Stranded Coal: 45 Gigawatts of Regulatory Life Support

Abstract

We identify 45,194 MW of coal generation capacity in the United States that operates below 30% capacity factor with no announced retirement date. This "stranded" fleet imposes an estimated $5.8 billion per year in costs on ratepayers – $2.2 billion more than replacing it with solar-plus-battery at current prices. Using EPA continuous emissions monitoring data, we measure the fleet's actual CO2 output at 91.6 million tons annually, 12.5% higher than previous estimates based on standard emission factors. The stranded fleet is concentrated in traditionally regulated states (76% of capacity), and these states retire coal at dramatically lower rates than restructured states (36.7% vs 59.1%, $p < 0.001$). The fleet grew 50% from 2022 to 2024, adding 15,000 MW of effectively defunct capacity with no exit plan. Plant-level analysis reveals that six corporate parents – Southern Company, Duke Energy, Talen/KeyCon, Evergy, Dominion Energy, and NRG Energy – control 56% of the stranded fleet. We rank every stranded plant on a composite retirement priority score based on capacity factor, CO2 emission rate, and total emissions, identifying Scherer (GA), Powerton (IL), Mayo (NC), and White Bluff (AR) as the highest-priority retirement candidates.

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1. Introduction

The US coal fleet is in structural decline. From 330 GW of historical capacity, only 184 GW remains operational, and the fleet-wide capacity factor has dropped from 50.5% in 2015 to 40.1% in 2024. Coal's generation share fell from 33% to under 20% over the same period, displaced primarily by natural gas and increasingly by wind and solar.

This decline is not uniform. Approximately 131 GW of coal still operates above 30% capacity factor – running frequently enough to cover variable costs and contribute meaningfully to the grid. But 58 GW has fallen below 30% CF, a threshold below which coal plants cannot cover fixed costs through energy sales in most markets. Of this marginal fleet, 13 GW has a planned retirement date filed with the Energy Information Administration. The remaining 45 GW has no exit plan.

These 45 GW represent a distinct economic category: plants that the market has abandoned but that regulatory structures preserve. They run sporadically, burn fuel inefficiently at partial load, employ staff year-round regardless of output, and earn returns for their owners through the rate base rather than through competitive dispatch. They are, in the economic sense, stranded assets being kept alive by institutional inertia.

This paper documents the stranded fleet, quantifies its costs and emissions, identifies who owns it, and proposes a priority framework for managed retirement. It builds on three prior analyses: a generator-level identification of the stranded fleet from EIA data (v1), an emissions update using EPA continuous emissions monitoring system data (v2), and an independent replication of findings from Gowrisankaran, Langer & Reguant (2024) on regulatory barriers to coal retirement.

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2. Data and Methods

2.1 Data Sources

Generator-level data: EIA Forms 860 and 923 via PUDL (Public Utility Data Liberation Project), maintained by Catalyst Cooperative under CC-BY-4.0 license. PUDL integrates annual generator filings (capacity, technology, location, status, retirement dates from Form 860) with monthly generation and fuel data (generation, capacity factor, fuel costs from Form 923) into a single Parquet dataset with consistent identifiers. We use the 2024 vintage for capacity factor and operational data, and the 2026 vintage for retirement filing status.

Emissions data: EPA eGRID 2022 (Emissions & Generation Resource Integrated Database), which aggregates continuous emissions monitoring system (CEMS) readings into annual totals at the unit and generator level. Every large fossil plant in the US reports measured CO_2, SO_2, and NO_x under the Clean Air Act. The eGRID unit table (UNT22) provides coal-unit-specific CO_2 emissions; the generator table (GEN22) provides coal-generator-specific generation. Together these yield measured emission rates that are more accurate than standard emission factors.

Regulatory classifications: A hand-coded classification of all 50 states plus DC into restructured, traditional, or hybrid categories based on whether the state has implemented retail electricity choice and competitive wholesale markets. The classification follows the convention used by Gowrisankaran et al. (2024): states with full retail choice (CT, DE, DC, IL, MA, MD, ME, MI, NH, NJ, NY, OH, PA, RI, TX) are classified as restructured; all others as traditional.

2.2 Defining "Stranded"

A coal generator is classified as stranded if it meets all three conditions:

1. Capacity factor below 30% in the 2024 data year
2. No planned retirement date filed with EIA
3. Operational status = "existing" (not retired or proposed)

The 30% threshold is significant for several reasons. It falls below the breakeven capacity factor for coal in most wholesale markets. It is below the average capacity factor for new utility-scale solar installations. And it is below the level at which a coal plant can cover its fixed operations and maintenance costs through energy sales alone.

We aggregate from generators to plants when presenting plant-level analysis, using the EIA plant_id_eia as the grouping key and capacity-weighted average capacity factor as the plant-level CF.

2.3 Emission Rate Methodology

Standard emission factors (e.g., 2,000 lbs CO_2/MWh for coal) are fleet-wide averages that obscure substantial plant-level variation. We replace these with measured rates from eGRID.

To isolate coal-specific emission rates at multi-fuel facilities, we filter the eGRID unit table to coal fuel codes (BIT, SUB, LIG, RC, WC, SC) and sum CO_2 emissions. We then filter the generator table to coal fuel codes and sum net generation. The ratio gives the coal-unit-level emission rate. This approach produces higher (more accurate) rates than whole-plant averages for facilities with gas co-generation, such as Crystal River (FL), where gas units dilute the plant-level rate.

The measured US coal fleet average is 2,292 lbs CO_2/MWh – 15% higher than the commonly assumed 2,000 lbs/MWh factor. The stranded fleet average is 2,251 lbs/MWh.

2.4 Cost Model

We estimate the all-in cost of operating the stranded fleet using three components:

Component	Assumption	Source
Fuel cost	$42.57/MWh	EIA 923 fleet average
Fixed O&M	$40/kW-year	EIA AEO industry average
Variable O&M	$7/MWh	EIA/Lazard estimates

The replacement benchmark is $45/MWh for solar-plus-4-hour-battery, reflecting 2024 PPA prices in most US markets.

2.5 Retirement Priority Score

Each stranded plant receives a composite score from three normalized components:

- **CF score** (30% weight): 1 minus normalized CF. Lower CF = higher priority.
- **CO2 rate score** (35% weight): Normalized lbs CO2/MWh. Dirtier = higher.
- **Total CO2 score** (35% weight): Normalized estimated annual CO2 tons. Larger emitters = higher priority.

This weighting reflects a policy preference for retiring the dirtiest and highest-emitting plants first, with lower capacity factor as a secondary signal of economic obsolescence.

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3. Results

3.1 The Stranded Fleet

The US coal fleet as of the 2024 reporting period contains 462 existing generators totaling 188,952 MW. Of these:

Category	Generators	MW	Share
Above 30% CF	316	130,446	69%
Below 30% CF, with retirement date	27	13,052	7%
Below 30% CF, no retirement date	114	**45,194**	**24%**

Nearly one in four megawatts of the US coal fleet is stranded.

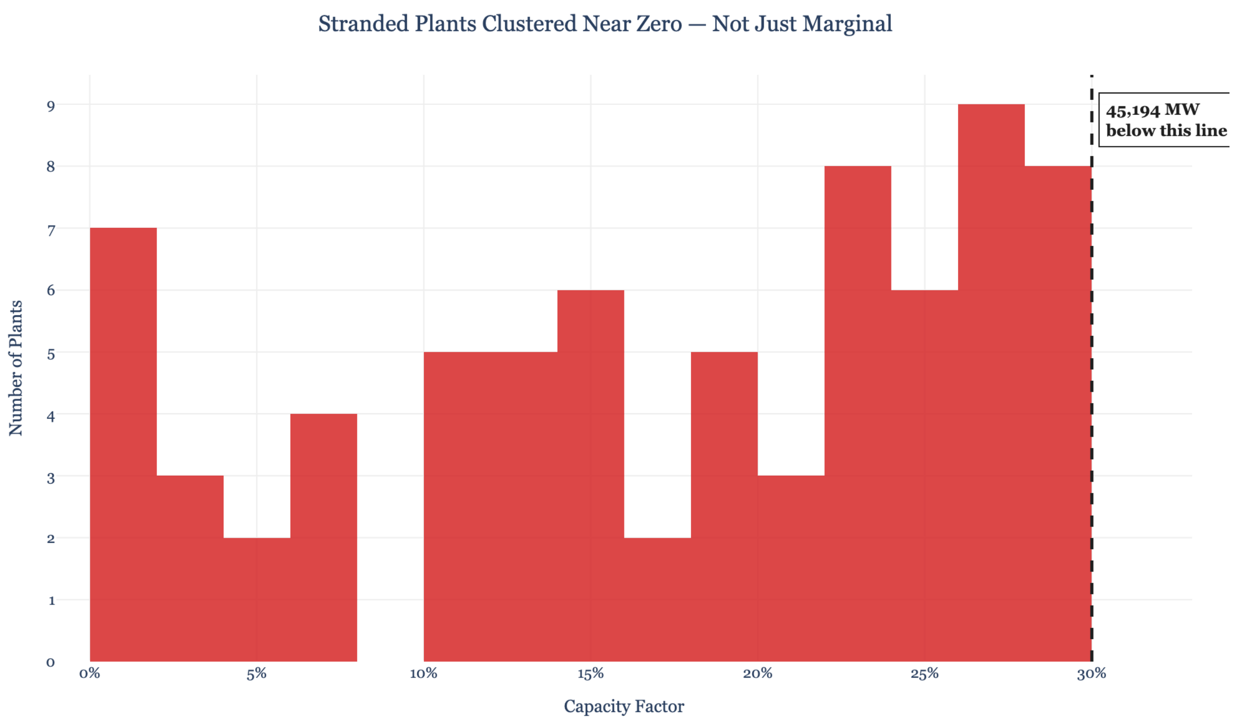

Figure 1: All 73 stranded plants have capacity factors below 30%. The fleet is not clustered at the margin — plants span the full range from 0% to 30% CF, with 45,194 MW below the stranded threshold.

The stranded fleet spans 22 states and 73 distinct plant sites. Figure 2 shows the geographic distribution: plants are concentrated in Appalachia, the Midwest, and the Southeast, with minimal presence in the West.

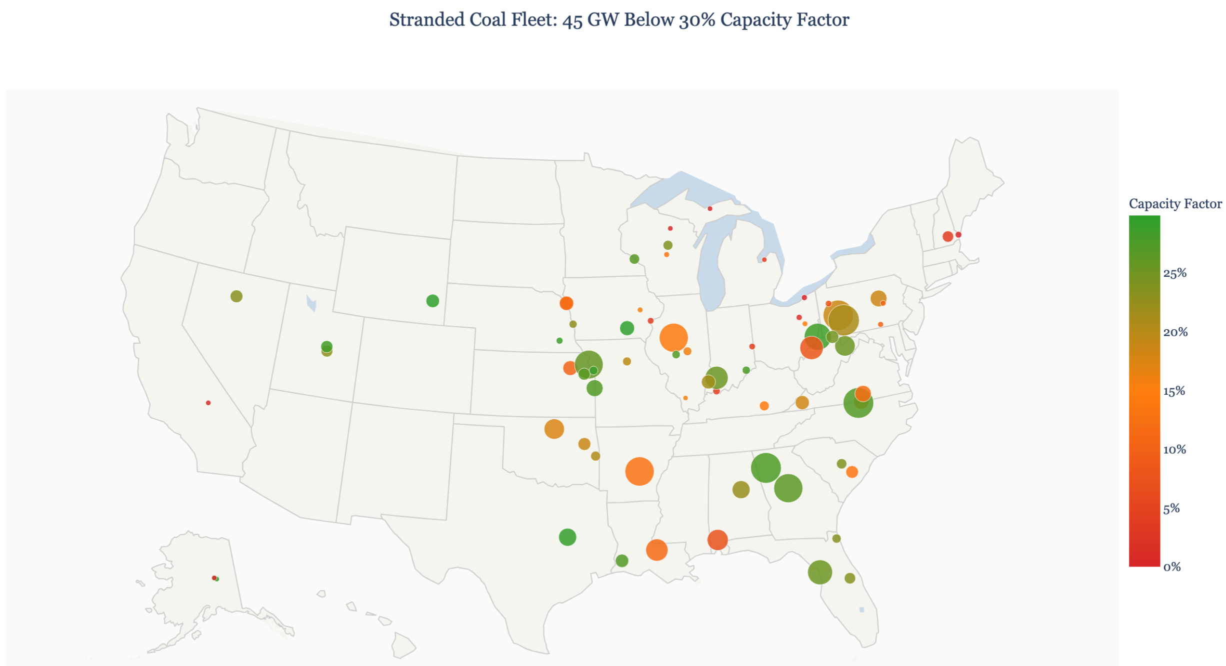

Figure 2: Geographic distribution of 73 stranded plants. Dot size is proportional to capacity (MW). Color indicates capacity factor: red = near-zero utilization, green = approaching the 30% threshold. Appalachian and Southeastern plants dominate by capacity.

The top ten states by stranded capacity are:

State	Stranded MW	Gen.	Avg CF	Regulation
PA	4,876	8	15.8%	Restructured
WV	4,717	7	21.2%	Traditional
GA	3,686	4	27.0%	Traditional
NC	2,664	4	23.6%	Traditional
IN	2,488	7	16.1%	Traditional
KS	2,371	5	24.0%	Traditional
IL	2,279	10	16.7%	Restructured
FL	2,240	4	24.3%	Traditional
AL	2,145	3	12.3%	Traditional
IA	2,137	6	13.3%	Traditional

By regulatory classification:

Classification	Stranded MW	Generators	Share
Traditional	34,284	72	**76%**
Restructured	8,812	33	19%
Hybrid	2,099	9	5%

3.2 The Fleet Is Growing

Year	Coal MW	Marginal MW (< 30% CF)	Stranded MW
2022	205,446	43,025 (21%)	30,052
2023	193,415	58,898 (30%)	40,516
2024	188,952	58,246 (31%)	45,194

The stranded fleet grew by 50% in two years (30,052 to 45,194 MW). Plants that ran at 35-40% CF in 2022 have slipped below 30% by 2024 without corresponding retirement filings. The marginal share of the fleet doubled from 21% to 31%. This is not a stable population.

3.3 Regulatory Environment and Retirement

Using the complete PUDL historical record (1,357 coal generators, 330 GW total historical capacity), we compute retirement rates:

Group	States	Historical MW	Retired MW	Rate
Restructured	12	110,475	65,324	**59.1%**
Traditional	34	219,324	80,515	**36.7%**

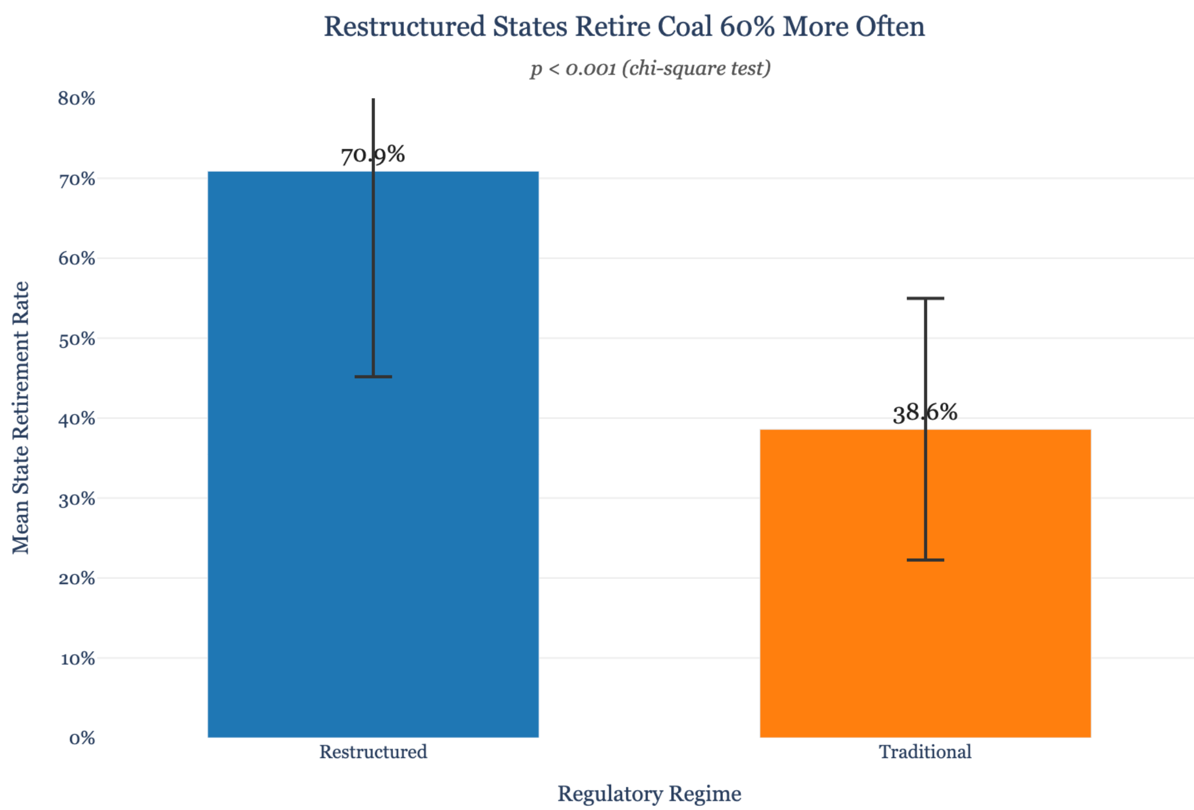

Figure 3: Unweighted mean state-level retirement rates by regulatory regime (error bars = 95% CI). State means (restructured 70.9%, traditional 38.6%) differ from MW-weighted fleet totals (59.1% and 36.7% cited in text) because small states with 100% retirement rates pull up the unweighted average. Both measures show the same direction and statistical significance ($p < 0.001$).

Statistical tests on state-level retirement rates ($n = 42$ states with > 500 MW historical coal):

Test	Statistic	p-value
Two-sample t-test	t = 3.663	**p = 0.0007**
Mann-Whitney U (one-sided)	U = 290	**p = 0.0012**
Cohen's d	**1.25**	Large effect

The difference is highly significant and substantively large. Restructured states have retired nearly 60% of their historical coal fleet; traditional states have retired barely more than a third. By 2023, restructured states had crossed the 50% retirement threshold, while traditional states still retained 70% of their 2015 coal fleet.

3.4 Measured Emissions

Using eGRID coal-unit data matched to 54 of the 55 stranded plants over 100 MW (R.S. Nelson, LA was not matched):

Metric	Value
Assumed CO2 rate (v1)	2,000 lbs/MWh
US coal fleet actual rate	2,292 lbs/MWh
Stranded fleet actual rate	2,251 lbs/MWh
Stranded fleet CO2 (measured rates)	**91.6 million tons/year**
Stranded fleet SO2	62,400 tons/year
Stranded fleet NOx	58,900 tons/year

The previous estimate using standard factors was 81.4 million tons. The measured rate is 12.5% higher because the stranded fleet is composed disproportionately of older subcritical units with degraded heat rates.

The ten dirtiest stranded plants by CO2 rate:

Plant	State	CO2 (lbs/MWh)	Heat Rate (Btu/kWh)
Muscatine	IA	3,418	16,295
Mayo	NC	2,760	13,464
River Valley	OK	2,677	12,826
Nearman Creek	KS	2,653	12,659
Laramie River	WY	2,557	12,190
North Valmy	NV	2,495	11,897
Powerton	IL	2,479	11,653
Sheldon	NE	2,456	11,708
Warrick	IN	2,449	11,933
Scherer	GA	2,448	11,669

Mayo (NC) produces 38% more CO2 per MWh than the coal fleet average. Muscatine (IA) produces 49% more. These are the plants that should have been first to retire. Instead they persist.

3.5 Who Owns the Stranded Fleet

Plant ownership analysis using PUDL utility identifiers reveals significant concentration:

Top utility owners:

Utility	MW	Generators	States
KeyCon Operating LLC	3,823	4	PA
Georgia Power Co	3,686	4	GA
Duke Energy Progress	2,664	4	NC
Virginia Electric & Power	2,656	5	VA, WV
Kansas City Power & Light	2,627	3	KS, MO
Alabama Power Co	2,144	3	AL
Oklahoma Gas & Electric	2,060	5	OK
Entergy Arkansas LLC	1,800	2	AR
Midwest Generations EME	1,786	2	IL
Kentucky Power Co	1,633	2	WV

Corporate parent groups:

Parent	Stranded MW	States	Regulation
Southern Company	5,830	AL, GA	Traditional
Duke Energy	4,811	FL, IN, NC	Traditional
Talen/KeyCon	4,688	PA	Restructured
Evergy	4,125	KS, MO	Traditional
Dominion Energy	3,042	SC, VA, WV	Mixed
NRG Energy	2,742	IL, TX	Restructured
Entergy	2,415	AR, LA	Traditional
Berkshire Hathaway Energy	2,293	IA, UT	Traditional
OGE Energy	2,060	OK	Traditional

Six corporate parents control 25,239 MW of the 45,194 MW stranded fleet (56%). Southern Company alone holds 5,830 MW across Alabama and Georgia. The concentration of ownership suggests that retirement decisions for the majority of the stranded fleet are made by a small number of corporate boards, most of which operate in traditionally regulated states where rate-base incentives favor continued operation.

3.6 Ratepayer Cost

The estimated all-in cost of operating the stranded fleet:

Component	Annual Cost
Fuel ($42.57/MWh)	$3.5 billion
Fixed O&M ($40/kW-yr)	$1.8 billion
Variable O&M ($7/MWh)	$0.6 billion
Total	**$5.8 billion**
Implied cost/MWh	**$72/MWh**

Replacement with solar-plus-battery at $45/MWh would cost $3.7 billion for the same generation, yielding annual savings of **$2.2 billion**.

The cost burden concentrates in traditionally regulated states:

Regulation	Stranded MW	Excess Cost
Traditional	34,284	$1.7 billion
Restructured	8,812	$0.4 billion

Regulation	Stranded MW	Excess Cost
Hybrid	2,099	$0.1 billion

Cost escalation at low capacity factors: Plants running below 10% CF pay an implied cost of $126/MWh – nearly 3x the replacement cost. This group includes Barry (AL), Pleasants (WV), Big Cajun 2 (LA), and the New Hampshire plants.

3.7 Retirement Priority Ranking

Plants ranked by composite priority score (high = retire first):

Rank	Plant	State	MW	CF	CO2 Rate	Score	Owner
1	Scherer	GA	1,782	26.4%	2,448	0.662	Georgia Power
2	Powerton	IL	1,786	14.2%	2,479	0.634	Midwest Gen/NRG
3	Mayo	NC	763	13.5%	2,760	0.600	Duke Energy Progress
4	White Bluff	AR	1,800	12.9%	2,365	0.597	Entergy Arkansas
5	Bowen	GA	1,904	27.5%	2,185	0.589	Georgia Power
6	Mitchell	WV	1,633	28.5%	2,312	0.587	Kentucky Power
7	Roxboro	NC	1,901	27.0%	2,164	0.579	Duke Energy Progress
8	Keystone	PA	1,872	18.5%	2,134	0.545	KeyCon/Talen
9	Conemaugh	PA	1,951	20.9%	2,087	0.544	KeyCon/Talen
10	Merrimack	NH	459	3.8%	2,372	0.536	Granite Shore

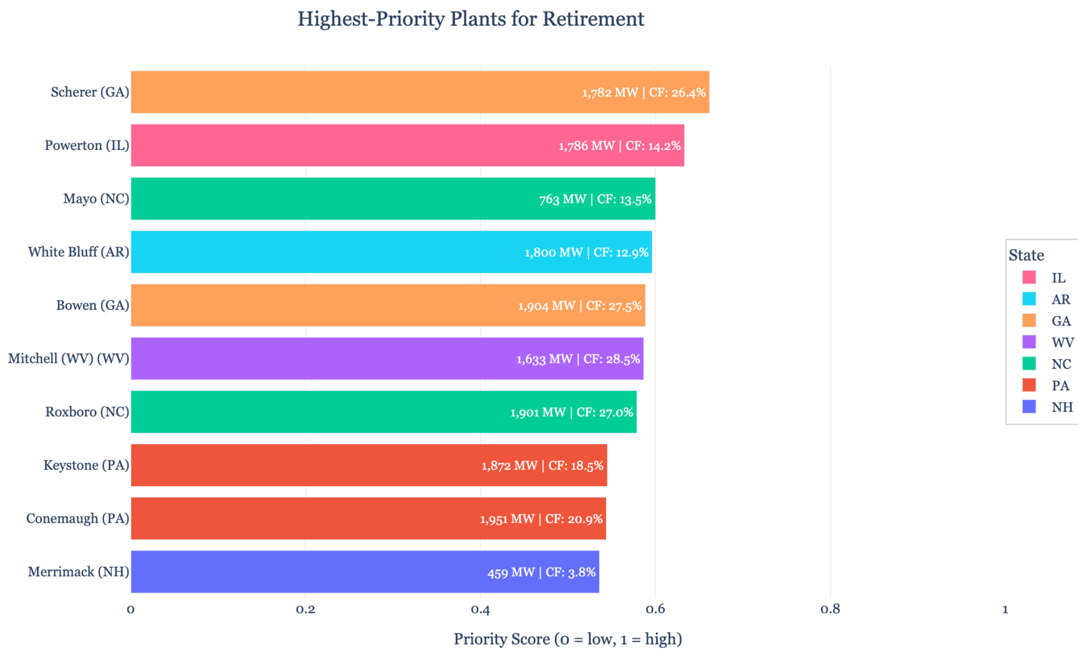

Figure 4: Top 10 stranded plants ranked by composite retirement priority score (weighted combination of capacity factor, CO2 emission rate, and total annual CO2 output). Bar labels show capacity (MW) and capacity factor. Colors distinguish states.

The top three – Scherer, Powerton, and Mayo – exemplify different pathways to the top of the ranking. Scherer scores highest because it combines a very high CO2 rate (2,448 lbs/MWh) with massive total emissions from its 1,782 MW capacity. Powerton ranks second because it pairs high CO2 rate with very low CF (14.2%), indicating severe economic obsolescence. Mayo ranks third because it has the second-highest CO2 rate in the stranded fleet (2,760 lbs/MWh), making every MWh it produces exceptionally dirty.

3.8 Case Studies

Pleasants, West Virginia: The most dramatic collapse in the dataset. This 1,368 MW plant ran at 67.4% CF in 2022 – a healthy baseload unit. By 2024 it had fallen to 7.9% CF, a 60 percentage point drop in two years. The decline tracks the plant's sale from FirstEnergy's regulated subsidiary to Omnis Pleasants LLC, an unregulated entity in the PJM wholesale market. Without rate-base protection, the plant cannot compete. West Virginia has 4,717 MW of stranded coal and only 220 MW of proposed clean energy.

White Bluff, Arkansas: 1,800 MW running at 12.9% CF with no retirement date in a state that has never retired a single coal generator (0% retirement rate). The plant's CF has been in freefall: 33.5% in 2022, 22.6% in 2023, 12.9% in 2024. Entergy Arkansas operates it under traditional cost-of-service regulation where the Arkansas Public Service Commission has not ordered retirement proceedings.

Conemaugh and Keystone, Pennsylvania: 3,823 MW of stranded coal under a single operator (KeyCon Operating LLC) in a restructured state. These plants should not exist in a competitive market. They persist through a joint-venture ownership structure that distributes costs across multiple utility parents, plus PJM capacity market payments that subsidize continued operation.

Barry, Alabama: 1,192 MW running at 7.3% CF. Alabama Power (Southern Company) operates the plant in a state with no retail competition. Estimated all-in cost exceeds $130/MWh. Together with Bowen and Scherer in Georgia, Southern Company holds 5,830 MW of stranded coal – the largest corporate holding in the fleet.

4. Discussion

4.1 Regulatory Mechanisms

The 22.4 percentage point gap in retirement rates between restructured and traditional states (59.1% vs 36.7%) is consistent with the Gowrisankaran, Langer & Reguant (2024) thesis that rate-of-return regulation creates systematic incentives to delay coal retirement. The effect size (Cohen's $d = 1.25$) is large, and the statistical significance is high ($p < 0.001$).

The mechanism is straightforward. In traditionally regulated states, a vertically integrated utility earns a return on assets in its rate base. Retiring a coal plant removes the asset and its associated return. The replacement capital (solar, battery, gas) enters the rate base, but the transition imposes costs (accelerated depreciation, decommissioning, workforce transition) that regulators may be reluctant to approve. The result is institutional inertia: plants that the market would shut down continue operating because the regulatory model rewards asset preservation.

The 76% concentration of stranded capacity in traditional states is the direct consequence of this mechanism. The 4.3x ratio of stranded MW in traditional vs restructured states (36,097 vs 8,361 using the 2026 vintage) is the clearest empirical evidence that regulation is keeping uneconomic coal running.

4.2 The Emission Factor Problem

The standard 2,000 lbs CO_2/MWh emission factor, widely used in policy analysis, understates coal fleet emissions by approximately 15%. The actual fleet average from eGRID continuous monitoring is 2,292 lbs/MWh. This discrepancy has accumulated over years of fleet evolution: as the most efficient coal plants retired (often in restructured states), the remaining fleet has become progressively dirtier on average.

For the stranded fleet specifically, the measured rate of 2,251 lbs/MWh produces 91.6 million tons of CO_2 annually rather than the 81.4 million tons estimated with the standard factor. The 10.2 million ton difference is equivalent to 2.2 million additional cars on the road. Any policy analysis of coal retirement benefits that uses 2,000 lbs/MWh is systematically underestimating the climate gains from retirement.

4.3 The Ownership Concentration Problem

Six corporate parents control 56% of the stranded fleet. This concentration has both risks and opportunities. The risk is that a small number of corporate decisions can delay retirement for a disproportionate share of the fleet. Southern Company's board, for instance, controls retirement decisions for 5,830 MW across two states. If Southern Company elects to continue operating Bowen and Scherer at their current CFs, Georgia ratepayers absorb over $187 million in annual excess costs.

The opportunity is that concentrated ownership means targeted engagement – with regulators, investors, or policymakers – can move large amounts of capacity. Convincing Georgia's Public Service Commission to order a replacement study for Bowen and Scherer would address 3,686 MW in a single proceeding.

4.4 Comparison to Gowrisankaran et al.

Our findings are broadly consistent with Gowrisankaran et al.'s structural model, which estimates the welfare cost of regulation-delayed coal retirement at $2-4 billion annually. Our direct cost comparison yields $2.2 billion in excess costs, falling within their range.

Our analysis adds three dimensions their paper does not emphasize. First, the fleet is growing rapidly (50% in 2 years), suggesting the welfare cost is increasing over time. Second, measured emission rates are systematically higher than standard factors, meaning the environmental benefits of retirement are larger than typically estimated. Third, ownership concentration implies that retirement decisions for the majority of the stranded fleet rest with fewer than ten corporate parents.

4.5 Limitations

Several limitations should be noted. The $45/MWh replacement LCOE is a national average; actual costs vary by region, with some areas (particularly the Southeast) facing higher interconnection costs and permitting delays. The cost model uses industry-average O&M figures; plant-specific costs may be higher or lower. The 30% CF threshold is a useful analytical boundary but not a precise economic breakeven; actual breakeven CF depends on fuel contracts, capacity payments, and regulatory cost recovery mechanisms specific to each plant.

The eGRID emission rates are from 2022 and applied to 2024 operating profiles. Plants running at very different CFs may have different heat rates due to partial-load penalties, likely making our 2024 estimates conservative (actual rates are probably higher). One plant (R.S. Nelson, LA) could not be matched in eGRID and is excluded from the emissions analysis.

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5. Conclusion

The US coal fleet contains 45 GW of effectively stranded capacity – plants that the market has abandoned but that regulatory structures preserve. This fleet is growing, is concentrated under a small number of corporate parents in traditionally regulated states, and produces 91.6 million tons of CO_2 annually at a cost of $5.8 billion to ratepayers.

The core finding is not that coal is declining. Everyone knows that. The finding is that a specific regulatory mechanism – rate-of-return cost recovery at vertically integrated utilities – is preserving 34 GW of uneconomic coal that would have exited in a competitive market. This preservation costs ratepayers $1.7 billion per year more than clean replacement and adds roughly 70 million tons of CO_2 that would not exist under market conditions.

The retirement priority framework identifies the ten plants where the intersection of economic obsolescence, emission intensity, and total emissions makes the case for retirement most compelling. The top-ranked plant, Scherer (GA), alone contributes over 5 million tons of CO_2 annually from 1,782 MW of capacity running at 26.4% CF under the protection of Georgia's traditional regulatory model.

Data Provenance

Source	Description	License
EIA Forms 860/923	Generator-level capacity, status, generation, fuel	Public domain
PUDL (Catalyst Cooperative)	Cleaned/normalized EIA data	CC-BY-4.0
EPA eGRID 2022	Plant/unit emissions and generation	Public domain
EPA CAMPD CEMS	Continuous emissions monitoring	Public domain
State regulatory classifications	Hand-coded from EIA/FERC filings	Project metadata

Analysis code: `reproduce.py` in this directory regenerates all numbers. Plant-level data: `data/stranded_fleet.csv` Retirement data: `data/retirement_by_regulation.csv` Verification of all claims: `verification.md`

References

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