Affordability, Rates, and Clean Capital Efficiency

PRESENTED BY

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PRESENTED TO

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MAY 5, 2025

Brattle

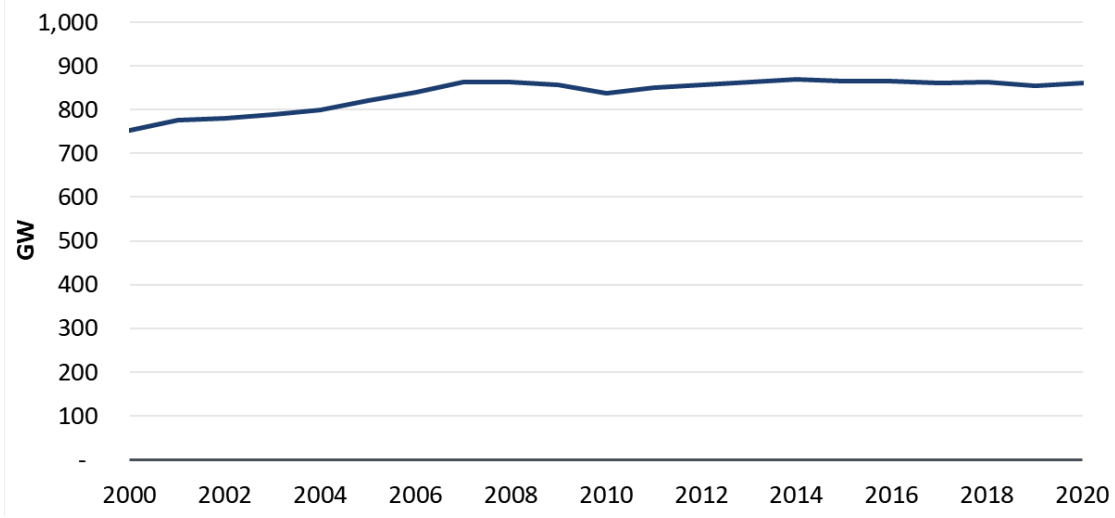
Contents

The Years 2000 – 2020 Were Good to the Electric Utility Sector

Over the past two decades, the electric industry has delivered reliable service to customers, characterized by stable electric demand, declining carbon emissions, and strong financial performance by investor-owned electric utilities

- Average U.S. peak demand grew at only 0.7% per year over the past two decades and has remained largely flat since 2008
- Electric sector emissions peaked in 2007 and fell 33% by 2019, driven by cleaner electric generation and end-use efficiency gains
- Investor-owned utilities delivered financial returns that roughly matched stock market performance over this period

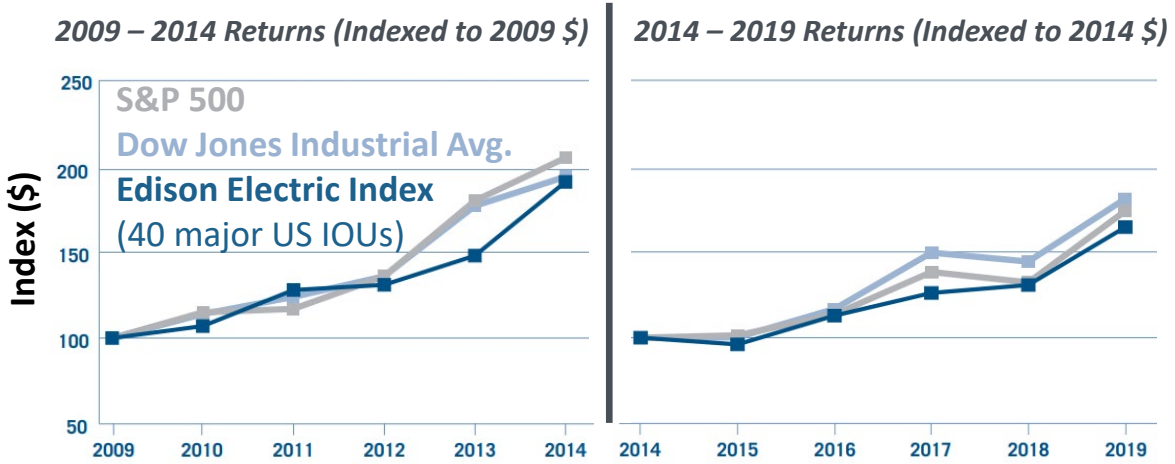
Historical U.S. Peak Electricity Demand



Sources and notes: Shows near-term forecasts of peak demand; NERC, 2023 Long-Term Reliability Assessment, December 2023, Supplemental Charts and Graphs, Table F.

Electric Utility Stock Return Compared to Market

Assumes $100 invested on 12/31/2009 (left) and 12/31/2014 (right)



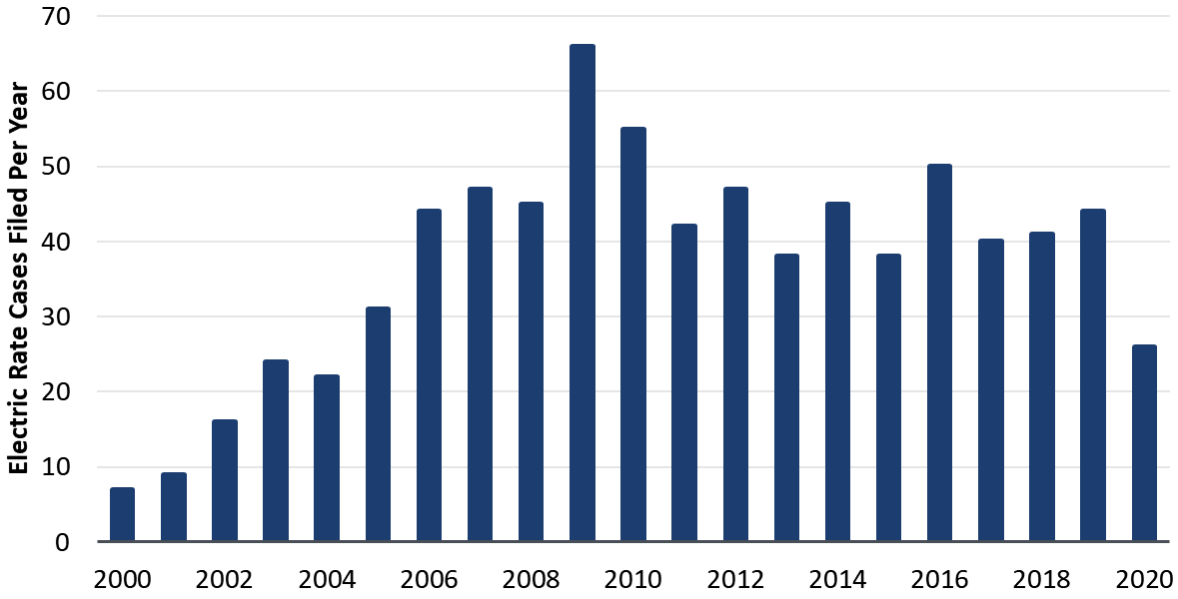
Sources and notes: Reflects reinvested dividends. See Edison Electric Institute, 2014 Financial Review, 2015; 2019 Financial Review, 2020.

…And Resulting Electric Rates Remained Steady

EIA reports that retail electric rates increased at a rate of approximately 2.2% per year in nominal terms between 2000 and 2020— a rate slightly faster than inflation, but moderate overall

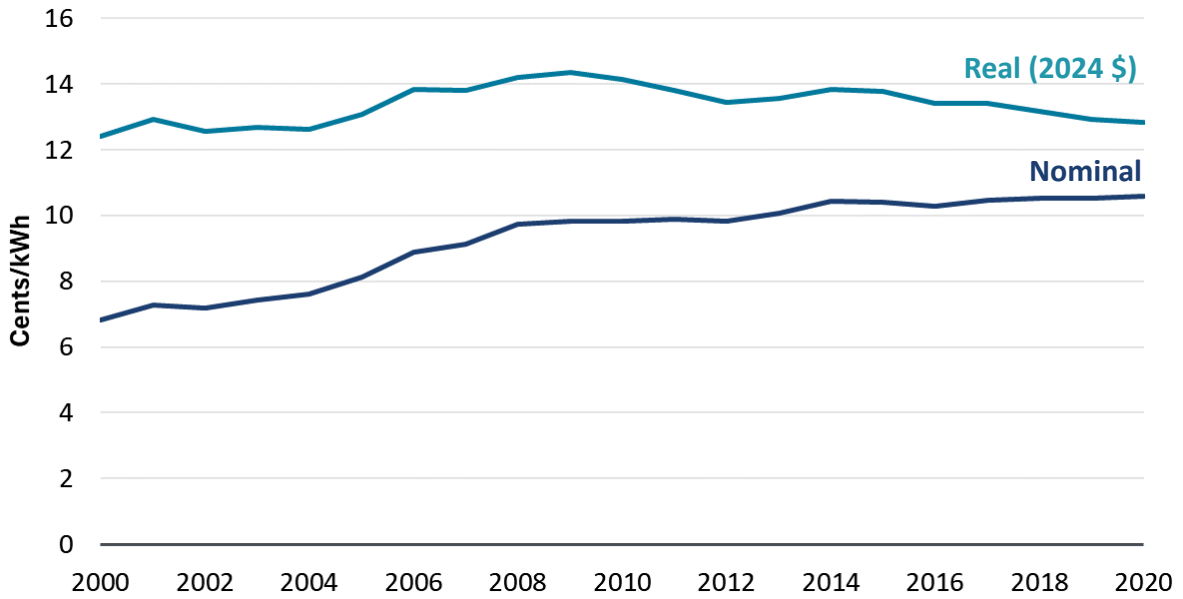
- The number of electric rate cases filed by electric utilities has remained steady since roughly 2006

Electric Rate Cases Filed Per Year, 2000 – 2020



Source: Data from S&P Global.

Average Electric Rates All Sectors (cents/kWh)



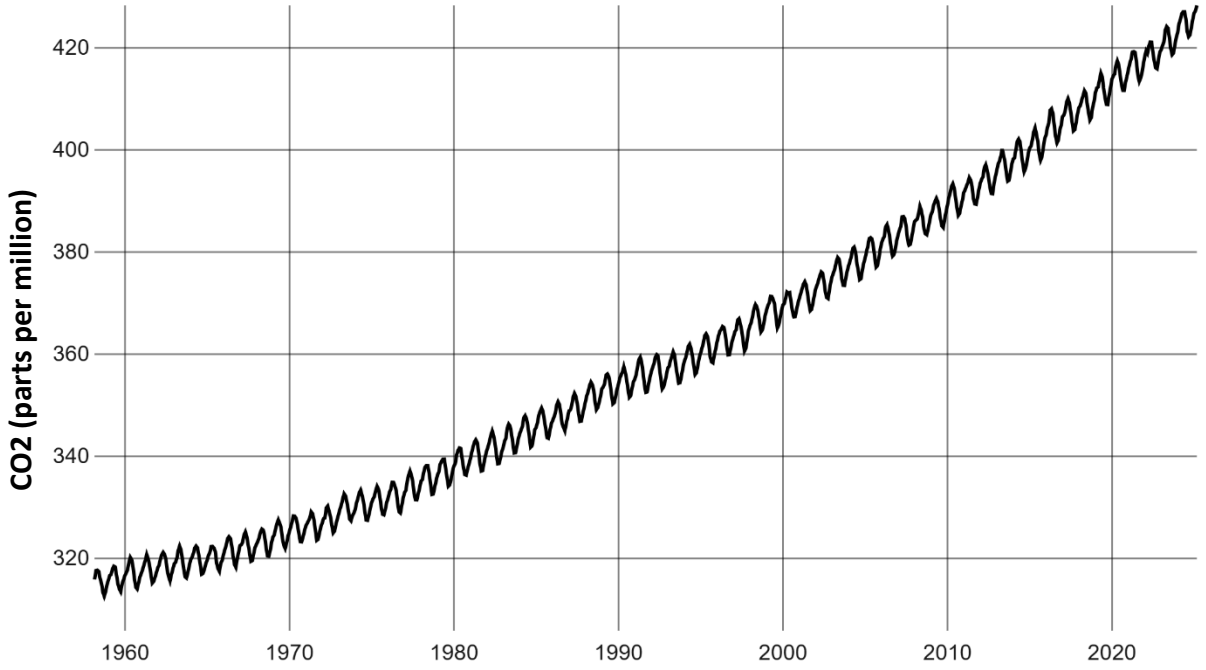
Sources and notes: U.S. Energy Information Administration (EIA), Electricity data browser, accessed April 30, 2025 and EIA, Annual Energy Review, 2012. Inflation adjustment from the U.S. Bureau of Labor Statistics' Consumer Price Index for All Urban Consumers.

The 2020s and 2030s will be Immensely Challenging and Important for the Industry

Climate Change and Resilience is More Important than Ever

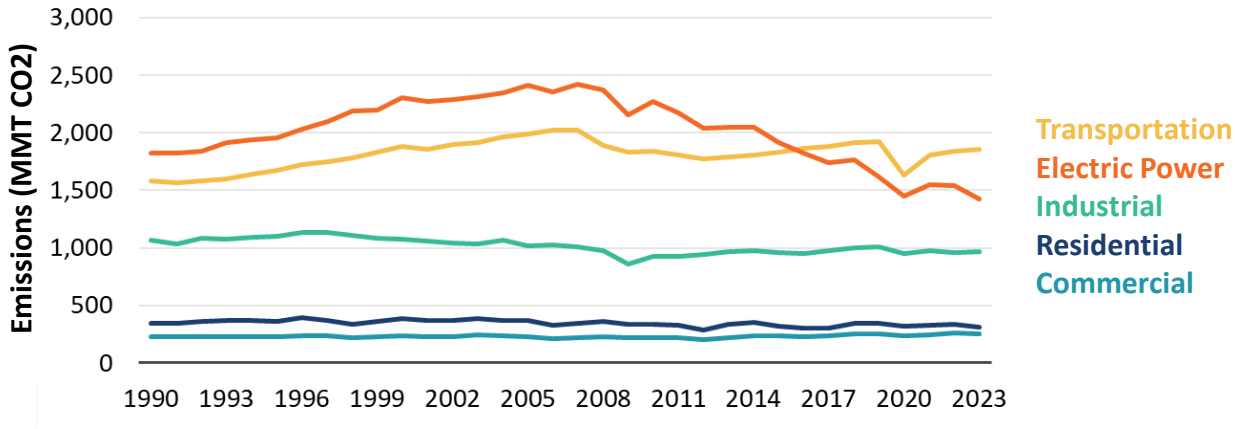
Global carbon dioxide concentrations and average temperatures are higher than ever. The U.S. electricity sector is a prominent emitter and driver of climate change

Global CO2 Emissions



Source: NASA, Carbon Dioxide, accessed April 30
Data Source: NOAA, measured at the Mauna Loa Observatory, March 2025.

U.S. Energy-Related CO2 Emissions by Sector



Source: U.S. Energy Information Administration, *Monthly Energy Review,* March 2024, Tables 11.1-11.6.

Contiguous U.S. Average Temperature

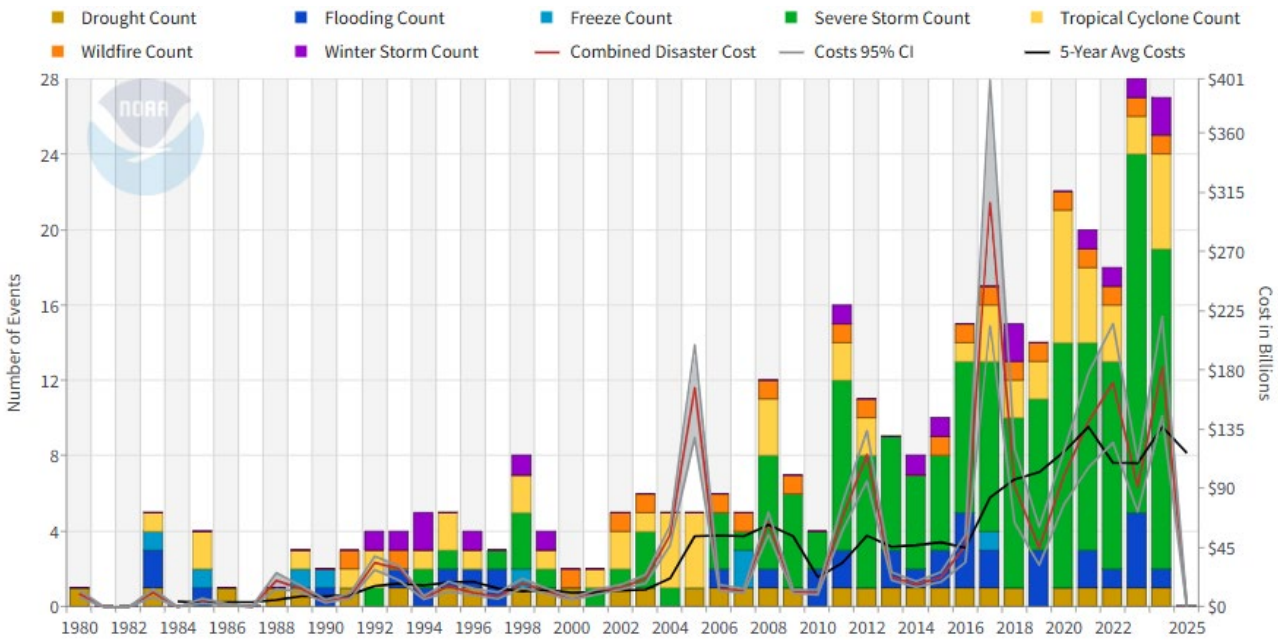
Source: NOAA, Contiguous U.S. Average Temperature, accessed April 17, 2025.

Challenge 1: The Costs of Climate Change Are Already Large, Visible, and Rising – Decarbonizing Power Remains Urgent

The frequency and magnitude of extreme weather events such as hurricanes, droughts, and wildfires are rapidly increasing due to climate change, which poses a distinct challenge for electric utilities and grid reliability

- Extreme weather is driving electric utilities to increase capital spending to restore damaged infrastructure and improve system resilience, as well as to cover rising costs of insurance, damage-related litigation, and preventative operating expenses
- Over half of utility transmission and approximately two-thirds of distribution capex is not for expansion but for replacement and resilience, per EEI

Count and Cost of U.S. Billion-Dollar Disaster Events



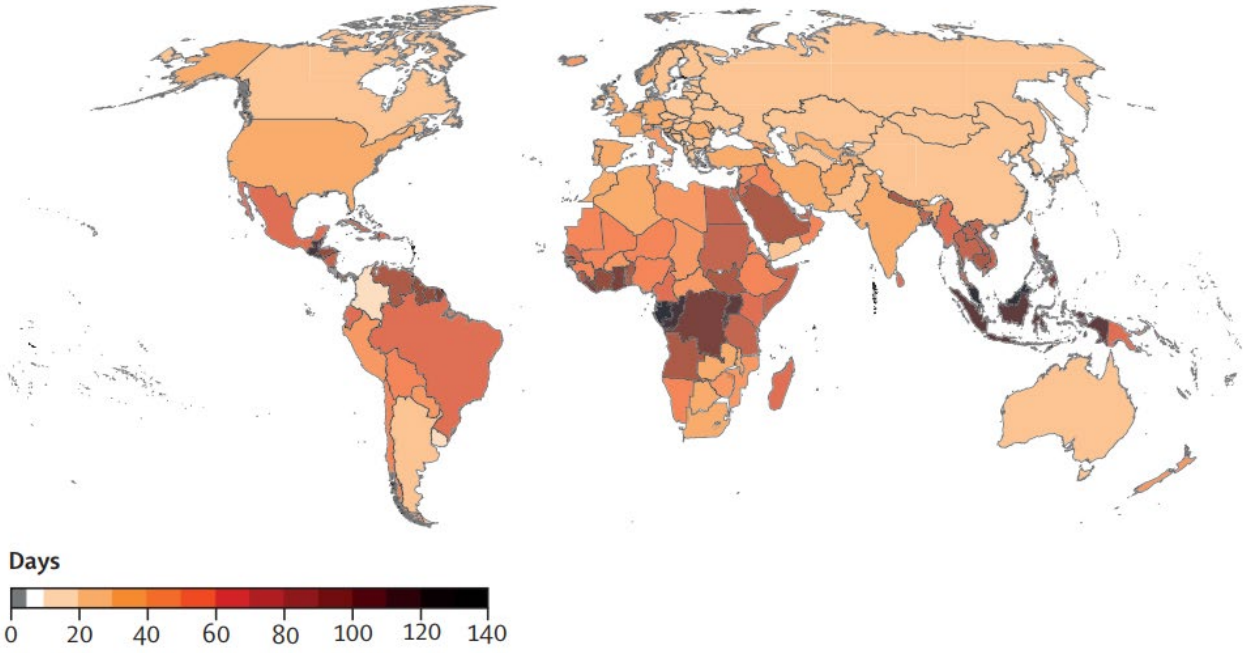
Source: All dollar values reported in nominal dollars; see NOAA, Billion-Dollar Weather and Climate Disasters, accessed April 22, 2025.

Challenge 1: The Costs of Climate Change Are Already Large, Visible, and Rising – Decarbonizing Power Remains Urgent (Cont.)

Decarbonization is critical to arrest climate change and protect vulnerable populations, who face serious and escalating threats related to extreme weather and heat, increased respiratory illness, and the growing spread of disease

- Globally, particulate matter air pollutants are the highest single risk factor for disease — more than high blood pressure, smoking, or diabetes
- Fine particulate matter and respiratory pollutants are strongly linked to heart attacks, strokes, asthma, chronic obstructive pulmonary disease, adverse pregnancy outcomes, and even dementia
- Excessive heat is already estimated to kill around 12,000 Americans annually – global deaths attributed to heat reached approximately 450,000 in 2021
- Between 2003 and 2022, global exposure to dangerous concentrations of particulates increased by 31%
- Extreme weather and climate change-related health impacts in 2023 alone caused the loss of 512 billion potential labor-hours (~ $835 billion in income losses)
- Food and water insecurity already triggering mass migration

Average Days Per Year Exceeding Minimum Mortality Temperature



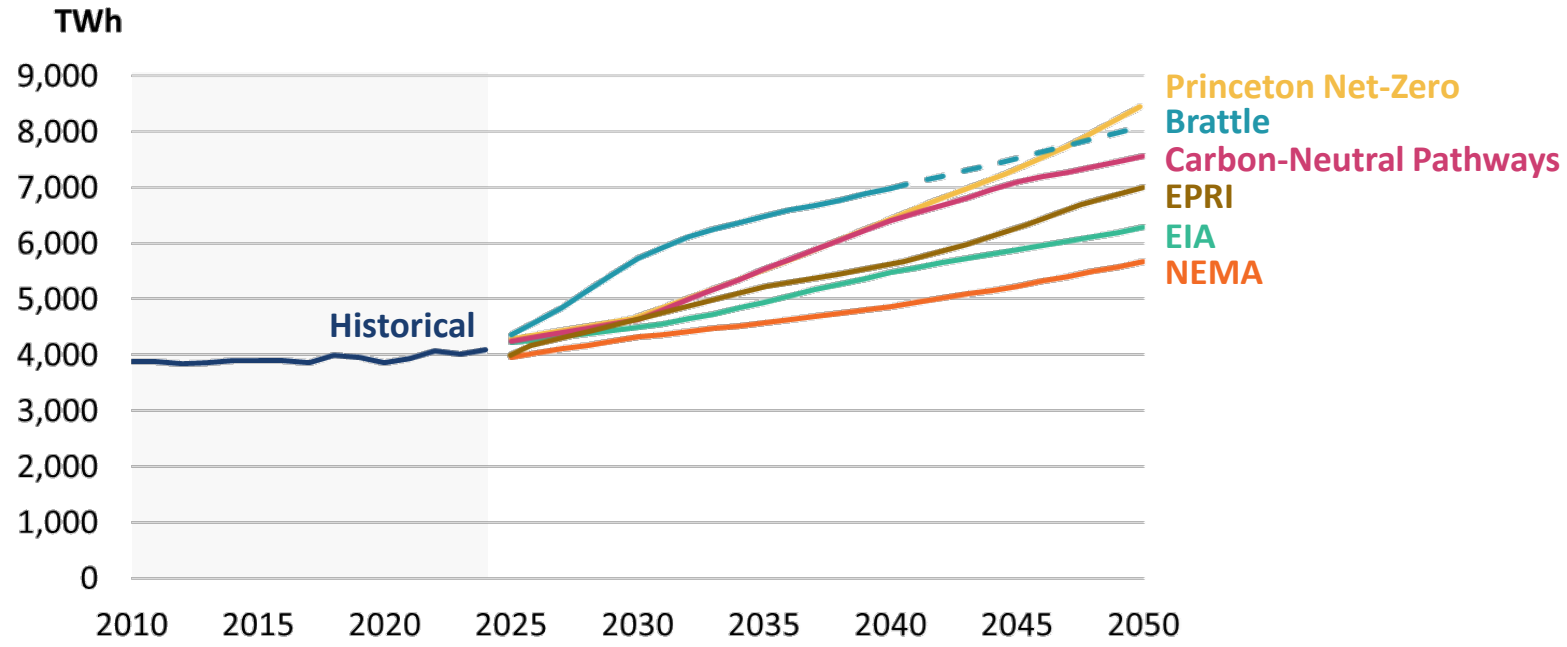
Sources and notes: Romanello et al., The 2024 report of the Lancet Countdown on health and climate change: facing record-breaking threats from delayed action, Lancet, 2024. See also GBD 2021 Risk Factors Collaborators, Global burden and strength of evidence for 88 risk factors in 204 countries and 811 subnational locations, 1990–2021, Lancet, 2024; and Shindell et al., The Effects of Heat Exposure on Human Mortality Throughout the United States, 2020.

Challenge 2: Non-Data Center Demand is Growing – and Needs to Grow Even Faster!

After several decades of flat demand, total US electricity consumption increased by 2% in 2024. To achieve economic and climate goals, recent forecasts suggest that consumption may need to double by 2050

- Growth in system consumption is driven by electrification, manufacturing growth, and data center load growth, as well as increased cooling load due to rising temperatures
- Data centers (DCs) only accounted for approximately 4% of total electricity usage in 2023, per Lawrence Berkeley National Lab
- Approximately 2.7% growth in average annual energy sales required through 2050 to double electricity consumption by then

Historical and Projected Total US Electricity Consumption



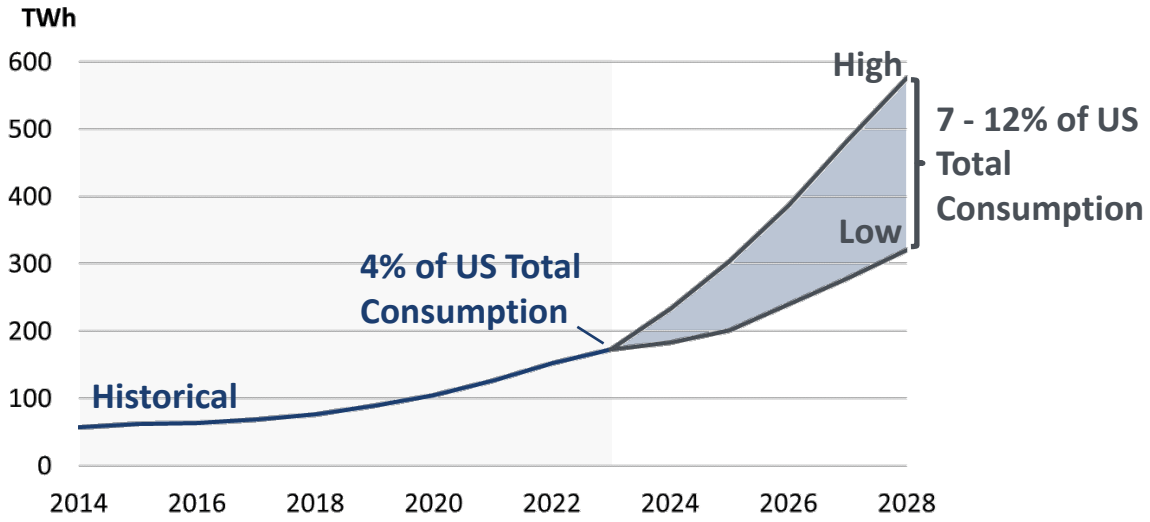
Sources and notes: Dashed segment of Brattle forecast beyond 2040 projected using forecast CAGR of electricity consumption from 2035 to 2040. Brattle forecast based on recent RTO and utility load forecasts for their own service territories. Historical data from EIA, Short-Term Energy Outlook Data Browser, 2025. See appendix for details and sources.

Challenge 3: Data Center Load Adds to Supply/Demand and Decarbonization Challenge

Data center load is expected to grow significantly, which will require utilities to expand generation and transmission infrastructure to meet the demand increase while upholding decarbonization goals

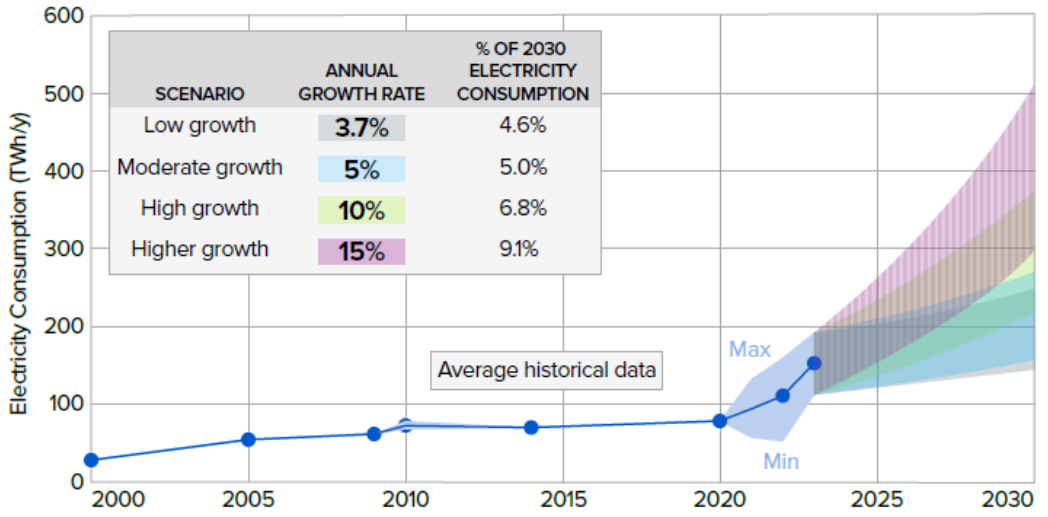
- LBNL and EPRI forecast that DC energy consumption will grow between 4% and 27% annually through the end of the decade and will account for at least 5% — and potentially more than 12% — of US electricity consumption by 2030
- Experts warn that utilities may be unable to meet DC demand due to supply chain issues and grid delays (tx, interconnection)

LBNL Forecast Data Center Energy Consumption



Source: LBNL, 2024 United States Data Center Energy Usage Report, 2024.

EPRI Forecast Data Center Energy Consumption



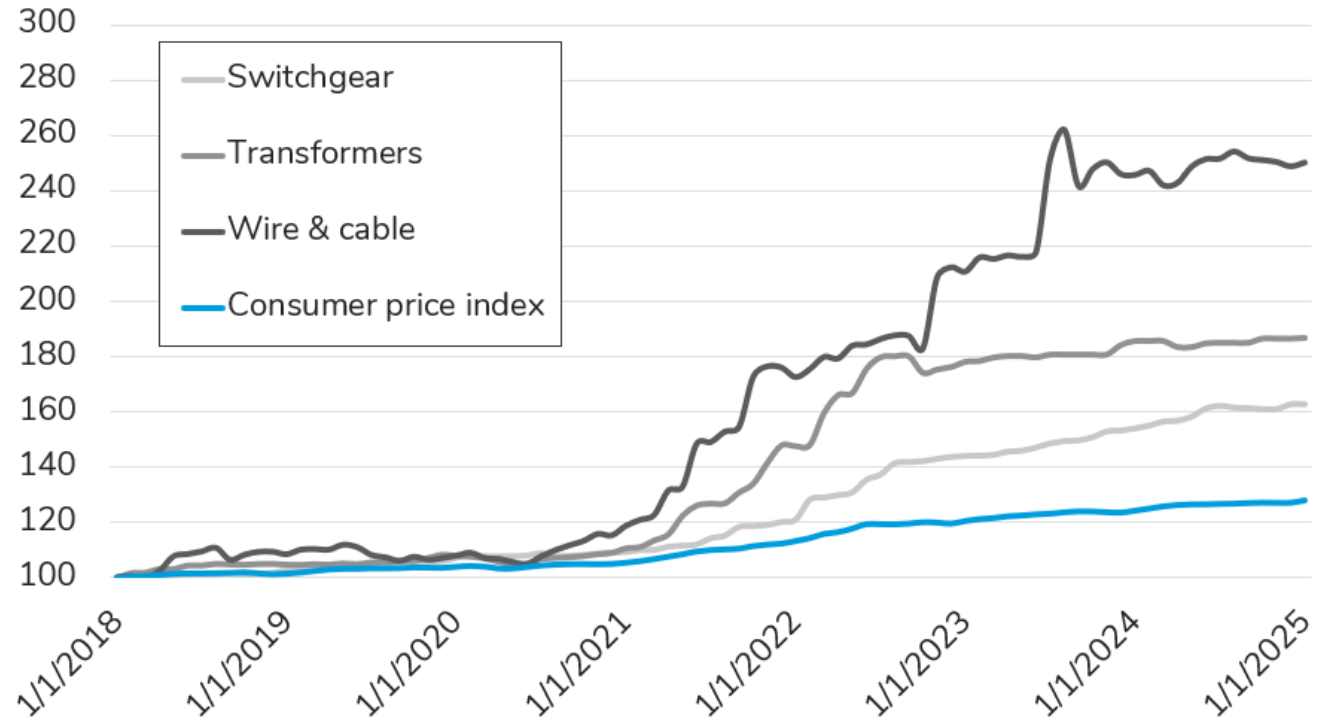
Source: EPRI, Powering Intelligence, 2024.

Challenge 4: Costs and Delays

Rising costs for critical power infrastructure have outpaced inflation since 2018, significantly impacting grid development

- According to Deloitte, in just four years raw copper prices have grown by 40% and finished power transformers cost an average of 60-80% more – after as much as a four year wait
- Consulting firm ICF's model for the cost of power predicts wholesale power costs will increase 19% in just the next three years
- According to CEO of NextEra Energy John Ketchum, the cost to build a natural gas plant has tripled in the last few years, and the time to build a new natural gas plant has grown from four and a half to six or more years

Producer Price Index for Critical Power System Equipment, St. Louis Fed



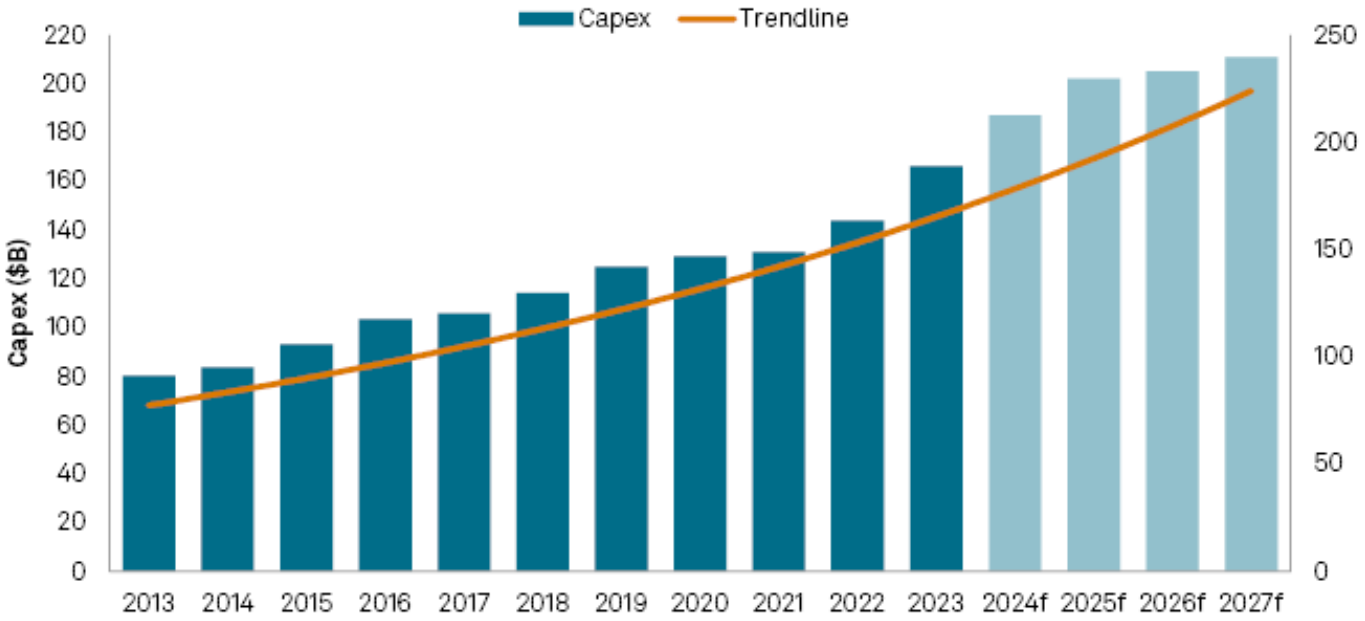
Source: Andy Lubershane, Steel for Fuel, 2025. Data from St. Louis Federal Reserve FRED databased, Producer Price Indices Accessed April 29, 2025.

Result: Increased Capital Expenditures

Updating electrical equipment and expanding generation potential to meet growing demand are already costly undertakings. This is worsened by the increasing costs throughout the electric equipment supply chain

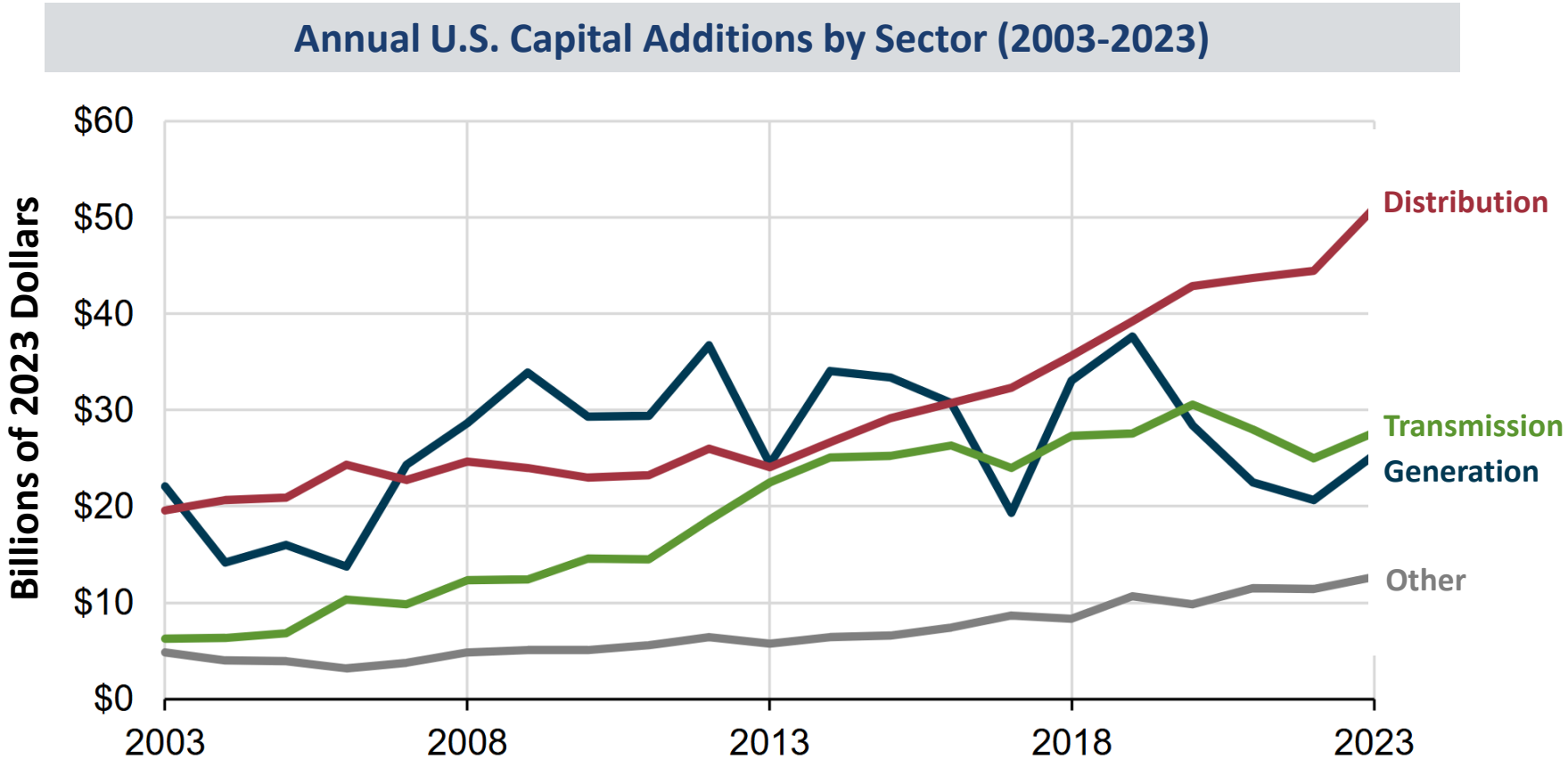
- As of July 2024, the projection of 2025 capital spending by investor-owned utilities was more than double 2014 spending in nominal dollars, according to EEI
- S&P predicts utility capex will continue increasing to a four-year total of almost $800 billion by 2028
- Last November, nine utilities serving data centers revised their forecasted capital spending upwards by an average of 22% versus year-ago levels according to Reuters

Energy Utility Actual and Estimated Capex



Source: Regulatory Research Associates, a group within S&P Global Commodity Insights, "Energy utility capex projected to eclipse $790B from 2025 through 2028," *S&P Global Market Intelligence,* January 9, 2025. Data compiled December 23, 2024.

Result: Generation No Longer the Largest Source of CapEx



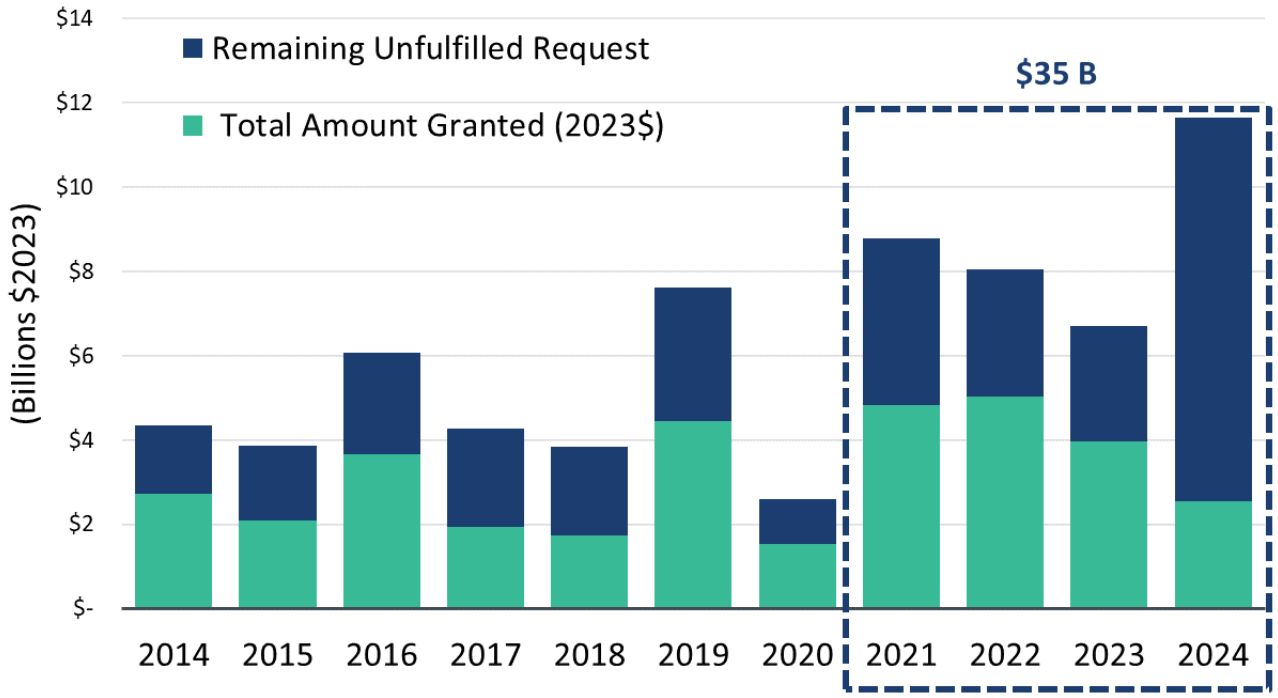
Sources and notes: Data from U.S. Energy Information Administration and Federal Energy Regulatory Commission (FERC) financial reports, accessed by Ventyx Velocity Suite. See EIA, Grid infrastructure investments drive increase in utility spending over last two decades, accessed April 30, 2025

Result: Era of Increased Rates

There is a pressing need to maximize throughput of existent systems to ease rate and emissions increases

- **Rates have been steadily increasing** in recent years: the aggregate amount requested from 2021 - 2024 was roughly $35 billion (in 2023$), more than the total amount granted in the previous 10 years combined
- Forecasts by utility analysts mirror expectations of growth and predict that **17 large utility companies** (out of about 45) may see **rate hikes above inflation** before 2027
- **Energy transition goals are backsliding,** as utilities are turning to new gas plants and/or deferred coal retirements to meet demand growth
- Signaling concern over regulatory recovery, S&P recently reported that **capital investment plans are pressuring credit quality** and companies are operating with minimal financial cushion from their downgrade thresholds

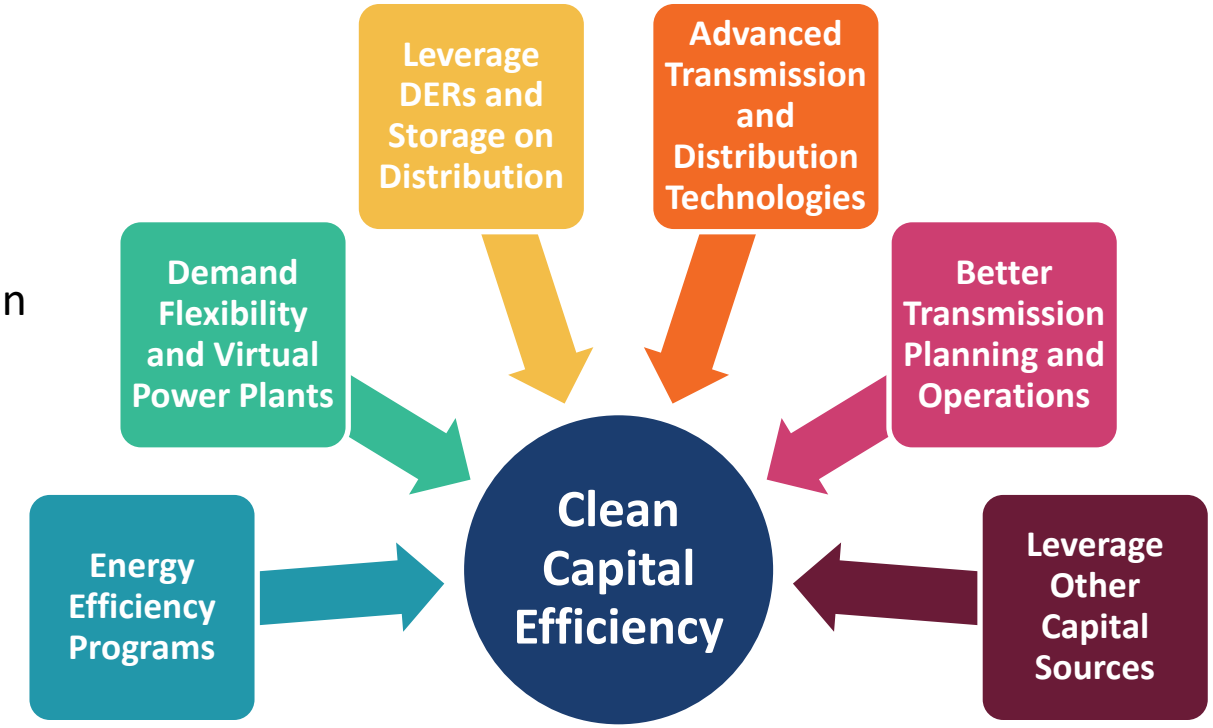
Total Amount Requested in Electric Rate Case Filings



Sources and notes: Data from S&P Global, expressed in 2023 dollars.

Strategy Under Challenge

- Demand necessitates long-term supply increases in sustained high-cost environment
- Not spending capital is not an option
- Regulators and public restive
- Shaky macro and policy environment



A Simple Idea:

- Squeeze as much energy service and throughput out of existing system
- Demonstrating greater efficiency creates the best "social license" to add new capital

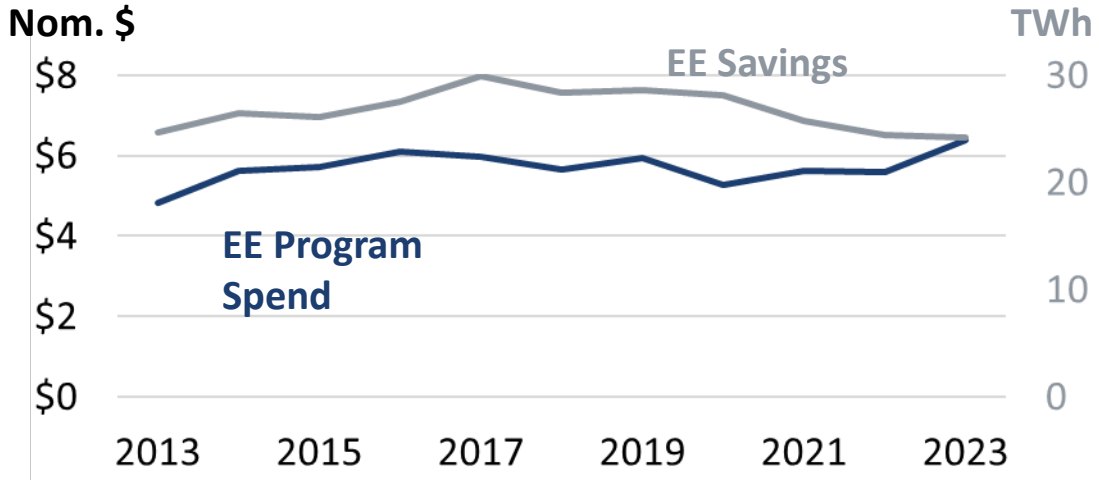
"Clean Capital Efficiency"

Energy Efficiency (EE)

It is critical that utilities "think outside the box" to galvanize EE efforts as a means of offsetting rate increases

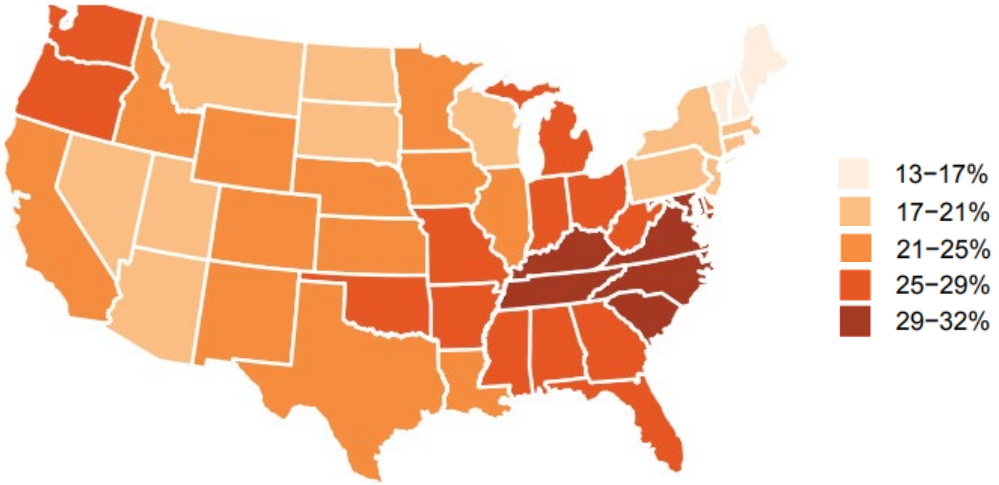
- Potential options include integrating EE into sectoral decarbonization targets such as building codes or IRA programs; expanding utility ownership of BTM efficiency assets; and considering co-benefits of EE (in addition to cost savings) in program evaluation
- EE particularly important and impactful for low-income households, who spend a larger portion of household income on energy bills than any other customer class
- Utility co-funding and collaboration with states is crucial to advance EE and make full use of the $8.8b of federal funds earmarked for home EE and electrification services in the IRA

U.S. Energy Efficiency Annual Spend and Electricity Savings



Source: EIA, Form EIA-861, 2013 – 2023 data files, accessed April 21, 2025.

Low-Income Household Potential Electricity Savings from EE



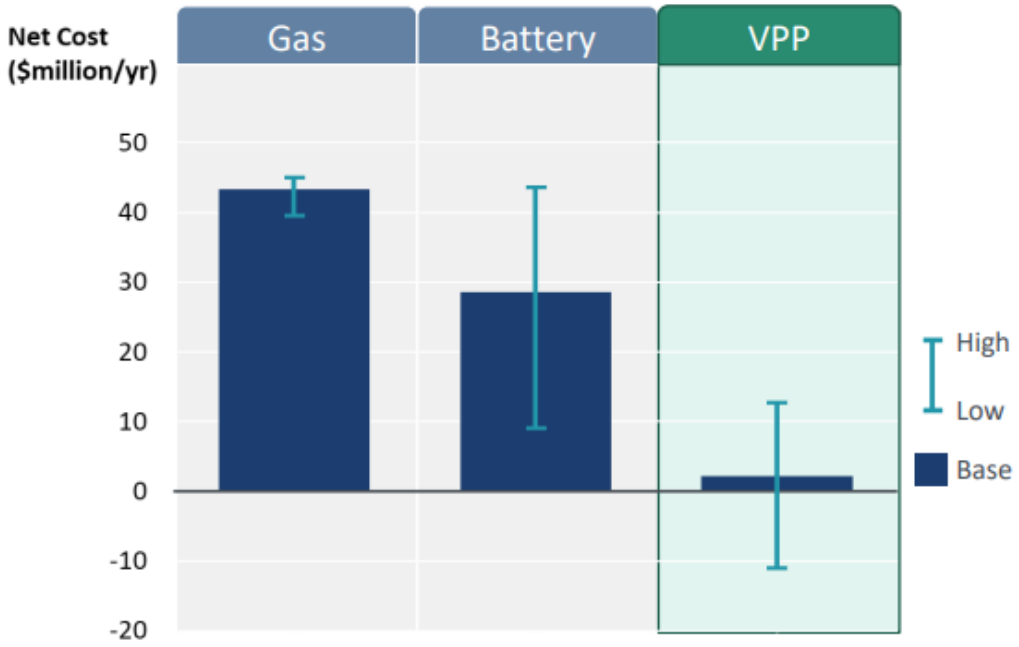
Source: US DOE, Low-Income Household Energy Burden Varies Among States — Efficiency Can Help In All of Them, 2019.

Demand Flexibility and Virtual Power Plants

Virtual Power Plants (VPPs) and Load Flexibility offer an emerging opportunity for utilities to costeffectively manage peak load and reduce overall consumption, all while engaging customers in the energy transition

- Similar to DR, VPPs aggregate controllable consumer energy technologies such as smart thermostats and EV chargers into “virtual” generating resources
- Recent analysis by the US Department of Energy and Brattle estimated the total addressable market for VPP deployment can increase from its current 30 GW to between 80 and 160 GW by 2030 – potentially supplying up to 20% of US peak demand by then
- However, greater reliance on VPPs will require utilities to adapt to a new method of grid control (i.e., orchestrating control over hundreds of thousands of small-scale resources)

Net Cost to Provide 400 MW of Resource Adequacy



Source: Represents range across all sensitivity scenarios. The Brattle Group, Real Reliability: The Value of Virtual Power, May 2023.

Leverage DERs and Storage on Distribution (“NWAs”)

“Non-Wires Alternatives” – which reduce or defer needs for traditional infrastructure upgrades – are not always cheap or feasible, but when/where they are, they should be used

- NWAs can and should be used (where appropriate) to defer costly transformer upgrades, even by a few years

Full dispatch of the distribution system is the next logical step beyond dispatching load

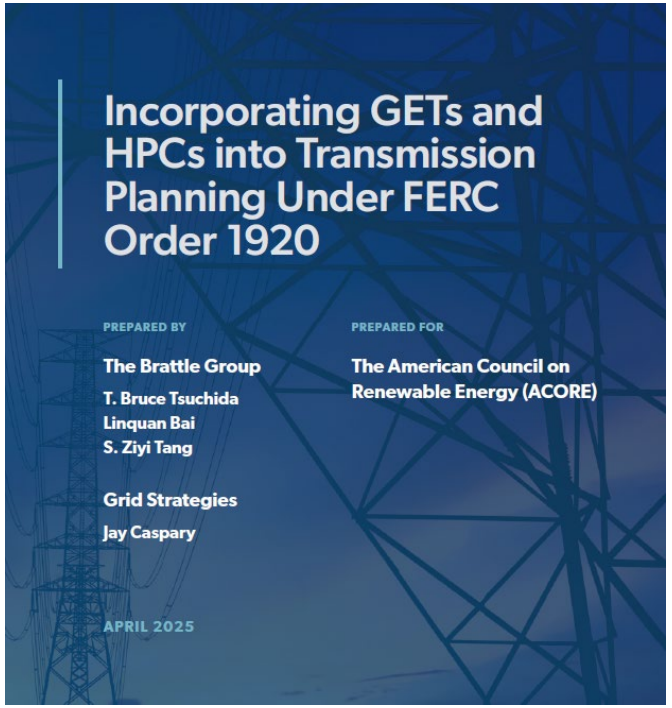
- Installing systems can be expensive and disruptive
- Installed base now significant enough to matter

Source: GE Vernova, Distributed Energy Resources Management System, 2025.

Advanced Transmission and Distribution Technologies (ATTs)

ATTs, which include dynamic line ratings, HVDC lines, and Grid Enhancing Technologies (GETs), provide benefits relative to traditional wires solutions, including cost savings, increased flexibility, and reduced losses

- ATTs include GETs, which are hardware and/or software changes that dynamically increase the capacity, efficiency, reliability, or safety of the power system faster and/or cheaper than traditional wires-based solutions



Link to the full report

Comparison of Potential Solutions to Relieve Congestion in PPL

	Reconductor	Rebuild	Dynamic Line Rating
Time to Implement	2-3 Years	3-5 Years	~1 Year
Downtime	Extended Outages	Extended Outages	No Outages
Cost	$0.5 Million per mile	$2-3 Million per mile	<$50 Thousand per mile*
Est. Capacity Benefit	+34%	+106%	+10-30%

Source: *<$1 Million total cost on 20-mile line & longer lines are cheaper. See Brattle, Incorporating GETs and HPCs into Transmission Planning under FERC Order 1920, 2025.

Better Transmission Planning and Operations

- Plan transmission by studying all measurable benefits; use scenario planning with "least regrets" criteria
- Study all GETs, including Remedial Action Schemes first, then reconductoring/HVDC conversions, then all new line options (rail corridor, HVDC, etc.)
- Reform interconnection process to "first ready/first connect," "connect and manage," or other accelerations
- Consolidate/coordinate local, regional, and interregional planning
- The FERC echoes the need for advanced transmission planning and technologies. Commissioner Judy Chang recently stated: "Planners in transmission utilities absolutely should be using the cutting edge, best in class, advanced technologies when building out our network…[To] squeeze as much as possible out of existing grid and new grid, we need to use the best technologies"

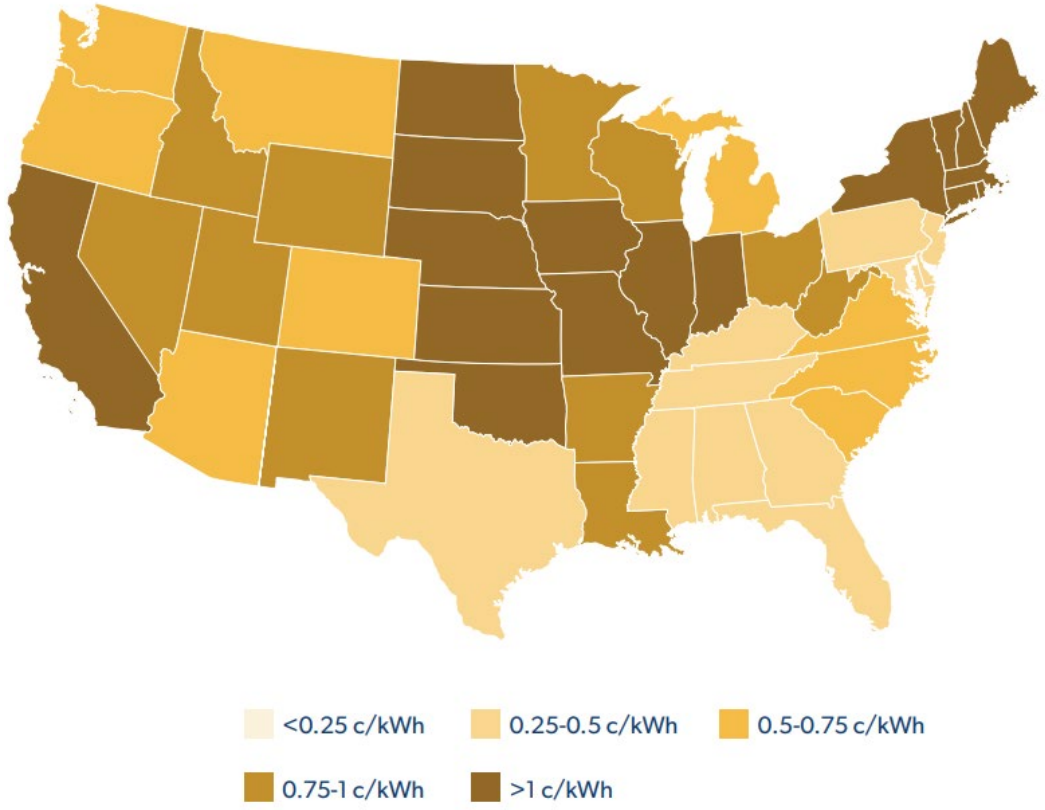
Brattle Report on Improved Transmission Planning

Source: See Brattle, Order 1920 Compliance: An Opportunity to Improve Transmission Planning beyond Mandates, October 22, 2024.

Leverage Other Capital Pools

- Electrification of transport and heat saves money in the long run, but there is high political sensitivity to electric rates
- Well formulated direct-to-consumer financial assistance to aid the transition is a win-win for economy and environment and relieves some utility burdens
- Similarly, federal and state financial assistance to large discrete infrastructure projects, such as the IRA tax credits, alleviate rate pressures
- Even with these other capital sources, utilities will remain the centerpiece of ownership and operation, and by far the largest investment vehicle

Increase in Customer Electricity Costs, Assuming Removal of Clean Electricity Production and Investment Tax Credits
(c/kWh in 2035)

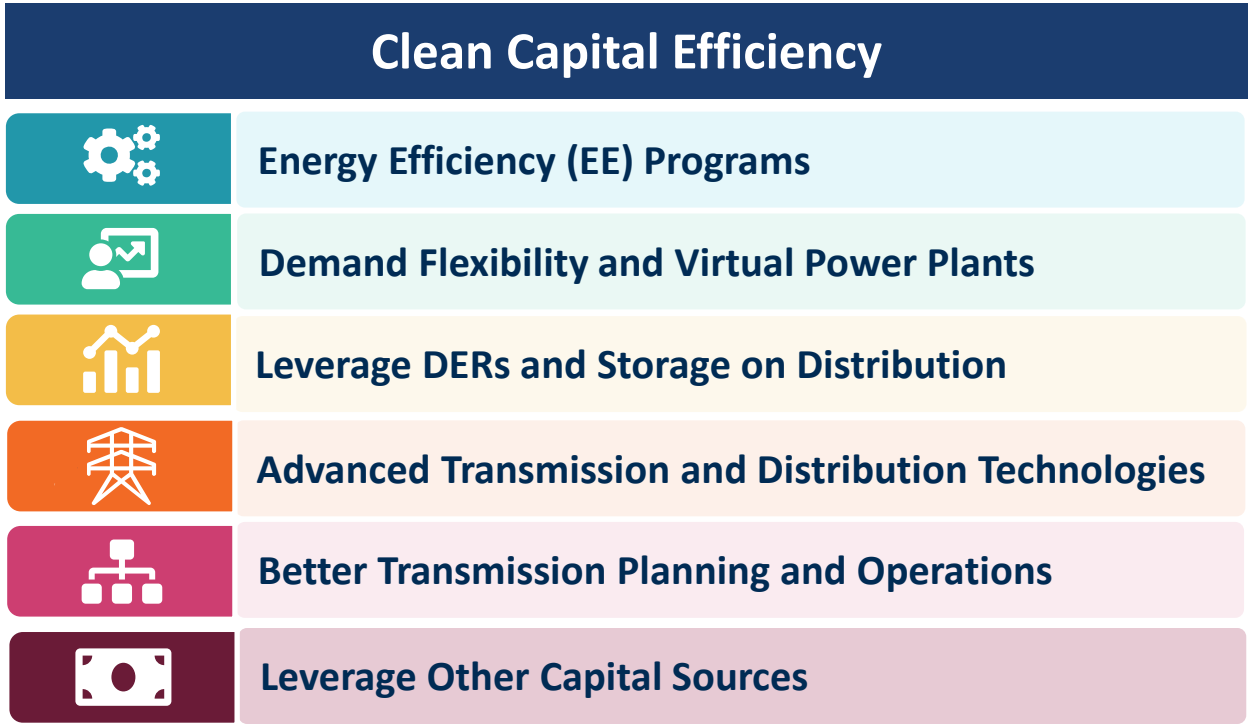


Source: The Brattle Group, A Wide Array of Resources is Needed to Meet Growing US Energy Demand, Published February 2025.

Summary

Growing electrification use for decarbonization and economic growth is essential, and we must find a way to affordably service demand

- Due to the level of growth pushing on an inelastic supply change, a long cycle of higher cost awaits
- Squeezing as much service out of existing infrastructure – **Clean Capital Efficiency** – is a necessary complement to system expansion



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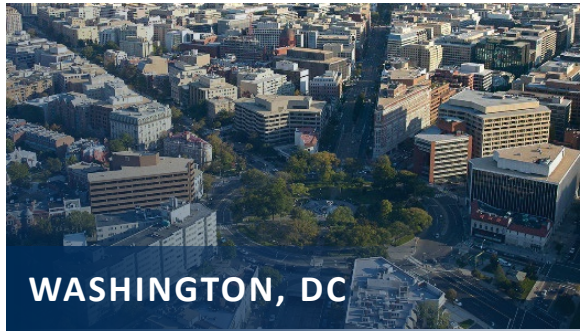

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Our Practices and Industries

TOP 25 PRACTICES

- Accounting
- Alternative Investments
- Antitrust & Competition
- Bankruptcy & Restructuring
- Broker-Dealers & Financial Services
- Consumer Protection & Product Liability
- Credit, Derivatives & Structured Products
- Cryptocurrency & Digital Assets
- Electricity Litigation & Regulatory Disputes
- Electricity Wholesale Markets & Planning
- Environment & Natural Resources
- Financial Institutions
- Healthcare & Life Sciences
- Infrastructure
- Intellectual Property
- International Arbitration
- M&A Litigation
- Oil & Gas
- Regulatory Economics, Finance & Rates
- Regulatory Investigations & Enforcement
- Securities Class Actions
- Tax Controversy & Transfer Pricing
- Technology
- Telecommunications, Media & Entertainment
- White Collar Investigations & Litigation

Clarity in the face of complexity

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Appendix

Electricity Consumption Forecast Sources

- **EIA Annual Energy Outlook:** EIA, Annual Energy Outlook 2025, Table 8, accessed April 30, 2025.
- **EPRI:** Excludes electrolysis load. Perry Stephens, EPRI Decarbonization Pathways Analysis, EPRI, January 13, 2025
- **Princeton Net-Zero America:** Uses "E+ RE-" scenario (aggressive end-use electrification; wind and solar rate of increase constrained to 35 GW/y (~30% greater than historical maximum single-year total). Includes effects of flexible intermediate loads that absorb variable wind and solar generation (electrolysis, direct air capture, and electric boilers). Princeton University, Net-Zero America: Potential Pathways, Infrastructure, and Impacts, October 29, 2021.
- **Brattle:** Based on most utility and RTO load forecasts. For a prior iteration of this forecast (circa February 2025) see Newell et al., A Wide Array of Resources is Needed to Meet Growing U.S. Energy Demand, The Brattle Group, 2025.
- **NEMA*:** Forecast produced by PA Consulting for NEMA. See NEMA, A Reliable Grid for an Electric Future, 2025.
- **Carbon-Neutral Pathways*:** Excludes electrolysis and electric boiler load. Williams et al., Carbon-Neutral Pathways for the United States, AGU Advances, 2020.

** Assumes linear growth between dates for which data is published (e.g., if consumption is forecast in 2025 and 2030, assumes linear growth between these dates).*