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REPORT

WAITING GAME:
HOW THE INTERCONNECTION QUEUE THREATENS RENEWABLE DEVELOPMENT IN PJM

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The 13.6-megawatt Wye Mills solar project features over 40,000 solar panels on 97 acres in Queen Anne's County, Md., on June 27, 2016.

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Executive Summary

For more than 20 years, U.S. policymakers have made steady progress toward a future in which renewable energy is supported by a reliable electric grid and widely available to consumers at a low cost. Favorable economics, demand from clean energy buyers, and public policies like state renewable portfolio standards (RPS) have been successful in driving renewable growth that has met and surpassed early expectations. In 2022 the Biden administration passed the seminal Inflation Reduction Act (IRA), the most ambitious climate legislation in U.S. history. With renewables now cheaper than fossil fuels and new incentives through the IRA, renewable power is expected to become widely available more quickly and cost-effectively than ever.[1]

As policymakers and private companies alike look ahead to meeting their renewable targets, public attention has turned toward interconnection queues, overburdened and slow processes run by regional transmission operators (RTOs) that have become a major barrier to wind and solar development.[2] These long-overlooked processes study proposed new power generation, identify necessary transmission infrastructure upgrades to bring that power online, and allocate those upgrade costs to developers. As developer interest in new renewables has skyrocketed, interconnection queues have struggled to keep pace, resulting in an ever-increasing backlog of projects and years-long delays. Because renewables are often located where poles-and-wires infrastructure is least developed, developers are also left with high upgrade costs.

The PJM Interconnection (PJM) is the largest RTO in the United States. As of September 2022, there were more than 202 gigawatts (GW) of renewable energy resources waiting in the PJM queue, over 95 percent of the total queue. (For context, there were 200 GW of clean energy resources operating in the entire United States in 2021.[3])

In 2020 PJM launched a stakeholder process to revamp the interconnection queue, clear the backlog, and prevent future delays. PJM stakeholders agreed on a plan in April 2022, and the plan was approved by the Federal Energy Regulatory Commission (FERC) in November.[4] Under the approved reforms, PJM will transition its serial study process to a cluster-based approach to evaluate interconnection for multiple generators at once. PJM expects this "first-ready, first-served" approach will increase the number of projects it can process each year.

This report explores the extent to which PJM's interconnection delays will hinder states in the region in meeting their statutorily mandated RPS targets for renewable energy procurement, and the impact of its proposed reforms. Our analysis shows that the PJM interconnection queue reforms will just barely provide enough renewable energy to meet aggregate RPS demand through 2027; states with the most ambitious RPS targets are likely to lack adequate supply to meet their demand starting before 2027.

Our analysis represents the best-case scenario in several key ways. First, PJM's new approach will not be rolled out until 2026. Until then, PJM will be scrambling to clear its backlog of pre-2021 projects—and when the new process is finally implemented, it is likely to be facing an onslaught of IRA-incentivized new renewable projects that could cause delays beyond what we have estimated here. Second, current RPS represent only the bare minimum of renewable energy demand. There is a clear trend toward RPS expansion and policy updates. States may adopt more ambitious standards in response to IRA funding, or state policies beyond the RPS could increase demand. Third, the long implementation timeline of the queue reforms also prolongs investment uncertainty for renewable developers, who already face skyrocketing costs: According to Lawrence Berkeley National Laboratory analysis, "For active projects still in the queue, estimated costs have grown eightfold since 2019."[5] These factors may lead to much-needed new renewable generation being delayed, not developed at all, or unable to take advantage of new incentives under the IRA. Should any of these very likely scenarios occur, PJM will fail to supply enough renewable energy to meet demand, and more states could fall short of their RPS.

FERC-approved reforms to the PJM queue are certainly a welcome start. However, additional action and further reforms will be necessary for states in the region to reach their renewable targets and meet any high-renewable future goals.

The PJM generation interconnection queue is in crisis

The PJM Interconnection is the largest grid operator in the United States and controls the world's largest competitive electricity market, covering 13 states plus the District of Columbia.[6] Today the majority of PJM's power comes from fossil fuel generation.[7] However, decarbonization efforts are well underway in the region. Most states in the grid operator's footprint have instituted public policies to encourage renewable energy development, reduce greenhouse gas emissions, or electrify sources of consumer demand. The most common and well-developed of these policies are state renewable portfolio standards (RPS).[8] As defined by the U.S. Energy Information Administration (EIA), "RPS set a minimum requirement for the share of electricity supply that comes from designated renewable energy resources by a certain date."[9] State RPS have been especially effective in driving renewable energy expansion; they propelled almost a quarter of all renewable capacity additions in 2019.[10]

However, PJM's ability to meet current and future renewable energy demand has been stymied in recent years by the backlog and delays in its generation interconnection queue. The interconnection queue is the process by which regional transmission operators (RTOs) study new proposed power generation, identify necessary transmission network upgrades to bring that power online, and allocate upgrade costs to power plant developers. RTO approval through the queue is a necessary step for new generators before power plants are built, are connected to the transmission system, and can participate in wholesale electricity markets.

The PJM queue has been overwhelmed by the volume of new interconnection requests in recent years, mostly from renewable energy generators.[11] However, the challenges faced by grid operators were not entirely unanticipated. PJM noted in a report to the Federal Energy Regulatory Commission (FERC) that the queue window that closed in March 2021 had 55 percent more requests than two windows prior had.[12] But as early as 2008, an industry white paper recognized the impending challenges of an "overwhelming increase in new generation interconnection requests" from public policies encouraging new renewable resources.[13] Renewable generation enjoyed significant expansion in its nascent years, creating growth trends that should have been clear writing on the wall. By 2003 wind power capacity had already quadrupled from 1990.[14] In 2012 the National Renewable Energy Laboratory (NREL) published research that found it was feasible for the United States to achieve a majority-renewables system by mid

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century.[15] In December 2022, the International Energy Agency increased its 2021 global renewable deployment forecast by 30 percent for the next five years.[16] Yet despite the consistency of industry trends, grid operators and their planning processes have struggled to keep up with renewable power expansion throughout the country. PJM is facing the not uncommon problems of a power grid that has historically been designed and built for fossil fuel generation.[17] As RTOs transition from fossil fuels toward renewable energy, dissonance between outdated planning processes and the emerging resource mix has become a major problem. Renewables make up more than 95 percent of new resources in the PJM interconnection queue and are often more geographically spread out, smaller, and built in areas with less developed network infrastructure than are fossil fuel power plants.[18] The transmission system required to deliver renewable energy from generators to the power grid is quite different from the one needed for fossil fuel generators.[19] Status-quo interconnection processes exacerbate these challenges through piecemeal transmission upgrades rather than through long-term, proactive planning. A 2022 Brattle Group report highlighted that although the United States invests $20 billion to $25 billion annually in transmission, less than 10 percent is built for economic benefits and public policy needs.[20] RTOs have recognized the need to ratchet up their ability to handle future renewable expansion under the IRA and federal infrastructure investments, but broad, urgent action will be necessary to realize expected growth. Under new federal initiatives and incentives in the Inflation Reduction Act (IRA), the Princeton ZERO Lab predicts that PJM will see an additional 1,000 megawatts (MW) of renewable energy projects enter the queue annually.[21] PJM must be able to bring these new generators online to maintain a reliable electricity grid as uneconomic fossil fuel plants retire. According to S&P analysis of power plant retirements, the PJM market had the most retired capacity in 2022 out of all U.S. markets, almost all of which was coal plants.[22]

In April 2022, PJM announced a stakeholder-driven proposal to overhaul its interconnection queue process. The proposal transitions its serial study process to a cluster method, allowing the grid operator to study multiple projects at once, thus reducing costs and study wait times.[23] FERC approved the proposal in November 2022. The transition period to clear the existing backlog is expected to take until 2026, at which point PJM can begin to process all requests submitted after October 2021.[24] This timeline leaves little maneuvering room for states in the nation's largest grid looking to take climate action. In this analysis, we examine the PJM queue processing schedule and the near-term demand for renewable energy from PJM state policies currently in place.

The PJM region can expect to see an unprecedented level of demand for renewable energy through 2030

This analysis uses state renewable portfolio standards to gauge a bare minimum of future renewable energy demand. Policymakers introduced renewable portfolio standards more than 20 years ago. Since then, most states have adopted RPS policies.[25] Because RPS are a widely used and easily quantified policy mechanism (e.g., "50 percent of electricity retail sales served by renewable resources by 2030"), they make for an easy regional benchmark for renewable demand. This report investigates how well PJM states will be able to meet RPS policies in effect as of September 2022 (table 1) during the queue reform transition timeline through 2030. When just state RPS are considered, without the impact of the Inflation Reduction Act (IRA) or other public policies, PJM will see unprecedented levels of demand for renewable energy through 2030. By 2031 we expect a 70 percent increase in renewable energy demand from aggregate RPS demand in PJM, relative to 2023 levels (table 2).[26]

As mentioned above, we consider RPS-driven demand for renewables to represent a bare minimum of future renewable energy needs. In recent years, RPS have led to additional statewide net-zero targets, clean energy standards, and other policies to drive decarbonization.[27] As of this writing, five states in PJM and the District of Columbia have greenhouse gas reduction targets in addition to their RPS.[28] Demand beyond RPS targets—and not encapsulated in this analysis—is robust and likely to increase as states seek to leverage funds and incentives from the IRA and the related Infrastructure Investment and Jobs Act, which are expected to spur $83 billion in grid investment through 2030.[29]

TABLE 1: RENEWABLE PORTFOLIO STANDARDS IN PJM.

State	RPS target
District of Columbia	100% by 2032
Delaware	25% by 2026; 40% by 2035
Indiana	10% by 2025
Illinois	40% by 2030; 100% by 2050
Maryland	50% by 2030
Michigan	15% by 2021
New Jersey	50% by 2030
North Carolina	12.5% by 2021
Ohio	8.5% by 2026
Pennsylvania	8% by 2021*
Virginia	100% by 2050**

Source: state databases

*Includes only Tier I resources; excludes the 10% Tier II targets (waste coal, solid waste, large hydro, and other industrial by-products). **For investor-owned utilities (IOUs), where the target applies to IOU retail sales minus any generation from the companies' nuclear fleet.

TABLE 2: AGGREGATE DEMAND FOR RENEWABLE RESOURCES FROM RENEWABLE PORTFOLIO STANDARDS IN PJM, INCLUDING RESOURCE CARVEOUTS, IN MEGAWATT-HOURS (MWH)

Year	Tier I + Offshore Wind Carveout	Solar Carveouts	Total RPS (non-Tier II)
2023	90,738	10,176	100,915
2024	98,856	10,676	109,532
2025	109,810	11,197	121,007
2026	117,797	11,365	129,162
2027	126,668	11,780	138,448
2028	136,739	12,082	148,821
2029	145,472	11,630	157,102
2030	155,837	11,208	167,045

Source: BloombergNEF.

Details of the PJM reform transition timeline

As of September 2022, there were more than 200 proposed gigawatts (GW) of renewable resources in the PJM queue. Not all these resources represent viable projects for future supply. Most proposals eventually withdraw their interconnection requests from the queue. While queue withdrawal rates have remained steady in recent years, the number of withdrawals has increased along with the total number of projects. Withdrawals are a problem because they often trigger restudy of subsequent nearby projects, slowing the process further.[30] Queue reforms aim to reduce withdrawal rates by increasing developer requirements and deposits at study milestones. The reform's impact on the future queue withdrawal rate is outside the scope of this report.

Before the full transition goes into effect in 2026, PJM's plan lays out a multiyear process to clear out the project backlog. Existing projects are sorted into two transition cycles, with some older projects processed under the current rules (for details, see Appendix D):[31]

- **Existing interconnection procedures** apply to projects that submitted interconnection requests no later than March 2018 (AD2 queue).
- **Transition period rules** apply to projects entering the queue from April 2018 through September 2021 (projects in the AE1, AE2, AF1, AF2, AG1, AG2, and AH1 queue windows) that have not been tendered an interconnection service agreement (ISA) or wholesale market agreement.
- Proposed permanent **"new rules"** apply to new service requests submitted on or after October 1, 2021 (AH2, AI1, and onwards).

Additionally, approximately 450 projects are slated for a "fast track." These projects would otherwise fall into one of the two transition cycles, but since they require $5 million or less in network upgrades, and therefore have relatively simple study requirements, they have been prioritized.[32] The detailed methodology of this report (Appendix A) contains a discussion of the rules and their application to the queue backlog.

However, clearing the backlog as proposed only addresses projects that entered the queue before October 2021. PJM won't even begin to process requests submitted after October 2021 until 2026 at the earliest. By then, it's possible that the number of requests will be extraordinarily high, thanks to IRA funding and other incentives. FERC has already expressed its concerns about what PJM's process may face in 2026, asking PJM whether new service requests in future years could result in "Cycle #1 becoming unmanageably large."[33] PJM's response was that the combination of increased developer requirements and cluster studies would mitigate the volume of requests and make the queue more manageable. However, while other RTOs use cluster studies to manage new renewable supply, they do not completely address queue volume. For example, at this writing, the California Independent System Operator (CAISO) is considering delaying its upcoming cluster study, as even "additional resources cannot sufficiently address the projected size of the queue."[34]

Our analysis shows that the proposed timeline for clearing the backlog before the new, more efficient processing system takes effect will have a significant impact on available renewables during those years and the years that immediately follow (as new projects are built and come online).

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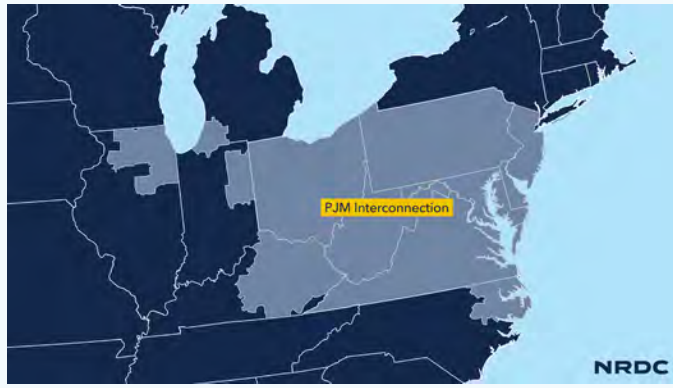
Wind towers and electrical high tension transmission lines together, alternative electricity generation and power distribution on a sunny mountain in Pennsylvania, PA, USA.

DATA SOURCES AND METHODOLOGY

For this report, we analyzed the impact of PJM interconnection queue reforms on anticipated renewable energy supply in the region through 2028. We took a multistep approach to estimate final interconnection agreement dates, commercial operation dates, and the quantity of renewable energy from the queue annually.

- Data were collected from the PJM interconnection queue to identify all potential utility-scale renewable (wind, solar, and hybrid) projects as of September 2022 within the PJM footprint (figure 1).[35]
- Data were filtered to projects under study or construction. These included:
  - 1,935 "active" projects
  - 267 projects in "engineering and procurement"
  - 62 projects "under construction"
- State-level capacity factors and estimated commercial viability (based on historical withdrawal rates) were applied to determine the approximate new renewable energy available annually through 2028.
- Resource eligibility laws were analyzed for eight states with an RPS, plus the District of Columbia; Indiana and North Carolina were excluded due to the relatively small portion of their loads served by PJM.

FIGURE 1: PJM FOOTPRINT



- Registered renewable generators and eligibility reports in the PJM Generation Attribute Tracking System (GATS) were used to estimate existing resource supply.
- Total renewable supply (existing resources plus queued projects) was compared to renewable energy demand from RPS policies (based on the BloombergNEF model of future electric sales and renewable demand) to determine annual state-level RPS compliance.[36]

The full, detailed methodology is available in **Appendix A**.

Interconnection reforms still leave a steep path ahead for states

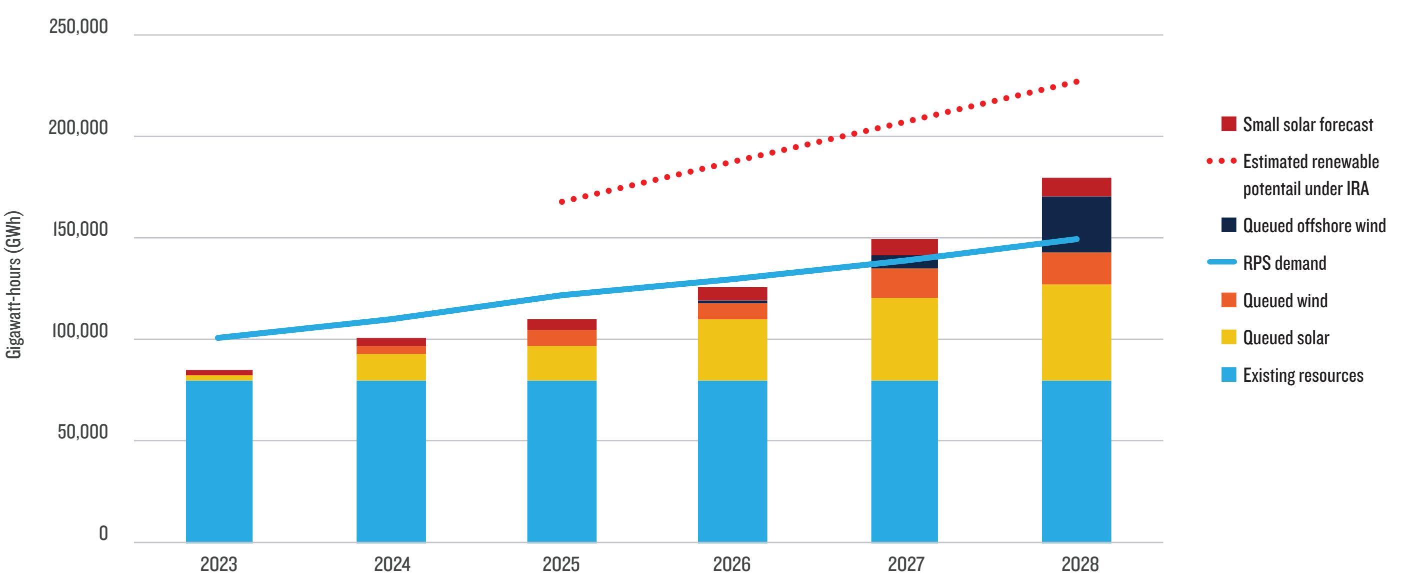
PJM's delay in processing new renewable projects leaves a steep path ahead for states with the most ambitious RPS targets, and little headroom for meeting demand beyond the bare minimum. Our analysis finds that the predicted pace of renewable buildout just barely meets aggregate RPS demand in PJM before 2030. However, some states will only technically meet minimum standards through 2027 because their relaxed RPS criteria allow for carbon-emitting resources. Additionally, this report only considers RPS legislation in effect at the time of this analysis and does not account for state legislatures potentially expanding clean energy targets to take advantage of federal funding. Ultimately, states without adequate resources already in the interconnection queue to meet near-term demand may be forced to delay goals, procure energy from other sources, or find other creative means to meet their RPS.

Our analysis compared aggregate, regional RPS demand in PJM to the total amount of RPS-eligible generation through 2028 (figure 2). Additionally, we included an estimate of IRA-fueled renewable energy growth based on the Princeton Net Zero modeling of IRA impacts in PJM. Figure 2 illustrates how little wiggle room there is in meeting RPS demand, which is expected to constitutes 22 percent of total PJM by 2035.[37] It also shows how PJM is likely to fall woefully short of realizing federal renewable energy ambitions.

Additionally, actual supply available for RPS compliance on an annual basis is likely to be lower than our estimates because queued resources that are eligible for state RPS will not necessarily be used for compliance. Utilities and developers often sign power purchase agreements far in advance of project completion. However, other private parties, such as large corporate purchasers participating in voluntary renewable markets, also enter these long-term contracts. In 2020 voluntary buyers procured 35 percent of non-hydroelectric renewable generation in the United States.[38] For large energy consumers, this may reduce the amount of energy that suppliers need to procure, but it also directs a significant amount of renewable development to private use. Availability of RPS-eligible energy imports from nearby states and regions also impacts supplier procurement.[39] We discuss the assumptions for these supply estimates in **Appendix A**.

On the basis of our analysis, we conclude that PJM states should just barely be able to meet their RPS targets through 2027. However, this is not necessarily good news. As discussed, it is likely that this analysis overestimates supply and underestimates demand. Given the lack of wiggle room between estimated PJM supply and statewide demand, states should be concerned about having enough renewable energy to meet their needs.

FIGURE 2: PROJECTED RPS-ELIGIBLE RENEWABLE RESOURCE SUPPLY IN PJM



Sources: independent analysis, BloombergNEF, and Princeton University data.

STATE RPS DESIGN WILL IMPACT ABILITY TO MEET RENEWABLE DEMAND

Our primary analysis looked at aggregate demand and supply. However, meeting renewable targets and benchmarks will be easier for some states than for others. Since all states in the PJM region connect to the same grid, the policy design in one state impacts the supply of renewable power in another. Specifically, states looking to increase the local economic benefits of construction and tax credits have introduced policies that limit how much out-of-state renewable energy can be used for RPS compliance—which has the impact of keeping more of their state-produced renewable energy in the state and reducing the supply available to neighboring states. This may make it easier for states with their own renewable resources to meet demand, and more difficult for those without those resources—or it may hamstring states with restrictions if they can't get their own generators online.

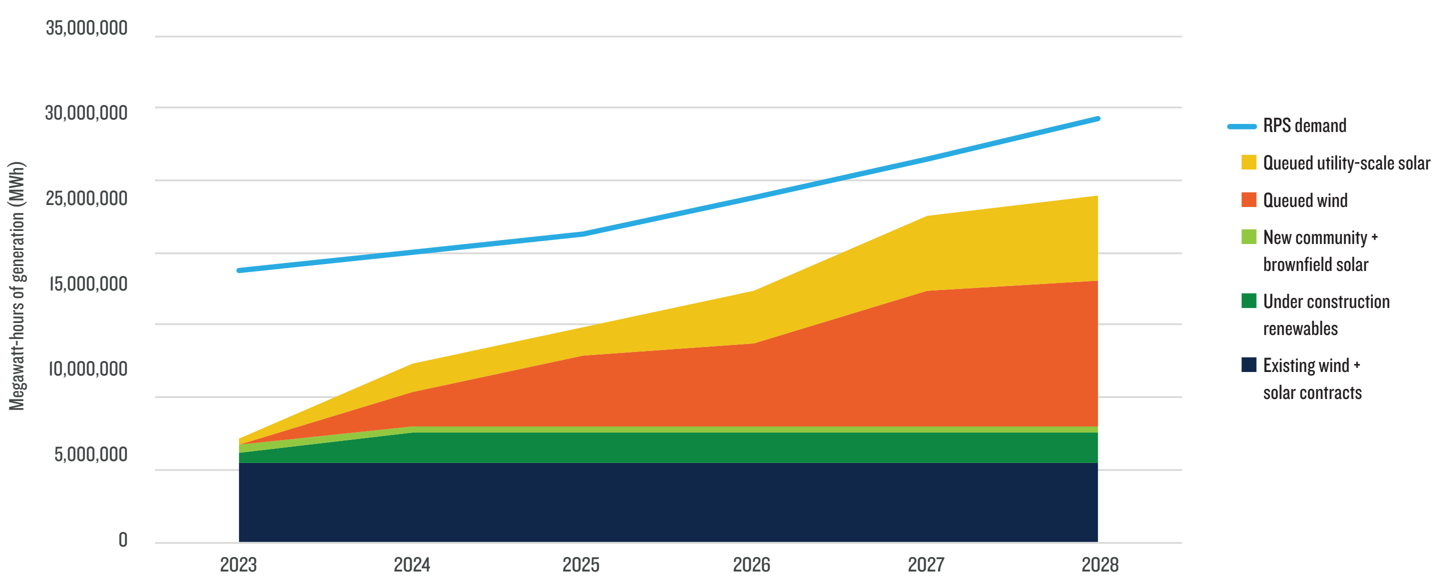
Illinois provides one example of a state with ambitious climate goals and abundant renewable resources that may struggle to meet renewable energy targets. Illinois's Climate and Equitable Jobs Act (CEJA) is one of the most far-reaching state climate laws in the country, and it effectively limits RPS-eligible resources to those located within Illinois, with very few exceptions.[40] Other PJM states have historically imported renewable energy certificates (RECs) from wind-rich Illinois. As the supply and market for RECs tighten, CEJA may create tension between resources used for Illinois's future targets and those used to meet regional demand. If both out-of-state imports and in-state renewable development are constrained, suppliers may be forced to rely increasingly on alternative compliance payments or other penalties.[41]

Compared with Illinois, states with more flexible RPS policies may allow unbundled RECs (credits sold separately from the associated renewable power), out-of-state RECs, and nonrenewable or carbon-emitting resources to qualify (e.g., biomass, waste heat), or apply the renewable portfolio standard to a fraction of suppliers' total electric load (e.g., excluding large commercial and industrial loads).[42] These flexible standards may make it easier for them to technically meet their RPS targets but do not have the same emissions reductions or economic benefits as in-state renewable development.

The part of Illinois under PJM jurisdiction is supplied by the Illinois utility Commonwealth Edison. While queued resources in the ComEd zone will produce substantial amounts of energy in future years, there remain significant gaps in meeting RPS requirements (figure 3).

Under CEJA requirements, ComEd has begun to explore additional policy options that may be necessary to achieve future climate goals. For example, a recent study with consultant E3 modeled 2,000 MW of transmission for RPS-eligible clean energy, beginning in 2027, from the neighboring Midcontinent System Operator (MISO), which covers the rest of Illinois.[43] Illinois's renewable energy targets are further discussed in **Appendix B**.

FIGURE 3: PROJECTION OF RPS-ELIGIBLE RESOURCES IN COMED RPS THROUGH 2028



Source: Illinois Power Agency; PJM.

Illinois is an outlier among PJM states in the breadth and ambition of its climate goals. Virginia has a comparable overall target of 100 percent carbon-free resources (by 2045 or 2050, depending on utility) but also has broader eligibility standards that allow up to 25 percent out-of-state resources.[44] Additionally, Virginia's RPS policy applies only to the state's two largest investor-owned utilities, Appalachian Power Company and Dominion Energy, which represent about one-third of total retail electric sales.[45] These policy design factors, plus the significant amount of offshore wind (OSW) energy queued for interconnection through Virginia, allow the state to meet its RPS targets ahead of schedule (figure 4).[46] Offshore wind energy has the highest expected capacity factors of all renewables resources in the PJM queue. Given the outsize renewable energy supply from offshore wind and its unique challenges, there is potential merit in studying this resource separately from the rest of the queue, an idea that the California system operator has recently begun to explore.[47]

As we see from looking at Illinois and Virginia, the PJM backlog will have unequal impacts in different states, depending on RPS structure and resource availability.

WITHOUT ADDITIONAL REFORM, STATES MUST CONSIDER THE IMPACT OF QUEUE DELAYS ON RENEWABLE POLICIES

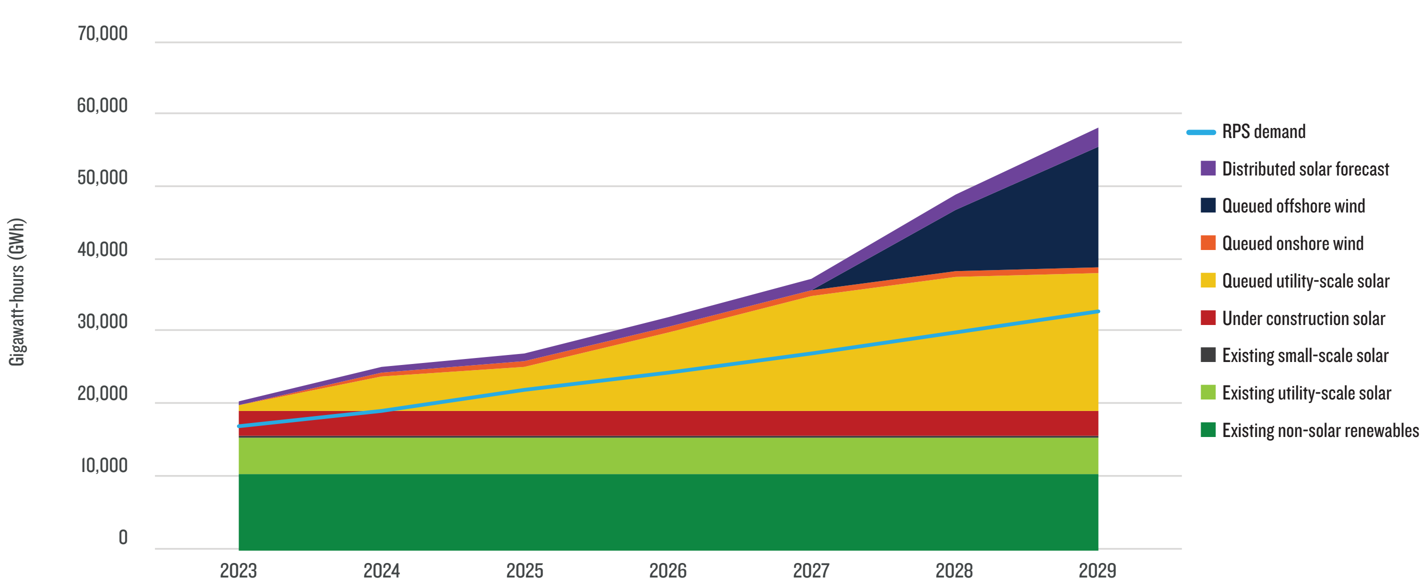
Good RPS policy design is the culmination of collaborative efforts between state policymakers and diverse stakeholders not just to achieve quantitative renewable energy goals but to build the right energy system for that state. State RPS are thoughtfully designed, with multiple interacting elements such as resource eligibility, transmission planning, and design features to develop certain types of resources in specific areas through carveouts, policy targets to develop or procure a specific subset of resources.[48]

One of the most crucial considerations in statewide RPS design is understanding the availability of desired renewable resources. This analysis should provide state policymakers with some of that information, as well as some caveats to consider.

Policymakers should note, however, that availability of renewable energy also depends on deliverability via transmission infrastructure—getting the energy from generators into the grid. Transforming infrastructure that was built to deliver energy from fossil fuel power plants to one that will deliver renewable energy from disparate locations and long distances will require new planning processes and investment. Our analysis made certain assumptions about deliverability that policymakers may need to adjust for their region or circumstances. While transmission needs are not the focus of this report, interconnection and transmission have a close and important relationship.

Policymakers should consider which renewable resource type is most likely to be available when they need it. We projected PJM energy capacity through 2028 by renewable type—wind, solar, and offshore wind (figure 5). These estimates are based on PJM's timeline for clearing the backlog and average construction times for each resource type (see Appendix A for full methodology). Our analysis shows modest growth from land-based wind and steady growth from solar projects that constitute most of the queue. If we assume a three-year construction timeline,

FIGURE 4: AVAILABLE RENEWABLE ENERGY RESOURCES TO MEET VIRGINIA'S RPS DEMAND THROUGH 2029



Sources: independent analysis of PJM data; PJM/IHS; BloombergNEF.

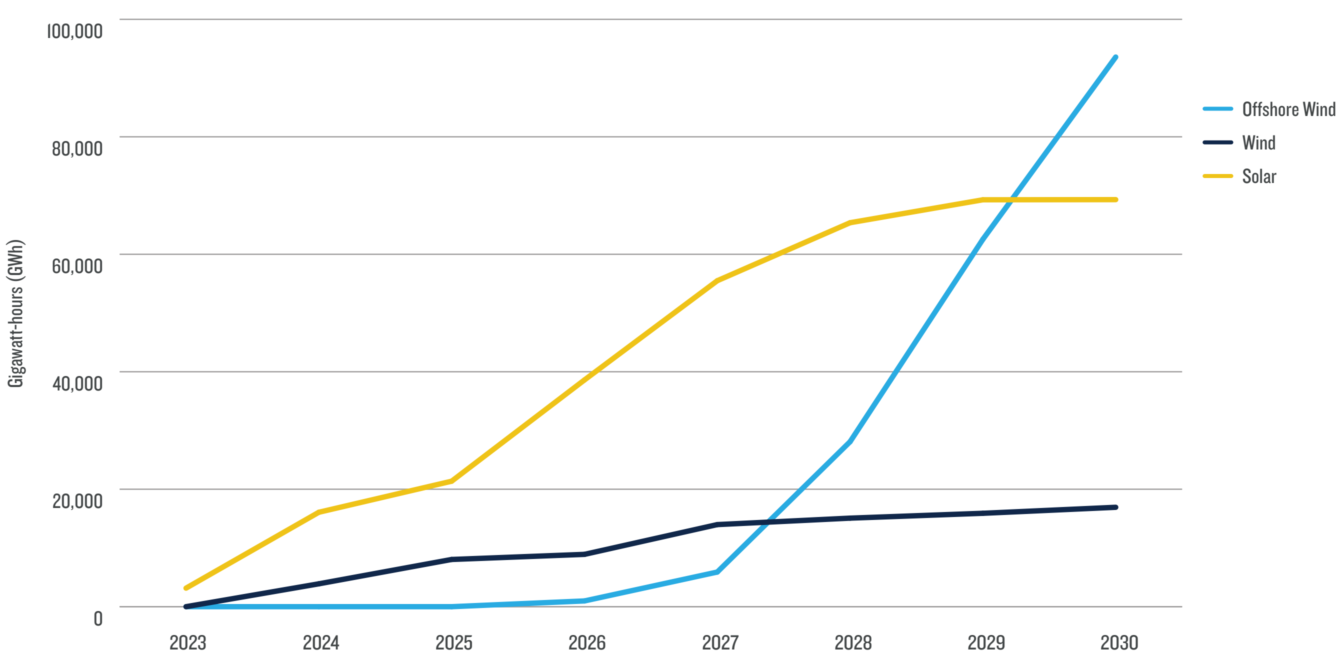
queued offshore wind supplies more than 60 GW of clean energy in 2028. The expected energy from offshore wind in 2028 is nearly equal to all of the solar in the queue.

When compared with queued projects' initial estimated commercial operation dates—dates that may have been considered in current RPS—there are, predictably, delays for most resources. Notably, our analysis shows that planned offshore wind operations are delayed by one to three years. Offshore wind has the potential to deliver vast quantities of renewable energy and will be critical to most states' long-term goals. But is unlikely that new offshore wind will come online before 2026. For example, Maryland has queued OSW projects initially expected to enter operation in 2026 that will likely not finish construction until 2028; the state is considering additional offshore wind targets and should keep this delay in mind when setting those target dates. Moreover, other potential development barriers (e.g., lawsuits, permitting challenges, manufacturing delays) were beyond the scope of this analysis. While these challenges are outside of state or RTO control, future reforms should consider them in the broader context of how important these resources are for policy goals. To the extent to which PJM and states are able, development barriers should be lowered, and transmission planning should be optimized to ensure that critical projects are not held up.

In addition to the large-scale renewable resources in the PJM interconnection queue, policymakers should be aware of growth in small-scale resources. These are not subject to the RTO interconnection queue process and are not directly visible to PJM but estimates for small-scale renewable growth were included in our estimates of aggregate renewable supply through PJM.[49] Growth in small-scale solar (i.e., distributed solar) is especially important for meeting RPS in states with strong solar incentives. For example, in New Jersey, existing small-scale solar projects and forecasted distributed solar growth represents 69–85 percent of total annual solar energy available in the state from 2023 to 2030.[50] However, small resources have their own set of challenges. Distributed solar must go through utility interconnection queues that are not necessarily a faster path to operation. Utilities have been generally slow to keep up with demand and upgrade the distribution network to accommodate distributed resources. For example, according to the Interstate Renewable Energy Council, Minnesota utility Xcel Energy has more than 300 projects waiting for approval. One analysis showed it would take 260 years to clear the Xcel queue at its current processing pace.[51]

State RPS that drove early renewable energy adoption are now leading to more ambitious public policies. For the first time, the federal government has its own goal to reach 100 percent clean power nationwide by 2035. Any new or updated renewable targets should consider interconnection queue speed and efficiency, along with other policy design elements, to set renewable targets that are equally ambitious and feasible.

FIGURE 5: CUMULATIVE ENERGY FROM QUEUED RENEWABLE PROJECTS (ONSHORE WIND, SOLAR, AND OFFSHORE WIND) BY PROJECTED OPERATION DATE



Source: independent analysis of PJM data

OFFSHORE WIND: BARRIERS AND POTENTIAL

Offshore wind developments on the Eastern U.S. shore have enormous potential to boost renewable energy production. Four PJM states have made OSW commitments totaling nearly 30 gigawatts, to be met by 2040 at the latest (table 3). However, many OSW projects face technical, legal, and permitting challenges that take time and financial power to navigate. Interconnection queue delays may be an additional barrier to timely delivery, more so than for other renewable resources.

The Department of Energy estimates that the domestic OSW potential is equal to double the total national electric demand.[52] Coastal state commitments in PJM recognize and aim to capitalize on this value. However, no OSW projects that are not currently in the PJM queue will begin interconnection studies before 2026, potentially delaying ambitious state action in the near term. Most existing projects in the queue fall into one of the two transition cycles, resulting in earliest possible queue exit in mid-2025 and 2026 respectively. As a result, queued offshore wind projects will be delayed from delivering power until 2028–29.

Additionally, these projects require considerable transmission buildout, some of which is already underway. In October 2022, the New Jersey Board of Public Utilities made arrangements for a second round of transmission planning to meet its increased offshore wind target.[53] Interstate OSW coordination has also begun, for example through the Southeast & Mid-Atlantic Regional Transformative Partnership for Offshore Wind Energy Resources (SMART-POWER) initiative to bridge efforts among North Carolina, Virginia, and Maryland.[54] It is crucial that OSW move through the queue at a pace that allows states to reap the benefits of their significant effort and investment.

TABLE 3: OFFSHORE WIND COMMITMENTS IN PJM

STATE	OFFSHORE WIND CAPACITY (MW)	
	Committed	Procured
NEW JERSEY	11,000	4,316
MARYLAND*	1,568	1,200
VIRGINIA	5,200	2,662
NORTH CAROLINA	8,000	

**Since the time of this analysis, Maryland legislature has passed a bill that increases the state's offshore wind energy target to 8,500 megawatts by 2031.*[55]

Source: state legislative codes.

Conclusion

Under the FERC-approved reforms, PJM has until 2026 to clear out the existing study backlog before its new, more efficient processes go into effect. States considering more ambitious RPS or additional clean energy policies should be aware that until 2026, the transition timeline limits new PJM supply to resources already in the queue. In the meantime, the IRA will intensify pressure on the queue as it provides unprecedented new opportunities through new investments in supply infrastructure and significant provisions for renewables.[56] While our analysis shows that PJM technically may have the capacity to meet most minimum RPS targets, the pace of the queue leaves little headroom for compliance. As we describe in the discussion of our results (Appendix B), projections that just meet the bare minimum renewable demand should not be mistaken for a scenario without significant challenges for public policy. There is little doubt that RPS targets and broader policy goals will be constrained by the speed and efficiency of the interconnection queue.

Moreover, PJM interconnection queue delays are symptomatic of broader issues with the antiquated systems for planning generation and transmission in the region.[57] Hopefully, PJM's reforms will lead to additional planning improvements; as FERC Commissioner Allison Clements noted in her concurrence regarding PJM's plan, "Additional steps including better transmission planning will be essential complements to PJM's proposal."[58] Recent studies have recognized the need for significant transmission expansion and improved planning in the energy transition.

Planning for a high-renewables future in PJM must involve deeper changes and include diverse stakeholder engagement, lessons learned from systems with faster interconnection processes, and transparent collaboration between planning authorities and the states. PJM must restore trust in the functioning of the queue by delivering on the reform timeline, accelerating studies where possible, and acting on proactive transmission planning to reduce system costs and provide a means for state policies to succeed.

Appendix A: Methodology

The key question this report set out to address is whether the approved PJM interconnection queue reforms will enable supply of sufficient renewable energy to meet future demand in the region. To this end, we examined renewable portfolio standard targets in PJM and compared them with renewable energy production projections. PJM has proposed a systematic approach to address the backlog of queued resources that have accumulated as the average time in the queue has steadily increased.[59] In 2026 PJM will begin to study new generation projects whose developers submitted interconnection requests after October 2021. The volume and capacity of these projects are unknown, since they will include projects submitted in future years. Accordingly, we limited our analysis to actively queued, backlogged resources that PJM will process under the reforms approved by FERC.[60] This detailed methodology explains each aspect of our approach to estimate RPS compliance as a benchmark for how well PJM reforms address future renewable energy demand:

- **Processing timeline for the backlogged queue.** For this, we estimated how much energy exits the queue annually through 2028, on the basis of commercial viability (percentage of projects expected to reach commercial operation) and state- and resource-specific capacity factors.
- **Role of existing generation in RPS compliance.** We assume existing renewable supply remains static; Section F of this appendix explains this approach in more detail.
- **Projected renewable energy demand from state RPS in PJM.** Our analysis excludes voluntary programs and nonbinding state goals. For these projections we used BloombergNEF data, which are based on EIA Form 861 sales data and the state policies currently in place.[61]

A. PROJECT WITHDRAWAL RATES AND COMMERCIAL VIABILITY

Most projects in the interconnection queue will withdraw, and this can happen at any stage of the process.[62] While withdrawals can occur for a number of reasons, Lawrence Berkeley National Lab analysis concluded that "withdrawn projects face the highest costs . . . [which is] likely a key factor in those withdrawals."[63] To estimate the commercial viability of projects in the queue backlog, we reviewed historical data in the PJM New Services Queue.

The PJM independent market monitor (IMM) has projected that out of all queued capacity, 12.7 percent of queued megawatts (MWs) will eventually enter operation.[64] However, we observed that historical data from the PJM New Services Queue suggest that this estimate of commercialization rates should be higher. Although

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not specified in the IMM report, it is possible that 12.7 percent was established on the basis of reported "MWs in service" from queue. We observed some anomalies in the PJM dataset regarding in-service MWs. Some operational generators are listed with zero value in the "MW In-Service" field. We cross-checked operational generators from the PJM New Services Queue with Form EIA-923 data, which include generator-level information about operational power plants over 1 MW connected to the grid.[65] We found that facilities listed in the PJM queue with zero operating MW were in fact generating power during 2021. For example, the PJM New Services Queue lists a Pennsylvania wind farm with a maximum facility output of 30 MW as zero in-service megawatts, despite generating power in 2021 according to EIA-923.[66] Additionally, some projects will revise proposed nameplate capacity during the interconnection study process. However, we observed that nameplate revisions have minimal impact on the net nameplate megawatts that enter service from the queue. Because of these anomalies, we filtered PJM New Services Queue data for projects that reached commercial operation between 2007 and 2017, see Table 4.

Table 4 lists the number of projects in each status category defined in the PJM New Services Queue from 2007 to 2017. It is challenging to accurately project the timeline and completion rate for projects in the "Engineering and Procurement" phase because many of these projects have been delayed for reasons unrelated to the PJM interconnection process. Delays due to litigation, environmental permitting, and securing financing and tax equity make it difficult to venture a broad guess about the number of projects that will eventually become operational. There are 267 projects under this status in the queue, including all queue windows. These projects may be in very different stages, some close to beginning construction and others languishing in court due to lengthy litigation. While we acknowledge that some of these delays are outside project developers' control, it is likely that many projects stuck in this phase will not reach operation within a time frame that is predictable or meaningful enough to have an impact on RPS supply through 2028. To simplify this analysis, we assumed that 20 percent of these projects will become operational.

We considered projects with a status of "In Service," "Partially in Service," and "Under Construction" to be effectively "operational" for the purpose of establishing a historical commercialization rate. The weighted average of projects reaching these stages is 18.2 percent. We grouped projects marked "Suspended" with withdrawals to represent projects that never reach operation.

We applied the 18.2 percent commercialization rate to all queued projects processed under the transition timeline, with two exceptions. First, we assumed that 100 percent of offshore wind will eventually reach operation due to state policy support behind these projects. Second, we also assumed that 100 percent of newer projects (those that entered the queue after 2018) that have been issued an interconnection service agreement and are at an advanced stage in the queue will reach operation.

Projects with an executed interconnection service agreement (ISA) *or* wholesale market agreement (WSA) *or* in queue window AA1–AD2 were assumed to have a 70 percent commercialization rate. This estimate accounts for our calculated 30 percent historical rate of renewable projects with an executed ISA that have a status of "Withdrawn."

B. FORECASTS OF FUTURE STATE RPS DEMAND FOR RENEWABLE ENERGY

The focus of our analysis was the minimum threshold for renewable development in PJM, which we define as annual aggregate demand from mandatory, state-defined renewable portfolio standards. As discussed in the body of this report,

TABLE 4: HISTORICAL QUEUE DATA FOR PROJECT COMMERCIALIZATION ESTIMATES, FILTERED BY QUEUE ENTRY YEAR

Queue Entry Year	In Service	Withdrawn	Under Construction	Engineering and Procurement	Partially in Service - Under Construction	Suspended	Active
2007	9	49	0	0	0	0	0
2008	12	67	0	0	0	0	0
2009	25	78	1	0	0	0	0
2010	52	312	0	0	0	0	0
2011	28	235	0	0	0	0	0
2012	10	47	0	0	0	0	0
2013	13	33	0	1	0	0	0
2014	29	56	0	2	1	0	0
2015	25	94	3	4	3	0	0
2016	44	165	14	38	6	12	3
2017	17	167	7	49	0	11	26

Source: PJM

actual regional demand for renewable energy in future years will far exceed RPS requirements, given voluntary renewable energy markets, procurement for broader public policies, and demand from developers looking to take advantage of IRA incentives. Additional demand sources beyond the RPS are outside the scope of this work. However, we do consider these drivers to be important in the context of this report.

We evaluated several potential data sources to estimate state renewable portfolio demand. The three considered sources were state utility commission reports on RPS requirements, BloombergNEF (BNEF) forecasts, and Lawrence Berkeley National Laboratory (LBNL) estimates. Some state utility commission reports have large, robust, and accessible datasets of future RPS requirements, while others report less information. Due to asymmetric information from commission reports across states, public reports were used for data validation instead of as a primary data source. Forecasts generated by LBNL, when compared with direct state data sources, underestimate demand in certain states.[67] We found the most accuracy in the RPS forecasts in BloombergNEF's *US Renewable Portfolio Standards–Adding 82% to Demand* report, when compared with commission reports to approximate accuracy.[68] One exception was Illinois, for which we observed that BNEF forecasts significantly underestimate renewable energy demand. Instead, Illinois Power Agency (IPA) forecasts of renewable energy needs for the Commonwealth Edison utility territory were used for future years.[69] Otherwise, we determined that BNEF data were accurate for the purpose of this analysis and thus were used to estimate RPS demand in other PJM states.

Michigan and North Carolina were excluded from this analysis, due to the relatively small amount of their load served by PJM. We note that while Michigan has enough in-state renewable power for its 15 percent renewable portfolio standard, it has expanded its targets beyond the RPS through the MI Healthy Climate Plan.[70]

C. INTERCONNECTION QUEUE PROCESSING AND OPERATION TIMELINE

This section assesses the proposed timeline laid out by PJM in its reform filing. PJM has prioritized backlog queues to complete projects in queue windows up through AD2 by the end of the year. We made the following assumptions about project timing and completion rates:

- Projects in queue windows AA1 through AD2 (submitted to the queue between October 2014 and March 2018) are subject to the existing interconnection procedures. The earliest final agreement date for these projects was 1/1/2023.
- Projects in queue windows AE1–AH1 (submitted to the queue from April 2018 to September 2021) with an interconnection service agreement or wholesale market agreement issued by the transition date of the reforms are also subject to existing interconnection procedures. The earliest possible final agreement date is 1/1/2024.
- Projects in AE1–AG1 (April 2018 to September 2020 submissions) that are not otherwise included in the above categories make up Transition Cycle 1 and have an earliest final agreement date of 7/1/2025.
- Projects in AG2–AH1 queue windows (March 2021 to September 2021) without an ISA or WSA by the transition date compose Transition Cycle 2. The earliest final agreement date for these projects is 9/1/2026.

New projects from queue window AH2 onwards (March 2022 and later) will not be processed until earlier projects are completed and the new process kicks off. The earliest final agreement date for these projects is 12/1/2027. PJM has said that it will continue to accept new projects while the transition is underway, but we only considered projects queued in window AH2 and onward as of September 2022.

Most new generation projects do not begin construction until an interconnection service agreement has been issued. PJM system impact studies involve an estimate of the time needed to construct the new facility and complete the necessary network upgrades. Based on a survey of a random selection of projects in the PJM queue, the average estimated construction timeline for each resource type is:

- **Solar:** 9 months
- **Land-based wind:** 18 months
- **Offshore wind:** 36 months

We added these construction time estimates to the earliest possible final agreement date for projects in each queue window to estimate commercial operation dates.

D. ESTIMATED QUANTITY OF ENERGY FROM RESOURCES IN THE QUEUE

Each project in the queue submits an interconnection request for a planned nameplate capacity (MW) and quantity of energy delivered (MWh). The proposed energy value for each projected was de-rated by commercial probability (described and defined in section A) and capacity factors. We derived resource-specific (and state-specific where available) capacity factors from data published by the Department of Energy (DOE), LBNL, and the International Energy Agency (IEA):

- **Solar:** Derived from the LBNL report *Utility-Scale Solar 2022*.[71]
- **Land-based wind:** Derived from the DOE's 2022 *Land-Based Wind Market Report*.[72] State-level land-based wind capacity factors were available for every PJM state except Virginia. West Virginia's average wind capacity factor was used as a proxy for Virginia's queued wind projects.
- **Offshore wind:** Because there are few offshore wind developments in existence worldwide, we used a 45 percent capacity factor for all queued offshore wind. This is based on the average 40–50 percent range of projects detailed in IEA's *Offshore Wind Outlook 2019*.[73]

We calculated expected annual output as:

Requested Energy (MW) x Commercial Probability (%) x Capacity Factor (%) x Hours in a year (8,760)

We de-rated the first year of annual output by operational days, depending on the estimated construction completion date for each project.

We assumed that the total cumulative output for each resource type would be available for state renewable portfolio requirements.

E. THE ROLE OF DISTRIBUTED GENERATION GROWTH IN MEETING RPS REQUIREMENTS

PJM uses distributed solar growth forecasts from IHS Markit (now under S&P Global) in its Long Term Load Forecast, projected as additions to distributed solar nameplate capacity.[74] We compared the IHS forecast data published in the 2021 Long Term Load Forecast for each state to actual small-scale (under 1 MW of nameplate capacity) solar growth from 2020 to 2021, as reported by the EIA. While small-scale generation is not directly impacted by PJM interconnection queue delays, these resources are important for states to achieve their overall RPS goals as well as solar carveout targets. When we compared the IHS/PJM forecast and EIA data, most PJM states' actual growth was within the forecast range.

We converted IHS forecasts of solar nameplate additions (MW) to annual expected energy output using an 18 percent capacity factor. This is the average residential and community solar capacity factor for PJM in the Vibrant Clean Energy WIS:dom model.[75] In most cases, we used this modified IHS forecast to estimate the amount of distributed solar (MWh) that will contribute to state RPS through 2028.

The one exception to this approach was for Illinois, where especially robust data were available for distributed and community solar forecasts in the Illinois Power Agency's Long-Term Renewable Resource Procurement Plan.[76] These data, including state-run procurement and auction results, allowed us to parse out which resources already exist and how many will be required for future development.

F. ESTIMATES OF EXISTING RPS-ELIGIBLE RENEWABLE RESOURCES

Resource eligibility varies among states. Wind and solar resources are eligible for RPS in all states; hydroelectric power is eligible in some; still others allow carbon-emitting resources (e.g., landfill gas) that make up a significant portion of PJM-wide RPS supply. One MWh of supply from these resources generates one renewable energy credit (REC) that can be used only once and cannot be duplicated. To avoid double counting of RECs, we used the PJM EIS-GATS dataset of RPS-eligible supply for Virginia as a proxy for PJM-wide RPS supply. RECs from solar, geothermal, landfill gas, municipal solid waste, hydro, and wind resources were eligible for the Virginia RPS in 2021. We distributed Virginia REC supply (excluding solar) on a prorated basis among states that allow out-of-state REC imports (all RPS states in PJM allow some amount of out-of-state RECs, except Illinois with its limited exceptions under CEJA). We then allocated and removed REC quantity estimates based on state-specific resource categories (for example, waste coal is an eligible Tier II resource only in Pennsylvania). To represent the approximate existing renewable resource mix in each state, we estimated baseline supply as the greater of (a) the prorated distribution of Virginia proxy RECs and (b) the quantity of RECs retired for each state in 2021.

Most PJM RPS states require that solar RECs used for Tier I or resource carveout requirements come from in-state resources. Delaware and Virginia allow some quantity of out-of-state solar energy, and some other states have grandfathered exceptions.[77] For simplification, and in acknowledgment of the regional trend toward in-state solar qualification requirements for RPS, we assumed that only in-state future solar resources qualify for RPS compliance.

The proxy estimate detailed above deals with non-solar resources. For our analysis, we estimated existing solar supply as the resources currently registered in the PJM EIS-GATS (all resources used for RPS compliance must be registered in GATS). We filtered these resources by small scale (under 1 MW of nameplate capacity) and utility scale (all larger solar resources). Actual state laws for what qualifies as small-scale or distributed solar may vary depending on the solar system configuration and size.

We assumed that in states with a resource carveout, resources apply first to the carveout requirement, and any excess capacity above the carveout requirement applies to the overall RPS (less the carveout).

DISTRICT OF COLUMBIA


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KEY FINDINGS

Distributed solar growth has been strong in the District of Columbia and is identified as a priority in the 2022 D.C. Public Service Commission compliance report.[78] If distributed solar growth continues at its expected pace, D.C. will meet its solar carveout requirements through 2030. For its overall RPS, the District continues to rely on out-of-state resources due to land constraints. Out-of-state resource supply may become limited as RPS requirements and other public policy targets ramp up faster than the rate of renewable buildout. While this report cannot definitively say whether D.C. will have challenges importing RECs, a constrained renewable energy market could potentially result in increased alternative compliance payments or REC prices.

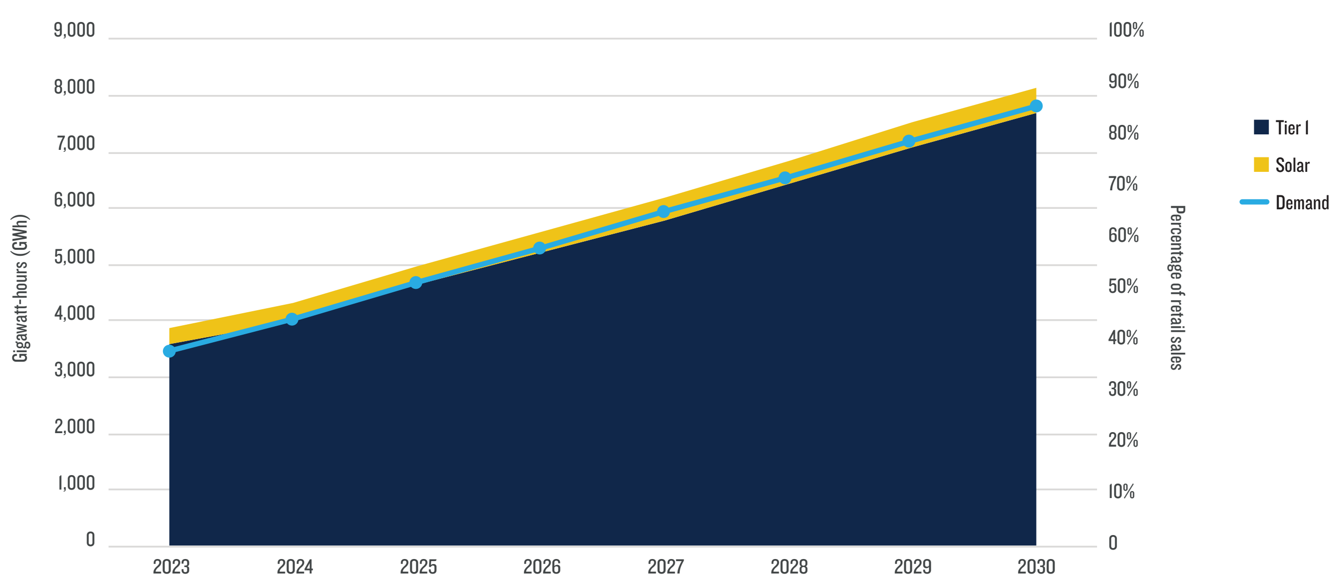
POLICY BACKGROUND

As of the time of this report, the most recent update to the District of Columbia's RPS has been the Clean Energy Act of 2018.[79] This legislation increased the RPS requirement to 100 percent of retail electricity sales from Tier I renewable resources by 2032, with no less than 5.5 percent from solar (figure 6).[80] The in-district solar requirement increases to 10 percent by 2041. D.C.'s RPS allows out-of-state resources in PJM to contribute to the RPS; existing RPS-qualified renewables in states outside of but adjacent to PJM are allowed to continue to create RECs until January 1, 2029.[81]

The D.C. Solar program has stronger limitations on out-of-district resources. The program allows only grandfathered solar and solar resources that connect to a distribution feeder serving the district.[82]

RPS compliance is enforced through alternative compliance payments when competitive suppliers and the main utility, Pepco, are unable to purchase enough RECs to meet RPS thresholds. In 2021 electricity suppliers paid $5.7 million in alternative compliance payments, a reduction from $8.2 million in 2020.[83]

FIGURE 6: RPS REQUIREMENT IN ENERGY (GWH) AND AS A PERCENTAGE OF RETAIL SALES THROUGH 2030



Source: Delaware state code.

RENEWABLE SUPPLY FOR RPS

New development of utility-scale (more than 1 MW of nameplate capacity) renewable resources is mostly infeasible in the district due to land constraints. As of September 2022, there were no utility-scale renewable projects located in D.C. in the PJM interconnection queue. We expect that renewable generation from nearby PJM states will continue to be the main contributor to overall RPS requirements. Future supply may allow D.C. to continue to procure enough RECs for its increasing targets, depending on regional market supply and district supplier contracts. Supply contract analysis is outside the scope of this analysis, so we have chosen to focus here on the feasibility of meeting projected solar carveout requirements. However, stakeholders may be interested in supply projections in nearby states when considering D.C.'s ambitious 100 percent target.

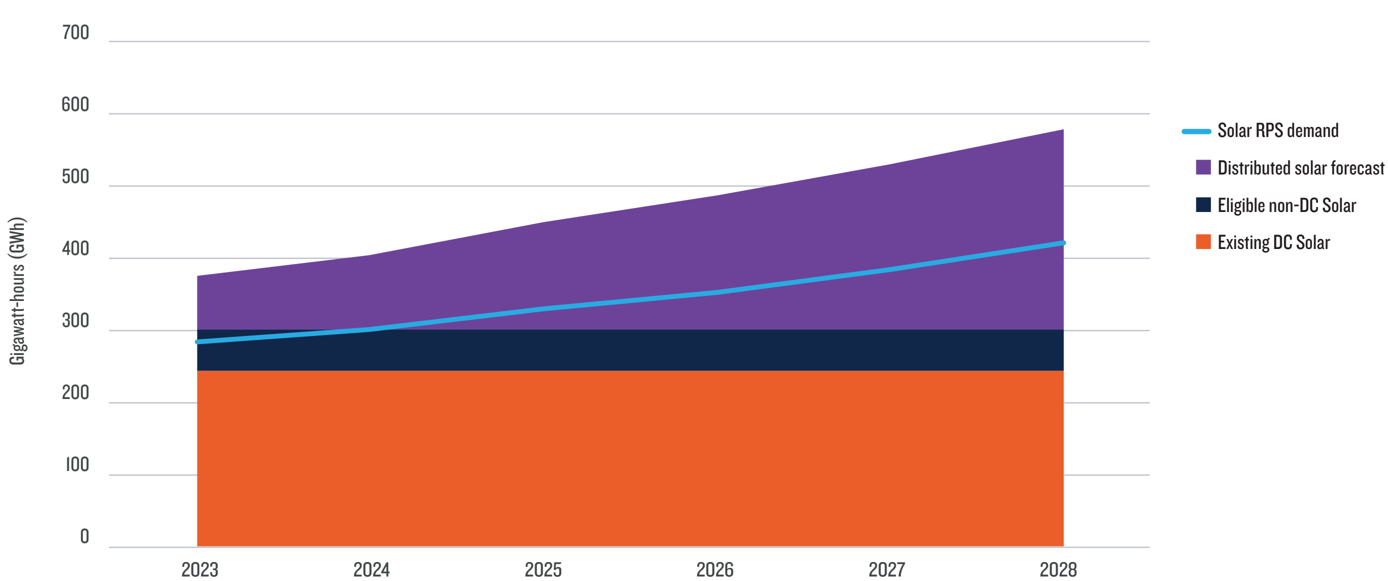
According to the District of Columbia Public Service Commission's most recent RPS compliance report, there are 154.7 MW of RPS-registered solar within the district. This includes 37.1 MW from grandfathered Maryland resources and 2,077 district solar systems, including 82 community solar projects.[84] On the basis of the methods detailed in Appendix A, we estimate that this solar capacity produces 244 MWh of energy annually. We used the IHS forecast for distributed solar growth from the PJM Long Term Load forecast to depict increases to small-scale solar supply (figure 7).

DELAWARE

KEY FINDINGS

Delaware splits its renewable portfolio standard into an overall RPS requirement and a solar program. In 2021, to satisfy RPS requirements, Delaware suppliers used in-state landfill gas and wind, more than 98 percent of which was from wind resources out of state. Illinois-sited wind generation represented more than a quarter of wind-generated RECs in Delaware in 2021.[85] It is possible that the market for wind-generated RECs will tighten with the implementation of Illinois's CEJA legislation increasing the state's RPS requirements.[86] Expansion of public policies beyond RPS is especially important to consider for states like Delaware that have weaker portfolio standards. For example, Pennsylvania's Alternative Energy Portfolio Standards (AEPS) set only an 8 percent renewable supply target for the state.[87] However, its Climate Action Plan, signed into law in 2021, establishes a 26 percent greenhouse gas emissions reduction target by 2025 and 80 percent by 2050.[88] These targets will certainly require more renewable energy in Pennsylvania than the 8 percent target in the AEPS, which may lead to reduced exports from the state. In 2021 Pennsylvania wind supplied the most renewable energy credits for the Delaware RPS.[89] Policy and supply tension could potentially force competition between states like Delaware with limited in-state renewable supply for REC imports.

FIGURE 7: PROJECTED SOLAR RESOURCE SUPPLY FOR THE DISTRICT OF COLUMBIA RPS THROUGH 2028



Source: independent analysis of PJM data; PJM/IHS; BloombergNEF.

POLICY BACKGROUND

The Delaware RPS mandates 40 percent renewable electricity supply by 2035, including a 10 percent solar photovoltaic carveout.[90] Senate Bill 33 most recently increased and extended the state RPS targets, in 2021.[91] RPS requirements will grow according to the schedule shown in table 5. We note that the RPS percentage targets include solar carveout targets, not in addition to percentage thresholds.

TABLE 5: DELAWARE RPS REQUIREMENTS THROUGH 2035

Year	Eligible Renewables	Solar
2022	22.00%	2.75%
2023	23.00%	3.00%
2024	24.00%	3.25%
2025	25.00%	3.50%
2026	25.50%	3.75%
2027	26.00%	4.00%
2028	26.50%	4.25%
2029	27.00%	4.50%
2030	28.00%	5.00%
2031	30.00%	5.80%
2032	32.00%	6.60%
2033	34.00%	7.40%
2034	37.00%	8.40%
2035	40.00%	10.00%

Source: DE Renewable Energy Portfolio Standards Act.

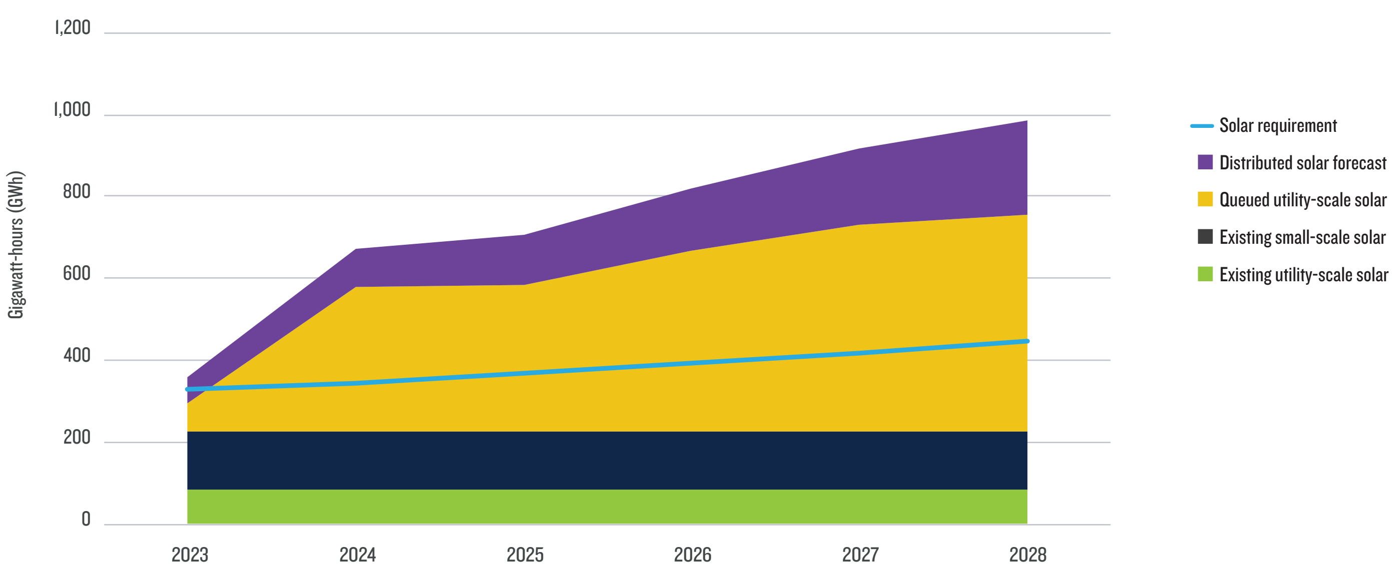
Delaware has a unique policy that involves credit multipliers for certain types of development. For example, wind turbines sited in Delaware before December 2012 receive 150 percent renewable energy credit for generated electricity (i.e., more than the 1 REC = 1 MWh definition that holds for most RPS). For simplification, this analysis does not include the credit multipliers that apply to RECs in Delaware. Readers should be aware that projections simply represent an estimate of gross RPS-eligible generation. Because actual RPS compliance would include credit multipliers, our projections may underestimate RPS supply.

RENEWABLE SUPPLY FOR RPS

Solar resources make up the bulk of the queue in PJM and in Delaware. As of September 2022, there were 23 solar and solar-plus-storage projects seeking interconnection in the PJM queue. We project that new Delaware-sited solar, plus distributed solar growth from the PJM Long Term Load Forecast, meets and exceeds Delaware's solar carveout requirements through 2028 (figure 8).

This analysis did not examine potential compliance with the overall Delaware RPS, as there are no non-solar projects in the PJM queue as of September 2022. We note that offshore wind projects in the queue technically interconnect through Delaware; however, these are projects developed under the Maryland offshore wind program and slated for its renewable energy goal.

FIGURE 8: PROJECTED SUPPLY OF RENEWABLE RESOURCES ELIGIBLE FOR THE DELAWARE RPS



Source: independent analysis of PJM data; PJM/IHS; BloombergNEF.

MARYLAND

KEY FINDINGS

Maryland has taken ambitious action to address climate change and institute state goals to expand renewable energy and reduce greenhouse gas emissions. The Maryland RPS was most recently expanded in 2019 by the Clean Energy Jobs Act, which targets solar, geothermal, and offshore wind development with annual benchmarks through 2030.[92] In 2021, Maryland legislators also revised the RPS to remove carbon-emitting industrial by-products from the list of eligible resources for compliance.[93] However, biomass and wood waste resources were a sizable portion of RECs used for Maryland RPS compliance in 2021.[94] The state's overall supply for non-carveout, Tier I resources is sufficient to meet Tier I RPS targets, although with significant contribution from existing biomass resources. Our methods applied only in-state solar supply that exceeds the carveout towards the overall RPS. Solar development uncertainty in Maryland leaves questions for how much solar will be available for the carveout and additional RPS demands.

Increased public policy targets and existing challenges in getting large-scale renewables online leave concerns for how well queue reforms will accommodate resource carveouts. Our analysis suggests that constrained utility-scale solar growth is a concern for the Maryland's compliance with their carveout. In every year through 2028, our projections show that distributed solar forecasts must exceed the historical pace of growth to meet carveout targets.

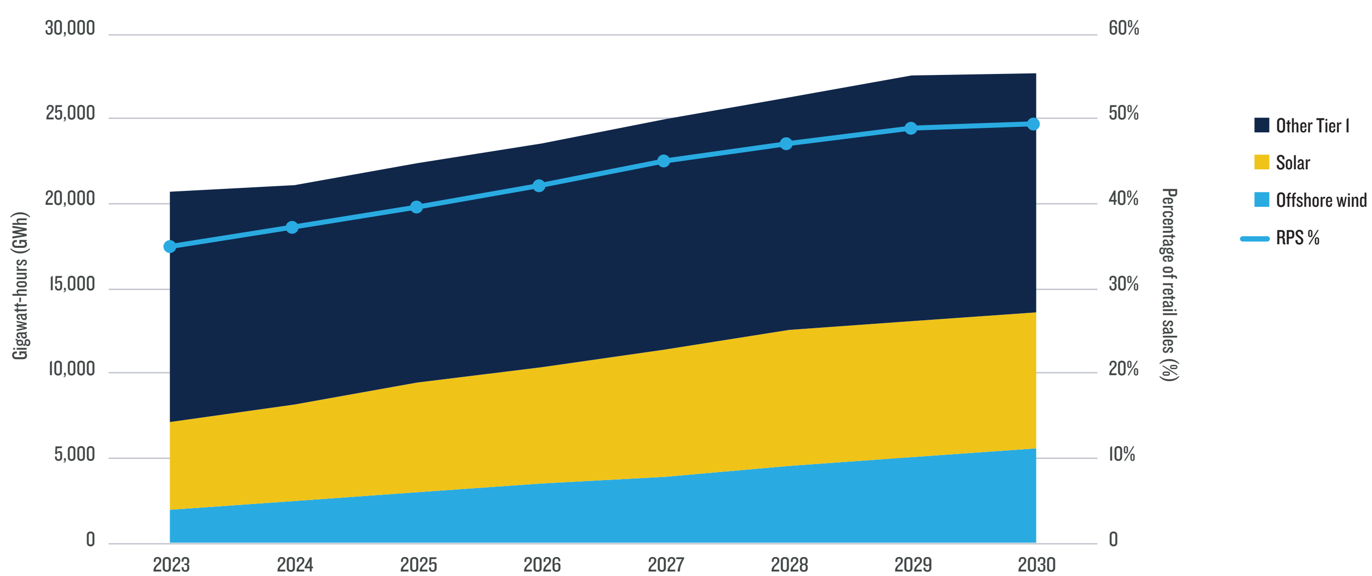
The PJM reform timeline also delays until 2028 queued offshore wind projects that were expected to enter operation in 2026. Maryland may be in peril of missing non-binding but generally expected targets for offshore wind before 2030 (i.e., the 400 MW offshore wind in 2026–27).[95]

POLICY BACKGROUND

Maryland's RPS sets several milestones for 2030: 50 percent of retail electric load served by renewables, including 14.5 percent from in-state solar resources and 1,200 MW of offshore wind development (figure 9). Lawmakers also made modifications to its RPS in 2021 to strengthen its eligibility requirements:[96] They:

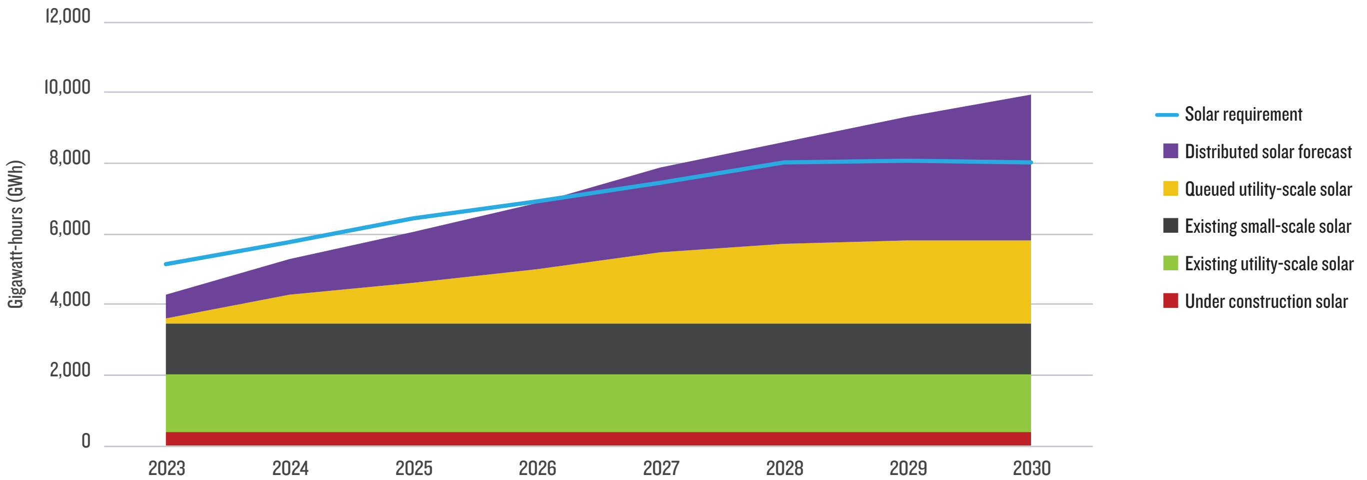
- reduced incremental solar procurement requirements in the 2020s and postponed the 14.5 percent solar compliance requirement from 2028 to 2030;
- increased alternative compliance payments for solar obligations; and
- removed black liquor, a paper mill by-product and carbon-emitting resource, from resources eligible for Tier I compliance.

FIGURE 9: MARYLAND RENEWABLE PROCUREMENT TARGET GROWTH THROUGH 2030



Source: Maryland state code, BloombergNEF.

FIGURE 10: PROJECTION OF SOLAR RESOURCES ELIGIBLE FOR THE MARYLAND RPS SOLAR CARVEOUT THROUGH 2028



Source: PJM/IHS; Independent analysis of PJM data; BloombergNEF.

RENEWABLE ENERGY SUPPLY FOR RPS

Maryland will meet its solar carveout requirement in 2026, in large part due to forecast distributed solar growth (figure 10).

The PJM Long Term Load Forecast includes distributed solar growth based on an IHS-developed moderate residential growth scenario. However, compared with data on small solar installations reported by utilities to the EIA, actual year-over-year growth for small-scale solar was just 4 percent between 2020 and 2021 in Maryland.[97] This growth was much lower than the PJM/IHS projection for 2021. While the pace of utility-scale construction catches up, stronger distributed solar growth is critical to the Maryland solar carveout compliance timeline.

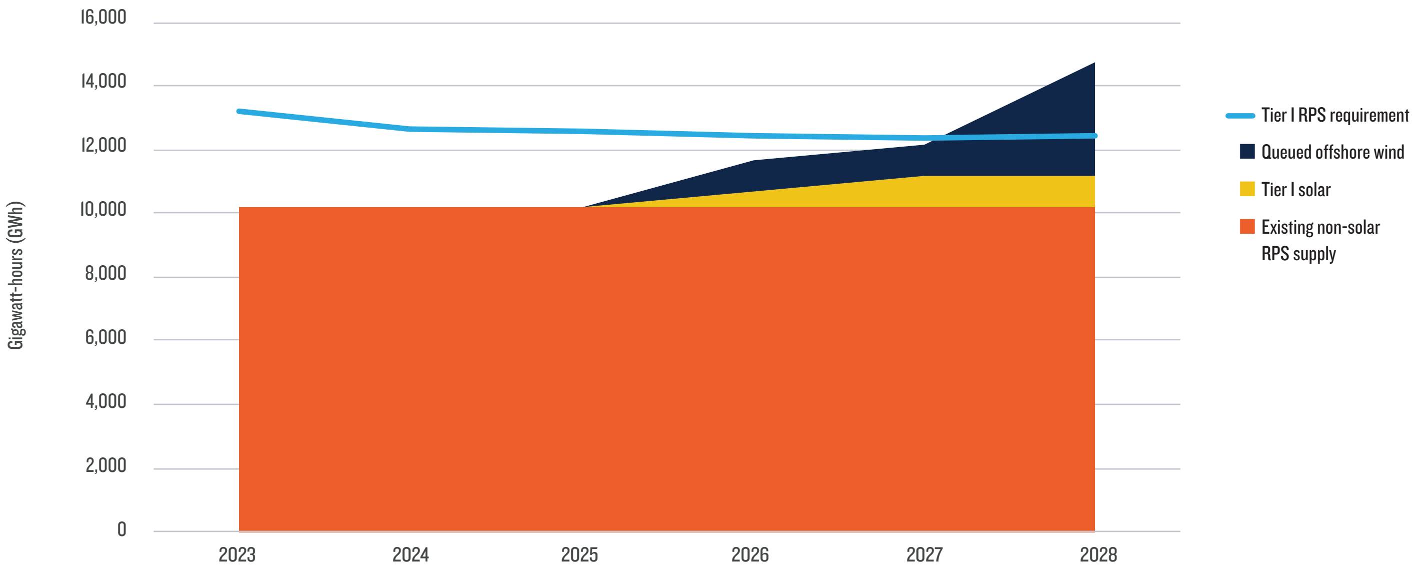
On the basis of offshore wind construction timeline estimates and the PJM reform timeline, we expect Maryland offshore wind upgrades and new facilities to enter operation according to the schedule in table 6.[98]

TABLE 6: PROJECTED SERVICE SCHEDULE FOR MARYLAND-SITED OFFSHORE WIND PROJECTS

Queue Window	Name	Status	Maximum Facility Output (MFO)	Energy (Megawatts)	Capacity (Megawatts)	Transition Procedure	Projected In Service Year
AB1	Indian River 230kV I	Engineering and Procurement	247.8	247.8	64.4	Existing Rules	2026
AF1	Indian River 230 kV I	Active	255.1	7.3	1.9	Cycle 1	2028
AF2	Indian River 230 kV I	Active	440	440	119	Cycle 1	2028
AF2	Indian River 230 kV II	Active	880	440	119	Cycle 1	2028
AG1	Milford-Cartanza 230 kV	Active	440	440	119	Cycle 1	2028
AG2	Milford-Cool Springs 230 kV	Active	460	460	130.6	Cycle 2	2029
AG2	Milford - Cool Springs 230 kV II	Active	900	440	124.9	Cycle 2	2029
AG2	Indian River 230 kV	Active	448.8	448.8	121.2	Cycle 2	2029
AG2	Indian River 230 kV II	Active	897.6	897.6	242.3	Cycle 2	2029
AH1	Indian River 230kV	Active	1035	1035	279	Cycle 2	2029
AH1	Milford - Indian River/Cool Springs 230kV	Active	1035	1035	279	Cycle 2	2029
AH1	Indian River 230kV	Active	1410	1410	380.7	Cycle 2	2029
AH1	Indian River 230kV	Active	323.1	68	17.7	Cycle 2	2029

Source: independent analysis of PJM data.

FIGURE 11: PROJECTED RENEWABLE RESOURCE SUPPLY ELIGIBLE FOR THE MARYLAND RPS TIER I REQUIREMENTS



Source: independent analysis of PJM data; PJM/IHS; BloombergNEF.

Maryland's RPS compliance is highly sensitive to renewable growth forecasts. As explained above, solar growth must surpass recent growth pattern to achieve targets over the next five years. If solar development falls short of carveout goals, overall RPS targets will also be jeopardized until offshore wind becomes available (figure 11).[99] As a note, variations in the RPS requirements depicted in figure 11 are a function of electricity demand variations since RPS are calculated as a percentage of retail electricity sales.

NEW JERSEY

KEY FINDINGS

New Jersey has long been a leader in solar energy and a "perennial top ten solar state," according to the Solar Energy Industries Association.[100] Its strong consumer incentives have driven growth of distributed solar resources that contribute up to 85 percent of the state's annual solar production (according to our analysis of solar output). Its solar carveout gradually declines in the next decade in favor of increasing the state's overall RPS requirements.

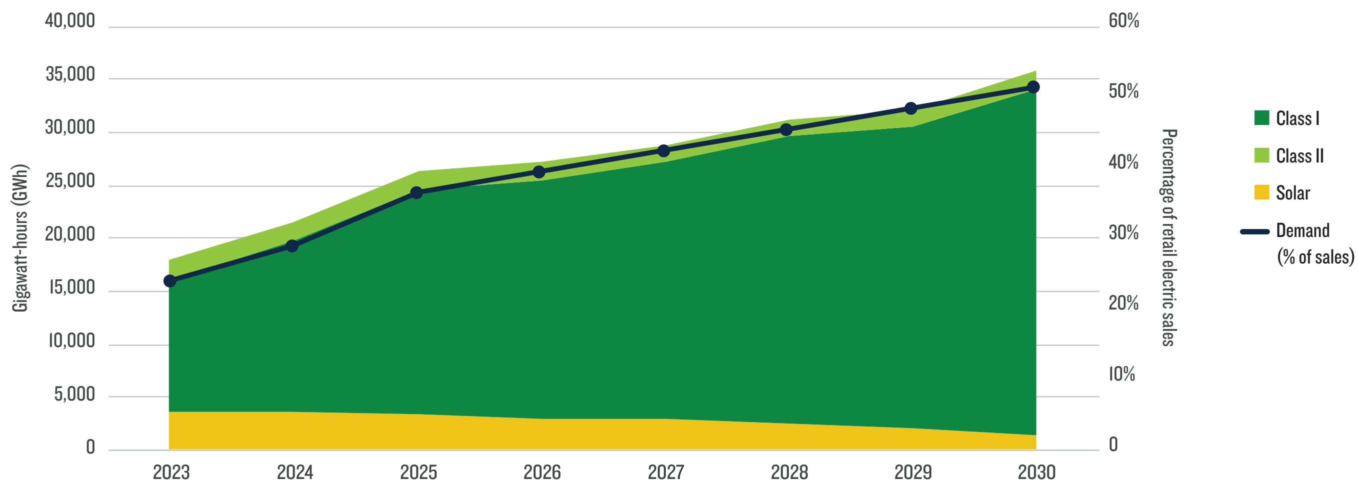
New Jersey also has strong offshore wind targets. These targets may be delayed but are still achievable by 2030. Future procurements will not enter the queue until 2025 at the earliest, so expectations of commercial operation dates should reflect the PJM processing timeline.

Overall RPS targets will be achieved in the later part of the decade, primarily due to offshore wind energy.

BACKGROUND

New Jersey's ambitious clean energy goals are laid out in its 2020 Energy Master Plan.[101] Executive Order 28 established a goal of 50 percent renewable energy by 2030 (of which 5.1 percent must come from solar through 2024, declining to 1.1 percent in 2033), and 100 percent clean energy by 2050. Executive Order 307 increased previous offshore wind targets to 11,000 MW by 2040.[102] Figure 12, below, shows the required energy (in gigawatt-hours) to meet RPS requirements (Class I and II), plus the solar carveout requirement.

FIGURE 12: NEW JERSEY RPS REQUIREMENTS IN AMOUNT OF ENERGY (GWH) AND PERCENTAGE OF RETAIL SALES THROUGH 2030



Source: New Jersey state code, BloombergNEF.

RENEWABLE RESOURCE SUPPLY FOR RPS

New Jersey imports most RECs used for Class I compliance, primarily from wind and landfill gas resources (table 7).[103]

TABLE 7: OUT-OF-STATE NON-SOLAR RENEWABLE RESOURCES CREDITS USED TOWARDS NJ CLASS I RPS REQUIREMENTS IN 2021

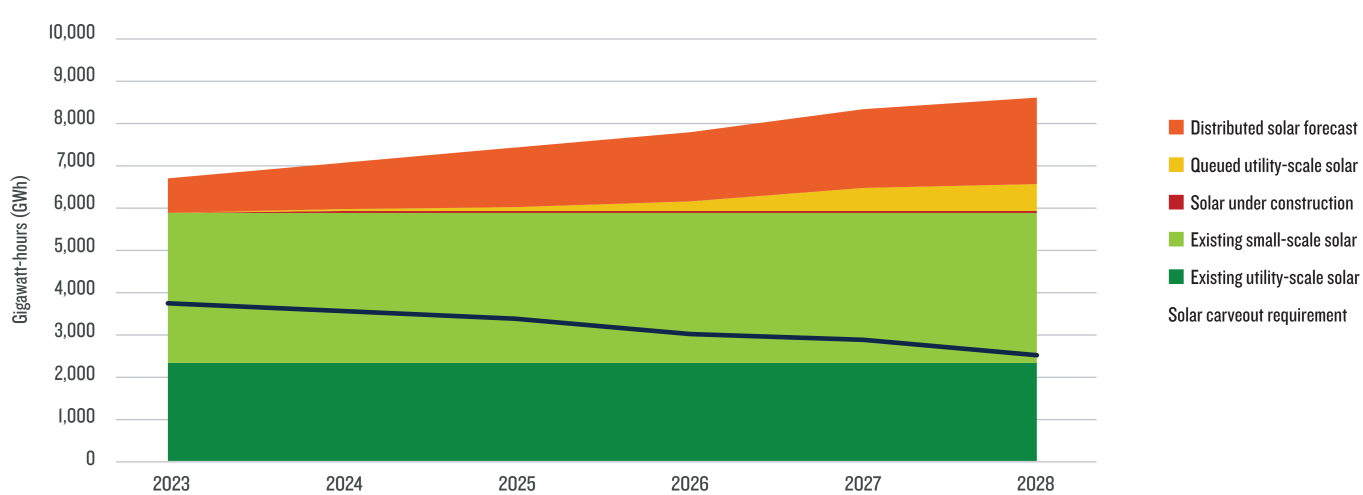
State	Wind	Landfill Gas
Illinois	103,051	
Indiana	118,008	
Ohio	15,099	1,000
Pennsylvania	29,585	5,884
West Virginia	10,912	90
Delaware		1,303

Source: PJM.

Some in-state resources were used for Class I compliance in 2021: 967 credits from landfill gas, 449 from solar, and 39 from wind.

Solar resources used for Class I or carveout requirements must be located within New Jersey.[104] The state's solar carveout declines through 2030 in favor of increasing the overall RPS. The reduced carveout threshold and robust supply of existing solar resources lead to easy compliance (figure 13).

FIGURE 13: DECLINING NEW JERSEY SOLAR CARVEOUT REQUIREMENT THROUGH 2028



Source: independent analysis of PJM data; PJM/IHS; BloombergNEF.

Our analysis examined typical offshore wind construction timeline estimates and the active projects in the PJM queue. We project that New Jersey offshore wind resources will enter operation annually from 2027 to 2029, on the basis of the queue submission window for each project (table 8). New Jersey's transmission planning coordination with PJM under the state agreement approach (SAA) has been widely recognized for the effort to accelerate offshore wind development and reduce costs.[105] We note that the SAA is not directly relevant to our analysis; the PJM transition timeline evaluates projects on the basis of network upgrade costs. Transmission projects built under the SAA are considered baseline projects instead of upgrades, so they have no direct impact on the interconnection studies. However, the SAA planning may shorten the study time.

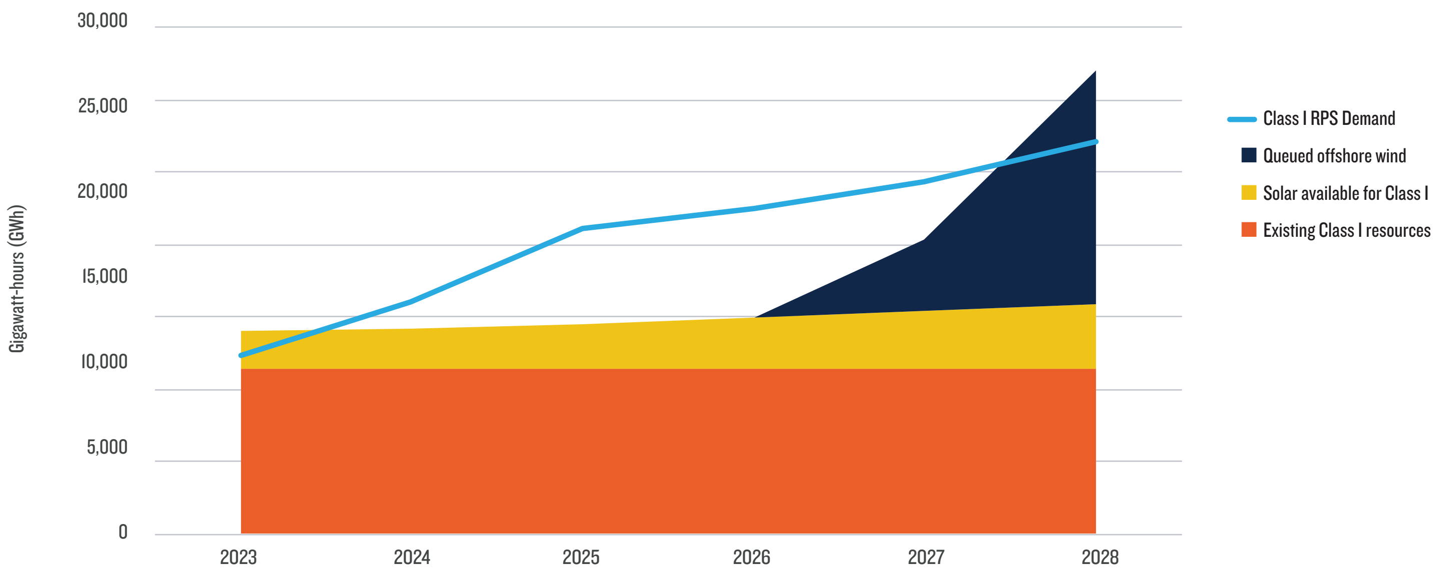
We analyzed an RPS compliance scenario in which excess solar beyond the carveout is used for the overall RPS and out-of-state renewable resource supply remains static, based on RECs used for Class I compliance in 2021. Under this scenario, we project that New Jersey will not be able to meet its RPS with in-state resource development from 2024 to 2027. In 2027, offshore wind resources will become available and rapidly supply energy that can be used toward the RPS target. Figure 14 depicts projected compliance through 2028. We truncated our analysis at this point, given that compliance beyond 2028 will be influenced by the unknown future quantity of resources entering the PJM queue. However, our analysis projected that New Jersey offshore wind will meet the existing renewable portfolio standards through 2028. Alternative compliance payments, banked RECs, or additional imports may be used to meet RPS requirements until offshore wind resources are built.[106]

TABLE 8: PROJECTED SERVICE SCHEDULE FOR NEW JERSEY-SITED OFFSHORE WIND PROJECTS

Queue Window	Name	Status	Maximum Facility Output (MFO)	Energy (Megawatts)	Capacity (Megawatts)	Transition Procedure	Projected In-Service Year
AE1	Oyster Creek 230 kV	Engineering and Procurement	816	816	229.3	Existing Rules	2027
AE1	BL England 138 kV	Engineering and Procurement	432	432	121.4	Existing Rules	2027
AE1	Oceanview Wind 230 kV	Active	816	816	225	Cycle 1	2028
AE2	Cardiff 230 kV I	Active	604.8	604.8	106.44	Cycle 1	2028
AE2	Cardiff 230 kV II	Active	604.8	604.8	106.44	Cycle 1	2028
AE2	Cardiff 230 kV III	Active	300	300	52.8	Cycle 1	2028
AE2	Larrabee 230 kV I	Active	882	882	155.23	Cycle 1	2028
AE2	Larrabee 230 kV II	Active	445.2	445.2	78.36	Cycle 1	2028
AE2	Higbee 69 kV	Active	300	300	84.3	Cycle 1	2028
AE2	Cardiff 230 kV	Active	1,200	1,200	337.2	Cycle 1	2028
AF1	Oceanview Wind 2 230 kV	Active	1,326	510	140.25	Cycle 1	2028
AG2	Deans 500 kV	Active	1,300	1,300	370.92	Cycle 2	2029
AH1	Oceanview Wind 3 230 kV	Active	2,056	730	300	Cycle 2	2029
AH1	Oceanview Wind 4 230 kV	Active	2,786	730	300	Cycle 2	2029
AH1	Larrabee 230 kV III	Active	805.2	360	63.36	Cycle 2	2029
AH1	Larrabee 230 kV IV	Active	1,300	1,300	228.8	Cycle 2	2029

Source: independent analysis of PJM data.

FIGURE 14: PROJECTED RENEWABLE RESOURCE SUPPLY ELIGIBLE FOR THE NEW JERSEY RPS, EXCLUDING THE SOLAR CARVEOUT REQUIREMENT



Source: independent analysis of PJM data; PJM/IHS; BloombergNEF.

OHIO

POLICY BACKGROUND AND KEY FINDINGS

Ohio has a low RPS threshold compared with those of other PJM states. Its RPS mandates that 8.5 percent of the state's electricity come from renewable sources by 2026, a standard that Ohio has already met. As of September 2022, the PJM queue contained 336 wind, solar, and hybrid projects in the state. The low standard frees up the state's renewable resource supply for export to other PJM states with higher renewable targets and clean energy buyers.

RENEWABLE ENERGY SUPPLY FOR RPS

We project that queued resources in Ohio will produce more than 16 terawatt hours (TWh) of renewable energy by 2029 when accounting for capacity factors and expected commercialization of projects in the queue (table 9).

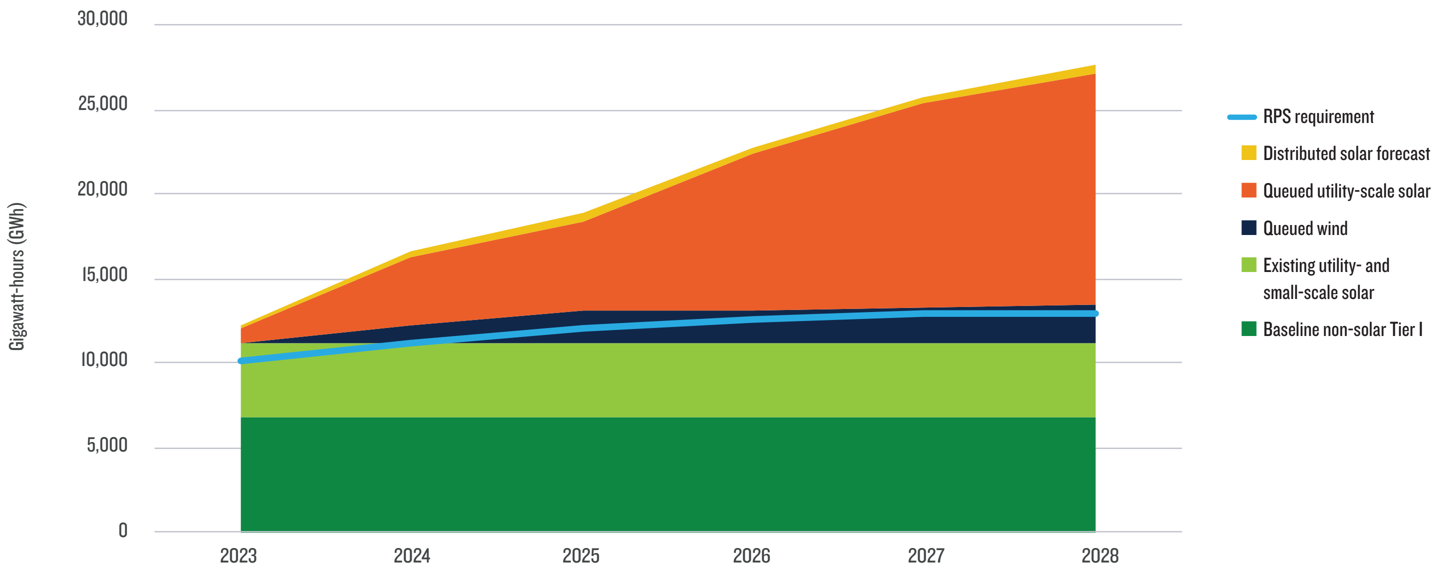
TABLE 9: EXPECTED RENEWABLE OUTPUT FROM OHIO-SITED GENERATOR REQUESTS IN THE PJM NEW SERVICES QUEUE, AS OF SEPTEMBER 2022. INCLUDES CAPACITY FACTORS AND QUEUE WITHDRAWAL RATES.

Operational Year	Queued Solar (GWh)	Queued Wind (GWh)
2023	815.89	-
2024	4,028.94	949.43
2025	5,326.91	1,893.68
2026	9,288.16	1,893.68
2027	12,038.10	2,076.05
2028	13,666.18	2,207.42
2029	14,310.62	2,233.26

Source: independent analysis of PJM data.

Because renewable growth far exceeds the in-state demand from mandatory standards, Ohio wind and solar are likely to be exported to other PJM states or used for voluntary goals, corporate offtake, and utility procurements. Ohio continues to have enough supply to meet and exceed the state RPS target of 8.5 percent (figure 15).

FIGURE 15: PROJECTED RENEWABLE RESOURCE SUPPLY ELIGIBLE FOR THE OHIO RPS THROUGH 2028



Source: independent analysis of PJM data; PJM/IHS; BloombergNEF.

ILLINOIS

KEY FINDINGS

The 2021 Climate and Equitable Jobs Act (CEJA) requires Illinois to procure 40 percent of its electricity from renewables by 2030 and 50 percent by 2040.[107] Our analysis of the PJM queue reforms project that queued resources will not be sufficient to reach the renewable targets set for the Commonwealth Edison (ComEd) territory through at least 2028. Resource eligibility restrictions for RPS-eligible wind and solar may reduce future exports from Illinois to other PJM states. Illinois wind power is a significant RPS resource in the region: In 2021 Illinois wind was credited toward RPS in Delaware, Maryland, New Jersey, Ohio, and Pennsylvania.[108]

POLICY BACKGROUND

CEJA has been recognized as one of the country's most ambitious climate and clean energy policies.[109] Among its extensive objectives, CEJA set increased RPS targets for 100 percent of load served by Illinois's major distribution utilities—ComEd, Ameren, and the portion of MidAmerican load for which the Illinois Power Agency (IPA) procures power.[110] The most recent IPA report on renewable procurement recognized earlier challenges with the less ambitious RPS targets of years past. Accordingly, CEJA has expanded funding for renewable project development. It also sets specific RPS targets for wind and solar, including targets for development of utility-scale solar projects, community solar, and solar located on brownfield sites.[111]

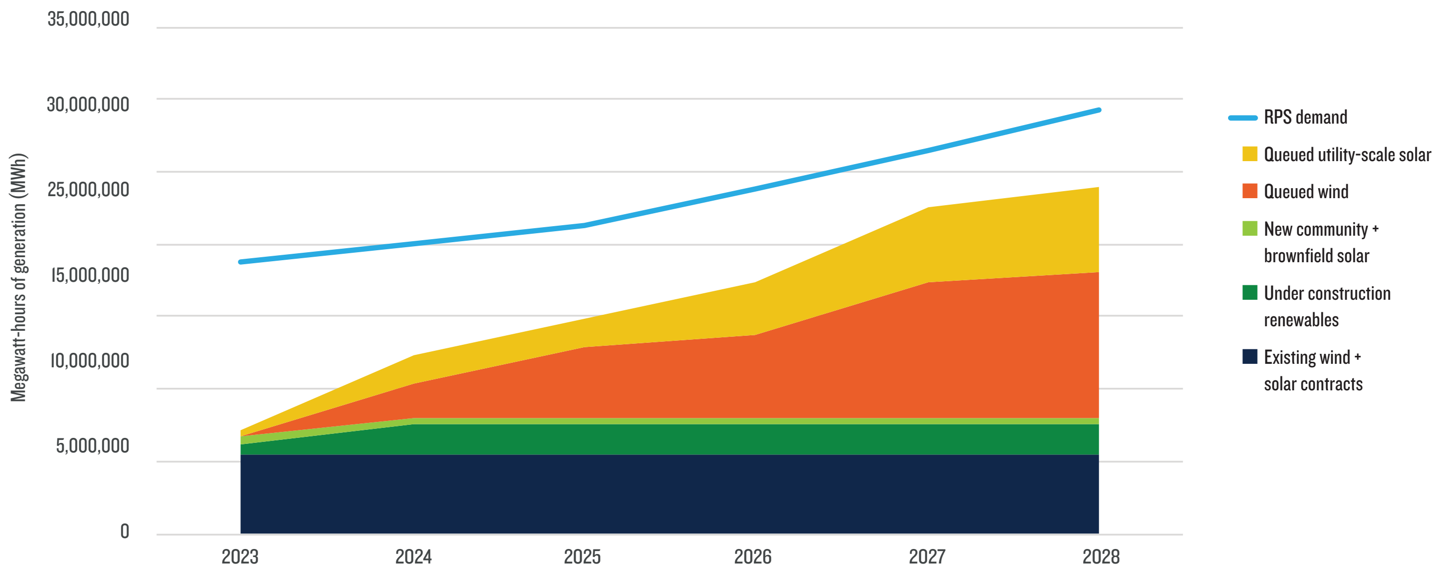
RENEWABLE RESOURCE SUPPLY FOR RPS

The IPA centrally procures renewable energy for each of the state's investor-owned utilities. Its August 2022 Long-Term Renewable Resources Procurement Plan (LTRRPP) projects the necessary RECs to satisfy RPS requirements and future retail electric sales for each utility.[112] In our analysis, we focused on the supply of RECs for ComEd, since its territory is the area of Illinois served by PJM. We assumed that queued generation for which ComEd is the transmission owner constitutes new RPS-eligible supply for ComEd load through 2028, based on the IPA load projections. The MISO queue and surrounding regions of Illinois are outside the scope of this analysis. We assumed that new generation in Illinois but outside PJM will not contribute to ComEd's RPS needs in the near term, considering recent capacity shortfalls in the MISO North region.[113]

The IPA LTRRPP interprets CEJA to effectively require that RPS-eligible generation be located within Illinois, with limited exceptions. The IPA developed a scoring system for new generation qualification; for ComEd, one wind generator in Indiana with an existing ComEd contract is grandfathered into the CEJA RPS.[114] This generator has not been individually identified in the IPA LTRRPP, and no new out-of-state generators have been approved for the new RPS, so this analysis excludes these marginal contributions from out-of-state resources.

Our analysis projects annual compliance gaps with the ComEd RPS requirements through 2028 (figure 16), on the basis of existing and contracted resources procured by the IPA and queued generation in the ComEd area.[115]

FIGURE 16: PROJECTION OF RENEWABLE RESOURCES ELIGIBLE FOR THE COMED RPS REQUIREMENTS UNDER CEJA THROUGH 2028. "NEW COMMUNITY + BROWNFIELD SOLAR" REFLECTS NEW RESOURCES UNDER THE ADJUSTABLE BLOCK PROGRAM. "EXISTING IPA CONTRACTS" IS A SUM OF EXISTING ADJUSTABLE BLOCK PROGRAM RESOURCES, 2010 LONG-TERM POWER PURCHASE AGREEMENTS, SOLAR FOR ALL, AND 2017–19 FORWARD PROCUREMENTS



Source: Illinois Power Agency; PJM.

NORTH CAROLINA

BACKGROUND

Due to the small area of North Carolina served by PJM, this analysis does not measure state progress toward its Clean Energy Plan, which sets forward an RPS and greenhouse gas emissions-reduction target of 70 percent by 2030.[116] However, the rural northeastern corner of North Carolina within PJM territory has significant onshore wind development that supplies the state and region. This production is accounted for in wind import estimates for other PJM states.

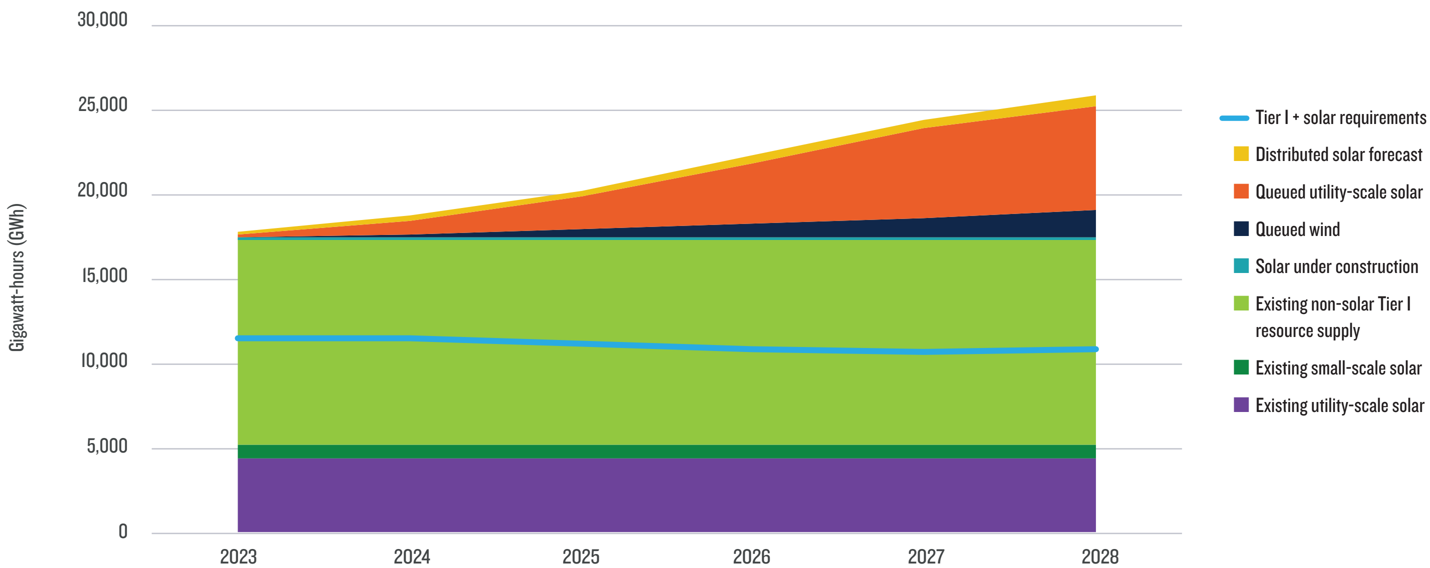
We note that while North Carolina has an ambitious offshore wind target of 8,000 MW by 2040, this policy goal is beyond the scope of this analysis.[117] The northernmost offshore wind energy area (WEA) of North Carolina is leased to the Kitty Hawk project contributing to Virginia's offshore wind carveout. The two other WEAs on the North Carolina coast were sold in May 2022 and are in more southern waters outside the PJM interconnection area.[118]

PENNSYLVANIA

Pennsylvania is a net exporter of energy and the second-largest net supplier of energy to other states, second only to Texas, according to the EIA.[119] While Pennsylvania is a member of the Regional Greenhouse Gas Initiative (RGGI), its renewable portfolio standard is modest and not reflective of its greenhouse gas emissions reduction commitments.[120] The Alternative Energy Portfolio Standard required that just 8 percent of retail electric sales come from Tier I renewable energy sources by 2021, and it does not increase the standard in future years.

Renewable energy needs for Pennsylvania's RGGI commitment are outside the scope of this analysis. Our analysis for Pennsylvania focuses on the renewable energy supply that we expect from the PJM interconnection queue through 2028. We expect that Pennsylvania will meet its RPS through 2030 with its existing Tier I renewable resource supply based on RECs used for compliance in 2021 (figure 17). We assumed that active queued renewables located in Pennsylvania, mostly solar resources, become RPS-eligible supply for other PJM states.

FIGURE 17: RENEWABLE RESOURCE SUPPLY ELIGIBLE FOR PENNSYLVANIA TIER I AND SOLAR CARVEOUT REQUIREMENTS UNDER ITS RPS



Source: independent analysis of PJM data; PJM/IHS; BloombergNEF.

VIRGINIA

BACKGROUND

Virginia's 2020 Clean Energy Economy Act sets out mandatory standards for the state's two investor-owned utilities (IOUs) to achieve 100 percent clean energy by 2050.[121] The state set the following schedule:

TABLE 10: RENEWABLE PORTFOLIO STANDARD BENCHMARKS FOR THE VIRGINIA INVESTOR-OWNED UTILITIES, APPALACHIAN POWER AND DOMINION

Year	Appalachian Power (ApCo)	Dominion
2023	8%	20%
2024	10%	23%
2025	14%	26%
2026	17%	29%
2027	20%	32%
2028	24%	35%
2029	27%	38%
2030	30%	41%
2035	45%	59%
2040	65%	79%
2045	80%	100%
2050	100%	

Source: Virginia State Corporation Commission.

The mandatory RPS applies only to IOU-served load, which constitutes most electricity served in the Commonwealth.[122] However, it is worth noting that, based on our analysis of BloombergNEF retail sales projections, the overall state procurement target comes to approximately 77 percent of retail sales by 2050 when including non-IOU suppliers and retailers.

RENEWABLE RESOURCE SUPPLY FOR RPS

Resources eligible for the Virginia RPS include geothermal, hydroelectric, municipal solid waste, landfill gas, wind, and solar.[123] Virginia currently imports most RECs used for RPS compliance, with the largest share coming from hydroelectric resources in Pennsylvania and Maryland.[124] We expect the proportion of RECs generated in-state to grow significantly as queued solar and offshore wind resources enter operation.

The queued offshore wind projects in Virginia fall into the first transition cycle of the PJM interconnection queue reforms. Based on a review of system impact studies for offshore wind, we estimate that offshore wind projects will take 36 months to complete facility and infrastructure construction.[125] Assuming a 36-month construction timeline, Virginia offshore wind will begin to deliver energy in 2028; the projected schedule is shown in table 11.

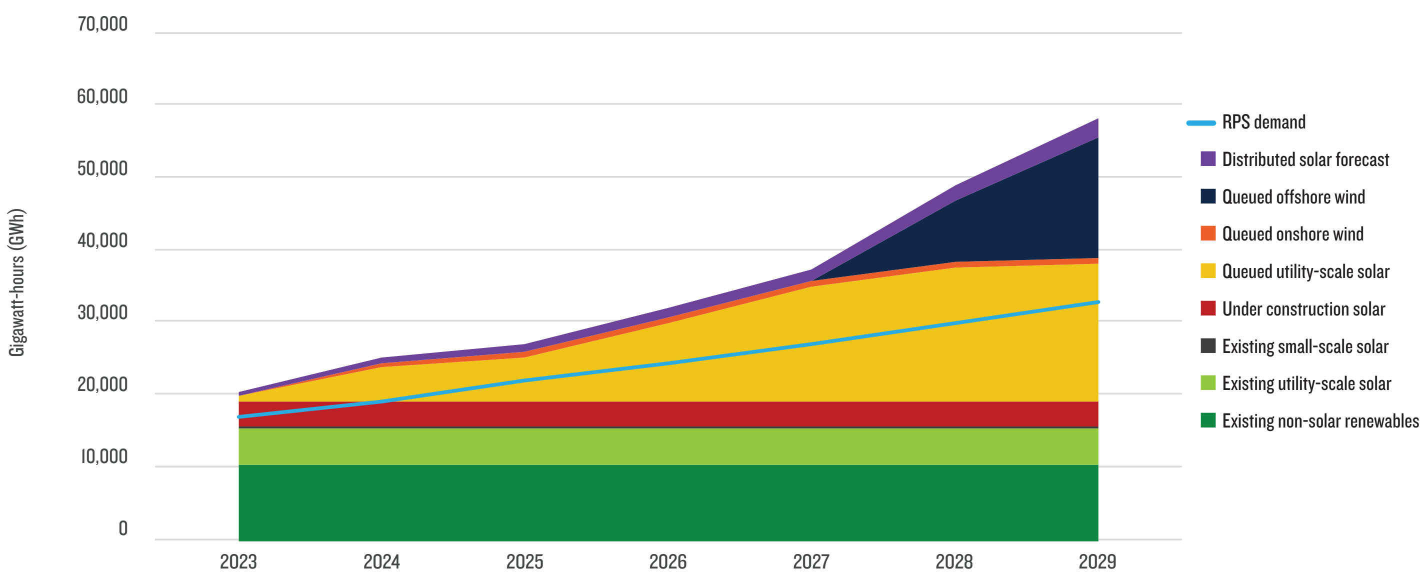
TABLE 11: QUEUED OFFSHORE WIND PROJECTS PLANNED TO INTERCONNECT THROUGH VIRGINIA. NUMBERS ARE ROUNDED FOR READER EASE AND FORMATTING

Queue Window	Name	Status	MFO	Energy (Megawatts)	Capacity (Megawatts)	Transition Procedure	Expected In-Service Year
AE2	Birdneck-Landstown 230 kV	Active	800	800	160	Cycle 1	2028
AE2	Birdneck-Landstown 230 kV	Active	800	800	163	Cycle 1	2028
AE2	Landstown 230 kV	Active	800	800	149	Cycle 1	2029
AF1	Oceana 230 kV	Active	880	880	268	Cycle 1	2028
AF1	Oceana 230 kV	Active	880	880	268	Cycle 1	2028
AF1	Oceana 230 kV	Active	880	880	268	Cycle 1	2028

Source: PJM

Offshore wind projects produce vast amounts of renewable energy due to high capacity factors (we use a 45 percent capacity factor for our estimates, averaged from the most recent International Energy Agency global offshore wind report). Virginia also has a large existing pool of renewable resources and should be able to meet its RPS targets through 2028 and likely beyond (figure 18 depicts supply through 2029 to demonstrate offshore wind potential we expect to become available). The existing resource pool includes in-state and out-of-state renewables. Once offshore wind resources enter production, we do not expect that Virginia will need to import additional out-of-state renewable energy through 2030. Virginia has renewable procurement benchmarks through the decades to achieve 100 percent renewable energy by 2050, which ramp up quickly after 2030 (table 10). However, the PJM queue reforms will be well underway by then (along with additional, unknown potential reforms to transmission and interconnection planning). Projections to 2050 are beyond the scope of this report.

FIGURE 18: PROJECTED RENEWABLE RESOURCE SUPPLY FOR THE VIRGINIA RPS THROUGH 2028



Source: independent analysis of PJM data; PJM/IHS; BloombergNEF.

Appendix C

Tables 12 and 13, below, outline the study and construction stage steps of the PJM interconnection queue process. These descriptions are taken from the 2021 *State of the Market Report* for PJM.[126]

TABLE 12: STUDY STAGES OF THE PJM INTERCONNECTION PROCESS

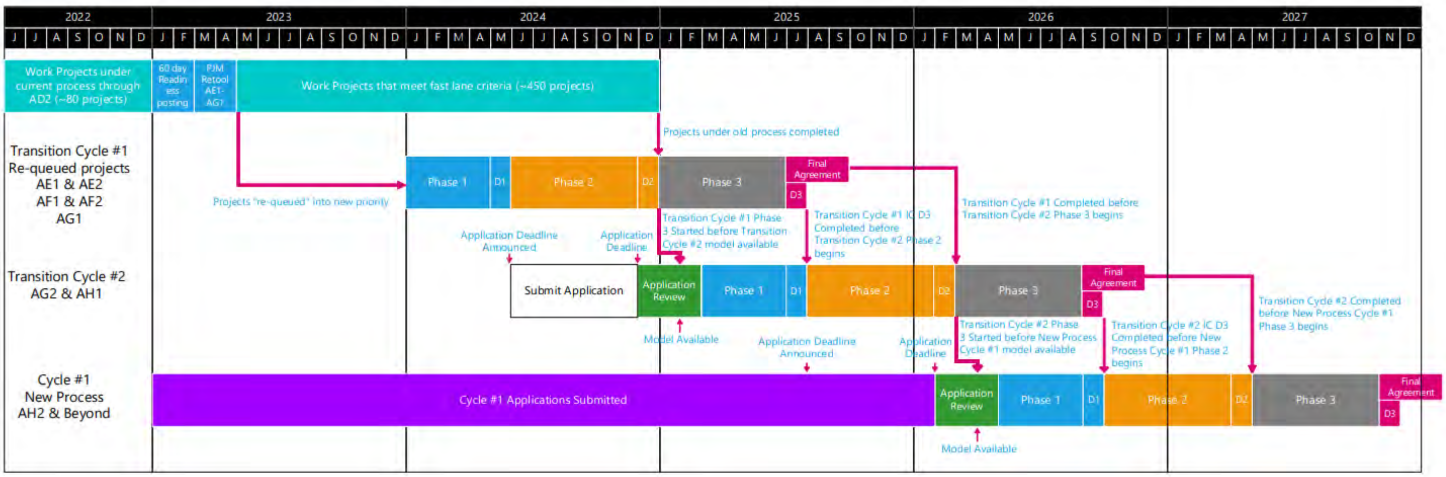
Study	Purpose
Feasibility Study	The feasibility study determines preliminary estimates of the type, scope, cost, and lead time for construction of facilities required to interconnect the project.
System Impact Study	The system impact study is a comprehensive regional analysis of the impact of adding the new generation and/or transmission facility to the system. The study identifies the system constraints related to the project and the necessary attachment facilities, local upgrades, and network upgrades. The study refines and more comprehensively estimates cost responsibility and construction lead times for facilities and upgrades.
Facilities Study	In the facilities study, stability analysis is performed and the system impact study results are modified as necessary to reflect changes in the characteristics of other projects in the queue.

TABLE 13: CONSTRUCTION STAGE PHASES OF THE PJM INTERCONNECTION QUEUE PROCESS

Agreement	Purpose
Interconnection Service Agreement (ISA)	An ISA defines the generation or transmission developer's cost responsibility for required system upgrades. For generation interconnection customers, the ISA defines the capacity interconnection rights for a capacity resource and any operational restrictions or other limitations. For transmission interconnection customers, the ISA defines transmission injection and withdrawal rights and applicable incremental delivery, available transfer capability revenue, and auction revenue rights.
Interim Interconnection Service Agreement (I-ISA)	If a developer wishes to start project construction activities prior to completion of the generation or transmission interconnection facilities study, the interim ISA would commit the developer to pay all costs incurred for the construction activities being advanced.
Interconnection Construction Service Agreement (CSA)	The CSA defines the standard terms and conditions of the interconnection, including construction responsibility, lays out a construction schedule, and contains notification and insurance obligations.
Upgrade Construction Service Agreement (USCA)	A new service customer who proposes to make an upgrade to an existing transmission facility or who seeks incremental auction revenue rights (IARRs) will receive an upgrade construction service agreement after the relevant study process is completed.
Wholesale Market Participation Agreement (WMPA)	Developers interconnecting to non-FERC jurisdictional facilities who intend to participate in the PJM wholesale market will receive a three-party agreement (WMPA). The WMPA is a non-tariff agreement that must be filed with the FERC; essentially it is an ISA without interconnection provisions.

Appendix D

FIGURE 19: TRANSITION TIMELINE FOR PJM INTERCONNECTION QUEUE REFORMS.[127]



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