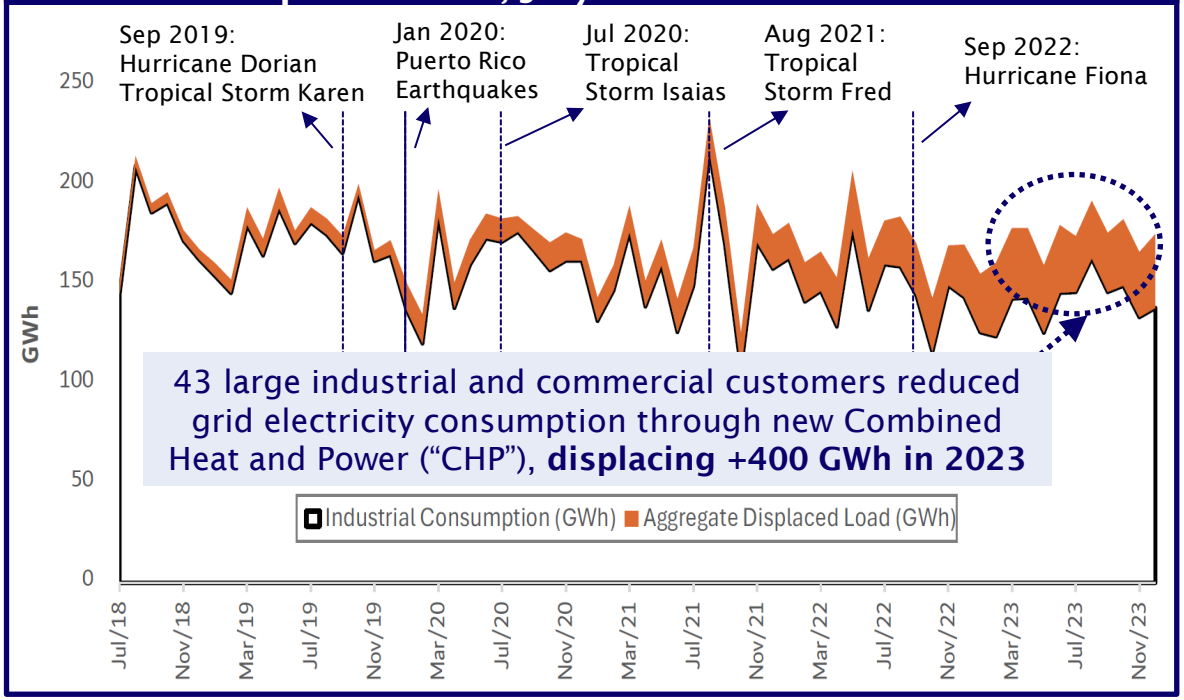
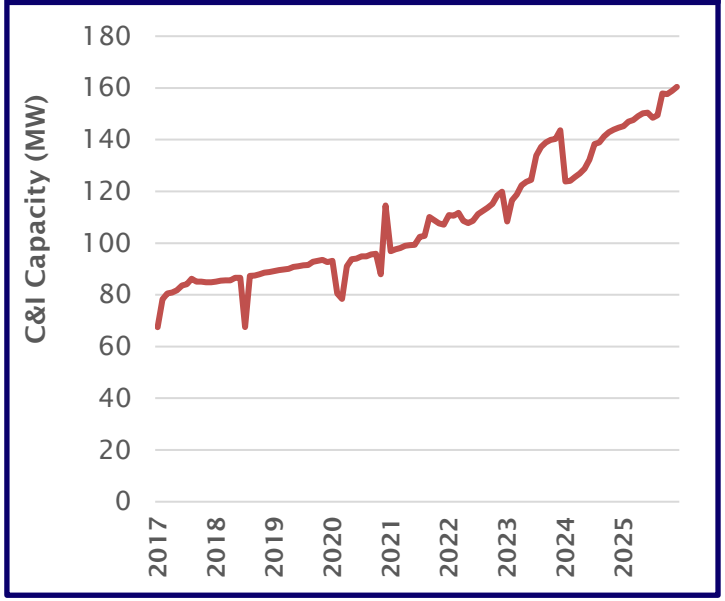
Customers are forced to find and finance alternatives, if they cannot get reliable power from the grid… and those alternatives are costly

Puerto Rico: Monthly industrial billed load vs. estimated CHP-displaced load, July 2018 – November 2023



Puerto Rico: Monthly Commercial and Industrial Customers' ("C&I") Self-Generation Capacity**



What is the cost of self-generation?

In 2024, the average retail electricity price in Puerto Rico was about **24 cents/kWh**, over 40% above the U.S. national average. The estimated levelized cost of a reliable self-supply solution* totaled to over **35 cents/kWh**, **making it 45% more expensive than electricity supplied by the utility**

Puerto Rico's businesses have steadily increased deployment of behind the fence generation in last 10 years, more than doubling such generation capacity from **70 MW to 160 MW**

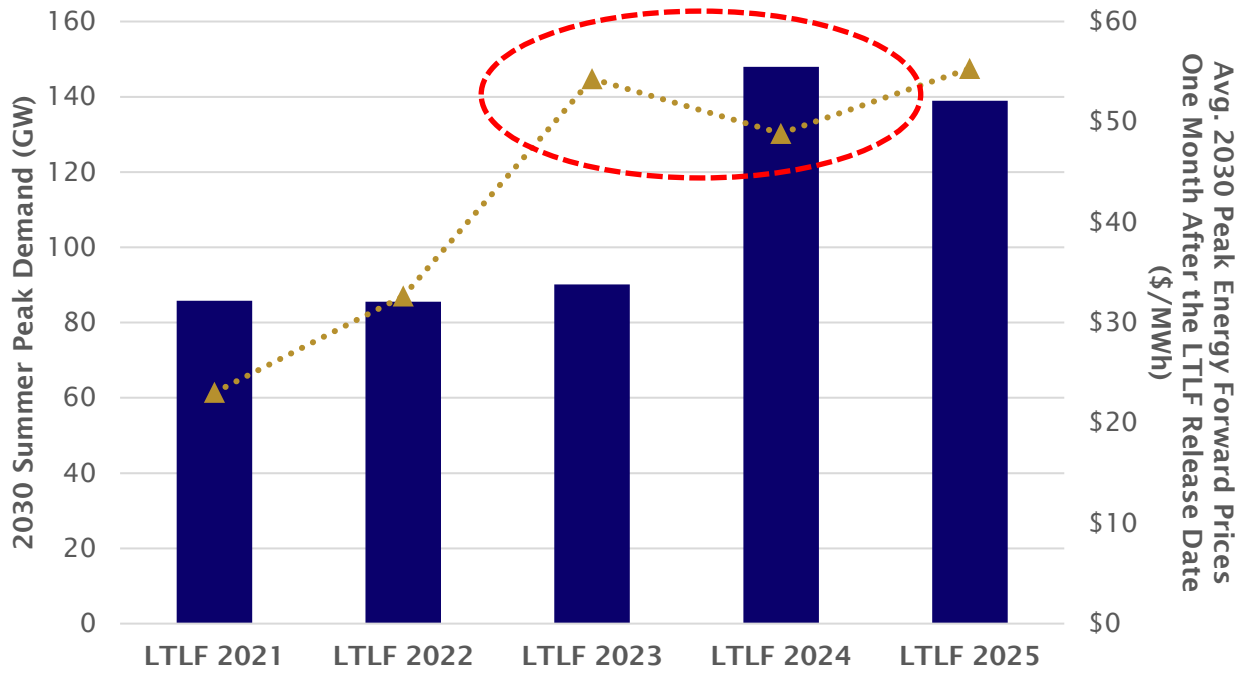
Note: (*) This estimate based on a 3 × 1 MW genset configuration to meet a high load factor industrial customer consuming 2 MW on peak (N-1 design for redundancy).

Sources: LUMA, LEI analysis, and U.S. Energy Information Administration ("EIA").

Note: (**) This capacity counts both net metering and non-net metering projects, based on data reported to the EIA.

Planning for reliability requires credible data: the market's willingness to invest in infrastructure can lag when critical information is missing or unrealistic

ERCOT's Long-Term Load Forecast ("LTLF") and Average of On-Peak Energy Forwards for 2030 sampled at different point in time



LTLF Year	2030 Summer Peak Demand (MW)	Avg. 2030 Peak Energy Forward Prices One Month After the Release Date (%)	LTLF Release Date
LTLF 2021	85,820	$22.67	*6-Jan-21*
LTLF 2022	85,569	$28.87	*18-Jan-22*
LTLF 2023	90,120	$51.42	*18-Jan-23*
LTLF 2024	147,977	$50.36	*18-Jul-24*
LTLF 2025	138,944	$55.50	*8-Apr-25*

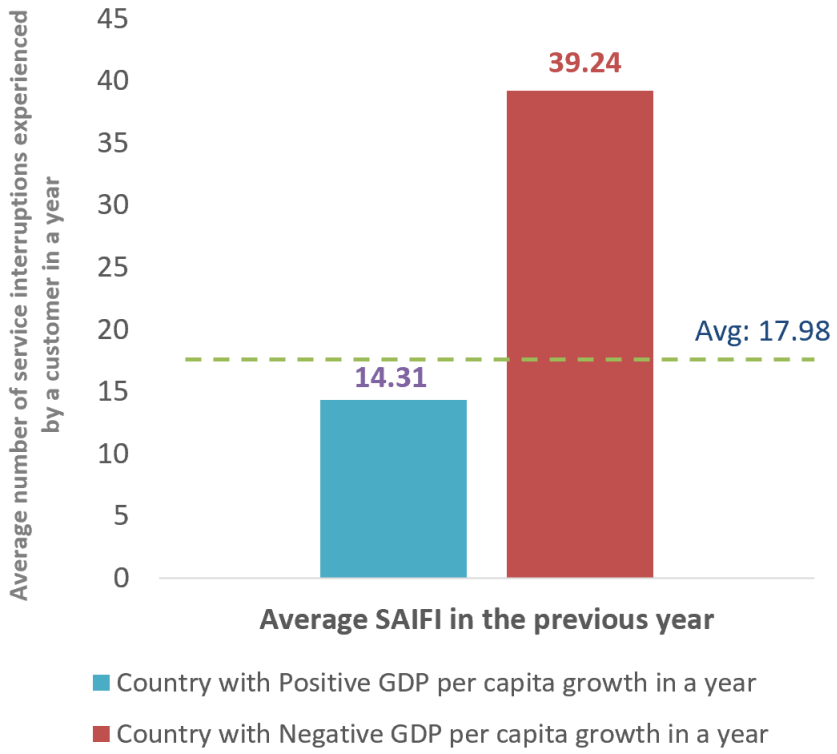
Source: ERCOT and S&P Capital IQ.

Poor reliability of the power system has consequences for economic health; examination of multi-national data shows a pattern between elevated system interruptions and negative GDP growth

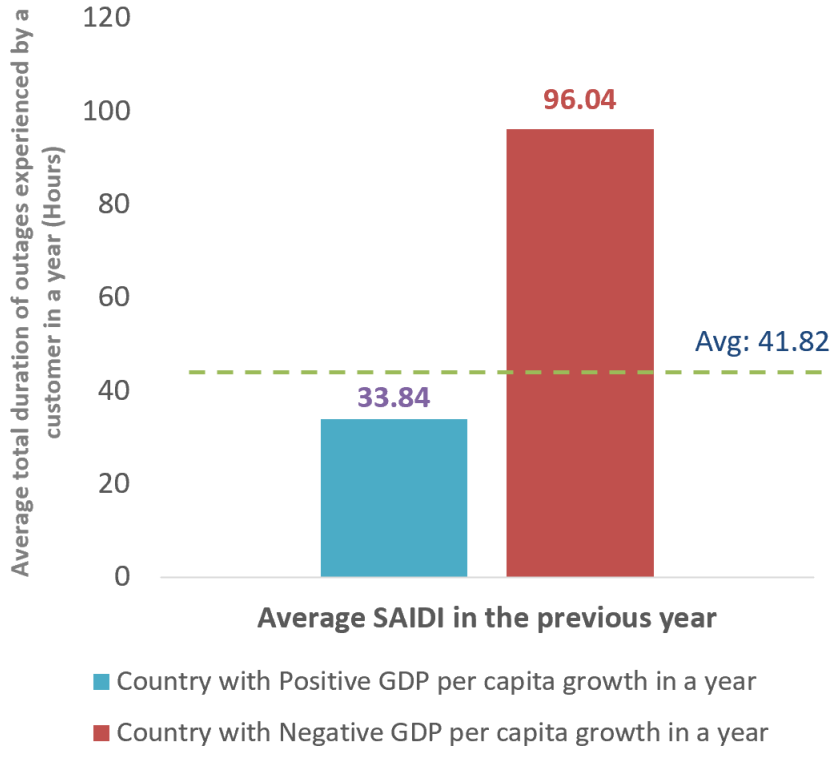
- LEI analyzed GDP growth statistics and SAIFI/SAIDI data for 152 countries, 2014–2019
- Dividing the countries based on positive or negative GDP per capita growth in each year, there is clear correlation with SAIDI/SAIFI measures in preceding year

Negative GDP per capita growth is associated with less reliable electricity grids in the preceding year

System Average Interruption Frequency Index ("SAIFI")



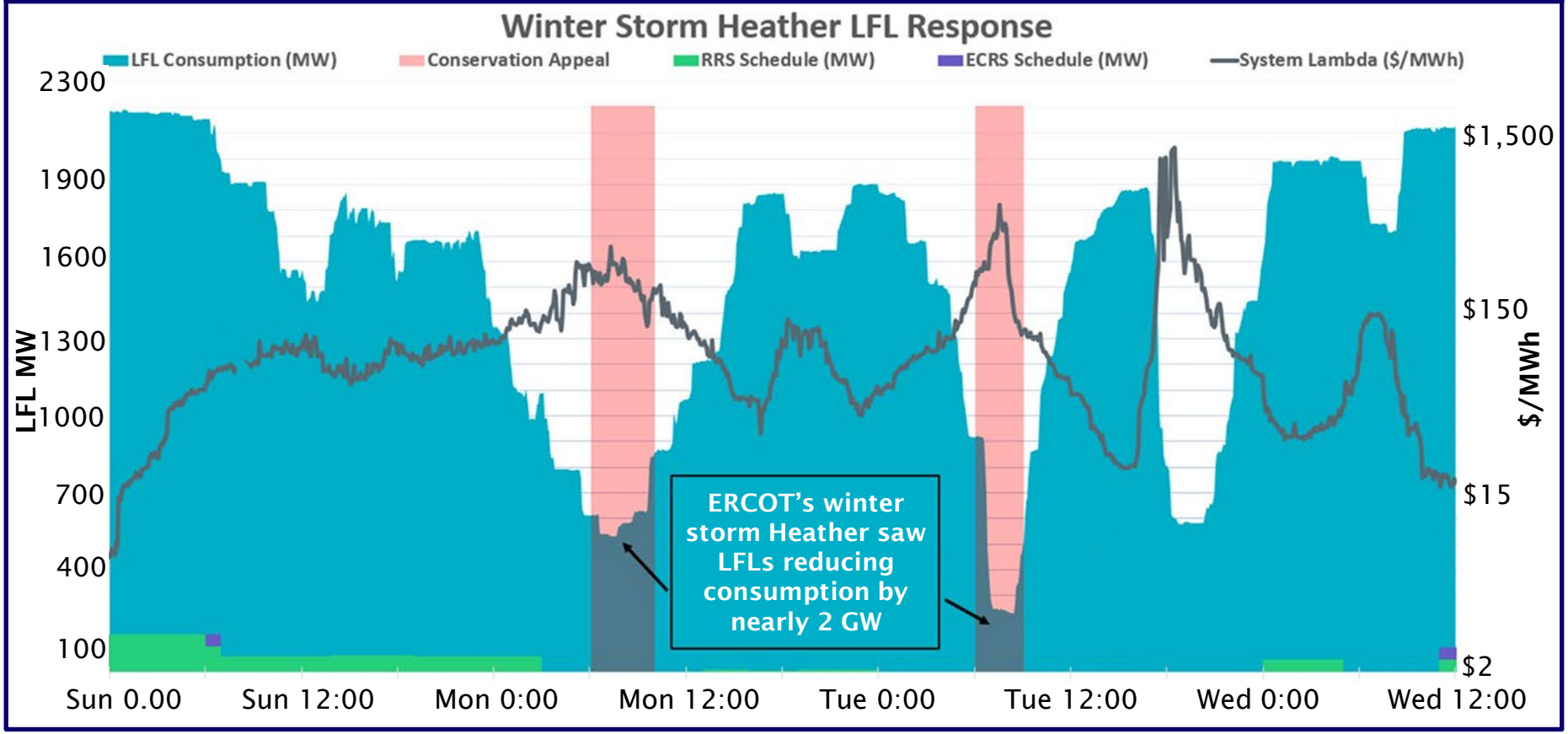
System Average Interruption Duration Index ("SAIDI")



Notes: The World Bank Doing Business Database provides the country-level SAIFI/SAIDI data from 2014 to 2019.
Sources: World Bank Doing Business Database, World Development Indicator Database.

We should no longer assume inelastic demand – customers across different activities are showing responsiveness to prices and other operating signals

ERCOT: Large flexible loads ("LFLs") are observed to respond to prices under tight conditions



For a subset of LFLs, ERCOT estimated the average strike price for facilities participating in Bitcoin mining. The estimate was derived using the economics of an S19j Pro miner under prevailing Bitcoin market conditions during the event, resulting in an estimated average strike price of **$122/MWh**

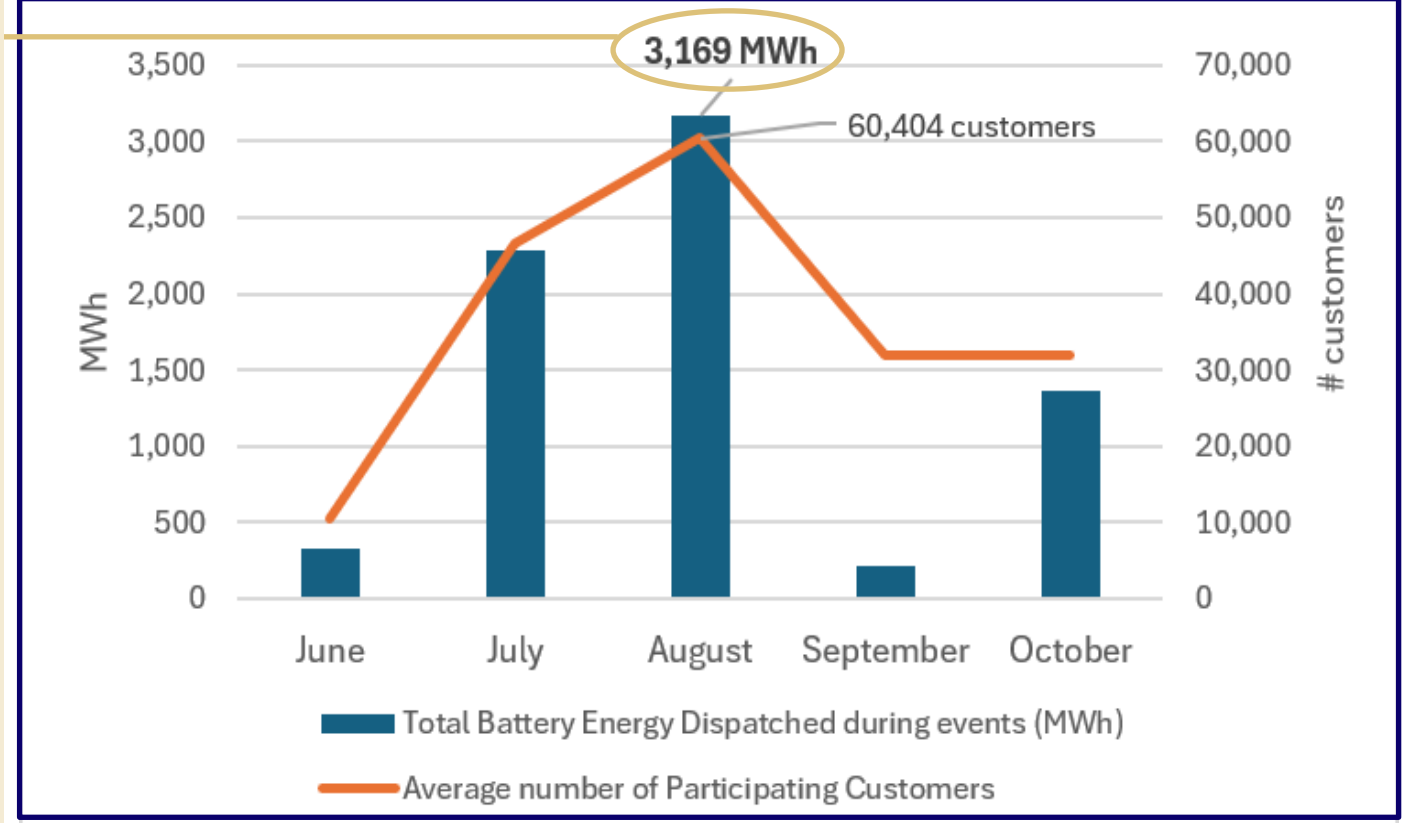
Sources: *ERCOT (2024).*

Even residential and small commercial customers are able to make meaningful contributions to wholesale markets and benefit others

Spotlight: Valuing the "insurance" provided by demand response

- In just August 2025, demand response from CBES prevented **manual load shed on 5 separate days**
- A 2025 study by LBNL estimated that a 24-hour, Puerto-Rico-wide outage would have resulted in **over $1 billion of power interruption costs**
- If each avoided manual load shed prevented cascading outage, the potential avoided costs during August alone could be **over $5 billion**

Puerto Rico Customer Battery Energy Sharing ("CBES") – Demand Response activations in June - October 2025



Based on statistics from Sunrun (CBES program administrator), CBES involved participation of 34,000 homes and 38,500 batteries, providing on average 23.8 MW to the Puerto Rico power grid per event (CBES resources deployed in 43 events over June –October 2025)

Sources: Negociado de Energia docket ("NEPR"), Lawrence Berkeley National Laboratory ("LBNL"), and LEI calculations.

There is a gap between the willingness to pay ("WTP") to avoid an outage (*involuntary interruption*) and WTP to *voluntarily curtail* consumption of electricity

Market	Headline Value of Lost Load ("VoLL") (2024 US$)
US ERCOT	$35,685/MWh
US MISO	$35,000/MWh
Great Britain	$30,370/MWh
Australia NEM	$19,791/MWh
Italy	$27,390/MWh
Spain	$25,478/MWh
Chile	$10,478/MWh

- **VoLL values (see table to right) are substantially higher than observed market prices**
  - For example, most U.S. markets currently apply a real-time offer cap of **$2,000** per MWh

Central Hudson's *"Commercial System Relief Program"* - voluntary demand response option in New York

- Customers earn **$110** per MWh performance payment for planned events and **$350** per MWh for unplanned events

Southern California Edison's "Scheduled Load Reduction Program" – voluntary demand response program in California

- The program provides a **$100** per MWh on-bill credit for bundled-service customers whose average monthly demand is 100 kW or more that reduce load by at least 15% on prescheduled days and times on weekdays from June 1 to September 30

Behavioral economics explains that it is logical for a customer to place an extremely high value on avoiding an involuntary outage, while remaining willing to voluntarily curtail some electricity consumption at much lower prices/compensation

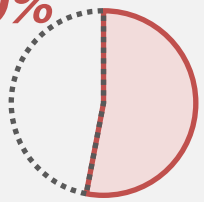
Lesson for Reliability and Affordability: we should focus on harnessing voluntarily action

Sources: Public market data, operational rules, and VoLL studies from different markets, U.S. Department of Energy ("DOE").

Electricity market design should start with understanding the needs of customers, and then designing services and products that can genuinely support those customers' priorities

J.D. Power: More business customers shopping for new rate plans

+50%

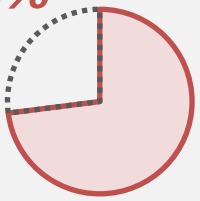


of commercial electric utility customers selected a new rate plan in 2025

"Specialty rate plans, interruptible rate plans, green-based rate plans and time-based rate plans have seen the sharpest interest among business customers in the past four years"

Smart Energy Consumer Collaborative: Small and medium enterprises are interested in rates offering more flexibility

+70%

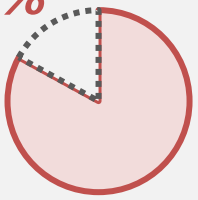


of small and medium-sized businesses expressing interest in learning more about new rates that would better suit their energy needs

"The same percentage also expressed interest in receiving bill credits for reducing electricity use at times of peak demand"

EPRI: Data center customers have specific requests that differ from other industrial customers

+80%



of surveyed utilities report data center customers have higher reliability needs and time to market constraints

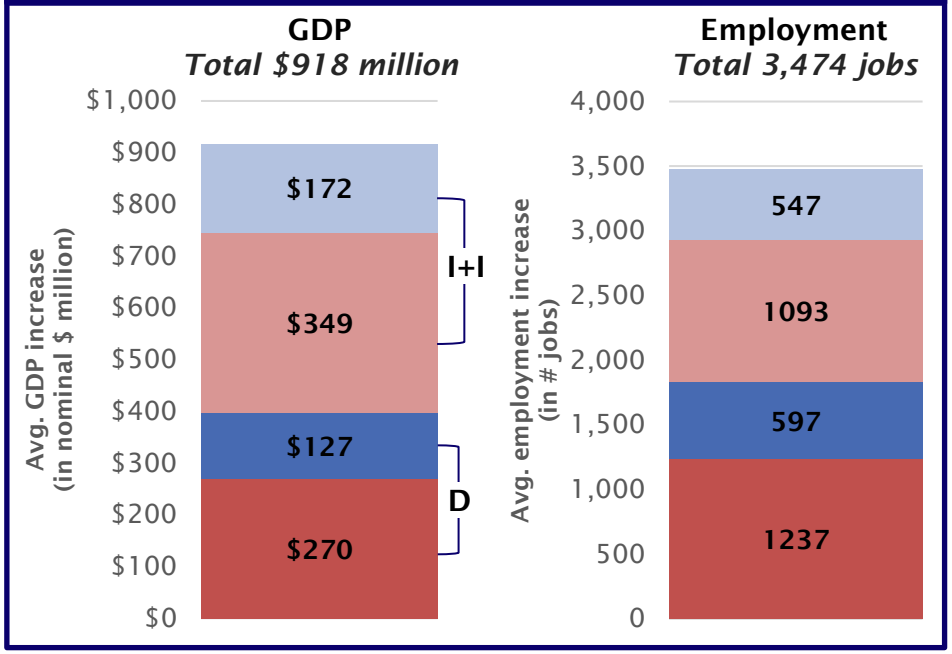
57% also reported a specialized need for 24/7 Carbon-Free Energy

Sources: JD Power, Smart Energy Consumer Collaborative ("SECC"), Electric Power Research Institute ("EPRI").

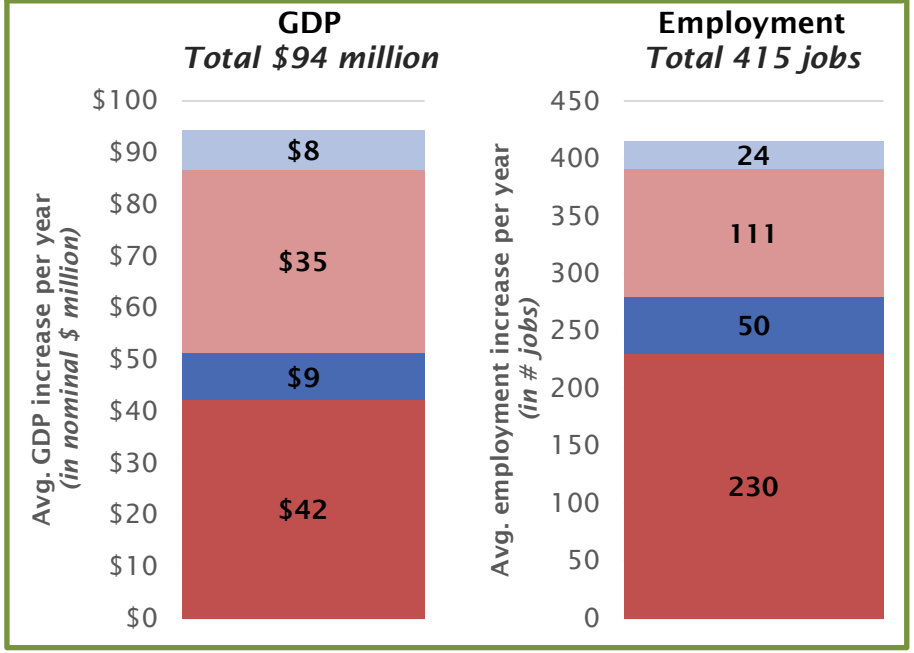
Investing in electricity-intensive sectors, as well as in the electricity infrastructure used to serve them, is a catalyst to economic growth – this phenomenon is known as the "multiplier" effect

- **What happens when we have a $632 million investment opportunity to build a new steel production facility in the U.S.?**
  - It will require generation and transmission investment totaling $192 million
  - Not all the money will be spent in the U.S. – for both the steel mill and electric infrastructure, domestic spending on construction services will total about $400 million

Example of CONSTRUCTION PHASE (short-term): GDP and employment growth (3 years)



Example of OPERATING PHASE (long-term): annual GDP & employment growth



Steel Industry | Direct ("D") Effects
Steel Industry | Indirect + Induced ("I+I") Effects
Electricity Infrastructure | Direct Effects
Electricity Infrastructure | Indirect + Induced Effects

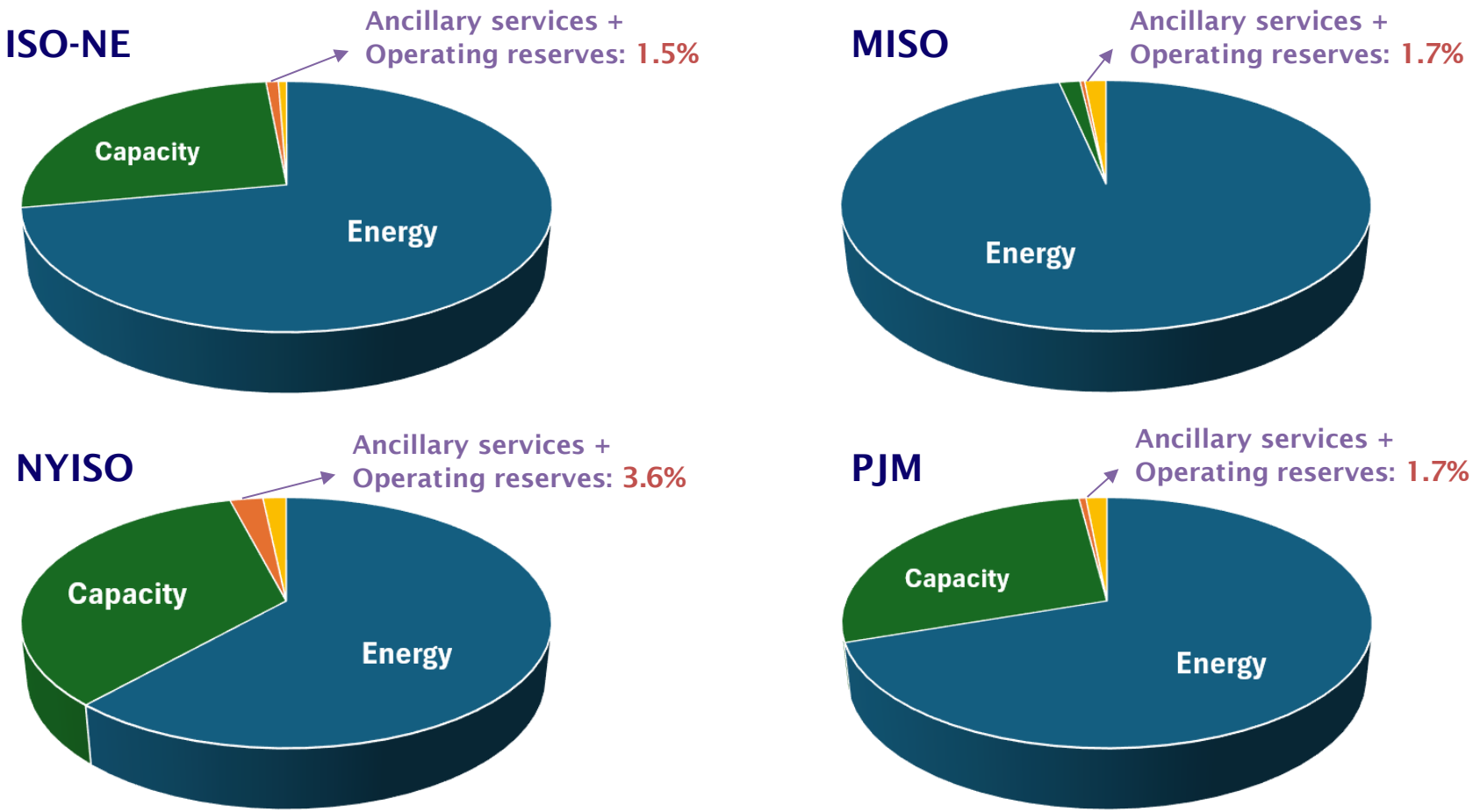
A total investment of $632 million could generate over **$900 million in total economic impact (1.5x multiplier) and create almost 3,500 new jobs**…

… and an additional +**$90 million in economic activity** (1.4x multiplier) and **+400 new jobs in the long-term**

Sources: 2025 CONE Report for PJM, 2024 NREL ATB. This analysis was performed using REMI-PI+.

Historically, the lion's share of market value resided in the market price of energy, even with ISOs purchasing ancillary services and stand-alone capacity

Ancillary services and operating reserves together only account for less than 10% of wholesale product costs by ISO/RTO in some major US markets



Notes: The total expenditure in the graphs includes costs for purchasing energy, capacity, operating reserves, and ancillary services by RTO/ISO. Data are based on the average costs of 2019 – 2022, if available.
Sources: FERC 2023 Common Metrics Report and 2022 NYISO State of the Market Report (Potomac Economics).

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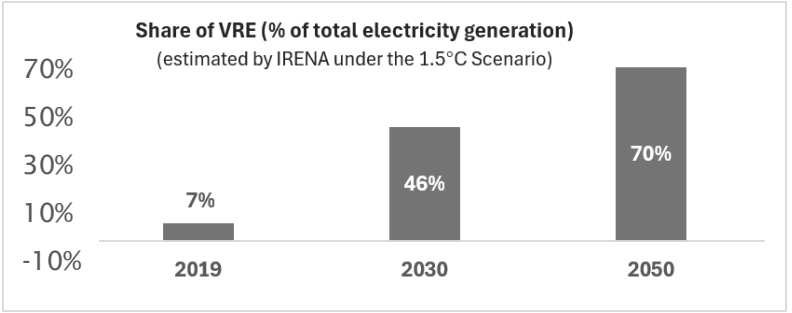
Power system flexibility is expected to become more valuable with increased renewable penetration and rising net load uncertainty

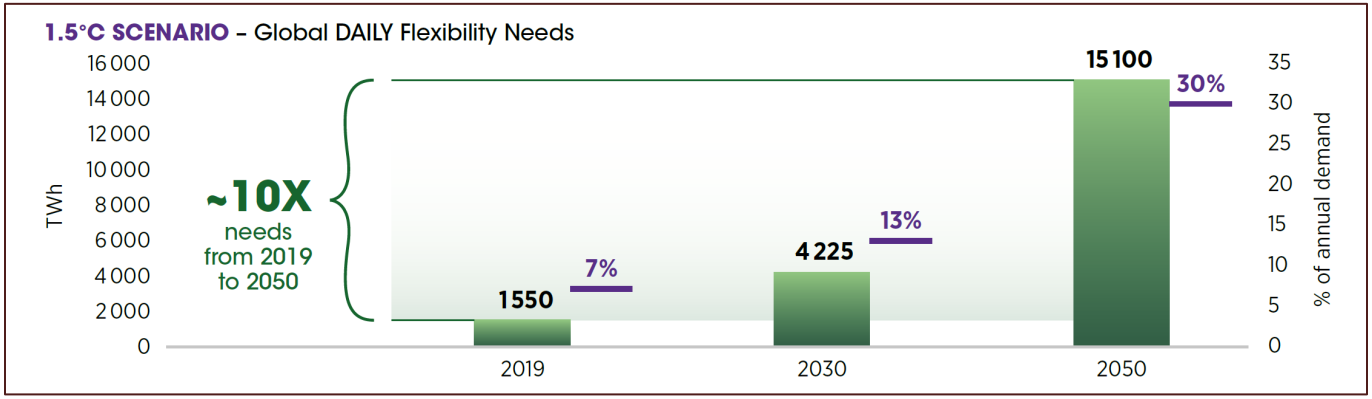
International Renewable Energy Agency ("IRENA") 2026 study findings: Rising variable renewable energy ("VRE") penetration is increasing the need for a diverse portfolio of flexibility resources to maintain a secure and cost-effective power supply

As the global wind and solar generation rises from 9% of total electricity generation in 2019…

…to an estimated 46% in 2030 and 70% in 2050…



…Daily flexibility needs for the power sector would increase 10x to manage the daily variability of net load (from 7% in 2019 to 30% by 2050 as share of annual electricity demand)



Notes: IRENA's definition of flexibility needs are quantified by measuring the cumulative energy (annual TWh) deviation of the net load (demand minus VRE generation) from its average value over the defined timescale.
Source: International Renewable Energy Agency

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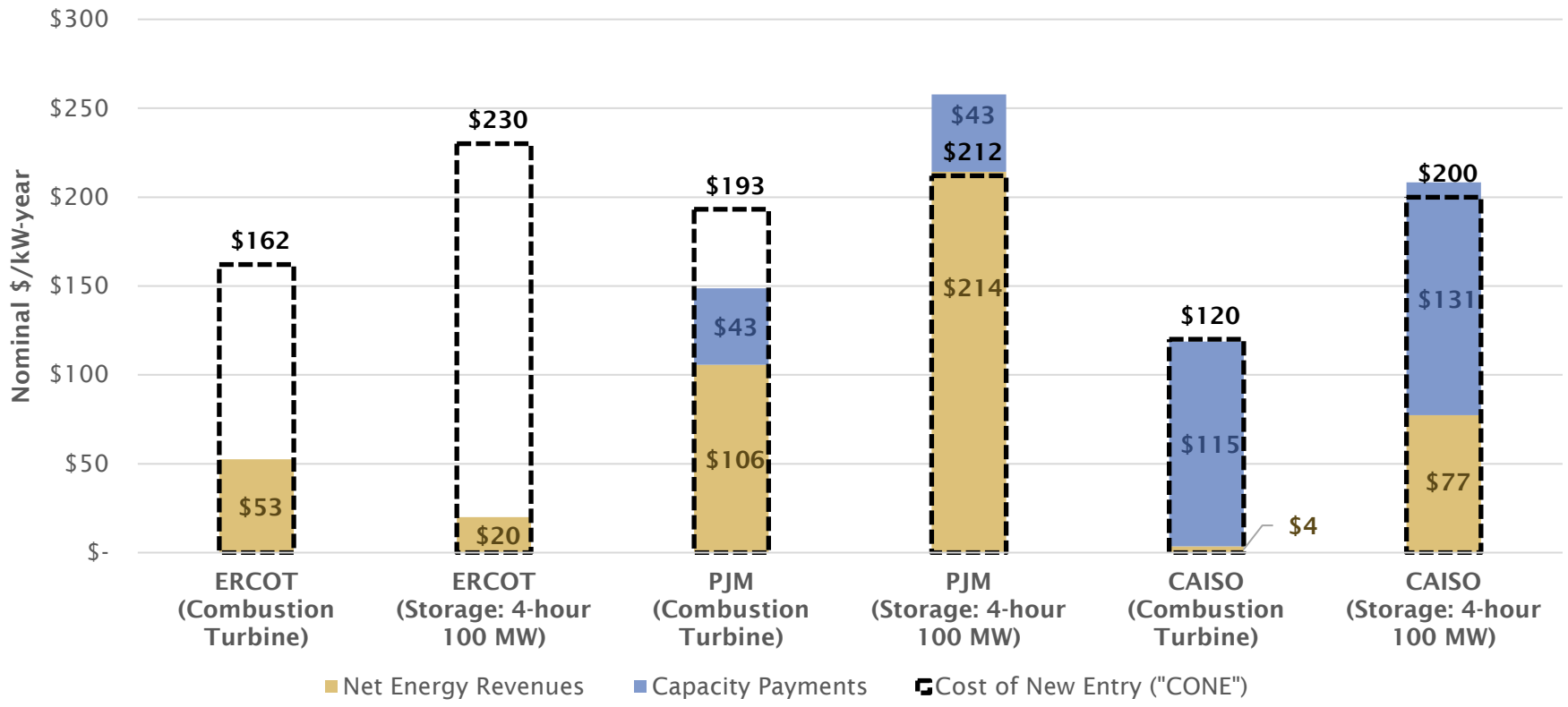
Compensation of generation resources is tied to the products that the ISO procures; ensuring the right "sizing" and "pricing" of products is critical for maintaining sustainable investment signals

- Some markets, like ERCOT, are facing a "missing money" as energy-market scarcity signals have been marginalized and ancillary services revenues are cannibalized by new resources
- Other markets indicate a strong dependence on capacity revenues, but those remain highly exposed to political intervention and saturation depending on definition of capacity

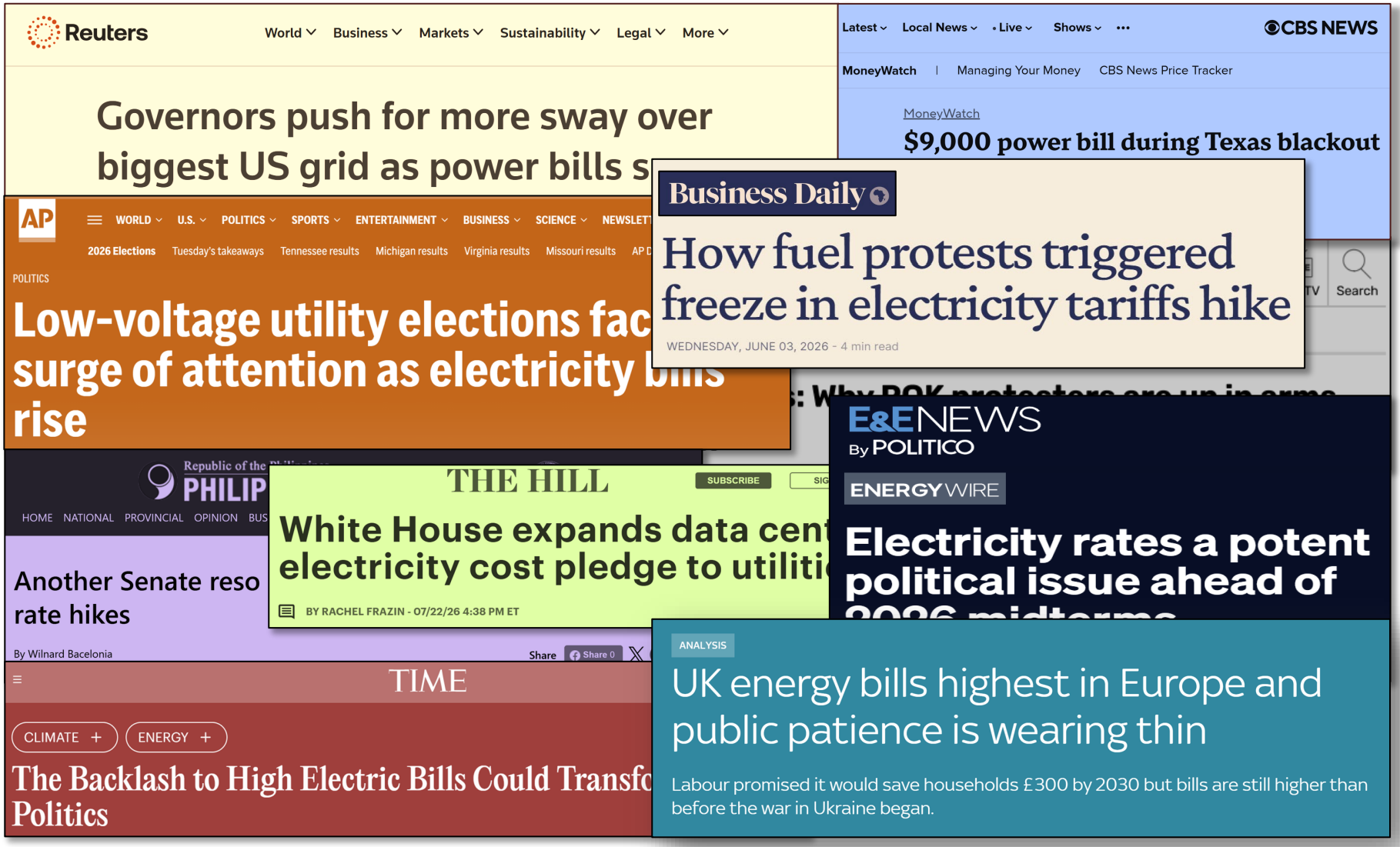
Missing money gap in selected U.S. power markets, 2025



Sources: LEI analysis based on Potomac Economics (ERCOT), Monitoring Analytics (PJM), Lazard, CAISO(a), CAISO(b), and ModoEnergy.

Note: Net revenues comprise energy and ancillary services revenues. For PJM and CAISO, net revenues also incorporate capacity revenues.

Electricity prices are inherently political because electricity is essential to households and businesses and carries a historical legacy of monopoly service and extensive regulation



Sources: Reuters, CBS News, Sky News, Politco, Associated Press, Philippine News Agency, Time, India Today, The Hill, Business Daily Africa.

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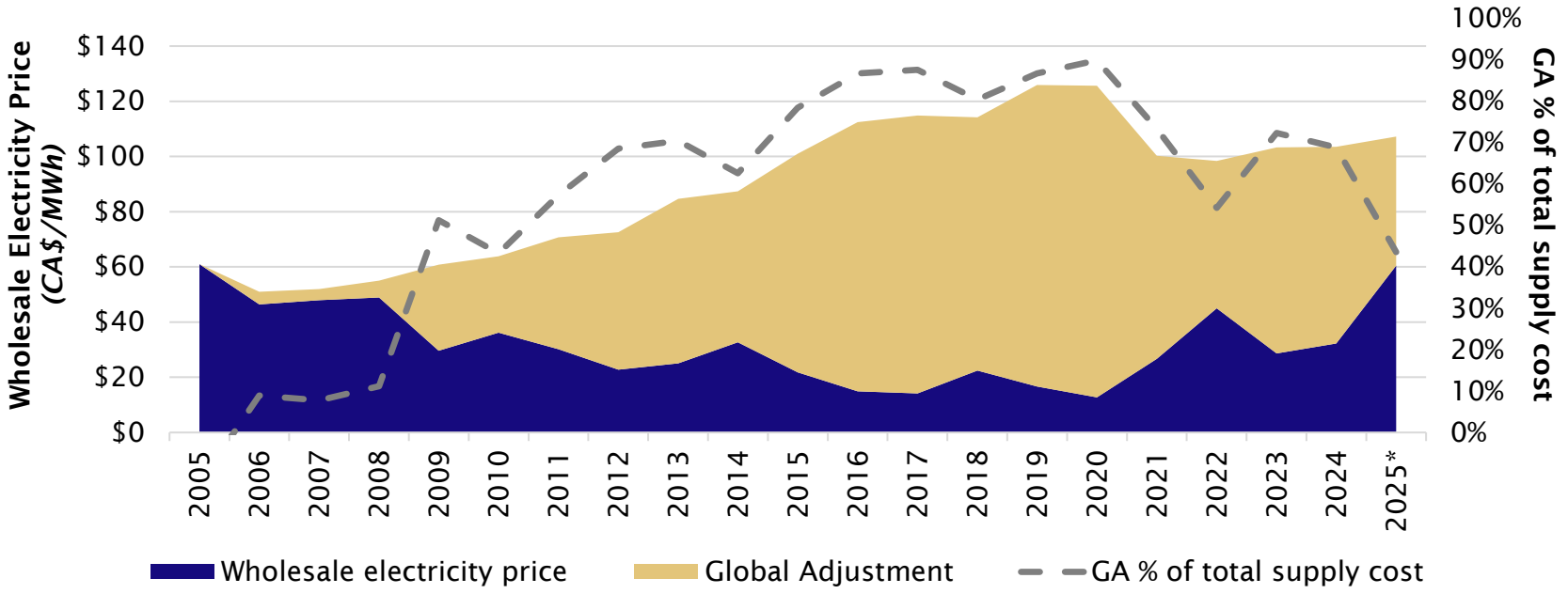
Even well-intentioned policies can create unintended consequences and hidden fees for electricity customers

The Global Adjustment ("GA") fee has been paid by retail electricity customers in Ontario since 2005, it covers the gap between market revenues and the cost of contracted and regulated generation, infrastructure upgrades, and conservation programs

Historical GA fee and wholesale electricity prices, 2005-2025



** 2025 prices combine HOEP (Hourly Ontario Energy Price; pre-May) and OZP (Ontario Zonal Price; post-May).*

Note: As of January 1, 2021, GA costs for all electricity consumers reduced because non-hydro renewable energy contract costs were shifted from the rate base to the tax base.

Source: IESO.

Ad hoc intervention can also crowd out innovation and opportunities for investors and customers

Ontario: Market Reform Reversed

- Ontario **suspended its wholesale electricity market in 2002**, only months after launch, following public backlash over price increases
- The intervention occurred despite more than **30% of customers being hedged**
- The policy shift **disrupted long-term market restructuring**

Texas: Reduced Retail Options

- Griddy exposed Texas customers directly to **ERCOT real-time wholesale prices**
- In aftermath of Winter Storm Uri, some customers who did not switch in time received **large invoices**
- Texas responded with HB 16, **banning this retail product** for residential and small commercial customers

Offshore Wind: Investment Disrupted

- In 2025, the Trump administration **withdrew leasing areas, cancelled permits, and paused or reviewed offshore wind projects**
- The measures **restricted new approvals** and increased uncertainty for ongoing projects
- **Lost opportunity** seen with the success of the UK offshore wind industry, where 2022 auction prices were 9x lower than gas

"*The United States has been **underinvesting in the innovation** needed for future electric system performance. Massive new private and public investments are needed in innovation, especially for more cutting-edge technologies on which the future grid will depend*" (National Academies of Sciences, Engineering, and Medicine, 2021)

Political scrutiny of the electricity costs is a deep-rooted aspect of our society, making adoption of textbook "free-market" framework unrealistic

We need market institutions and regulations to be resilient to political intervention - *credible, transparent, and socially sustainable*

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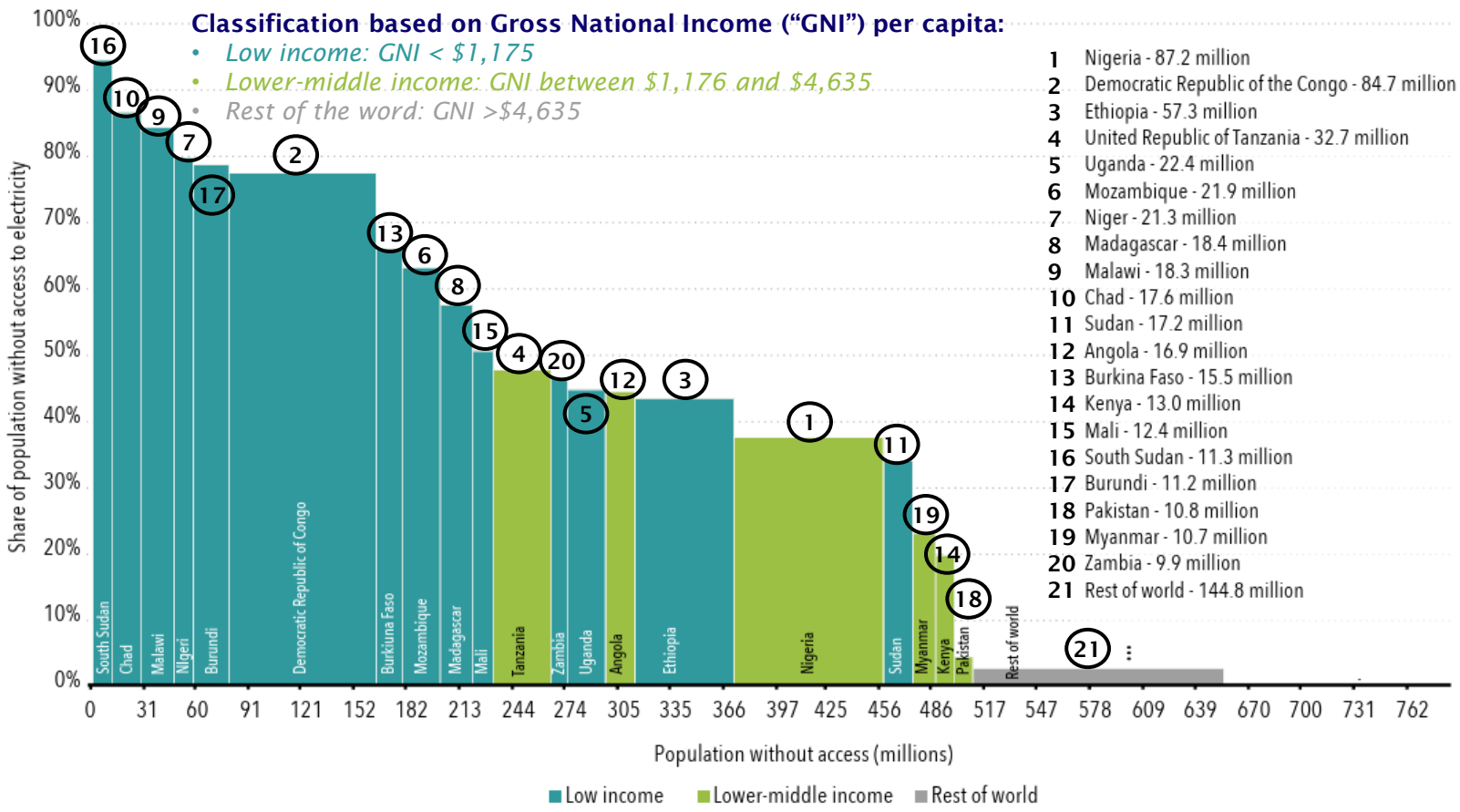
Basic electricity access remains a persistent issue in many countries around the world

Share of population electricity in top-20 access-deficit countries, 2024



UN estimated **$30 billion in annual funding** is needed in transmission, distribution, and generation infrastructure between 2021 and 2030 to reach universal electricity access

Sources: World Bank Energy Tracking Report (2026), World Bank, International Renewable Energy Agency (2024).

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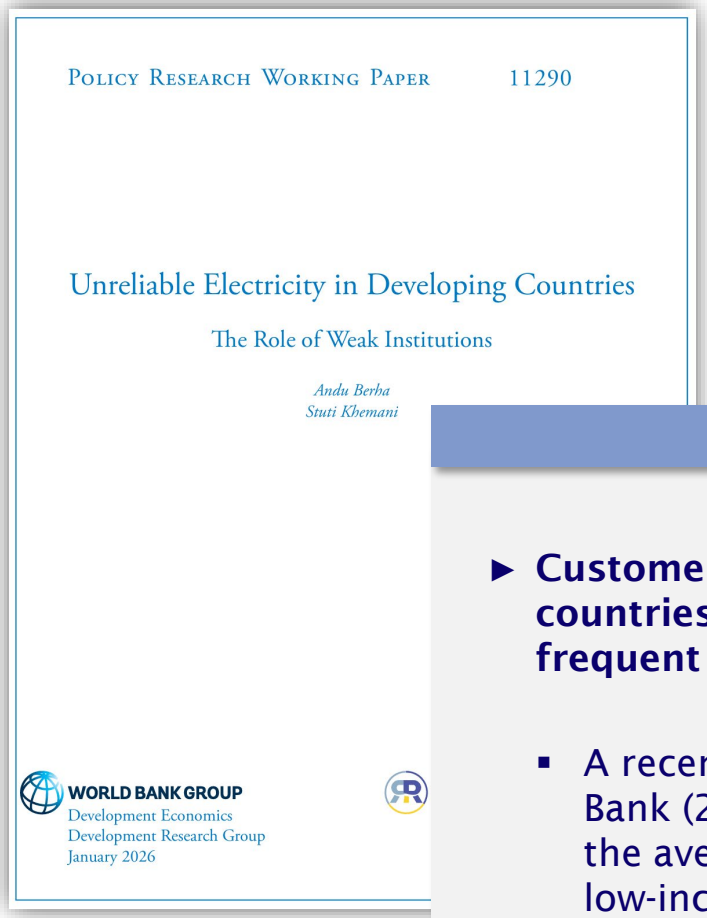
But access alone is not enough - reliability determines ultimate value to households and firms



Unequal Reliability

- **Customers in low-income countries endure more frequent and longer outages**
  - A recent study by the World Bank (2026) estimated that the average customer in low-income countries faces:

80.43 additional hours of lost service

60.35 more outages per year

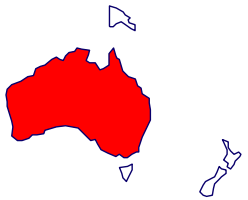
*When compared to customers in high- and upper-middle-income countries, $p < 0.01$

Sources: World Bank.

One challenge for the power market is to ensure that industrial expansion strengthens the public grid rather than bypassing it

- **Industrial customers across sectors turn to behind-the-meter generation to secure reliable, dedicated power supply**



MW	Alberta (2025)	Chile (2025)	ERCOT (Texas, 2025)	Western Australia (2024)
Residential off grid / self-supply *(rooftop solar and other DERs)*	~441 (6%)	503 (5%)	1,238 (2%)	2,180 (10%)
Commercial & Industrial off grid / self-supply	~2,412 (32%)	3,000 (31%)	9,547 (17%)	330 (2%)
Average Demand	7,465	9,720	55,734	21,287
% of BTM installed capacity over average demand	38%	36%	19%	12%)

Sources: Australian Department of Climate Change, Energy, the Environment and Water, Sustainable Energy Now ("SEN"), Alberta Electric System Operator(a) ("AESO"), AESO(b), Chilean Power Coordinator, ERCOT(a), ERCOT(b).

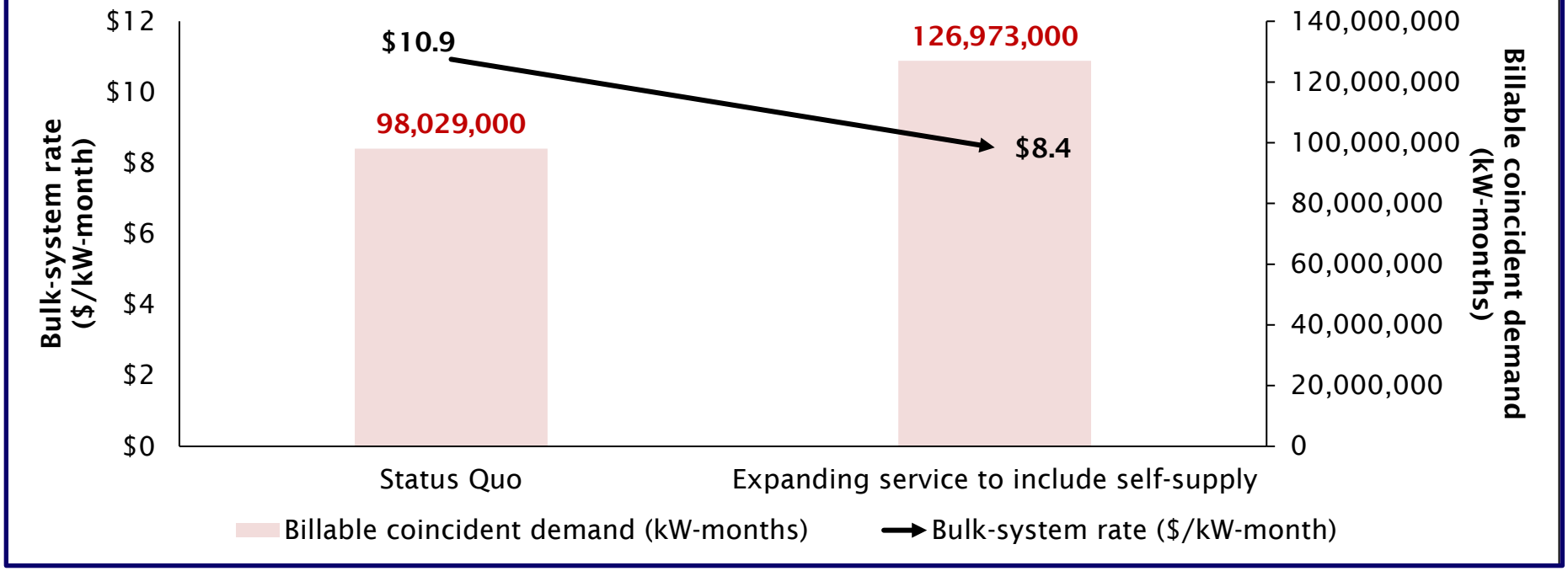
For example. in Alberta, including self-supplied industrial load in the transmission billing base could materially lower unit rates

Added billable demand
+28.9 million kW-months

Rate reduction in $ terms
–$2.49/kW-month

Rate reduction in % terms
22.8% reduction in bulk-system rate

Illustrative 2026 bulk-system transmission rate impact



Note: The illustrative counterfactual holds the 2026 bulk-system coincident-demand cost pool constant at $1.071 billion and assumes the current transmission system can accommodate the additional load without incremental investment. LEI treats AESO/FTI's reported 2,412 MW peak-load metric for 40 self-supply customers as additional coincident billable demand at each monthly peak (2,412 MW × 12 = 28.944 million kW-months).

Sources: AESO, Appendix B-1 – 2026 Rate Calculations; AESO/FTI, Internal Demand Rates Workshop 2 Presentation (updated June 5, 2026).

Electricity sector can be like a custom-built home – the more thought we can put into the planning and design, the more value and enjoyment we will receive from the final product

1 Reliability is the foundation

reliable electricity is a basic requirement to a well-functioning economy

2 Grid connection matters (and its Two Way)

customers are price elastic; market rules should reflect demand side value

3 Design for the Customer

market design reforms should start with needs of customers

4 Ensure integrity of overall structure

Markets need to reward flexibility and reliability

5 Avoid patches; fix problems

market rules should be credible, socially sustainable to be able to withstand political pressure

6 Protect those under the same "roof" (Inclusive)

a more reliable and affordable electric power system should benefit everyone

Designing electricity markets and commercial arrangements, and planning for infrastructure and institutions capable of supporting the economy we want