CUTTING CARBON WHILE KEEPING THE LIGHTS ON

LEVERAGING EXCESS CAPACITY TO KICKSTART A CLEAN ELECTRICITY FUTURE

insight brief

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HIGHLIGHTS

- Given recent cost declines of wind and solar technologies and persistently low natural gas prices, legacy coal plants in the United States face persistent financial losses and are under market pressure to retire.
- However, in considering economic retirement opportunities, utilities and regulators often raise concerns about reliability if coal capacity retires.
- In this brief, we find that these concerns are generally misplaced, and that the United States is on track to have 60 GW of excess generation capacity in 2025, above and beyond reserve margin targets.
- Because of this excess capacity, 27% of coal capacity could be economically retired without replacement in 2025. Furthermore, 56% could be retired if economically replaced by wind and solar alone and 100% could be retired if replaced by portfolios of renewables, storage, and demand-side management, all while maintaining reserve margin targets.
- There is a near-term opportunity to capture both the economic and climate benefits of this transition, even as the industry grapples with how to ensure and measure resource adequacy in a grid dominated by variable generation and affected by more frequent, more extreme weather events.

INTRODUCTION: MAINTAINING RELIABILITY IN A CHANGING GRID

Today, there is an apparent tension between two US electricity industry trends. First, driven largely by favorable economics, **utilities are replacing expensive and carbon-intensive fossil generation**, particularly coal, with wind, solar, and storage, at a faster rate now than ever. Portfolios of **clean energy resources** (renewables, storage, and often demand-side management) are now lower-cost while providing the same reliability as fossil power plants.

Second, system planners are recognizing a need to revisit the way they manage reliability in this rapidly shifting grid landscape, where weather-driven, variable renewable resources and storage are increasingly replacing "dispatchable" generating capacity from coal plants.[i]

[i] "Dispatchable" or "firm" capacity generally refers to fossil fuel-dependent generation or dammed hydroelectric facilities that can operate independently of short-term, weather-driven natural resources (i.e., wind and solar).

Power outages in California in August 2020 and in Texas in February 2021 highlight the urgency of naming and resolving this apparent tension. In California, the state's grid operators found that the **root causes** of these outages were climate change–driven extreme weather, inadequate market coordination, and inaccurate forecasting. However, some industry observers immediately jumped to the incorrect conclusion that California's renewable energy targets and progress to date were somehow at fault. In Texas, some observers made **similar, false claims** that the state's significant share of wind energy was to blame for the outages.

Taken to its extreme and applied to other regions of the country, this line of thinking would imply that fossil generation cannot be retired without compromising reliability. This conclusion relies on the premise that most regional grids in the United States are already running up against reliability limits, and any changes to the resource mix threaten additional outages.

This study assesses and rebuts that line of argument, and identifies the near-term opportunity to phase out costly, legacy coal generation across much of the country, either with or without direct replacement by lower-cost clean energy resources, all while maintaining grid reliability.

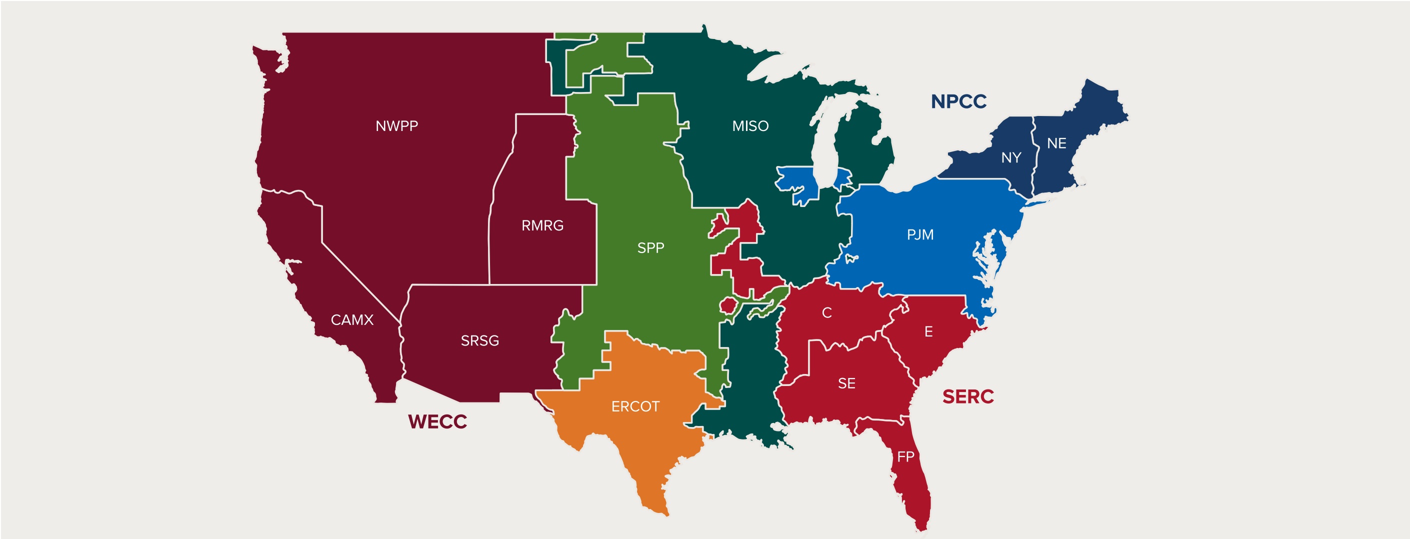
We focus our analysis on the 2020–2025 time period, under an assumption that present-day reserve margin targets will continue to govern system planning and operations in the next few years. In our conclusions, we place our findings in the context of other, recent reliability studies and ongoing discussions of new system reliability metrics better-suited to low-carbon grids under increasing stresses from severe extreme weather events.

SCOPE AND APPROACH

The basis for this study is an evaluation of regional reserve margins tracked by the North American Electric Reliability Corporation (NERC). These margins are a common measure of "resource adequacy," or the ability of a given power system to meet peak load conditions. We use the NERC assessment areas shown in Exhibit 1 to gauge the near-term status of regional reserve margins against target levels.

EXHIBIT 1

NERC Assessment Areas Located Primarily in the United States



First, we use the current and projected load and generation capacity from **NERC's Long-Term Reliability Assessment** to characterize each region's balance of load and generating capacity. We introduce a set of corresponding "electricity transition categories," defined in Exhibit 2, that describe the status of each region's balance. In Category 1 regions, dispatchable capacity exceeds demand and reserve margin targets.

In Category 2 regions, dispatchable generation can meet predicted load but wind and solar capacity are needed to meet the reserve margin. In this category, the nameplate capacities of wind and solar are adjusted by their "effective load carrying capacity," or ELCC. This estimates the resource's likelihood to be able to contribute to meeting peak load. In Category 3 regions, ELCC-adjusted wind and solar capacity contributes to meeting predicted peak demand. We note that California and Texas, where recent major outages occurred, are in Category 3 regions with demonstrable supply shortages; this report focuses primarily on Category 1 regions where there is significant excess supply.

Second, we calculate the dispatchable capacity that can be retired without replacement ahead of 2025 and still allow the region to meet its predicted peak load plus reserve margin target. This assumes ELCC-adjusted capacity values for existing wind and solar that account for declining ELCCs as additional wind and solar are deployed. In the calculation, we include planned additions and retirements of all generation types.

EXHIBIT 2

Electricity Transition Categories

Electricity transition category	Definition	Implications for retiring dispatchable generation
1. Excess dispatchable capacity	Meets reserve margin target entirely with fossil fuel, nuclear, and hydro generation.	Expensive fossil generation can be retired without replacement while maintaining reserve margin target.
2. Wind & solar help meet reserve margin target	Can meet predicted peak demand with fossil, nuclear, and hydro generation. Relies on wind and solar to meet reserve margin.	Expensive fossil generation can be retired with replacement by a combination of ELCC-weighted renewables and/or other capacity resources (storage, demand-side management).
3. Wind & solar needed to meet expected demand	Relies on ELCC-weighted wind and solar to meet predicted peak demand.	

Third, in each region, we consider how much coal capacity could be retired if coal generators were replaced by lower-cost solar and wind, with these resources' capacity credit reduced according to their region-specific ELCC that accounts for the newly built wind and solar. Specifically:

1. We compare the long-run marginal cost of energy (MCOE) of each region's coal plants with regionally appropriate renewables prices from the **National Renewable Energy Laboratory (NREL) 2020 Annual Technology Baseline**. We estimate long-run marginal coal costs using marginal cost, fixed O&M, and operational data from the Bloomberg New Energy Finance (BNEF) Power Plant Stack. Finally, we calculate ongoing capital expenditures using the method described in the **Electricity Market Module Assumptions** of the US Department of Energy-Energy Information Administration's (EIA) ***Annual Energy Outlook 2020***.

2. Where we find that renewable prices are lower than coal plant MCOE, we determine the amount of wind and solar capacity that would need to be built in each region to replace the energy from the uneconomic coal plants. We assume wind and solar are added according to the capacity ratio in each region's current interconnection queue.

3. Finally, we calculate how much additional uneconomic coal could be retired by valuing this additional wind and solar capacity at regionally appropriate ELCCs, lowered to account for higher renewables penetrations.

We provide further calculation details in the Technical Appendix.

KEY FINDINGS

Finding 1: Most US regions have surplus dispatchable capacity through 2025

Exhibit 3 summarizes the state of each NERC assessment area in 2020 and 2025. In 2020:

- Most regions in the United States are in Category 1, with more dispatchable (mostly fossil) generation than is needed to meet reserve margin targets.

- The Southwest Power Pool (SPP) is in Category 2, and wind contributes to meeting reserve margin targets.

- ERCOT (covering most of Texas) does not currently meet its reserve margin at all and relies on a small fraction of its installed wind and solar capacity to help meet peak demand (Category 3).[ii]

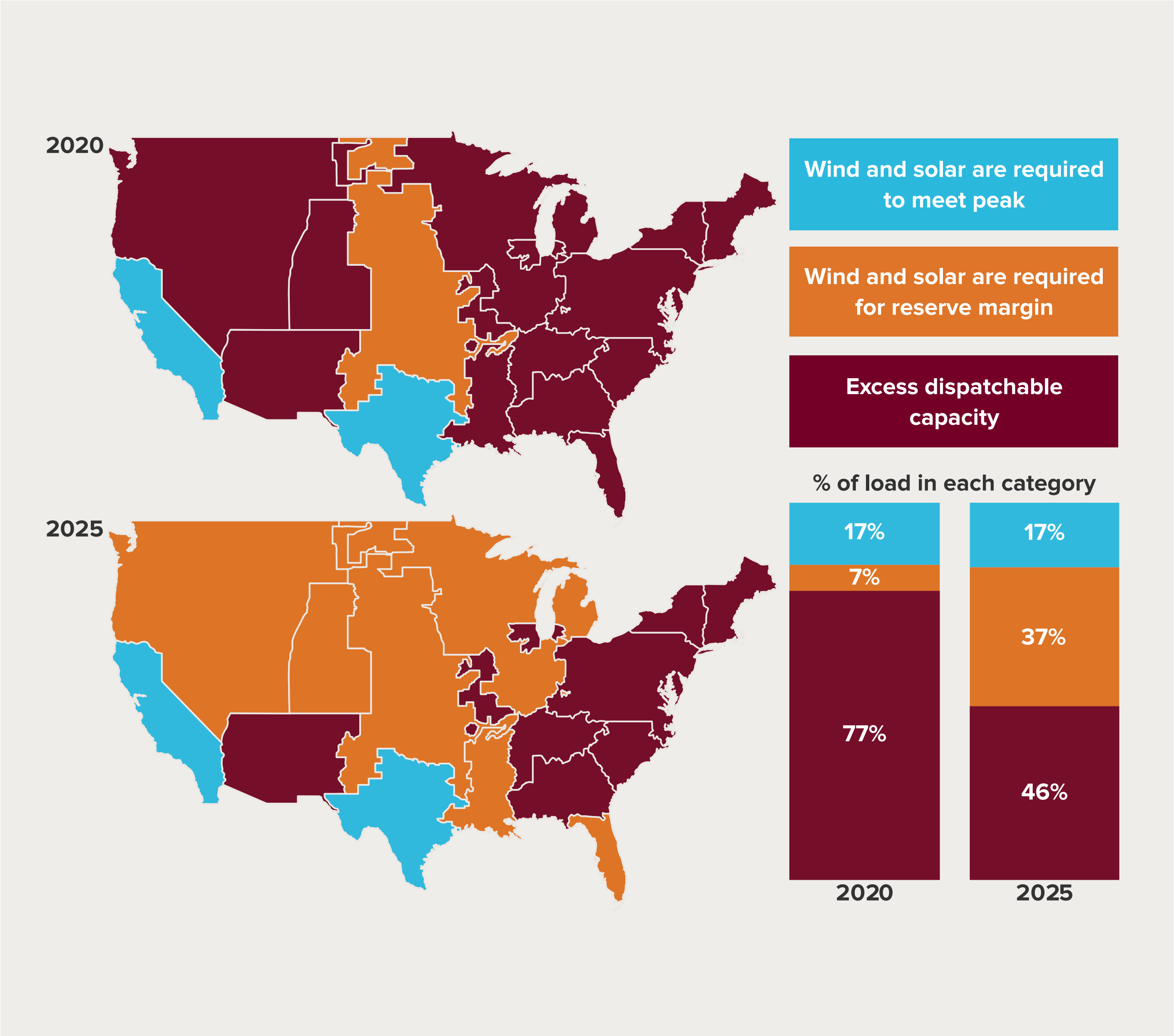
- CAMX (covering California) uses both wind and solar to meet peak demand (Category 3).

[ii] The reliance on a small fraction of renewable capacity to meet peak demand during contingency events was "**the least significant factor**" in the February 2021 outages, according to ERCOT officials, with **preliminary evidence** suggesting that the dominant cause of the outages was the weather-related unavailability of gas- and coal-fired generation.

In 2025, planners in more regions anticipate using wind and solar to meet their reserve margin targets, but not peak demand. Overall, NERC planning data suggests that nearly half the electricity load in the country will occur in regions with excess capacity above reserve margin targets (Category 1), including the entire Eastern United States (except Florida). Much of the Midwest and West will move into Category 2.

EXHIBIT 3

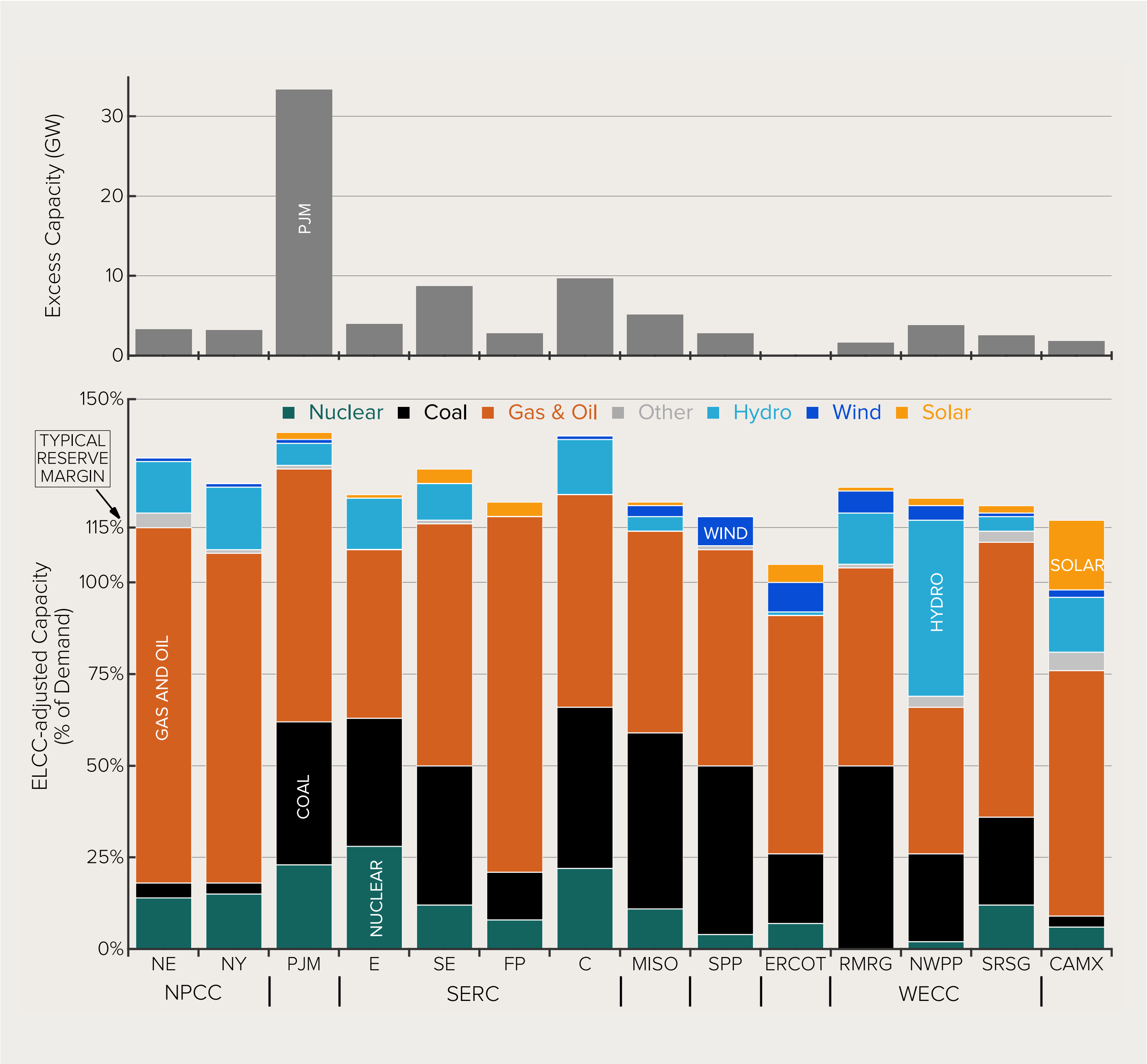
Renewable Transition Category for Each NERC Region in 2020 and Projected for 2025



In Exhibit 4, we show how each generation type contributes to the 2020 capacity requirement. We also show the absolute amount of excess capacity in each region beyond that needed to meet its reserve margin target, assuming the ELCC-adjusted capacity credit for wind and solar. Most excess capacity is in the eastern United States, especially the PJM Interconnection system, which has over 30 GW of excess generating capacity above a 15% reserve margin target. In a number of eastern regions, including PJM, dispatchable thermal capacity exceeds the reserve margin without accounting for any wind or solar.

EXHIBIT 4

Excess Capacity in 2020 above a 15% Reserve Margin Target (top) and ELCC-Adjusted Capacity by Fuel Type (bottom)

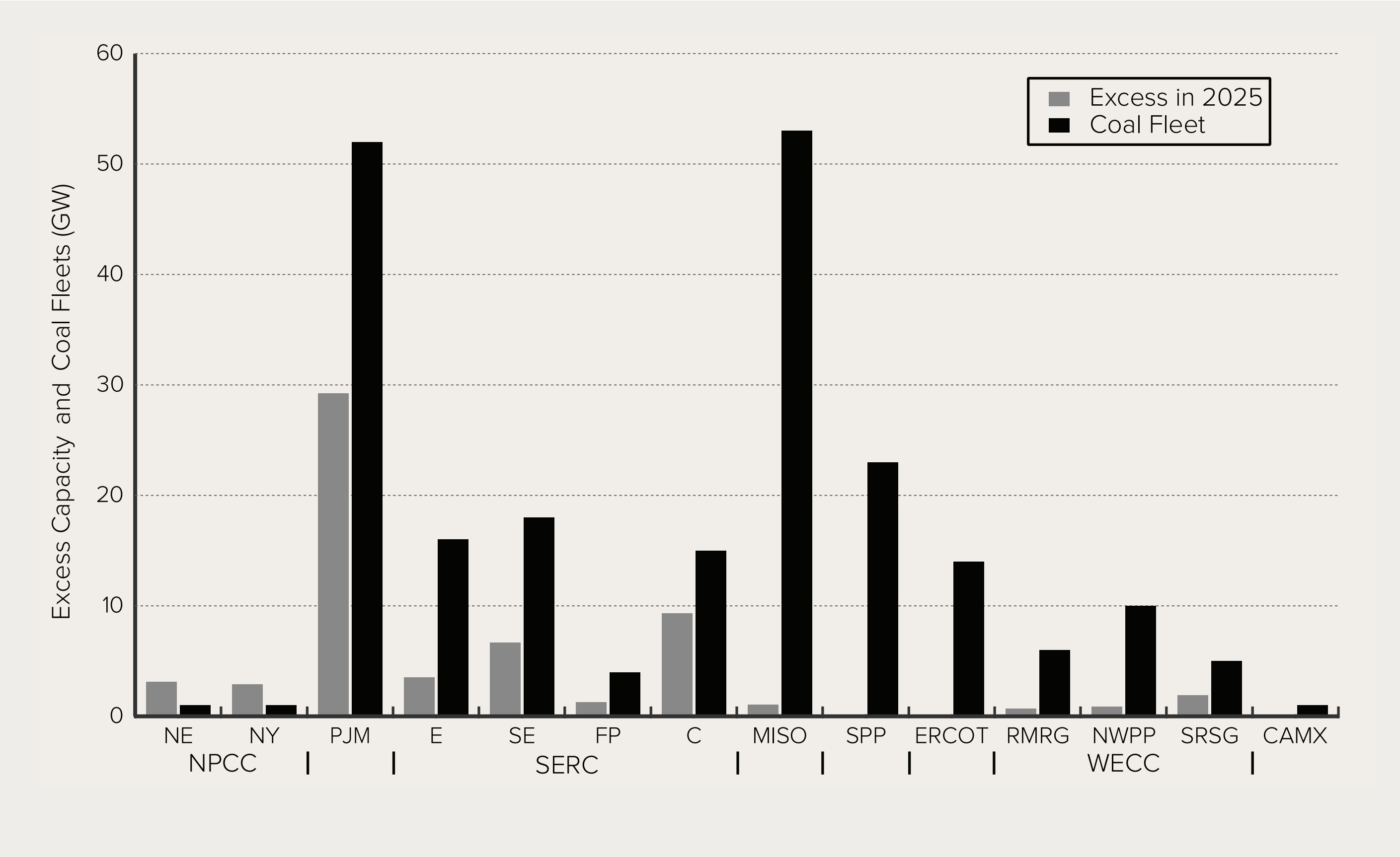


Finding 2: In 2025, the United States can retire 27% of coal capacity without replacement while maintaining reserve margin targets

The excess capacity expected to remain online in 2025 suggests that 27% of the US coal fleet could be retired without replacement by any new resource, while still meeting regional reserve margin targets. Exhibit 5 compares projected excess capacity in 2025 (gray bars) and coal fleet (black bars). In PJM, over half of the coal fleet can be retired while maintaining a 15% regional reserve margin. Similarly, large fractions of coal capacity in the Southeast (SERC) are unnecessary for meeting reserve margin targets. In contrast, ERCOT, MISO, SPP, and RMRG do not expect to have significant excess capacity in 2025; retiring coal plants in these regions would require replacement with other resources to meet 2025 reserve margin targets.

EXHIBIT 5

Comparison of 2025 Regional Excess Capacity and Coal Fleets



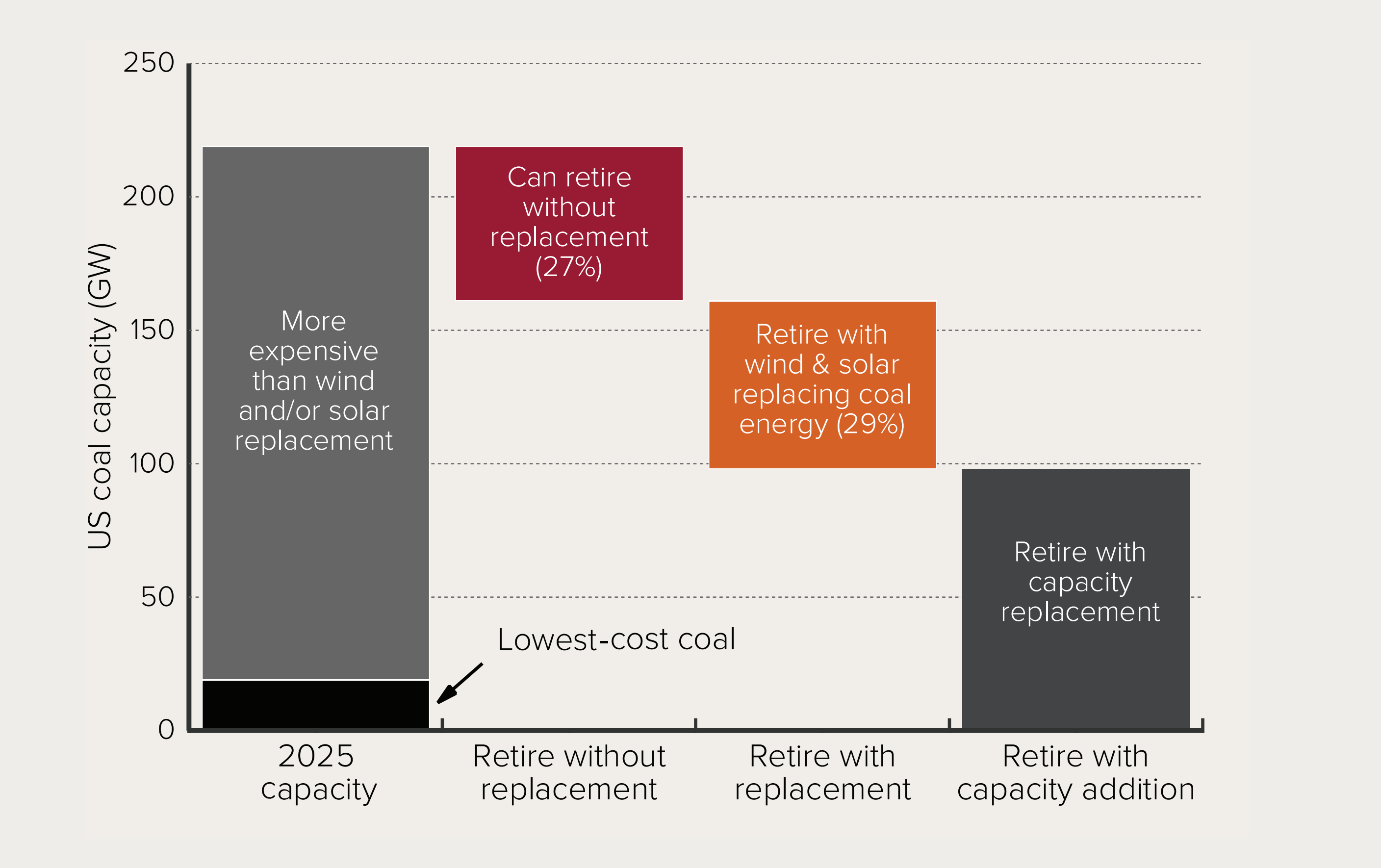
Finding 3: Over half of the remaining US coal fleet can be retired and replaced with wind and solar alone while still meeting 2025 reserve margin targets

In addition to the opportunity to retire 27% of coal capacity without replacement, as described above, cost-effective replacement of coal generation with wind and solar generation can provide capacity (adjusted by ELCC) that allows additional coal to be retired and still meet reserve margin targets. Exhibit 6 shows the national coal fleet (black and gray) and the fraction that can be retired without replacement (maroon). It also shows the amount that can be retired and replaced if planners account for the ELCC-adjusted capacity of lower-cost wind or solar added to replace electricity currently generated by uneconomic coal plants (orange). The nameplate capacity of this wind (137 GW) and solar (344 GW) is a combined 480 GW.

To retire the remaining coal by 2025 while maintaining reserve margin targets, utilities can procure additional capacity, likely cost-effectively, with "clean energy portfolios" that combine renewables, storage, and demand-side management approaches. In our 2019 report, we found that **clean energy portfolios** could provide the same capacity and energy services at lower cost than 90% of proposed new gas generation.

EXHIBIT 6

US-Wide Opportunity to Replace 2025 Coal Capacity without Compromising Reserve Margins



CONSERVATISMS AND LIMITATIONS OF THIS ANALYSIS

Our approach relies on a straightforward analysis of resource adequacy, based on definitive NERC data covering present-day reserve margins and their likely evolution. Through this we arrive at directional conclusions around the level of excess and replaceable coal capacity across US grid regions in the next five years. Below we outline several conservatisms and limitations inherent in this approach:

- **Replacement resources:** The most important conservatism in this study is that we limit our analysis of replacement resources to wind and solar alone. We do not account for the capacity replacement value of stand-alone storage. There is currently 55 GW of energy storage in current **interconnection queues**, equivalent to nearly half the remaining coal fleet that could be replaced by wind and solar alone in 2025. We also do not account for the increasing **prevalence of "hybrid" solar and wind projects** that also include storage and thus have higher capacity value than wind or solar alone. Finally, we do not account for the ability to procure demand-side resources (including both **energy efficiency** and **demand flexibility** resources) that reduce generation capacity needs.

  In our economic assessments, we also neglect that operators are using today's coal at lower capacity factors; taking these lower capacity factors into account would further erode coal economics. As has been shown by leading utilities across the United States in recent procurements, portfolios of these resources can cost-effectively replace aging, uneconomic coal plants while maintaining system reliability.

- **Transmission:** As a conservatism, we do not account for the ability of any existing or new inter-regional transmission capacity to help meet reserve margin targets across NERC assessment areas. A related limitation of the study is that we do not directly model power flow, or the ability of intra-regional transmission to accommodate a shifting resource mix even given surplus capacity at the regional level. We note that other researchers have directly addressed these limitations with production-grade modeling software and arrived at detailed conclusions that support our directional findings. For example, UC Berkeley researchers, in their **2020 study**, highlighted the ability to retire all existing coal plants by 2035 and replace them with renewable energy and storage while maintaining system reliability. The associated transmission investments added only 0.2¢/kWh—less than 2%—to average retail rates.

- **Coal generation costs:** In assessing the economic case for renewables to replace coal, we only consider the direct, going-forward costs of coal plant operations. We do not consider the impact of any price or cap on carbon emissions, the costs of emission control upgrades, or costs associated with other environmental externalities. We note that any price on carbon emissions is likely to lead to rapid, economically driven retirement of coal and replacement with lower-carbon resources, predominantly renewables. For example, **a 2020 study by Energy and Environmental Economics (E3)** found that even a $10/ton price on carbon emissions would lead to the economic retirement of all coal capacity in PJM by 2030.

- **Reserve margin levels:** We recognize the importance of reassessing reserve margin targets given the increasing severity of extreme weather that has contributed to the recent outages in California and Texas, but we do not undertake that analysis here. This paper focuses on regions where supply significantly exceeds reserve margin targets, and we note that no region in this category has experienced a major outage related to inadequate generation capacity in recent years.

Collectively, these conservative design choices lead our results to underestimate the coal capacity that could be cost-effectively retired by 2025 and replaced with clean energy resources without violating reserve margin targets.

CONCLUSIONS AND IMPLICATIONS

Reliability after 2025

In this analysis, we examined the near-term opportunity to reduce costs and carbon emissions through 2025, without violating reserve margin targets. This near-term analysis explicitly does not look beyond 2025 and the challenges of maintaining reliability with higher levels of variable generation; however, other system modelers have begun tackling this challenge. In a variety of recent studies, using definitive power system modeling software, diverse authors show the technical and economic feasibility of deep emissions reductions.

Generally, these studies show that 1) it is low-cost to eliminate the vast majority of emissions quickly by expanding wind and solar, and 2) existing natural gas capacity provides adequate balancing for the first 70%–90% of emissions reductions, with little or no need for additional dispatchable generation capacity in the near term. Below, we highlight a few of these studies.

- UC Berkeley and GridLab, using industry-standard modeling tools, found that a **90% carbon-free US electricity system, achieved in 2035, lowered rates from today**. Energy Innovation outlined corresponding polices that could achieve **100% carbon-free electricity by 2035**.

- Evolved Energy Research showed that a variety of pathways can reach net-zero economy-wide US carbon emissions by 2050 through coal retirement and accelerated growth of wind and solar, while retaining reliability. The costs of these decarbonization paths are similar to a reference scenario with limited emissions reductions. In the Evolved pathways, the electricity system both decarbonizes and expands to support increased demand from **buildings** and **transportation electrification**, which **cost-effectively reduces end-use emissions**.

- E3 showed that California **can maintain resource adequacy as California's grid decarbonizes to meet state policy targets**, including supporting electrification of other sectors, but that some dispatchable generation will be needed.

To assess system reliability for the resource mixes modeled in these studies, industry experts increasingly recognize that legacy definitions for resource adequacy are insufficient. For example, the **Energy Systems Integration Group (ESIG)**, with contributions from professional grid planners at member utilities, recently summarized the **shortcomings of a reserve margin approach**. ESIG's **Redefining Resource Adequacy task force** is highlighting the need for new metrics that better capture reliability contributions from new technologies (including storage and demand flexibility) in low-carbon grids with large amounts of weather-dependent generation.

Least-Regrets Opportunities to Kickstart the Energy Transition

New metrics and approaches to defining resource adequacy will be critical in the coming decades as the US power system evolves—but today, there is no technical reason to delay taking the first steps. Because many US utilities have historically over-invested in coal, nuclear, and gas capacity, there is a unique opportunity in the next five years to phase out over 100 GW of costly coal generation, replace it with renewables, and maintain reliability.

As this and other studies show, the barriers to reducing cost and emissions quickly in the US power system are primarily institutional, not technical or economic. RMI and others have suggested ways to address these institutional challenges, including **leading-edge procurement processes** that enable effective competition from clean energy resources, financial tools to **enable accelerated retirement of legacy coal plants** without rate increases, **transmission coordination and expansion** to better integrate new renewable and existing dispatchable capacity, **21st-century approaches to resilience** that avoid the pitfalls on display in Texas and elsewhere of relying on centralized fossil generation, and **market reforms** that minimize excess reserve margins and lower customer costs.

Over the past 10 years, utilities have proven that large amounts of wind and solar can be added to their grids without sacrificing reliability. As utilities increasingly rely on variable generation for peak capacity, they are right to carefully update their resource adequacy planning. But for the next five years at least, while the United States enjoys significant excess capacity that we have already bought and paid for, there is no technical or economic reason to slow renewable deployment while waiting for new resource adequacy metrics to be finalized and adopted.

ABOUT RMI

RMI is an independent nonprofit founded in 1982 that transforms global energy systems through market-driven solutions to align with a 1.5°C future and secure a clean, prosperous, zero-carbon future for all. We work in the world's most critical geographies and engage businesses, policymakers, communities, and NGOs to identify and scale energy system interventions that will cut greenhouse gas emissions at least 50 percent by 2030. RMI has offices in Basalt and Boulder, Colorado; New York City; Oakland, California; Washington, D.C.; and Beijing.