

**U.S. House Committee on Energy and Commerce
Subcommittee on Energy, Climate, and Grid Security
Fiscal Year 2024 Department of Energy Budget Request
[May 11, 2023]**

Documents for the record

At the conclusion of the hearing, the Chair asked and was given unanimous consent to include the following documents into the record:

1. An article from The Wall Street Journal, entitled, “The West Needs Russia to Power Its Nuclear Comeback,” May 10, 2023, submitted by Chair Duncan
2. A letter from Department of Energy Secretary Jennifer M. Granholm to Ranking Member Rosa L. DeLauro, House Committee on Appropriations, submitted by Ranking Member Pallone.
3. An article from The Wall Street Journal, entitled, “EV Startups Are Proving Warren Buffett Right,” May 11, 2023, submitted by Rep. Curtis
4. A letter to Secretary Granholm from distribution transformer supply chain stakeholders, February 15, 2023, submitted by the Majority
5. A Report entitled “Energy Transition in PJM: Resource Retirements, Replacements & Risks,” February 24, 2023, submitted by the Majority

<https://www.wsj.com/articles/nuclear-power-makes-a-comeback-underpinned-by-russian-uranium-24ed8e12>

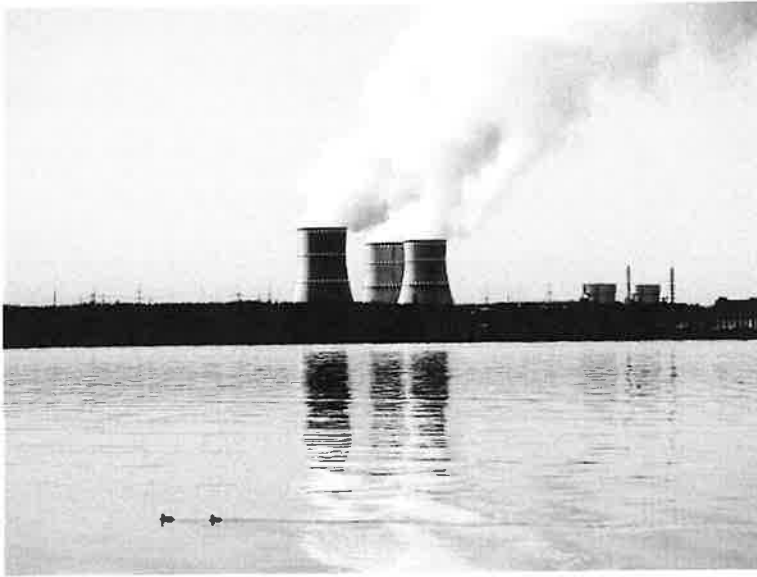
WORLD

The West Needs Russia to Power Its Nuclear Comeback

U.S., Europe add reactors but still heavily dependent on Moscow for crucial ingredients to produce fuel

By *Jennifer Hiller* [Follow](#), *Daniel Michaels* [Follow](#) and *Kim Mackrael* [Follow](#)

Updated May 10, 2023 5:22 pm ET



Nuclear fuel is one of the few Russian energy sources not banned by the West amid the war in Ukraine. PHOTO: SEZGIN PANCAR/ANADOLU AGENCY/GETTY IMAGES

Nuclear power in the West is having a long-awaited revival, with new reactors opening in the U.S. and Europe and fresh momentum toward building more soon.

A gaping hole in the plan: The West doesn't have enough nuclear fuel—and lacks the capacity to swiftly ramp up production. Even more vexing, the biggest source of critical ingredients is Russia and its state monopoly, Rosatom, which is implicated in supporting the war in Ukraine.

Nuclear power supplies nearly 20% of U.S. electricity, and roughly 25% of European electricity, but in recent decades has struggled to gain traction in most of the West as a green

alternative to fossil fuels, for reasons ranging from cost to waste disposal and an erosion of expertise in building reactors.

Pockets of stiff resistance remain: Germany closed its last reactors in April, in a phaseout that began more than a decade ago.

But there are signs of a shift back in nuclear power's direction, as governments are drawn to its carbon-free electricity as a tool for fighting climate change and lessening dependence on Russian oil and gas.

In the U.S., after years of delays and billions in cost overruns, a nuclear reactor in Georgia in March began splitting atoms for the first time, a crucial step toward reaching commercial operation. Another reactor at the facility, owned by a unit of Atlanta-based Southern, is scheduled to be operational next year.

Finland last month started regular electricity output at Europe's largest nuclear reactor, the continent's first to open in 16 years, which will eventually produce one-third of the country's electricity.

Poland in November chose the U.S. company Westinghouse Electric to build its first nuclear-power plant, which will include three reactors and cost about \$20 billion.

A recent Gallup poll found that Americans are more supportive of the technology than at any point in the past decade.

Westinghouse, a storied pioneer of electric power, has struggled in the nuclear sector and repeatedly changed hands amid market swings and tighter industry regulation after the reactor accidents at Three Mile Island, Chernobyl and Fukushima.

A group including private-equity firm Brookfield Asset Management bought Westinghouse for almost \$8 billion in October, in a move billed as a bet on nuclear power's resurgence.



Finland has begun regular electricity production at Europe's largest nuclear reactor. PHOTO: OLIVIER MORIN/AGENCE FRANCE-PRESSE/GETTY IMAGES

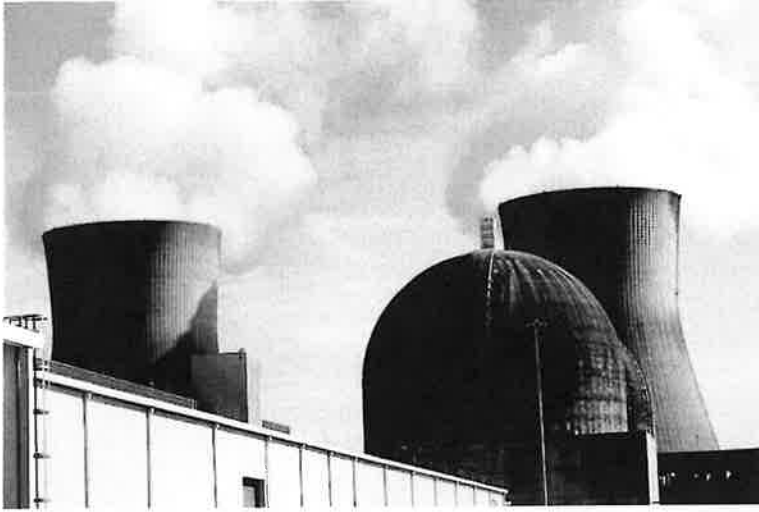
Westinghouse said this month that it next plans to launch a line of smaller reactors that could cost as little as \$1 billion each.

Westinghouse Chief Executive Patrick Fragman said there is a growing public acceptance of nuclear power and that the company has corrected previous mistakes. "We are in a radically different place and we have taken a lot of the lessons of the past," he said in an interview.

Despite the industry's progress, the dependence on Russian enriched uranium for nuclear fuel has proven intractable.

Nuclear fuel is one of the few Russian energy sources not banned by the West as a result of the war in Ukraine. The reason is rooted in a program from the early 1990s, soon after the Cold War ended, aimed at shrinking the threat of Soviet nuclear warheads falling into the wrong hands.

Under the 1993 deal, the brainchild of a Massachusetts Institute of Technology researcher named Thomas Neff and dubbed Megatons to Megawatts, the U.S. bought 500 metric tons of highly enriched uranium, enough for 20,000 warheads, and had it converted into reactor fuel.



A nuclear reactor in Georgia started to split atoms in March after years of delays and billions in cost overruns. PHOTO: JOHN BAZEMORE/ASSOCIATED PRESS

Arms-control advocates hailed it as a win-win: Moscow got urgently needed cash, Washington reduced its proliferation headache and U.S. utilities got inexpensive fuel. It remains one of the world's most successful nuclear-disarmament programs.

The deal “did what was promised,” Dr. Neff said in an interview. “We have many fewer nuclear weapons and stuff to make them out of than we did.”

The problem, critics said, was that the deal delivered Russian nuclear fuel so cheaply that rival suppliers struggled to compete. Before long, U.S. and European companies were scaling back and Russia was the world's biggest supplier of enriched uranium, with nearly half of global capacity.

Before the deal ended in 2013, Russian suppliers, now organized as Rosatom, signed a new contract with the U.S. private sector to provide commercial fuel beyond the government-to-government program. Rosatom still supplies as much as one-fourth of U.S. nuclear fuel.

U.S. companies collectively sent almost \$1 billion last year to Rosatom, according to a recent analysis from Darya Dolzikova at the Royal United Services Institute in London.



Russia has seized Ukraine's Zaporizhzhia nuclear-power plant, the largest in Europe. PHOTO: ASSOCIATED PRESS

"That's money that's going right into the defense complex in Russia," said Scott Melbye, executive vice president of uranium miner Uranium Energy and president of the Uranium Producers of America, an industry group. "We're funding both sides of the war."

Rosatom was formed by Russian President Vladimir Putin in 2007 from various parts of the country's nuclear-power industry and is closely controlled by the Kremlin. Its top managers have been deeply involved in running Ukraine's Zaporizhzhia nuclear-power plant, Europe's largest, which Russia seized last year and has used as a base for attacks on territory controlled by Kyiv.

Pressure is growing to expand Western uranium-enrichment capacity, not only because a big part of the U.S. economy relies on Russian fuel. A proposed new generation of reactors, which proponents and investors including Microsoft founder Bill Gates are touting as less risky and more environmentally friendly than current reactor designs, requires a special type of fuel that is the nuclear equivalent of high-octane gasoline.

The only source of that fuel today is Rosatom.

"We need fuel to turn our reactor on," said Jeff Navin, director of external affairs at TerraPower, the Gates-backed company that plans to build its first reactor in Wyoming. He said the U.S. is paying the price for its yearslong unwillingness to build a domestic supply chain for nuclear fuel. "Our options are either build it out now, or hope for some magical solution emerging in another country," Mr. Navin said.



Russian President Vladimir Putin meeting last year with Alexey Likhachev, CEO of state-run nuclear company Rosatom. PHOTO: MIKHAIL KLIMENTYEV/AGENCE FRANCE-PRESSE/GETTY IMAGES

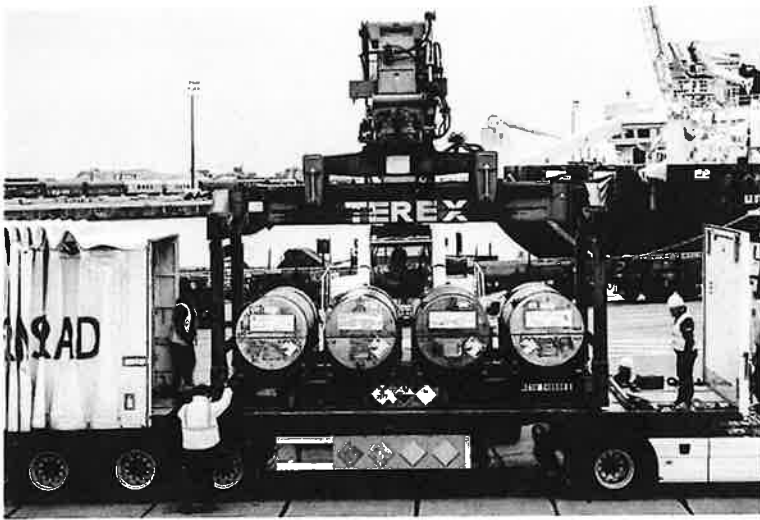
The multinational Urenco owns one of only two uranium-processing facilities in the U.S., in Eunice, N.M., just across the Texas border. The company says it is spending roughly \$200 million on new capacity and can invest much more if Russian uranium is sanctioned.

The catch: It wants government guarantees on quantities allowed in the market.

Urenco's fear, said Kirk Schnoebelen, head of U.S. sales, is that in several years low-price Russian enriched uranium might swamp world markets, tanking prices.

Mr. Schnoebelen said the concern is born of history. Urenco in the 1990s began planning what was to be the first new uranium-enrichment plant in the U.S. in decades.

But because of the Megatons deal, "the business case for that project was utterly destroyed," he said. Today that history "absolutely" informs the U.S. nuclear industry's thinking and makes corporate boards reluctant to invest the necessary billions, he added.



Cylinders of Russian uranium were loaded on a truck in Dunkirk, France, earlier this year. PHOTO: SAMEER AL-DOUMY/AGENCE FRANCE-PRESSE/GETTY IMAGES

A bipartisan group in Congress is now pushing legislation to ban U.S. use of Russian uranium, build a national uranium reserve, boost domestic ability to refine uranium into fuel and add uranium to the country's critical minerals list.

"When the Ukraine war is over, it is not going to be over," said Idaho Sen. Jim Risch, a Republican and co-author of the legislation. "It's going to take generations before there's any trust again in the Russians."

Westinghouse's Mr. Fragman said the legislation is long overdue.

"Governments need to keep an eye on what is going on in the nuclear industry," he said. "At some point when a certain number of Western facilities shut down there should have been an alarm bell."

Write to Jennifer Hiller at jennifer.hiller@wsj.com, Daniel Michaels at Dan.Michaels@wsj.com and Kim Mackrael at kim.mackrael@wsj.com

Corrections & Amplifications

Uranium processor Urenco wants government guarantees on import quantities of Russian uranium to limit their impact on pricing. An earlier version of this article said Urenco wants government guarantees on uranium pricing. (Corrected on May 10)



The Secretary of Energy

Washington, DC 20585

March 17, 2023

The Honorable Rosa L. DeLauro
Ranking Member
Committee on Appropriations
United States House of Representatives
Washington, DC 20515

Dear Representative DeLauro:

I share the concern expressed in your letter dated January 19, 2023, about potential impacts of proposals that would cap fiscal year (FY) 2024 discretionary spending at the FY 2022 enacted levels. While Congressional Republicans have not released a specific plan, cuts on this scale would have very real and damaging impacts on our families, our communities, our economy, and our competitiveness—undermining a broad range of critical services the American people rely on in their everyday lives.

President Biden's FY 2024 Budget, which he released on March 9, details his plans to invest in America, continue to lower costs for families, protect and strengthen Social Security and Medicare, and reduce the deficit. Meanwhile, Congressional Republicans have reportedly proposed unprecedented cuts in FY 2024 funding for key services, programs, and protections such as education, public safety, research, nutrition and more. Such action would have serious consequences for Department of Energy programs and initiatives at the Federal, state, Tribal, and local levels, and would jeopardize recent bipartisan gains targeted at improving the lives of everyday Americans.

Impacts would be felt across the country and could rise to the level of jeopardizing the Department's ability to do its part in protecting national security interests from energy security and nuclear security threats.

Capping funding at this level would also hamper our ability to cut energy costs for families and businesses across the country, reduce the number of everyday Americans that can access tax breaks for clean energy, and reduce the impact of the Bipartisan Infrastructure Law.

Specific examples of potential impacts are listed below.

Scenario 1: *Across-the-board cap on FY 2024 discretionary spending at FY 2022 levels. Example impacts are listed below.*

- A reduction to FY 2022 funding levels would delay all National Nuclear Security Administration (NNSA) major construction projects of at least one year, increasing operational risks and the likelihood of cost increases. The FY 2022 funding level represents a 1/3 reduction from planned execution in FY 2024.

- The W93 and W87-1 warhead modernization programs would be delayed at least 1-2 years, with significant risks for the aging U.S. stockpile, DoD plans for delivery system modernization, and U.S. support for the United Kingdom's Replacement Warhead.

Hundreds of Energy Efficiency and Renewable Energy research projects and 2-3 large infrastructure projects at national labs would be cancelled or paused, resulting in up to one thousand (1,000) layoffs within the labs, partner organizations, and the local construction and support workforce across the country. This would negatively impact the ability of the national laboratories to continue to advance cutting edge research.

Scenario 2: *Across-the-board 22 percent reduction to current enacted funding levels (FY 2023) for FY 2024. Example impacts of this scenario are listed below. Scenario 1 impacts would also be intensified.*

- At a minimum, research at Office of Science national laboratories and universities would be reduced by about \$700 million, resulting in substantial reduction of nearly 5,200 scientists, students, and technical staff.
 - Many of the Administration research priorities would receive significantly less funding resulting in curtailed research efforts in the areas of Climate Change; Artificial Intelligence; High Performance Computing; emerging technologies in Quantum Information Science, Microelectronics, and Biotechnology; Fusion Energy; and Isotope Production.
- At a minimum, Office of Science facility operations funding would be reduced, resulting in only 68 percent of operational funding and a substantial reduction of over 6,000 users of the over 38,000 annual users at the 28 scientific user facilities across the national laboratories.
 - All facilities would have a significant reduction in force of personnel, with loss of critical expertise. A review would be required to determine which facilities to close to maintain adequate operations at the remaining user facilities. Facilities cannot operate safely at this funding level. This action would result in major economic impact to the United States, both in the short-term and in the long-term as the U.S. will be subject to loss of scientific talent and leadership.
- At a minimum, thousands of low-income households (anywhere from 4,400-8,800) would be deferred from weatherization services, and reductions in state energy programs more broadly would limit efforts to cut energy costs for families and businesses, disproportionately affecting smaller states and US territories.
- Reductions of this magnitude would have significant setbacks of U.S. geopolitical competitiveness to adversarial nations like Russia and China.
 - This would include the reduction of the Idaho National Laboratory operational status to the minimal allowable for safe and secure support of DOE and national security programs and research.

It would also include elimination of all efforts to support the deployment of American nuclear energy technologies as the preferred alternative to Russian and Chinese technologies in countries looking to implement large scale power sources.

These are a few examples of the serious impacts of these scenarios on ongoing efforts by the Department in the areas of national security, safety of critical infrastructure, threats to the Nation's competitive edge, and impacts on consumers and industry.

Sincerely,

A handwritten signature in black ink, appearing to read 'J. Granholm', with a stylized, cursive script.

Jennifer M. Granholm

<https://www.wsj.com/articles/ev-startups-are-proving-warren-buffett-right-9ca794b0>

MARKETS HEARD ON THE STREET

EV Startups Are Proving Warren Buffett Right

Polestar became the latest electric-vehicle manufacturer to cut its outlook for 2023

By *Stephen Wilmot* Follow

Updated May 11, 2023 1:16 pm ET



Polestar, which went public last June, is one of the healthiest EV startups. PHOTO: KRISZTIAN BOCSI/BLOOMBERG NEWS

“The auto industry is just too tough.” That was Warren Buffett’s response to a question about the opportunities presented by the shift to electric vehicles at Berkshire Hathaway’s annual meeting last Saturday. A few days of earnings reports from EV startups later, it is hard to disagree.

Polestar Automotive **PSNY -12.47% ▼** became the latest manufacturer to cut its outlook for 2023 alongside first-quarter results Thursday. Volvo Cars, one of Polestar’s major shareholders, needs more time to perfect the software for a new production platform that Polestar will use for its new sport-utility vehicle, Polestar said. The Polestar 3 will now hit the market in 2024 rather than later this year as previously hoped.

Chief Executive Thomas Ingenlath also said market conditions were deteriorating, which means the Swedish company can’t make up the shortfall by selling more of its existing Polestar 2 sedans. “We don’t intend to push cars into the market at any price just to achieve a

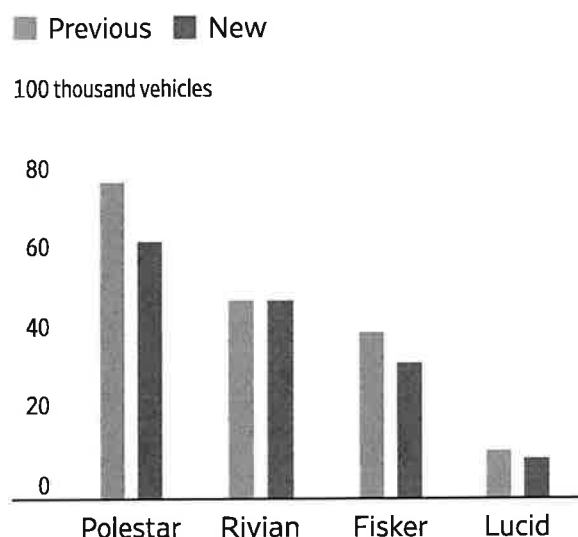
volume that we once announced,” he said in an apparent reference to Tesla’s price-cutting strategy.

Polestar, which went public via a special-purpose acquisition vehicle last June, is actually one of the healthiest EV startups out there. That is because it can lean on the assets of its dominant shareholders, Volvo and China’s Geely—a huge advantage in such a capital-intensive endeavor as launching a car company, even if it does put Polestar at the mercy of others’ schedules. The Polestar 2 is made in a Geely factory in China and the coming Polestar 3 will be made both in China and a Volvo factory in Ridgeville, S.C., for example.

California startups Lucid Group **LCID -1.40% ▼** and Fisker **FSR -2.09% ▼** also downgraded their production forecasts earlier this week. Luxury sedan maker Lucid burned through over \$1 billion while delivering just 1,406 vehicles in the first quarter amid signs of weakening demand. Fisker is only just starting to deliver cars, though at least it has the advantage of an experienced production partner in contract manufacturer Magna International.

Deceleration

Targeted production in 2023



Notes: Mid-point of guidance where applicable; Lucid expects production of more than 10,000

Source: the companies

Rivian Automotive on the other hand relieved investors by sticking to its 2023 production target of 50,000 vehicles. It also narrowed its quarterly gross loss by more than expected to about \$75,000 per vehicle sold, following aggressive cost cuts. After an initial jump, the shares closed up less than 2% Wednesday, but that was a nice contrast with Tuesday's falls for Lucid, Fisker and embattled truck startup Nikola, which announced the sale of its European factory stake. Polestar stock fell 11% at the open Thursday.

After precipitous declines over the past 18 months, Rivian and Lucid both have market values of about \$13.1 billion. But Rivian has a lot more cash, so its enterprise value, which strips that out, is only \$4.9 billion, compared with \$12.5 billion for Lucid. On that basis, Rivian shares appear much more attractively valued at about \$98,000 for every car it expects to produce this year, compared with more than \$1.2 million per car for Lucid.

Rivian shares are still extremely risky as the company burns through billions of dollars a quarter on its way toward a goal of making its first gross profit late next year. Even with \$11.2 billion of cash and equivalents, it will need to raise more—and that is if everything goes right. Shorting Lucid could be a better option for investors, but that comes with the risk that its dominant Saudi Arabian shareholder gives up on the public market and takes it private.

Polestar, which already makes gross profits, probably has the best shot at surviving in its current form. But Thursday's update was a reminder that much still lies beyond its control.

Write to Stephen Wilmot at stephen.wilmot@wsj.com

Corrections & Amplifications

Lucid Group and Fisker downgraded their production forecasts earlier this week. An earlier version of this article incorrectly said they downgraded delivery forecasts. Also, Rivian and Lucid shares are valued by one metric at about \$98,000 and more than \$1.2 million, respectively, for every car the companies expect to produce this year. An earlier version of this article said the figures referred to the value for every car expected to be sold. (Corrected on May 11)

February 15, 2023

Secretary Jennifer Granholm
U.S. Department of Energy
1000 Independence Ave., SW
Washington, DC 20585

Dear Madam Secretary:

On behalf of a broad coalition representing critical stakeholders in the distribution transformer supply chain, we seek your immediate attention on an issue that could significantly impact national security and grid reliability. We write to strongly urge the Department of Energy (DOE) to reconsider its intention to increase energy conservation standards for distribution transformers, as signaled in its recent Notice of Proposed Rulemaking (NOPR).ⁱ

Our coalition, comprised of the National Electrical Manufacturers Association (NEMA), American Public Power Association (APPA), National Rural Electric Cooperative Association (NRECA), Edison Electrical Institute (EEL), Leading Builders of America (LBA), National Association of Homebuilders (NAHB), and GridWise Alliance (GridWise), is an assemblage of organizations whose members are at the forefront of the clean energy transition. Utilities and energy service providers, represented by APPA, EEL, and NRECA, provide electricity to all Americans. LBA and NAHB represent homebuilders constructing affordable and energy-efficient communities. Grid component manufacturers, represented by NEMA and GridWise, produce the critical equipment, including distribution transformers, needed to ensure its safe and reliable delivery.

Since 2021, our organizations have been communicating with DOE regarding the severe and ongoing supply chain challenges that have prolonged and complicated distribution transformer production and availability. The inability to quickly manufacture and deliver these critical components threatens the ability of the electric sector to service current and planned housing markets, swiftly recover and restore service following natural disasters, and deliver the benefits of economy-wide electrification.

Last June, working with electric service providers, you directed the Electricity Subsector Coordinating Council to establish a “Tiger Team” to examine the supply chain crisis. It concluded that current transformer production is not meeting demand—demand that is expected to increase for the foreseeable future. Moreover, both the electric and manufacturing sectors have raised awareness of the risks caused by lengthy lead-times in the production, procurement, and deployment of transformers. Under existing production output capabilities, manufacturers estimate the current order-cycle for most new distribution transformers to be longer than 16 months.

The Administration also recognized the severity of this crisis by issuing the June 6, 2022, Presidential Determination through the Defense Production Act (DPA) to prioritize the domestic production of transformers to bolster grid resiliency and national security. In response to that Determination and a subsequent Request for Information issued by DOE, manufacturers provided numerous recommendations on how best to scale up production. One such proposal included the standardization of “emergency-use” products, or transformers built to lower energy conservation standards to meet DPA expectations of greater output.ⁱⁱ Similarly, in a joint letter to you by APPA and NRECA on October 19, 2022, these organizations encouraged DOE to

reprioritize some Inflation Reduction Act funds under the DPA designated for heat pumps to distribution transformer production, including labor recruitment and retention.ⁱⁱⁱ

Despite this information and our organizations' close work with DOE to explore short and long-term solutions to this crisis, on January 11, 2023, the Department issued a NOPR that would, through its various requirements, further exacerbate the supply chain situation. The proposed rule would dictate that manufacturers increase the efficiency of distribution transformers by a mere tenth of a percentage point.

DOE *already* mandates distribution transformers be manufactured to incredibly high efficiency standards. Currently, NEMA calculates a three-phase liquid-immersed distribution transformer with a kilovolt-ampere (kVA) output rating of 2500 is already 99.53% efficient; a similar single-phase type with a kVA of 833 is 99.55% efficient.^{iv} Importantly, due to the intricate ways transformers are designed and assembled, increasing their efficiency even by a fraction of a percentage point could add months to an already lengthy order-cycle.

Our organizations agree that energy efficiency standards play an important role in reaching decarbonization benchmarks while transitioning our nation to a clean and increasingly electrified economy. However, as proposed, the rule would delay the realization of these benefits by worsening supply chain complications already well known to DOE.

Additionally, the proposed rule would require manufacturers to transition to a different type of steel, which is largely untested, less flexible, and more expensive.^v Further, the existing supply chain of this alternative steel is very limited and mostly foreign-sourced. This rule would impose unnecessary cost burdens and further delay the delivery of such critical products. Simply put, this DOE proposal does nothing to address, and is likely to exacerbate, the current distribution transformer shortage crisis.

Given the unprecedented demand for distribution transformers, our organizations urge DOE to maintain the current efficiency levels required of these products. Getting these already highly efficient products into the market more quickly should be the highest priority and will result in the realization of electrification benefits much sooner—benefits that will far outweigh any gains achieved through a fractional percentage increase in efficiency.

Thank you for your time and consideration of this issue. We welcome the opportunity to discuss this with you further and appreciate your leadership in this area.

Sincerely,

American Public Power Association
Edison Electrical Institute
GridWise Alliance
Leading Builders of America
National Association of Home Builders
National Electrical Manufacturers Association
National Rural Electric Cooperative Association

CC: Rep. Kevin McCarthy – Speaker of the U.S. House of Representatives
Rep. Hakeem Jeffries – U.S. House Minority Leader
Sen. Charles Schumer – U.S. Senate Majority Leader
Sen. Mitch McConnell – U.S. Senate Minority Leader

Rep. Cathy McMorris Rogers – Chair, Energy and Commerce Committee
Rep. Frank Pallone – Ranking Member, Energy and Commerce Committee
Rep. Kay Granger – Chair, Appropriations Committee
Rep. Rosa DeLauro – Ranking Member, Appropriations Committee
Sen. Patty Murray – Chair, Appropriations Committee
Sen. Susan Collins – Ranking Member, Appropriations Committee
Sen. Joe Manchin – Chair, Energy and Natural Resources Committee
Sen. John Barrasso – Ranking Member, Energy and Natural Resources Committee
Alejandro Moreno – Asst. Sec. (Acting), Energy Efficiency & Renewable Energy, DOE
John Podesta – Sr. Advisor to the President: Clean Energy Innovation & Implementation
Elizabeth Sherwood-Randall – White House Homeland Security Advisor

ⁱ *Energy Conservation Program: Energy Conservation Standards for Distribution Transformers*, 88 Fed. Reg. 1722 (Jan. 11, 2023).

ⁱⁱ https://www.nema.org/docs/default-source/advocacy-document-library/nema-gridwise-comments-doe-dpa-rfi-11.30.22.pdf?sfvrsn=2969fc7b_4

ⁱⁱⁱ <https://www.cooperative.com/news/Documents/Trades%20Letter%20Supply%20Chain%20DPA%20Final.pdf>

^{iv} https://www.nema.org/docs/default-source/nema-documents-libraries/doe-transformer-efficiency-regs.pdf?sfvrsn=8253222a_0

^v U.S. Dep't of Energy, DOE Proposes New Efficiency Standards For Distribution Transformers, <https://www.energy.gov/articles/doe-proposes-new-efficiency-standards-distribution-transformers> (DOE explains that "almost all transformers produced under the new standard would feature amorphous steel cores").



Energy Transition in PJM:

Resource Retirements, Replacements & Risks

Feb. 24, 2023

For Public Use

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Executive Summary

Driven by industry trends and their associated challenges, PJM developed the following strategic pillars to ensure an efficient and reliable energy transition: facilitating decarbonization policies reliably and cost-effectively; planning/operating the grid of the future; and fostering innovation.

PJM is committed to these strategic pillars, and has undertaken multiple initiatives in coordination with our stakeholders and state and federal governments to further this strategy, including interconnection queue reform, deployment of the State Agreement Approach to facilitate 7,500 MW offshore wind in New Jersey, and coordination with state and federal governments on maintaining system reliability while developing and implementing their specific energy policies.

In light of these trends and in support of these strategic objectives, PJM is continuing a multiphase effort to study the potential impacts of the energy transition. The first two phases of the study focused on energy and ancillary services and resource adequacy in 2035 and beyond. This third phase focuses on resource adequacy in the near term through 2030.¹

Maintaining an adequate level of generation resources, with the right operational and physical characteristics², is essential for PJM's ability to serve electrical demand through the energy transition.

Our research highlights four trends below that we believe, in combination, present increasing reliability risks during the transition, due to a potential timing mismatch between resource retirements, load growth and the pace of new generation entry under a possible "low new entry" scenario:

- The growth rate of electricity demand is likely to continue to increase from electrification coupled with the proliferation of high-demand data centers in the region.
- Thermal generators are retiring at a rapid pace due to government and private sector policies as well as economics.
- Retirements are at risk of outpacing the construction of new resources, due to a combination of industry forces, including siting and supply chain, whose long-term impacts are not fully known.
- PJM's interconnection queue is composed primarily of intermittent and limited-duration resources. Given the operating characteristics of these resources, we need multiple megawatts of these resources to replace 1 MW of thermal generation.

¹ See [Energy Transition in PJM: Frameworks for Analysis | Addendum](#) (2021), and [Energy Transition in PJM: Emerging Characteristics of a Decarbonizing Grid | Addendum](#) (2022).

² See previous work on Reliability Products and Services, including [PJM's Evolving Resource Mix and System Reliability](#) (2017), [Reliability in PJM: Today and Tomorrow](#) (2021), [Energy Transition in PJM: Frameworks for Analysis | Addendum](#) (2021), and work completed through the RASTF and PJM Operating Committee (2022).

The analysis also considers a “high new entry” scenario, where this timing mismatch is avoided. While this is certainly a potential outcome, given the significant policy support for new renewable resources, our analysis of these long-term trends reinforces the importance of PJM’s ongoing stakeholder initiatives, including capacity market modifications, interconnection process reform and clean capacity procurement, and the urgency for continued, combined actions to de-risk the future of resource adequacy while striving to facilitate the energy policies in the PJM footprint.

The first two phases of the energy transition study assumed that PJM had adequate resources to meet load.

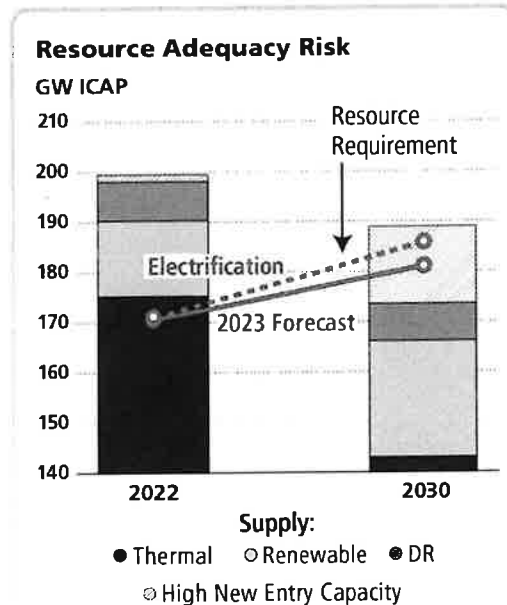
In this third phase of this living study, we explore a range of plausible scenarios up to the year 2030, focusing on the resource mix “balance sheet” as defined by generation retirements, demand growth and entry of new generation.

The analysis shows that 40 GW of existing generation are at risk of retirement by 2030. This figure is composed of: 6 GW of 2022 deactivations, 6 GW of announced retirements, 25 GW of potential policy-driven retirements and 3 GW of potential economic retirements. Combined, this represents 21% of PJM’s current installed capacity³.

In addition to the retirements, PJM’s long-term load forecast shows demand growth of 1.4% per year for the PJM footprint over the next 10 years. Due to the expansion of highly concentrated clusters of data centers, combined with overall electrification, certain individual zones exhibit more significant demand growth – as high as 7% annually.⁴

On the other side of the balance sheet, PJM’s New Services Queue consists primarily of renewables (94%) and gas (6%). Despite the sizable nameplate capacity of renewables in the interconnection queue (290 GW), the historical rate of completion for renewable projects has been approximately 5%. The projections in this study indicate that the current pace of new entry would be insufficient to keep up with expected retirements and demand growth by 2030. The completion rate (from queue to steel in the ground) would have to increase significantly to maintain required reserve margins.

In the study, we also consider generation entry beyond the queue using projections from S&P Global. Those projections indicate that, despite eroding reserve margins, resource adequacy would be maintained if the influx of renewables materializes at a rapid rate and gas remains the transition fuel, adding 9 GW of capacity. The analysis performed at the Clean Attribute Procurement Senior Task Force (CAPSTF) also suggests that further gas expansion is economic and competitive.⁵



The projections in this study indicate that it is possible that the current pace of new entry would be insufficient to keep up with expected retirements and demand growth by 2030.

³ Unless otherwise noted, thermal capacity values are expressed in ICAP, without adjustment for EFORD.

⁴ [PJM Load Forecast Report, January 2023](#).

⁵ [CAPSTF Analysis, Initial Results](#); Emmanuele Bobbio, Sr. Lead Economist – Advanced Analytics; PJM, Dec. 16, 2022.

Balance Sheet Summary (2022–2030)				
Retirements	New Entry Wind Solar ⁶	New Entry Stand-alone Storage	New Entry Thermal	Load Growth ⁶
40 GW 60% Coal 30% Natural Gas 10% Other	Low = 48 GW-nameplate / 8 GW-capacity High = 94 GW-nameplate / 17 GW-capacity	Low = 3 GW High = 4 GW	Low = 4 GW High = 9 GW	2023 Forecast = 11 GW Electrification Forecast = 13 GW
				
Unless otherwise noted, thermal capacity values are expressed in ICAP, without adjustment for EFORD.				

For the first time in recent history, PJM could face decreasing reserve margins should these trends continue. The amount of generation retirements appears to be more certain than the timely arrival of replacement generation resources and demand response, given that the quantity of retirements is codified in various policy objectives, while the impacts to the pace of new entry of the Inflation Reduction Act, post-pandemic supply chain issues, and other externalities are still not fully understood.

The findings of this study highlight the importance of PJM's ongoing stakeholder initiatives (Resource Adequacy Senior Task Force, Clean Attribute Procurement Senior Task Force, Interconnection Process Subcommittee), continued efforts between PJM and state and federal agencies to manage reliability impacts of policies and regulations, and the urgency for coordinated actions to shape the future of resource adequacy. The potential for an asymmetrical pace in the energy transition, in which resource retirements and load growth exceed the pace of new entry, underscores the need to enhance the accreditation, qualification and performance requirements of capacity resources.

The composition and performance characteristics of the resource mix will ultimately determine PJM's ability to maintain reliability. It is critical that all PJM markets effectively correct imbalances brought on by retirements or load growth by incentivizing investment in new or expanded resources.

⁶ Includes hybrid projects with battery storage

Background

Resource adequacy is the ability of the electric system to supply the aggregate energy requirements of electricity to consumers at all times, taking into account scheduled and reasonably expected unscheduled outages of generation and transmission facilities. To achieve the goal of resource adequacy, PJM maintains an Installed Reserve Margin in excess of the forecast peak load that achieves a loss-of-load expectation (LOLE) of one day in 10 years. This LOLE standard is consistent with that prescribed in the ReliabilityFirst Corporation standard for planning resource adequacy.⁷

Long-term reliability and resource adequacy are addressed through the combined operation of PJM's electricity markets, and in particular the capacity market, called the Reliability Pricing Model (RPM). Each PJM member that provides electricity to consumers must acquire enough power supply to meet demand, not only for today and tomorrow, but for the future. Members secure these capacity resources for future energy needs through a series of base and incremental capacity auctions, as well as Fixed Resource Requirement plans.

The capacity market ensures long-term grid reliability by procuring the appropriate amount of power supply resources needed to meet predicted energy demand up to three years in the future. These capacity resources have an obligation to perform during system emergencies, and are subject to penalties if they underperform. By matching generation with future demand, the capacity market creates long-term price signals to attract needed investments to ensure adequate power supplies. This exchange provides consumers with an assurance of reliable power in the future, while capacity resources receive a dependable flow of income to help maintain their existing capability, attract investment in new resources, and encourage companies to develop new technologies and sources of electric power.

Methodology

The size, composition and performance characteristics of the resource mix will determine PJM's ability to maintain reliability. This study explores a range of scenarios in the context of resource adequacy, focusing on the resource mix "balance sheet" as defined by demand growth, generation retirements and new entry of generation. Using the methodology described in this section, PJM evaluates the future of resource adequacy by estimating the amount of capacity required to cover load expectations versus expected capacity for the years 2023 through 2030.

The study's initial supply levels are 192.3 GW of installed capacity from generation resources and 7.8 GW of installed capacity from demand response capacity resources. The generation mix is approximately 178.9 GW of thermal resources and 13.3 GW of renewables and storage.⁸

⁷ RFC Standard BAL-502-RF-03: Planning Resource Adequacy Analysis, Assessment and Documentation

⁸ This value includes the capacity value of run-of-river hydro, pumped storage hydro, solar, onshore wind, offshore wind and battery energy storage.

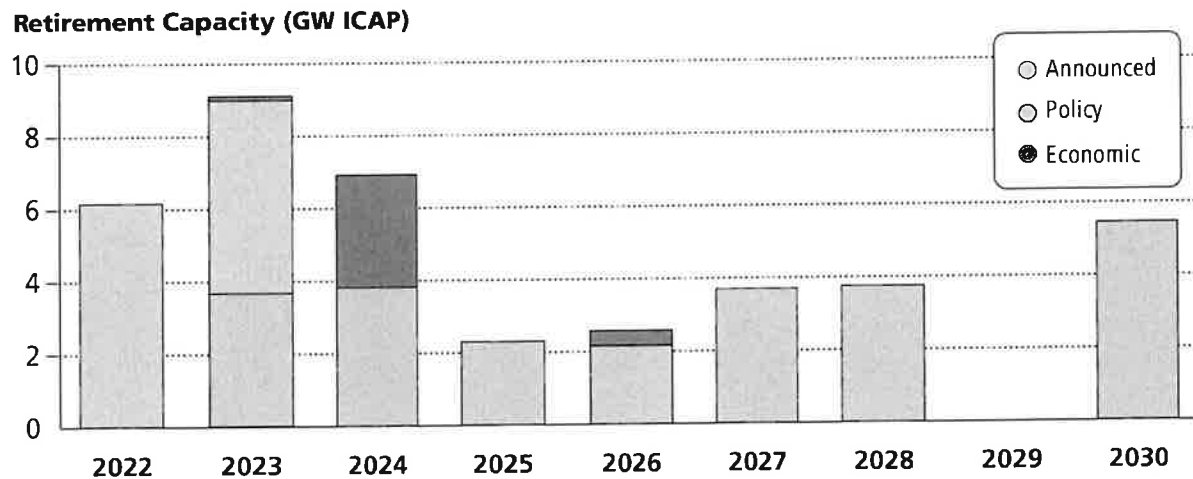
Supply Exits

PJM is undergoing a major transition in the resources needed to maintain bulk power grid reliability.

Historically, thermal resources have provided the majority of the reliability services in PJM. Today, a confluence of conditions, including state and federal policy requirements, industry and corporate goals requiring clean energy, reduced costs and/or subsidies for clean resources, stringent environmental standards, age-related maintenance costs, and diminished energy revenues are hastening the decline in thermal resources.

This study estimates anticipated retirements through 2030 by adding announced retirements with retirements likely as a result of various state and federal policies, and then with those at risk for retirement due to deteriorating unit economics. Potential policy-driven retirements, in this context, reflect resources that are subject to current and proposed federal and state environmental policies, in which it is conservatively assumed that the costs of mitigation and compliance could economically disadvantage these resources to the point of retirement. **Figure 1** highlights the 40 GW of projected generation retirements by 2030, which is composed of: 12 GW of announced retirements⁹, 25 GW of potential policy-driven retirements¹⁰ and 3 GW of potential economic retirements. Combined, this represents 21% of PJM's current installed capacity.¹¹ This section describes each category of potential retirements in more detail.

Figure 1. Total Forecast Retirement by Year (2022–2030)



⁹ Includes 6 GW of 2022 retirements.

¹⁰ Note that 7 GW of the 25 GW of supply with policy risk was also identified to have more immediate economic risk. The year that these 7 GW of potential policy retirements shown in **Figure 2** is based on timing identified in the economic analysis. In **Figure 4**, these 7 GW are shown in terms of the regulatory compliance timeline alone. The timeline of these potential quantities of resource retirements does not factor in any reliability "off-ramps" that may be included in established policies.

¹¹ In this study, PJM assumes that a resource that exits would not return to service in a future delivery year, even if operational conditions improve. Historically, a small percentage of retiring units would instead enter a "mothball" or standby state, in which the unit is put into a state where it may not operate for one or more years; however, in order to obtain an operating permit renewal, the mothballed unit would have to comply with the most recent environmental standards, likely requiring costly upgrades, making investing in newer, cleaner technologies more inviting.

Announced Retirements

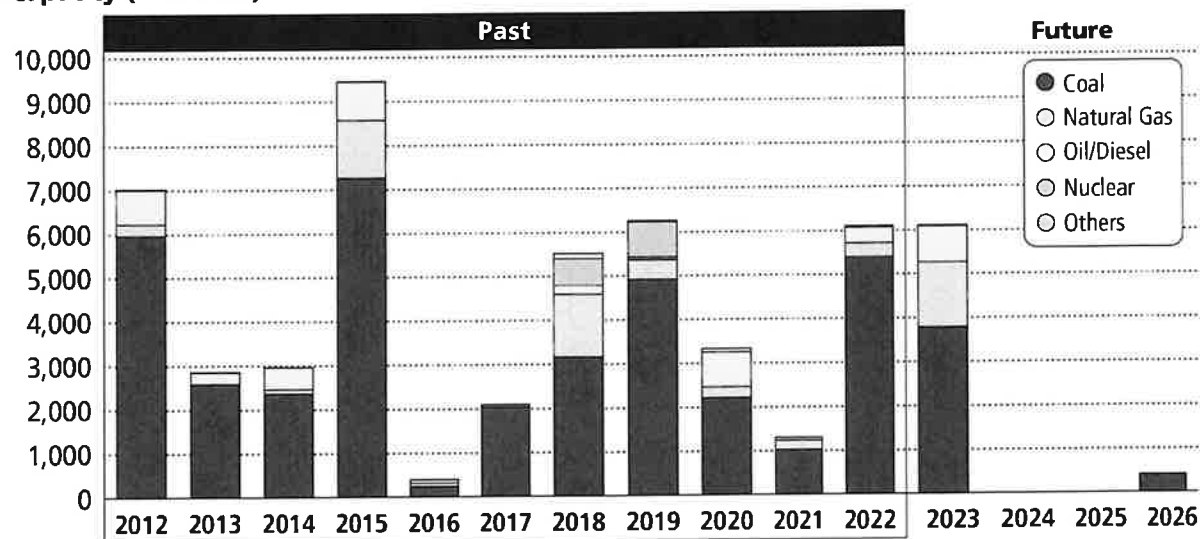
One of PJM's responsibilities is to ensure the continued reliability of the high-voltage electric transmission system when a generation owner requests deactivation. Through its Generation Deactivation process,¹² PJM identifies transmission solutions that allow owners to retire generating plants as requested without threatening reliable power supplies to customers. PJM may order transmission upgrades or additions built by transmission owners to accommodate the generation loss. PJM has no authority to order plants to continue operating. However, in some instances, to maintain reliability, PJM may formally request that a plant owner continue operating, subject to rates authorized by the Federal Energy Regulatory Commission (FERC), while transmission upgrades are completed.

Plant owners considering retirement must notify PJM at least two quarters before the proposed deactivation date. PJM and the transmission owners complete a reliability analysis in the subsequent quarter after notification to PJM. Generator retirements and any required system upgrades to keep the grid running smoothly are included in the PJM Regional Transmission Expansion Planning process and are reviewed with PJM members and stakeholders at the PJM Transmission Expansion Advisory Committee.

Between 2012 and 2022, 47.2 GW of generation retired in PJM, as detailed by fuel type in **Figure 2**. In 2022, approximately 6 GW of generation deactivated and an additional 5.8 GW announced ("future") deactivations over the 2023–2026 time frame. The deactivations are slightly above the 10-year average of 4.3 GW, but well under the historical annual peak of 9.5 GW in 2015. Coal-fired resources account for approximately 89% of retired capacity in 2022.

Figure 2. Past and Announced Future Retirements

Capacity (MW ICAP)



¹² See process details in PJM Manual 14-D, Section 9, and tracking of deactivation requests at <https://www.pjm.com/planning/services-requests/gen-deactivations>.

Potential Policy Retirements

An analysis of federal and state policies and regulations with direct impacts on generation in the PJM region yielded the largest group of potential future retirements in this study.¹³ As highlighted in **Figure 3**, the combined requirements of these regulations and their coincident compliance periods have the potential to result in a significant amount of generation retirements within a condensed time frame. These impacts will be reevaluated as these policies and regulations evolve. PJM will continue to work with both federal and state agencies on the development and implementation of environmental regulations and policies in order to address any reliability concerns.

Below are the policies and regulations included in the study:



EPA Coal Combustion Residuals (CCR): The U.S. Environmental Protection Agency (EPA) promulgated national minimum criteria for existing and new coal combustion residuals (CCR) landfills and existing and new CCR surface impoundments. This led to a number of facilities, approximately 2,700 MW in capacity, indicating their intent to comply with the rule by ceasing coal-firing operations, which is reflected in this study.



EPA Effluent Limitation Guidelines (ELG): The EPA updated these guidelines in 2020, which triggered the announcement by Keystone and Conemaugh facilities (about 3,400 MW) to retire their coal units by the end of 2028.¹⁴ Importantly, but not included in this study, the EPA is planning to propose a rule to strengthen and possibly broaden the guidelines applicable to waste (in particular water) discharges from steam electric generating units. The EPA is expecting this to impact coal units by potentially requiring investments when plants renew their discharge permits, and extending the time that plants can operate if they agree to a retirement date.



EPA Good Neighbor Rule (GNR): This proposal requires units in certain states to meet stringent limits on emissions of nitrogen oxides (NOx), which, for certain units, will require investment in selective catalytic reduction to reduce NOx. For purposes of this study, it is assumed that unit owners will not make that investment and will retire approximately 4,400 MW of units instead. Please note that the EPA plans on finalizing the GNR in March, which may necessitate reevaluation of this assumption.



Illinois Climate & Equitable Jobs Act (CEJA): CEJA mandates the scheduled phase-out of coal and natural gas generation by specified target dates: January 2030, 2035, 2040 and 2045. To understand CEJA criteria impacts and establish the timing of affected generation units' expected deactivation, PJM analyzed each generating unit's publicly available emissions data, published heat rate, and proximity to Illinois environmental justice communities and Restore, Reinvest, Renew (R3) zones. For this study, PJM focuses on the approximately 5,800 MW expected to retire in 2030.

¹³ Policies impacting forward energy prices, such as the Regional Greenhouse Gas Initiative and Renewable Energy Credits, are implicitly included in economic analysis but are not explicitly included in analysis of policy-related retirements.

¹⁴ See State Impact PA, Nov. 22, 2021. These facilities have not filed formal Deactivation Notices with PJM.



New Jersey Department of Environmental Protection CO₂ Rule: New Jersey's CO₂ rule seeks to reduce carbon dioxide (CO₂) emissions of fossil fuel-fired electric generating units (EGUs) through the application of emissions limits for existing and new facilities greater than 25 MW. Units must meet a CO₂ output-based limit by tiered start dates. The dates and CO₂ limits are:

- June 1, 2024 – 1,700 lb/MWh
- June 1, 2027 – 1,300 lb/MWh
- June 1, 2035 – 1,000 lb/MWh

PJM used emissions data found in [EPA Clean Air Markets Program Data](#) to evaluate unit compliance. Where a unit's average annual emissions rate was greater than the CO₂ limit on the compliance date, the unit was assumed to be retiring. In this study PJM, estimated retirements at approximately 400 MW in 2024 and approximately 2,700 MW in 2027.

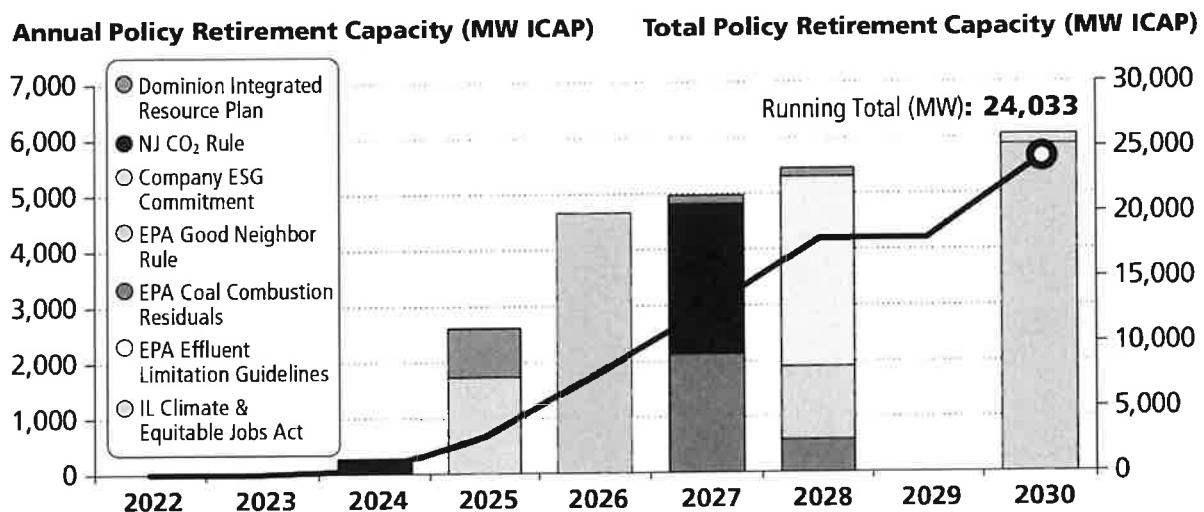


Dominion Integrated Resource Plan (IRP) commits to net zero carbon in its Virginia and North Carolina territory by 2050. PJM studied Dominion's Alternative Plan B retirement schedule, approximately 1,533 MW, for this analysis. Alternative Plan B proposes "significant development of solar, wind and energy storage resource envisioned by the VCEA," (Virginia Clean Economy Act of 2020), while maintaining natural gas generation for reliability, which is reflected in our analysis.



Company ESG (Environmental, Social, Governance) commitments are included where there is a commitment to retire resources per legal consent decree or other public statement. This includes the elimination of coal use and the retirement of the Brandon Shores, 1,273 MW, and Wagner, 305 MW, facilities in Maryland and the retirement of Rockport, 1,318 MW, in Indiana.

Figure 3. Potential Policy Retirements



Potential Economic Retirements

The third category of retirements in this study, beyond those formally announced and made likely by policy implementation, were identified through an analysis of revenue adequacy, the ability to economically cover going-forward costs from the wholesale markets. A net profit value was calculated for each existing generation resource using an estimate of future revenues and historical costs.

$$\text{Net Profit} = (\text{Gross Energy \& Ancillary Service Revenue} - \text{Production Costs}) \\ + (\text{Capacity Revenue}) - (\text{Fixed Avoidable Costs})$$

The results reveal that a portion of the thermal fleet is at risk of becoming unprofitable in the coming years.

The capacity market's Variable Resource Requirement (VRR) represents the set of prices for which load is willing to procure additional supply beyond the minimum reliability requirement. There are three points in the sloped demand curve, the first of which is anchored at a price 1.5 times the Net Cost of New Entry (Net CONE). Should the auction clear at this price level, the auction result signals that demand is willing to pay for the construction of new supply, minus the expected energy revenues the resource should expect to earn in the energy markets. As such, it is important to align the revenue expectations for the marginal resources with forward revenues, especially under PJM's continually changing landscape of business rules.

Energy & Ancillary Services Revenue and Production Cost

This study used a scaling approach to estimate forward unit-specific energy and ancillary services (E&AS) revenues from historical energy and ancillary service revenues by applying the following:

$$\text{Fwd Unit E\&AS Revenue} = \text{Hist Unit E\&AS Revenue} * \frac{\text{Fwd Reference E\&AS Revenue}^{15}}{\text{Hist Reference E\&AS Revenue}} * \frac{\text{Reference Avg Heat Rate}}{\text{Unit Avg Heat Rate}}$$

For a given reference resource type, unit dispatch was simulated using both historical and forward energy hub-adjusted energy prices. For the equivalent production cost model, the relative ratio of revenues and heat rates indicate the net effects of both rising fuel costs and energy price revenue. A unit on the margin in the energy markets, typically a natural gas unit, would set a locational price near its short-run marginal costs. Infra-marginal units, potentially coal units, would receive higher revenues as price-taking resources, and thus may see increased profitability. This is reflected in the analysis, in which a reference coal unit's forward revenues increased an average of 139% over previous revenue estimates.

¹⁵ The forward energy and ancillary services revenue calculation used in this study is the method that was developed for use in the Forward Net Energy & Ancillary Services Offset calculation originally developed in 2020, and filed as part of the most recent Quadrennial Review.

Capacity Revenues and Fixed Avoidable Costs

Unit-specific capacity revenues were calculated from prices and cleared quantities in the 2023/2024 Base Residual Auction (BRA). The study used the published 2023/2024 BRA Default Gross Avoidable Cost Rate (ACR) values as representative total fixed costs (\$/MW-day) required to keep the generating plant available to produce energy. In other words, these are projected costs that could be avoided by the retirement of the plant. Avoidable costs represent operational factors like operations and maintenance labor, fuel storage costs, taxes and fees, carrying charges, and other costs not directly related to the production of energy. When available, unit-specific ACR values from the 2023/2024 BRA supply offer mitigation process were used, otherwise the class average Gross ACR was used.

Results and Estimated Impact

This study assumes that a simulated economic loss would result in a retirement of the resource at the next available delivery year in which the unit is not committed for capacity. As such, a unit with a revenue loss that did not clear in the 2023/2024 BRA would exit in 2023, while a unit with a revenue loss that cleared in the 2023/2024 BRA would exit in 2024. While units that do not clear a single BRA may remain energy-only resources, this conservative assumption was used to provide awareness.

The economic analysis identified approximately 10 GW of supply in immediate economic risk, of which 7 GW of supply is also affected by policy risk, and 3 GW of supply is economic risk only. In aggregate, 6 GW are steam resources, and 4 GW represent combustion turbines and internal combustion resources. Several of the units identified were older steam boilers that had once converted from coal-fired to natural gas fuel; these resources are less efficient than a modern heat-recovery steam generator in a combined cycle unit. Fifty-three percent of the resources identified for economic risk did not have a PJM capacity obligation in Delivery Year 2023/2024, either through the FRR process or market clearing.

Supply Entry

The composition of the PJM Interconnection Queue has evolved significantly in recent years, primarily increasing in the amount of renewables, storage, and hybrid resources and decreasing in the amount of natural gas-fired resources entering the queue. The PJM New Services Queue stands at approximately 290 ICAP GW of generation interconnection requests, of which almost 94% (271 ICAP GW) is composed of renewable and storage-hybrid resources.

Natural Gas Headwinds

In the last decade, resources in the PJM region have benefitted from the proximity to the Marcellus Shale, an area that extends along the Appalachian Mountains from southern West Virginia to central New York. Beginning around 2010, gas extraction from hydraulic fracturing transformed this region into the largest source of recoverable natural gas in the United States. This local fuel supply decreased the prices for spot market natural gas in much of the PJM region, and prices in the PJM region often trade at negative basis to the Henry Hub spot price.

The entry of natural gas resources in the PJM region peaked in 2018, with 11.1 GW of generation commercializing that single year. From 2019 to 2022, a total of 8.1 GW of natural gas generation began service, or about a third of the 23 GW observed from 2015–2018. Queue proposals have also declined; over the last three years, only 4.1 GW of new natural gas projects entered the queue, while 15.1 GW of existing queue projects withdrew.¹⁶

Recent movement in the natural gas spot markets across the U.S. and Europe add another degree of uncertainty to future operations. In 2022, European natural gas supply faced many challenges resulting from the war in Ukraine and subsequent sanctions against Russia. Liquefied natural gas (LNG) imports into the EU and the U.K. in the first half of 2022 increased 66% over the 2021 annual average,¹⁷ primarily from U.S. exporters with operational flexibility. This international natural gas demand is a new competitor for domestic spot-market consumers, resulting in significantly higher fuel costs for PJM's natural gas fleet.

This study assumes that, of the approximately 17.6 GW of natural gas generation in the queue, only those that are proposed uprates of existing generation, or currently under construction, will complete.¹⁸ This results in 3.8 GW of entry from under-construction natural gas resources to be completed for the 2023/2024 Delivery Year. While 12 GW of natural gas have reached a signed Interconnection Service Agreement (ISA) stage, it is unclear what percentage of this capacity may move forward. If significantly more natural gas capacity achieved commercial operation, it could help avoid reliability issues.

Renewable Transition

PJM's projected resource mix continues to evolve toward lower-carbon intermittent resources. Entry into the queue from renewable and storage resources has been growing at an annualized rate of 72% per year since 2018, or 199 GW of capacity entry versus 2.8 GW commercializing and 42.1 GW withdrawn. This influx of renewable projects has led to a joint effort between PJM and its stakeholders to enact queue reforms intended to clear the backlog of projects, improve procedures around permitting and site control, simplify analysis by clustering projects, and accelerate projects that don't require network upgrades. FERC approved the proposed package in November 2022, with expected implementation in 2023.

Commercial Probability and Expanding Beyond the Queue

PJM staff developed several forecasts of the rate by which projects successfully exit the queue (the "commercial probability" of reaching an *In-Service* state). Since 1997, the PJM New Services Queue has tracked proposed generation interconnection projects from their submittal and study stages to completion of an ISA and Wholesale Market Participation Agreement (WMPA) and construction. At any point in the process, a resource may withdraw from the queue, effectively ending its commercial viability.

¹⁶ This capacity represents natural gas projects that were submitted prior to 2020 and withdrawn in the 2020–2022 time frame.

¹⁷ [Europe imported record amounts of liquefied natural gas in 2022](#), U.S. Energy Information Administration, June 14, 2022.

¹⁸ Under construction includes the New Service Queue *Partially in Service* – *Under Construction* and *Under Construction* statuses.

The study utilized a logistical regression classification algorithm to predict the probability of a project reaching an *In-Service* entry (or *Withdrawn* exit) based on several properties of the project. A logistical regression searches for patterns within training datasets, resulting in a model that can forecast a probability of a result. After applying the logistical regression model for 10 years of historical project completion (Y-queue to present) without project stage, approximately 15.3 GW-nameplate/8.7 GW-capacity were deemed commercially probable out of 178 GW of projects examined.

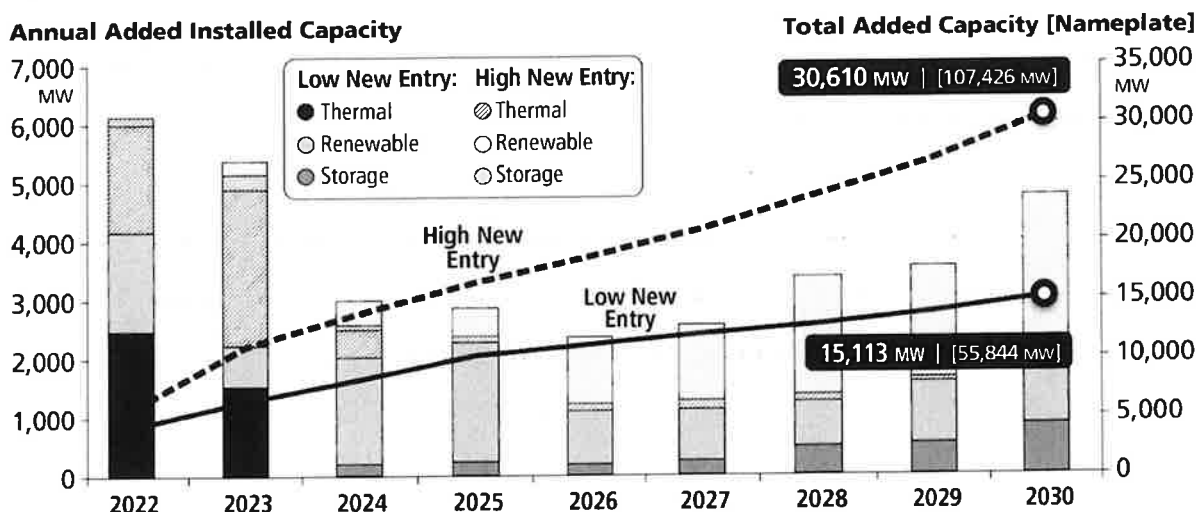
The model results for thermal resources were reasonably in line with expectations. However, the model produced extremely low entry from onshore wind, offshore wind, solar, solar-hybrid and storage resources. The uncertainty of completion rates of newer resource types, like offshore wind, likely plays a role in these model outcomes. After adjusting the new renewable capacity by Effective Load Carrying Capability (ELCC) derations, this commercial probability analysis estimates net 13.2 GW-nameplate / 6.7 GW-capacity to the system by 2030, as shown in **Figure 4**.

Given that this process may not capture recent policy changes and fiscal incentives toward renewable and storage development, and that the existing queue has fewer resources entered after 2026, PJM staff utilized two S&P Global Power Market Outlook analyses' generation expansion models. As estimates of future entry beyond the queue, these models are used to provide additional insight for the two scenarios: "Low New Entry" utilizes the "Planning Model,"¹⁹ and "High New Entry" utilizes the "Fast Transition" model.²⁰ Based on these models, PJM added additional capacity to its commercial probability data in each scenario.

These forecasts of generation expansion are economic resource planning solutions, which take state RPS requirements and capacity margins into account to ensure new renewable builds. Over the study period, the Low New Entry scenario adds 42.6 GW-nameplate/8.4 GW-capacity to supply expectations, resulting in total entry of 55.8 GW-nameplate/15.1 GW-capacity. The High New Entry scenario adds 107 GW-nameplate/30.6 GW-capacity after ELCC derations. Net natural gas entry was approximately 5 GW, and renewables was 48.5 GW-nameplate/10.4 GW-capacity, as shown in **Figure 4**.

¹⁹ S&P Global, North American Power Market Outlook, June 2022, planning model. This planning case incorporated effects from the 2021 Infrastructure Investment and Jobs Act, but not the 2022 Inflation Reduction Act.

²⁰ S&P Global, North American Power Market Outlook, Sept. 2022, Fast Transition model. This planning case assumes carbon net neutrality by 2050 through the IRA and additional policies, such as state clean energy policies, and as such assumes adjustments for increased electrification of heating, tax credits for renewable generation and higher levels of fossil retirements.

Figure 4. Forecast Added Capacity

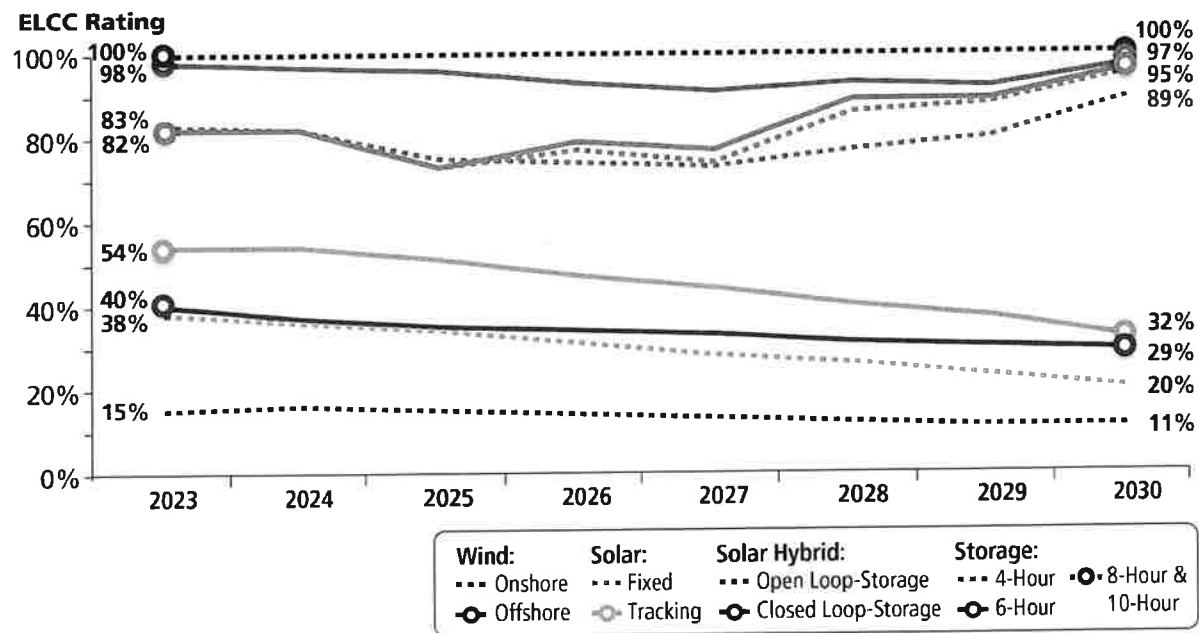
Impact of Capacity Accreditation on Existing Renewables and Storage

In July 2021, FERC accepted PJM's ELCC methodology for calculating unforced capacity values for intermittent and energy storage capacity resource classes. The ELCC analysis²¹ examines load and resource performance uncertainty, and calculates an hourly loss-of-load probability (LOLP) to meet a one-in-10 year loss of load expectation (LOLE) adequacy criteria. The ELCC method examines the alignment of a given resource type's capacity to high risk hours, as well as the change in risk hours proportional to the changes in portfolio size. The adjustments to accredited capacity went into effect in the 2023/2024 BRA executed in June 2022.

This study examined the current renewable generation fleet for the impact of future changes in capacity accreditation. Today, there are approximately 3.5 GW of onshore wind and solar capacity resources participating in the RPM capacity market as intermittent resources. From 2022 to 2030, this accredited capacity is expected to decline by 1.2 GW to 2.3 GW due to portfolio effects resulting in the increase of entry from other intermittent renewable resources.²² This adjustment is consistent with the renewable expectations presented in the [December 2021 Effective Load Carrying Capability \(ELCC\) Report](#).

²¹ [Manual 20, Section 5: PJM Effective Load Carrying Capability Analysis](#)

²² Approximate nameplate needed to replace 1 MW of thermal generation: Solar – 5.2 MW; Onshore Wind – 14.0 MW; Offshore Wind – 3.9 MW. These are average values.

Figure 5. Effective Load Carrying Capability (ELCC) Rating by Resource Type

Demand Expectations

Load forecasting is an important part of maintaining the reliability of the bulk electric system. Forecasting helps PJM make decisions about how to plan and operate the bulk electric system in a reliable manner, and how to effectively administer competitive power markets. PJM's Resource Adequacy Planning Department publishes an annual [Load Forecast Report](#), which outlines "long-term load forecasts of peak-loads, net energy, load management, distributed solar generation, plug-in electric vehicles and battery storage."

Along with the energy transition, PJM is witnessing a large growth in data center activity. Importantly, the PJM footprint is home to Data Center Alley in Loudoun County, Virginia, the largest concentration of data centers in the world.²³ PJM uses the [Load Analysis Subcommittee](#) (LAS) to perform technical analysis to coordinate information related to the forecast of electrical peak demand. In 2022, the LAS began a review of data center load growth and identified growth rates over 300% in some instances.²⁴ The 2023 PJM Load Forecast Report incorporates adjustments to specific zones for data center load growth, as shown in **Figure 5**.

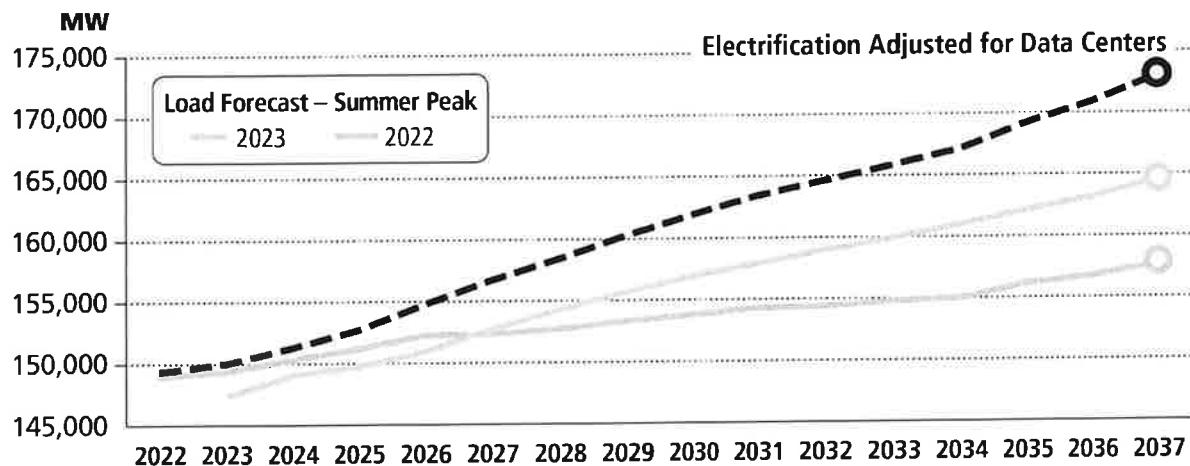
²³ See [Loudoun County Department of Economic Development](#), 2023.

²⁴ [Load Analysis Subcommittee: Load Forecast Adjustment Requests](#), Andrew Gledhill, Resource Adequacy Planning, Oct. 27, 2022

Additionally, PJM is expecting an increase in electrification resulting from state and federal policies and regulations. The study therefore incorporates an electrification scenario in the load forecast to provide insight on capacity need should accelerated electrification drive demand increases.²⁵ This accelerated demand increase is consistent with the methodology used in the Emerging Characteristics of a Decarbonizing Grid paper.²⁶ That paper found electrification to have an asymmetrical impact on demand growth, with demand growth in the winter, mainly due to heating, more than doubling that in the summer. This would move the bulk of the resource adequacy risk from the summer to the winter.

Figure 6 highlights how updated electrification assumptions and accounting for new data center loads have impacted the summer peak between the 2022 and 2023 forecasts.²⁷

Figure 6. Impacts of Electrification and Data Center Load on Forecasts



What Does This Mean for Resource Adequacy in PJM?

PJM projects resource adequacy needs through the Reserve Requirement Study (RRS). The purpose of the RRS is to determine the required capacity or Forecast Pool Requirement for future years or delivery years based on load and supply uncertainty. The RRS also satisfies the North America Electric Reliability Corporation/ReliabilityFirst Adequacy Standard BAL-502-RFC-03, Planning Resource Adequacy Analysis, Assessment and Documentation, which requires that the Planning Coordinator performs and documents a resource adequacy analysis that applies a LOLE of one occurrence in 10 years. The RRS establishes the Installed Reserve Margin values for future delivery years. For this study PJM used the most recent 2022 RRS, as well as the 2021 RRS for comparison.

²⁵ Electrification assumptions are 17 million EVs, 11 million heat pumps, 20 million water heaters, 19 million cooktops in PJM by 2037, built on top of the 2022 Load Forecast.

²⁶ [Energy Transition in PJM: Emerging Characteristics of a Decarbonizing Grid](#), May 17, 2022.

²⁷ [2023 Load Forecast Supplement](#), PJM Resource Adequacy Planning Department, January 2023.

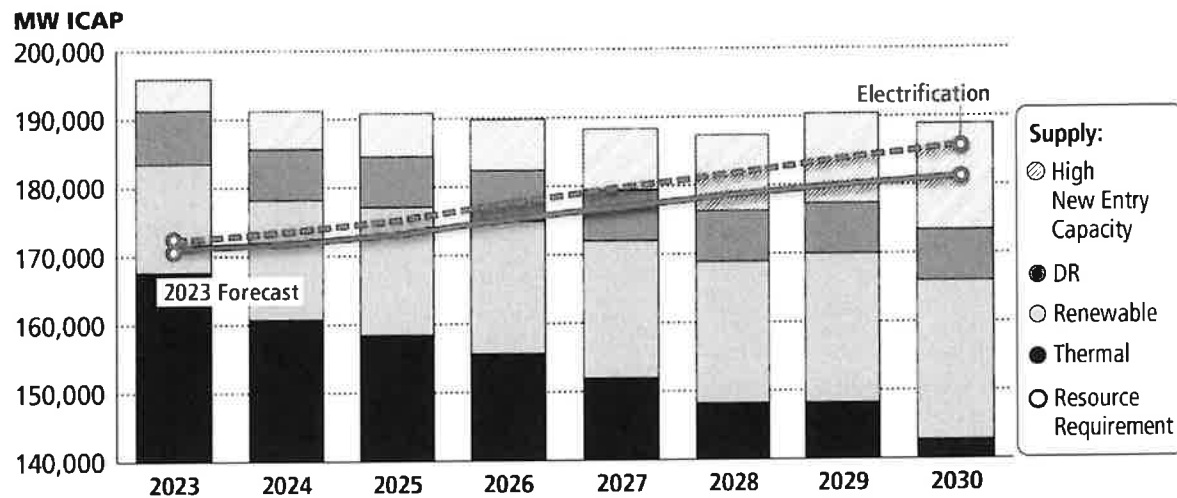
Combining the resource exit, entry and increases in demand, summarized in **Figure 7**, the study identified some areas of concern. Approximately 40 GW PJM's fossil fuel fleet resources may be pressured to retire as load grows into the 2026/2027 Delivery Year. At current low rates of renewable entry, the projected reserve margin would be 15%, as shown in **Table 1**. The projected total capacity from generating resources would not meet projected peak loads, thus requiring the deployment of demand response. By the 2028/2029 Delivery Year and beyond, at Low New Entry scenario levels, projected reserve margins would be 8%, as projected demand response may be insufficient to cover peak demand expectations, unless new entry progresses at a levels exhibited in the High New Entry scenario. This will require the ability to maintain needed existing resources, as well as quickly incentivize and integrate new entry

Table 1. Reserve Margin Projections Under Study Scenarios

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

As witnessed during the rapid transition from coal resources to natural gas resources last decade, PJM markets provide incentives for capacity resources. The challenge will be integrating the level of additional resources envisioned to meet this demand, and therefore addressing issues such as resource capacity accreditation is critical in the near term. The low entry rates shown in our Low New Entry scenario are illustrative of recent completion history applied to the current queue. RTO capacity prices in recent auctions have been low for several delivery years, and capacity margins have historically reached around 28% of peak loads. As capacity reserve levels tighten, the markets will clear higher on the VRR curves, sending price signals to build new generation for reliability needs.

The 2024/2025 BRA, which executed in December 2022, highlighted another area of uncertainty. Queue capacity with approved ISAs/WMPAs is currently very high, approximately 35 GW-nameplate, but resources are not progressing into construction. There has only been about 10 GW-nameplate moving to in service in the past three years. There may still be risks to new entry, such as semiconductor supply chain disruptions or pipeline supply restrictions, which are preventing construction despite resources successfully navigating the queue process.

Figure 7. The Balance Sheet

For the first time in recent history, PJM could face decreasing reserve margins, as shown in **Table 1**, should these trends – high load growth, increasing rates of generator retirements, and slower entry of new resources – continue. The amount of generation retirements appears to be more certain than the timely arrival of replacement generation resources, given that the quantity of retirements is codified in various policy objectives, while the impacts to the pace of new entry of the Inflation Reduction Act, post-pandemic supply chain issues, and other externalities are still not fully understood.

The findings of this study highlight the importance of PJM's ongoing stakeholder initiatives (Resource Adequacy Senior Task Force, CAPSTF, Interconnection Process Subcommittee), continued efforts between PJM and state and federal agencies to manage reliability impacts of policies and regulations, and the urgency for coordinated actions to shape the future of resource adequacy.

The potential for an asymmetrical pace within the energy transition, where resource retirements and load growth exceed the pace of new entry, underscores the need for better accreditation, qualification and performance requirements for capacity resources.

The composition and performance characteristics of the resource mix will ultimately determine PJM's ability to maintain the reliability of the bulk electric system. Managing the energy transition through collaborative efforts of PJM stakeholders, state and federal agencies, and consumers will ensure PJM has the tools and resources to maintain reliability.