Alternative Resource Adequacy Structures for Maryland

REVIEW OF THE PJM CAPACITY MARKET AND OPTIONS FOR ENHANCING ALIGNMENT WITH MARYLAND'S CLEAN ELECTRICITY FUTURE

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NOTICE

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The Maryland Public Service Commission (PSC) further entered into a memorandum of understanding with The Brattle Group for the sole purpose of granting The Brattle Group access, as a Maryland PSC Authorized Person, to confidential data made available by PJM Interconnection. The Brattle Group executed PJM's Schedule 10 Non-Disclosure Agreement (NDA) as an Authorized Person of the Maryland PSC and abided by the terms of the NDA with regard to confidential data utilized in this study. The Brattle Group's access to confidential data acquired by the Maryland PSC from PJM was for the sole purpose of validating assessments related to resource adequacy alternatives in PJM and associated impacts on Maryland ratepayers. The Brattle Group has not shared these data with the MEA, MES, or any other parties.

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Executive Summary

Maryland has for two decades relied on competitive wholesale markets within the PJM Interconnection (PJM) regional transmission organization (RTO) to procure low-cost and reliable power. Maryland customers have benefitted enormously from participation in the broad regional marketplace for electricity, saving on the order of $270-340 million per year from wholesale power market participation.[1] These savings have derived largely from efficient generation dispatch across the large multi-state region, reductions in the quantity of resources needed to maintain reliability, and competition in PJM's markets that spurred innovative technologies such as demand response and low-cost new generation.[2]

Maryland's longstanding policy choice to rely on competitive markets places the risk of uneconomic investments on private investors rather than customers, thus avoiding the possibility of large customer cost inflation from poor resource planning decisions. This reliance on markets means that Maryland policymakers have not exercised direct control over which resources and which resource types would be built. More recently, however, Maryland has mandated a transition to a decarbonized power supply mix. The *2019 Clean Energy Jobs Act* requires 50% renewable power supply by 2030, of which at least 14.5% is to be supplied by in-state solar resources and up to another 1,200 megawatts (MW) from offshore wind, subject to a budget cap. The Act further requires a study of the costs of achieving a 100% clean energy supply mix by 2040.[3] Attracting enough investment in clean energy to meet these goals will require financial support outside of the PJM wholesale power markets, since those markets were designed to achieve low-cost and reliable power supply while remaining indifferent to the underlying resource types. To date, the PJM markets have not been designed to *promote* the meeting of states' environmental objectives.

Over the past few years, a conflict has developed between states' clean energy objectives and Minimum Offer Price Rule (MOPR) provision within PJM's Reliability Pricing Model (RPM) capacity market. Policymakers, renewable advocates, and environmental groups are concerned that the MOPR will impose excess costs on customers in states with increasing clean energy mandates and conflict with policy goals for clean energy. We were asked by the Maryland Energy Administration (MEA) to describe the impacts of the MOPR on Maryland customers and clean energy policies, assess the Fixed Resource Requirement (FRR) and other options that Maryland might pursue to mitigate the costs of MOPR, and conduct an economic analysis comparing the relative merits of available options.

1 Derived from the PJM value proposition estimating $3,200 to $4,000 million per year in regional savings across PJM, and applying the 8.4% load share of Maryland customers from PJM BRA Auction Results Planning Parameters from the 2022/23 Delivery Year.

2 PJM's capacity market has played a key role in lowering costs, producing capacity prices significantly below administrative estimates of the long-run marginal costs of supply. This was partly due to an initial surplus, but even as load growth and retirements increased the need for new supply, the competitive market has attracted and retained a great variety of resources at low prices. See Monitoring Analytics, State of the Market Report for PJM: Volume II, Section 5 – Capacity Market, Table 5-21: Capacity market clearing prices: 2007/08 through 2021/22 RPM Auctions, March 12, 2020.

3 Maryland State Senate, "Clean Energy Jobs" Senate Bill 516, passed on May 25 2019.

THE EXPANSION OF THE MINIMUM OFFER PRICE RULE TO POLICY RESOURCES

The generation portion of Maryland customer electricity bills reflects competitive wholesale market prices, primarily for energy, but also for "capacity", and various smaller components. PJM's capacity market is a centralized competitive auction mechanism for ensuring adequate electricity supply regionally and by location across the PJM footprint. The Base Residual Auction (BRA) is conducted three years prior to delivery and procures enough capacity resources to meet the projected peak demand plus an uncertainty reserve margin. Generation, demand response, and storage resources across PJM offer their qualified capacity at a price. Then the auction selects the lowest-cost resources to take on a capacity supply obligation in exchange for a payment at the auction clearing price. Three years later, in the delivery period, the costs of capacity procurements are allocated to load-serving entities (LSEs) and passed along to customers in proportion to their peak electricity consumption.

The MOPR is a provision of the capacity market rules that was originally intended to prevent market manipulation by entities with a large net-buyer position. Absent MOPR, a large net buyer or state agency on behalf of its constituents could aim to suppress market prices by offering a small amount of uneconomic capacity supply into the market below cost in order to suppress market clearing prices. By taking a loss on that small sell position, net buyers could then benefit from lower prices on their much larger short position in the market. Such manipulative behavior has the potential to erode economic value and undermine private investors' confidence in market price formation. The MOPR was designed to discourage manipulative price suppression by forcing large net buyers to offer at a minimum price equal to the resource's true costs (symmetrical rules are imposed on sellers of capacity in order to prevent them from exercising economic or physical withholding to inflate prices). When applied for its narrow original purpose of preventing market manipulation, MOPR and the symmetrical rules preventing withholding can support effective competition and efficient market outcomes and would have no impact on states' environmental policies.

The conflict with state policy objectives has arisen from a Federal Energy Regulatory Commission (FERC) order in December 2019 that expanded the application of PJM's MOPR.[4] In that order, the FERC approved the repurposing of MOPR to apply much more broadly to all capacity resources that may earn any "out of market" policy support. Under the expanded MOPR, policy-supported resources are required to offer their capacity into RPM at higher prices. A policy resource's MOPR price is set at the levelized going-forward investment and fixed costs, minus anticipated energy and ancillary service revenues. Revenues earned from policy support or state mandated renewable energy credit (REC) programs cannot be discounted from the MOPR price. The resulting MOPR price is high enough that many new clean energy resources will fail to clear the capacity market. The (flawed) logic used to justify this expansion of MOPR is that, without it, policy-supported resources would unfairly reduce capacity prices; under this theory, the MOPR "corrects" market prices to the higher level that would prevail absent states' policies.

We disagree with this theory. In our view, the underlying conflict is that states wish to address the harms of greenhouse gases and air quality pollutants that are not presently considered within the wholesale markets. With no means of expressing these policy requirements within the PJM markets (and given differences among states in valuing emissions reductions), states have enacted legislation to address these priorities. States have used a combination of market-oriented and non-market-oriented policies to pursue their clean energy objectives. These policies will have the intended effect of displacing fossil

4 Federal Energy Regulatory Commission (FERC), "Order Establishing Just and Reasonable Rate," issued December 19 2019.

generation within wholesale energy and capacity markets, with a side-effect of reducing energy and capacity prices.

To the extent that policy resources fail to clear the capacity market due to the MOPR, this will deprive clean energy resources of revenues reflecting the capacity value they provide, instead favoring fossil-fired generation. It will artificially increase capacity market clearing prices relative to underlying supply-demand conditions. These effects impose excess costs on customers in two ways: first, by requiring customers to make higher clean energy program payments in order to bring clean resources online, since they will not earn a portion of their revenues from the capacity market; and second, by producing higher capacity prices that are paid to all clean and fossil plants that clear the capacity auction. For wind resources, the impacts of MOPR to reduce their total revenues are moderated by the relatively low capacity rating; for solar resources the impact of excluded revenues is much greater.

These excess customer costs are not necessary to reconcile clean energy policies with competitive markets. To the contrary, applying the MOPR to policy-supported resources undermines both the clean energy policies and the competitive capacity market itself. It undermines clean energy policies by making them more costly and by supporting excess fossil generation. It undermines the market by disconnecting market outcomes from fundamentals: ignoring the supply of policy-supported resources that are excluded from the capacity market (but still built) artificially inflates the capacity market clearing price and retains more fossil generation than needed to meet reliability targets. Over time, these distortions would become larger as the amount of policy-supported resources grows in Maryland and across the PJM footprint. The market would become a riskier and riskier proposition for investors as the market price becomes increasingly detached from fundamentals, elevated by an increasingly controversial rule.[5]

ESTIMATED IMPACTS OF THE MOPR IN MARYLAND

In Maryland, the expanded MOPR will not apply to most existing resources, but will apply to any new renewables, demand response, storage, or energy efficiency developed under current state law. If policy support were extended to the Calvert Cliffs nuclear plant, MOPR would also apply to that resource. Assuming MOPR is maintained in its current form, we estimate that the quantity of capacity resources subject to MOPR will grow from less than 500 MW today up to 1,200 MW of unforced capacity (UCAP) by 2025 and up to 1,650 UCAP MW by 2030. The quantity of resources subject to MOPR is much smaller than the 12,884 MW of installed capacity (ICAP) of renewable resources that will be needed to meet Maryland's 2030 renewable goals because existing renewables are exempt, because we assume only 500 ICAP MW of offshore wind will be developed within the applicable budget cap, and because renewables' UCAP capacity value is significantly discounted from the nameplate ICAP value.[6] Compared to a no-MOPR capacity market, this MOPR expansion may cost Maryland customers an additional $236 million per year by 2025 and $194 million per year by 2030. The exclusion of clean energy resources from clearing the capacity market will also induce the uneconomic retention of excess capacity that is not needed for reliability, primarily aging coal, oil, and gas-fired power plants that would otherwise retire.

5 For a more complete discussion, see written testimony of Dr. Kathleen Spees and Dr. Samuel A. Newell, "The Economic Impacts of Buyer-Side Mitigation in New York ISO Capacity Market," November 18, 2020.

6 Solar, onshore wind, and offshore wind currently have capacity value at 42%, 18%, and 26% of ICAP ratings; by 2030 we assume capacity values decline to 35%, 18%, and 22% respectively.

There are a large number of alternative market-based and planning-based approaches to supporting reliability and resource adequacy, but not all of these options are immediately available to Maryland.[7] Most importantly given the context of this study, Maryland does not have unilateral authority to simply eliminate the MOPR on policy resources within the PJM capacity market. Eliminating MOPR would require a different set of rules to be proposed by PJM or stakeholders and accepted by FERC, a reversal through federal appeals, or the adoption of new federal legislation. We anticipate that the makeup of the FERC could be favorable to the elimination of MOPR no later than mid-2021 and that appeals to overturn the expanded MOPR before the U.S. Court of Appeals for the Seventh Circuit Court could be ruled on as soon as late 2021.[8] There is also a possibility of eliminating the impacts of MOPR through broader market reform efforts, such as through PJM's recently-announced capacity market workshops to be completed by March 2021, reforms that may be initiated by New Jersey's ongoing Resource Adequacy docket, and a formal January 2021 communication from the Organization of PJM States, Inc. (OPSI) on the topic.[9] Nevertheless, in case MOPR continues to apply to policy-supported resources, Maryland will need to consider its options.

As a provision allowed within the PJM Tariff, Maryland does have the ability to exit the PJM capacity market under an FRR alternative. The FRR could be elected for individual utility zones, for the entire State of Maryland, or in collaboration with other PJM states. Once selected, Maryland would need to continue utilizing the FRR alternative for a minimum of five years.[10] Under the FRR, Maryland would have the flexibility to select and remunerate capacity resources any way it chooses, as long as the total quantity of capacity resources equals the minimum quantity PJM sets as required to meet total and locational reliability needs. The FRR alternative creates an opportunity to circumvent the application of MOPR to policy resources contracted on behalf of Maryland customers, so that the clean energy resources they support would not be excluded from supplying capacity, thus avoiding some or all of the costs imposed by MOPR. The FRR alternative is not a single design alternative, but instead is an open-ended option for Maryland to determine any and all features of how capacity needs could be met. We describe and evaluate a range of alternatives for how the FRR could be implemented, including:

- **Planning-Based FRR.** An FRR entity designated by the State would be given authority to engage in planning and bilateral contracting with capacity resources under the contract prices and terms that the FRR entity deems most favorable, subject to State oversight. The FRR entity could be directed to narrowly consider only the cost of capacity contracts in its planning activities, or could be directed to

7 For a broader discussion of alternative resource adequacy structures beyond those that we view as available to Maryland at the present time, see Pfeifenberger et al., "A Comparison of PJM's RPM with Alternative Energy and Capacity Market Designs," Prepared for PJM Interconnection, LLC, The Brattle Group, September 2009.

8 For additional analysis of the current status of MOPR and the outlook for FERC policy and appeals. See Jeff Dennis, "MOPR and More: Where the Minimum Offer Price Rule and Related Measures Stand Going Into 2021," Advanced Energy Economy, December 16, 2020.

9 See PJM Inside Lines. "PJM Announces New Series of Capacity Market Workshops". January 29, 2021; State of New Jersey, Board of Public Utilities. "Investigation of Resource Adequacy Alternatives"; and Organization of PJM States, Inc. "Resource Adequacy Letter". January 8, 2021.

10 If selecting an FRR alternative for all of Maryland or for any individual distribution territory, Maryland would be required to stay within the FRR alternative for a minimum of five years, possibly beginning with the 2024/25, 2025/26, or 2026/27 delivery year (which would require formal election of the FRR alternative by February 2022, September 2022, or March 2023 respectively). For FRR election deadlines, see PJM capacity market schedule, "Capacity Market (RPM)," 2022/23 through 2023/24 Delivery Years.

consider environmental attributes or other policy priorities. Policy resources contracted on behalf of Maryland customers would be included in the resource plan, thus circumventing MOPR application.

- **Auction-Based FRR.** An FRR entity would procure all needed capacity for Maryland under an auction-based approach, with capacity commitments selected on a least-cost basis for total and locational capacity needs. As under the planning-based FRR, policy resources would be included in the FRR plan and thus avoid MOPR application. Beyond this explicit inclusion of contracted policy resources, the FRR auction would select resources on a least-cost basis (regardless of whether the underlying resource type is fossil or clean).
- **Integrated Clean Capacity Market (ICCM).** A proposal currently under formal consideration by the New Jersey Board of Public Utilities and all New England states would replace the current capacity market with one that achieves both capacity needs and states' clean energy objectives, while eliminating the application of MOPR to policy resources. Under the ICCM, an auction administrator would conduct a joint auction to procure the resources needed to meet capacity requirements (in UCAP MW terms) and state-mandated clean energy requirements (in REC MWh terms) at the lowest combined cost. In the PJM context, the ICCM could be implemented under a Maryland-alone FRR, a multi-state FRR, or across the PJM footprint as a replacement to the current capacity market.

A key advantage of all FRR options is that they would avoid MOPR-related costs. If implemented under a Maryland-alone FRR, it is possible that only a portion of the MOPR costs would be avoided. The full costs of MOPR may not be avoided under a Maryland-alone FRR, since MOPR would still raise prices in other states and indirectly affect the price of capacity available to Maryland. The full costs of MOPR could be avoided if Maryland were to engage in a multi-state FRR or PJM-wide solution that eliminates the application of MOPR to policy resources.

The primary disadvantages across the Maryland-alone FRR options are the loss of competitive benefits from participating in a broad regional marketplace, and a number of implementation risks and costs that would arise in a smaller Maryland-alone resource adequacy structure. If implemented under a Maryland-alone FRR design, the State would face increased challenges associated with small, segmented submarkets or Locational Deliverability Areas (LDAs) separated by complex transmission constraints. These sub-markets would be prone to price volatility, lumpy resource entry and exit, exposure to the exercise of market power, and the potential for periodic reliability challenges. Additional challenges surround the interactions between the FRR-based capacity prices and prices paid in subsequent RPM auctions; capacity sellers will offer into the FRR auction at a price informed by the anticipated RPM price, including an uncertainty or risk premium. If implemented hastily or with design flaws, these structural challenges could result in an FRR structure that produces higher prices and customer costs (more than offsetting the savings from avoiding MOPR). These challenges can be at least partially addressed by utilizing best practices in auction design, robust monitoring and mitigation, and the implementation of a sloping capacity demand curve for the smallest import-constrained subregions. A multi-state FRR or PJM-wide solution would offer a better means of addressing these same challenges while maintaining access to the cost-saving benefits of broader regional competition.

The selection and compensation of the FRR entity poses another suite of challenges. The current PJM FRR rules are most naturally aligned with selecting a distribution utility as the FRR entity. We do not recommend this choice in Maryland given that this would put affiliated companies on both sides of the same capacity transaction. To avoid oversight challenges with such affiliate transactions, a state agency or independent evaluator contracted directly to a Maryland state agency could conduct any FRR capacity procurements. The FRR entity itself may be the same or different from the independent evaluator but must also be compensated for its activities including the risks it would take on as the buyer of capacity obligations and associated risk of penalties under PJM settlements.

Under the broad umbrella of the FRR, the alternative design structures differ greatly from each other; their primary advantages and disadvantages summarized in Table 1. The primary advantage of a planning-based FRR is that it would offer more leeway to the FRR entity (under State oversight) to incorporate a range of policy objectives into resource selection. This leeway is also a disadvantage however, given the increased risks of administrative forecasting errors and regulatory capture that could drive uneconomic resource selection and higher customer costs. The reliance on planning judgement and oversight is further generally inconsistent with Maryland's policies in support of competitive retail markets and competitive resource decisions.

An auction-based FRR if implemented in its simplest form and utilizing best practices in auction design is likely the lowest-cost approach and would maintain some of the benefits of a competitive capacity marketplace including competition and pricing transparency. An auction-based FRR would present a number of implementation costs and complexities associated with the complex transmission topology and small sub-markets, but is the simplest FRR option available. This approach would accommodate Maryland's policy-supported resources, but would not actively support the achievement of environmental goals (as this would be purely a resource adequacy construct).

An ICCM or similar design approach would offer all of the advantages of an auction-based FRR, plus the additional benefits of achieving enhanced competition (and lower costs) toward meeting state policy goals and the option to accelerate achievement of clean energy if costs are low. A Maryland-alone ICCM would continue to face the challenges associated with small sub-markets and complex transmission topology, with an additional disadvantage of greater implementation complexity. A multi-state or PJM-wide ICCM or similar design would address the challenges of MOPR and offer a first-best solution for supporting both reliability and clean energy, but would require regional collaboration to implement.

TABLE 1: RELATIVE ADVANTAGES OF ALTERNATIVE RESOURCE ADEQUACY DESIGN OPTIONS

DESIGN	ADVANTAGES	DISADVANTAGES
Current PJM Capacity Market *(with MOPR on Policy Resources)*	• Regional competition • Track record of reliability at low cost • No implementation costs or risks • Market power mitigation authority • Avoid FRR lock-in period • Possibility that MOPR will be eliminated in any case within a timeframe of a few years before major costs are imposed • Maintain focus on first-best regional solution	• MOPR-driven costs • MOPR maintains more aging fossil plants that are not needed for reliability and misalign with policy objectives • MOPR is inconsistent with clean energy mandates
Planning-Based FRR	• Eliminate MOPR on policy resources & mitigate MOPR cost impacts • Ability to consider a wide range of policy objectives	• Lose competitive market benefits, associated risk of less efficient planning decisions • Shift risk of uneconomic investments & contracts from generators to customers • Potential for excess influence from FRR planning entity • Aligning FRR entity and customer interests • Compensating FRR entity for risks • Misaligned with retail choice • Misaligned with market-based investments • Reduced transparency • High implementation complexity & risks • 5-year FRR lock-in period
Auction-Based FRR	• Eliminate MOPR on policy resources & mitigate MOPR cost impacts • Simplest FRR option • Multi-state approach could achieve most competitive benefits of a no-MOPR RPM	• Lose efficiency benefits of broader regional competition (unless pursuing a multi-state FRR approach) • Small sub-market challenges including exposure to price volatility, exercise of market power, and periodic reliability (mitigated with a multi-state approach) • Compensating FRR entity for risks • Medium implementation complexity & risks • 5-year FRR lock-in period
Integrated Clean Capacity Market	• Eliminate MOPR on policy resources & mitigate (not eliminate) MOPR price impacts • Greater competition among clean resources • Efficiency benefits of co-optimizing capacity and clean energy procurements • Option to accelerate clean energy achievement if prices are low • Multi-state approach could achieve most competitive benefits of a no-MOPR full RPM *plus* a regional clean energy marketplace	• Lose some regional market benefits (unless pursuing a multi-state or PJM-wide approach) • Compensating FRR entity for risks (not relevant if achieved under a regional approach) • Small sub-market challenges including exposure to price volatility, exercise of market power, and periodic reliability (mitigated with a regional approach) • High implementation complexity & risks

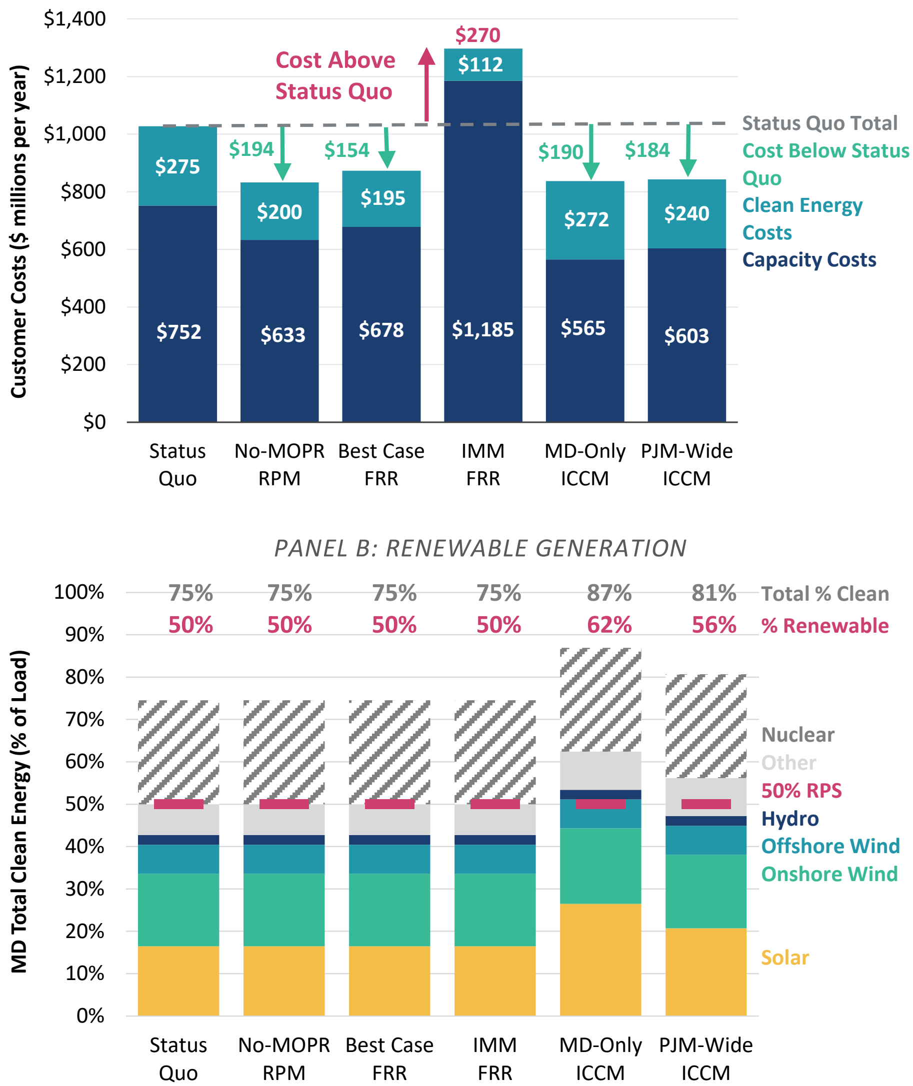
IMPACTS OF ALTERNATIVES ON CUSTOMER COSTS AND RESOURCE MIX

We conducted detailed modeling of the PJM RPM auction, MD FRR auction, and MD and PJM ICCM auctions in 2025 and 2030 to analyze the potential impacts of the various design scenarios on capacity costs, payments for clean energy, patterns of retirement and new entry, and resource supply mix. Implications for total customer costs and clean energy achievement are summarized in Figure 1, including:

- **Best-Case Auction-Based FRR:** The best case outcome under a competitive FRR leads Maryland customers to avoid approximately 80% of the costs imposed by MOPR. There are two primary drivers of these savings: (1) customers pay for roughly 3% less capacity under the FRR, because Maryland must only procure the reliability requirement, whereas in the RPM, more capacity is procured due to the downward sloping demand curve; and (2) electing FRR allows thousands of MW of resources that cannot clear due to MOPR in the PJM RPM to provide capacity to Maryland. This unlocks clean capacity contracted for customers in Maryland and other states to serve the capacity needs under a Maryland FRR. This effectively increases the supply of capacity across the PJM footprint, lowering capacity prices and saving costs for Maryland customers and other PJM customers alike.
- **IMM-Assumed Pricing for FRR:** The substantial cost savings under a "Best-Case FRR" depends on the willingness of non-MOPR capacity suppliers to offer into the Maryland FRR at competitive prices. However, there are a number of challenges that could potentially drive higher prices such as risk-averse offers that prove to exceed the prices available in the subsequent PJM capacity auction, lack of supply participation, localized market power, or other FRR implementation challenges. If such higher prices are not addressed or are locked in via multi-year contracts (such as under a planning-based FRR), these higher FRR costs could exceed the savings from avoiding MOPR. In our modeling we adopt assumptions used by the PJM independent market monitor (IMM) in studying the potential costs of FRR, yielding costs as much as $270 million per year (in 2030) higher than under status quo.
- **Maryland-Only ICCM:** If Maryland elected the FRR and designed a single-state ICCM to procure both capacity and RECs, cost savings could be similar to those seen under a Best-Case FRR outcome. We find that such a market design could attract substantial additional clean energy resources beyond the current RPS targets if implemented with a downward-sloping demand curve for RECs. This could drive clean energy achievement above the 50% standard to 62% renewable by 2030 (from 75% to 87% total clean energy if including nuclear). This additional new entry would further reduce capacity prices in both the PJM RPM and FRR auctions. The cost savings from reduced capacity payments would roughly offset the additional payments for clean energy attributes. However, this Maryland-alone ICCM design is subject to several of the potential risks identified under the "IMM FRR" case above. As with a capacity-only FRR, the a Maryland-alone FRR would need to be implemented according to best practices and considering interactions with the subsequent PJM auctions to prevent these risks from materializing.
- **PJM-Wide ICCM:** While not a design that Maryland can unilaterally implement, a PJM-wide ICCM would achieve the benefits of avoiding MOPR costs and achieving higher levels of cost-effective clean energy deployment. Maryland could exceed its renewable standard and attract 56% renewable energy by 2030 (81% total clean including nuclear). At the same time a broad regional marketplace would mitigate the risks associated with a Maryland-alone FRR. The broad regional ICCM also amplifies the impact of downward-sloping demand curves for clean energy across the PJM footprint, increasing PJM-wide clean energy generation increases from 54% of load under the status quo to 65% of load by 2030.

FIGURE 1: CUSTOMER COSTS AND RENEWABLE GENERATION IN 2030 BY DESIGN SCENARIO

PANEL A: CUSTOMER COSTS IN MARYLAND



Notes, Panel A. Clean energy resource costs include payments to new onshore wind, offshore wind, and utility-scale solar resources in excess of their energy and capacity revenues. Capacity costs include Maryland's share of PJM capacity costs (when participating in the PJM auction) or the Maryland FRR cost (when not). *Panel B:* "Other" clean energy includes Landfill Gas, Municipal Solid Waste, Agriculture Waste, Black Liquor, Other Biomass Gas, Wood/Waste Solids, and Geothermal currently providing RECs to meet Maryland RPS target today.

RECOMMENDATIONS FOR MARYLAND

In light of the many policy trade-offs and uncertainties involved, **we do not make a recommendation as to whether Maryland should adopt an FRR alternative or stay within the current PJM capacity market**. We do however offer a number of recommendations for how Maryland policymakers could proceed to maximize the customer and policy benefits in either case, while mitigating likely implementation risks.

We do **recommend that Maryland postpone any decision on the election of the FRR alternative until after key uncertainties are resolved**. Given pending changes in the makeup of the FERC, ongoing appeals (of which Maryland is a party), and ongoing regional capacity market reform initiatives, it is possible that MOPR application to policy resources could be eliminated within the next year. Under this scenario, Maryland could avoid any risks or costs associated with FRR implementation while maintaining the benefits of the broad PJM market. We recommend postponing the decision to adopt an FRR alternative until at least late 2021 when the policy stance of the new FERC may be clearer, after current appeals to the Seventh Circuit Court have been ruled upon, and after determining whether there is a viable path to a long-term sustainable capacity market design achievable through regional coordination with other states and PJM. Based on the current RPM schedule, Maryland has until February 2022 to determine whether it would elect the FRR alternative for the five-year period beginning with the 2024/25 delivery year, and will have additional decision points approximately every six month thereafter.

We offer the following **recommendations regardless of whether Maryland opts to pursue an FRR** alternative or stay within the current PJM capacity market**:**

- **Eliminate application of MOPR to policy resources**. Maryland does not have unilateral ability to eliminate the MOPR on policy resources, so we offer this recommendation more broadly. We recommend that Maryland and others continue to work through FERC proceedings, appeals, and PJM stakeholder processes to limit and ultimately eliminate the application of MOPR to policy resources, in order to avoid the market distortions and excess costs described above. Even if Maryland opts to pursue the FRR alternative, price reductions achieved by the elimination of MOPR would benefit Maryland customers via lower FRR-based capacity payments and a more attractive regional marketplace after the conclusion of the five-year FRR term.
- **Continue to pursue PJM wholesale market evolution to align with policy objectives.** In coordination with PJM stakeholders, continue to pursue a range of enhancements to the PJM wholesale market design that will align with Maryland's clean energy goals. These enhancements would likely include enhancements to scarcity pricing, ancillary service markets, capacity resource accounting, improved integration of seasonal capacity resources, and integration of emerging technologies such as storage and distributed resources. PJM already has initiatives in all of these areas.
- **Engage with other PJM states and stakeholders on an ICCM or similar proposals for long-term sustainable capacity market design.** A first-best resource adequacy market design for Maryland and other states with significant clean energy goals would continue to rely on broad regional competition for attracting a suite of resources for efficiently maintaining reliability and meeting policy goals. Even if Maryland opts to pursue an FRR alternative for a temporary period, we recommend that Maryland pursue such a first-best outcome as the most attractive long-term sustainable option. If a first-best regional market design for resource adequacy can be developed, it could be implemented through a multi-state FRR or adopted PJM-wide as a replacement to the current RPM.

With respect to an FRR construct, we caution that the net benefits (or net costs) to Maryland could vary widely depending on how it would be implemented. Under the best possible design and idealized pricing assumptions, an FRR alternative is likely to procure capacity at cost-effective prices while avoiding the customer costs from MOPR. However, we emphasize the challenges that will be associated with achieving an efficient implementation of FRR given Maryland's complex transmission topology and small segmented sub-markets. If implemented hastily, with design flaws, or with insufficient monitoring and mitigation provisions, the FRR could produce uneconomic procurement choices that induce excess capacity payments exceeding the costs of MOPR for years beyond the five-year FRR election period. We thus stress the importance of differentiating alternative FRR proposals based on their merits and implementing FRR in a deliberative fashion after robust vetting by all stakeholders and independent experts.

If Maryland decides to pursue the FRR election, we offer the following recommendations to maximize benefits and minimize risks:

- **Proceed with the formal development and evaluation of a range of resource adequacy structures, including Maryland-alone FRR and multi-state FRR options.** To preserve the option of selecting the FRR alternative if the options to stay within the PJM capacity market prove unattractive, we recommend that Maryland proceed with the formal development and evaluation of a range of viable single-state and multi-state FRR design alternatives. We recommend proceeding with this design and evaluation effort immediately in order to allow sufficient time to develop fully-considered and vetted approaches that would reduce the risk of design and implementation flaws.
- **Select an FRR design aligned with primary design goals.** If the only purpose of the FRR is to prevent policy-supported resources from being excluded from the capacity market, we recommend developing a straightforward auction-based FRR that procures capacity at least cost (without considering other resource attributes). If the State wishes to express environmental goals as well through the FRR design, then we recommend pursuing an ICCM or similar design to procure both capacity and clean energy products at the lowest combined cost.
- **Use an auction-based rather than planning-based FRR.** We recommend an auction-based approach to capacity procurement under an FRR alternative in order to preserve competitive, transparency, and cost savings benefits of the current PJM capacity market. This will minimize the role of administrative judgement in resource selection and price-setting, instead relying on a competitive format to drive efficient pricing.
- **Select a state agency or independent evaluator to implement auctions or resource selection.** To avoid challenges with affiliate transactions, we recommend that the distribution utilities not be asked to develop the FRR design, select resources, determine FRR payment prices, or determine payment terms. Instead, we recommend that a state agency or independent evaluator contracted directly with a state agency should take the role of selecting resources and payment terms.
- **Maintain unbundled capacity product for one-year commitments.** To minimize customer risks associated with uneconomic supply commitments, we recommend maintaining consistency with the current PJM capacity auction by procuring unbundled capacity credits for one-year duration. If clean energy attribute credits are also procured, these might be procured under longer-term commitments for new resources.
- **Enable competitive retailer self-supply and hedging.** Utilizing accounting mechanisms similar to the current PJM capacity market, ensure that competitive retailers within Maryland have adequate opportunities to self-supply their capacity (and, if relevant, clean energy attribute) requirements. Minimize any FRR costs that would be allocated as non-bypassable charges in order to preserve the ability of competitive retailers to identify lower-cost capacity resources for their customers.
- **Utilize best practices in resource adequacy and auction design.** We recommend adopting FRR design elements in alignment with best practices in resource adequacy design. Among these elements are a robust market monitoring and mitigation framework, sloping demand curves for the smallest LDAs, transparent rules-change processes, and (possibly) an RPM-derivative pricing component.

I. Background

As a participant in the PJM wholesale power market since its inception, Maryland has relied on the regional marketplace to provide low-cost and reliable electricity. While the regional competitive market has performed well in offering secure low-cost supply to Maryland, the PJM wholesale power market was not designed to meet Maryland's growing demand for a cleaner electricity supply mix. In recent years, Maryland has policies for a clean energy future including a 50% Renewable Portfolio Standard (RPS) by 2030 and planning a pathway toward 100% clean energy by 2040. To meet these legislative mandates, Maryland incentivizes renewable energy resources to enter the market with competitive solicitations for offshore wind, renewable energy credit (REC) markets, and various other policy incentives.

A significant disconnect has arisen between Maryland's policy goals and the PJM capacity market after a controversial order in December 2019 by the Federal Energy Regulatory Commission (FERC).[11] This ruling expanded the application of the Minimum Offer Price Rule (MOPR) by the Federal Energy Regulatory Commission to apply a higher minimum floor price to resources that receive "out-of-market" state subsidies. The expanded MOPR if maintained in its present form will limit the ability of new renewable energy resources to clear the PJM capacity market and impose excess costs on Maryland customers. As a policy, the expanded MOPR runs counter to Maryland's clean energy policies and goals.

We prepared this report for the Maryland Energy Administration (MEA) on behalf of the Maryland Energy Service to assist in identifying and evaluating resource adequacy design alternatives that could mitigate the impact of the expanded MOPR and aligns with Maryland's clean energy goals.

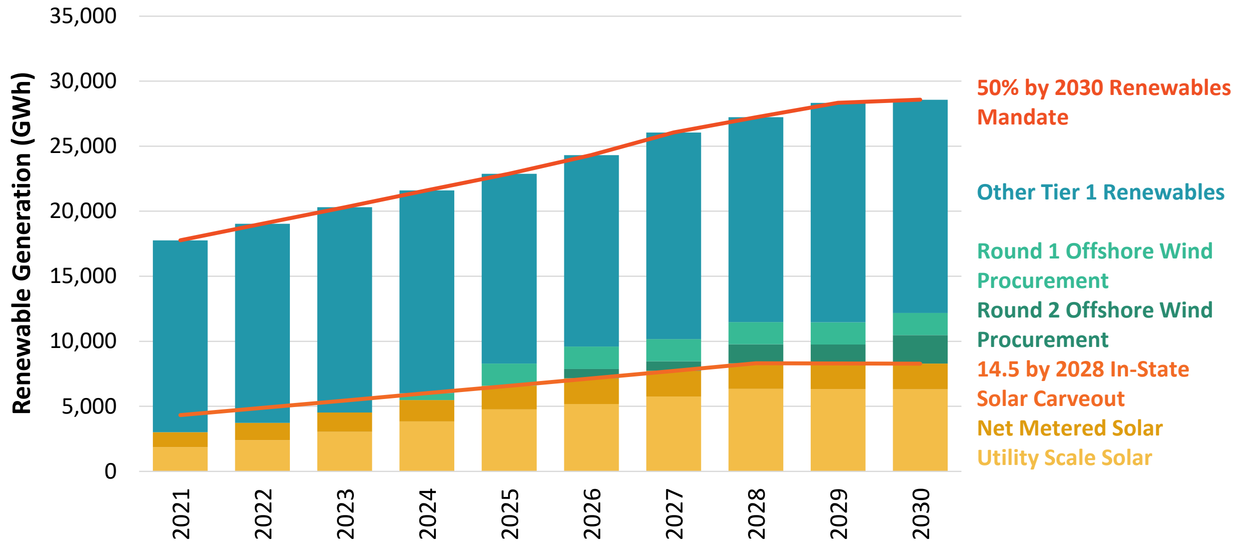
A. Maryland's Environmental Policy Goals

Maryland is a leading state in its commitment to reducing greenhouse gas emissions and eliminate fossil fuel generation from its supply mix. Under the *2019 Clean Energy Jobs Act*, Maryland adopted a 50% by 2030 RPS and will commission a study to assess the overall costs and benefits of increasing its RPS target to 100% by 2040. Figure 2 summarizes the timeframe for achieving Maryland's legislated 50% renewable energy mandate, including a 14.5% carve-out for in-state solar, and a requirement to develop least 1,590 MW of offshore wind capacity by 2030.[12]

[11] Federal Energy Regulatory Commission (FERC), "Order Establishing Just and Reasonable Rate," issued December 19 2019.

[12] Over time, Maryland increased its RPS targets with provisions for wind and solar resource carve-outs to encourage the development of renewable energy. In 2004, Maryland adopted its initial Renewable Energy Portfolio Standard (RPS) of 7.5% from Tier 1 and 2.5% from Tier 2 resources by 2019. Under the *2013 Maryland Offshore Wind Energy Act*, an initial 390 MW of capacity was procured as a part of Round 1 offshore wind projects. An additional 1,200 MW have been authorized under the *2019 Clean Energy Jobs Act* as part of the second round of offshore wind projects. The Round 2 procurement schedule of these wind projects specifies 400 MW must be procured by 2026, 800 MW must be procured by 2028, and 1,200 MW must be procured by 2030. The net rate impact for Round 2 offshore wind projects is limited to $0.88 per month for each residential customer and 0.9% of the annual electric bill for non-residential customers.

FIGURE 2: CLEAN GENERATION NEEDED TO MEET MARYLAND'S 50% BY 2030 RENEWABLE MANDATE



Sources and Notes: Maryland load is based on retail sales forecasts from the Public Service Commission of Maryland's "Ten Year Plan (2020-2029) of Electric Companies in Maryland," September 1, 2019. Round 1 offshore wind carve-out includes generation from Skipjack (120 MW) and Maryland US Windfarms (270 MW). The Round 2 offshore wind carve-out, 14.5% solar carve-out, and 50% renewable mandate are from the Maryland "2019 Clean Energy Jobs Act," SB 516, passed on May 25, 2019. The solar carve-out includes both utility-scale and net-metered solar generation. Solar carve-out, and net-metered solar cap is from "Report on the Status of Net Energy Metering in the State of Maryland." Based on apparent solar installed capacity as of end of 2020, we assume the solar carve-out is not currently being met, but that incremental solar capacity additions will come online to meet the carve-out level by 2025. Other Tier 1 Renewables includes onshore in-state wind and out-of-state onshore wind RECs. "Clean Energy Jobs," SB 516, passed on May 25 2019. Clean Energy Jobs," SB 516, passed on May 25 2019.

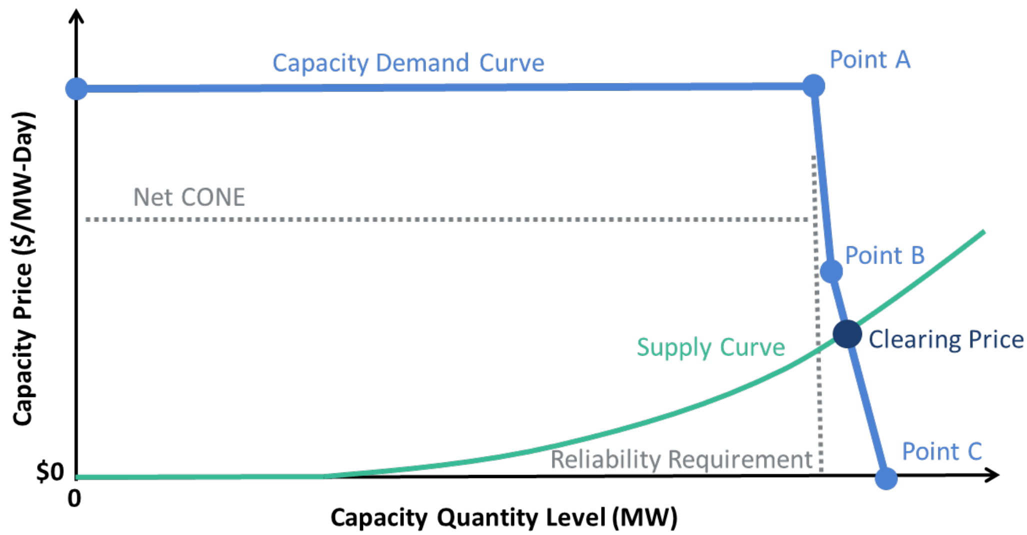
B. The Role of PJM's Capacity Market in Supporting Reliability

WHAT IS THE PJM CAPACITY MARKET?

PJM's capacity market, the Reliability Pricing Model (RPM), is a market-based system for procuring commitments from capacity resources that they will be available to meet system and locational reliability needs. The quantity of capacity procured must be sufficient to meet a reliability standard of no more than *one expected loss-of-load event in ten years* (0.1 LOLE or 1-in-10) reliability standard. PJM establishes a reliability requirement based on forecasted peak load plus the installed reserve margin (IRM) needed to maintain 1-in-10 reliability. The capacity market aims to procure sufficient generation, storage, or demand response to meet reliability needs at the lowest possible cost through the three-year forward competitive Base Residual Auctions (BRAs). The RPM uses locational pricing that reflects transmission system limitations and uses a pay-for-performance incentive structure to incentivize resources to deliver on their capacity commitments during reliability events.

PJM uses an administratively-determined Variable Resource Requirement (VRR) curve to procure capacity under the RPM, as illustrated in Figure 3. The VRR is a downward-sloping demand curve that specifies the prices and demand relative to the IRM.[13] Prices in the VRR curve are tied to the administrative estimate of the Net Cost of New Entry (Net CONE), which is the estimated price at which new generation resources would be willing to enter the market. System wide and locational VRR curves are designed to allow for the procurement of sufficient capacity to achieve resource adequacy, mitigate price volatility, and mitigate the ability for sellers to exercise market power.[14] Market participants with existing resources are required to offer available capacity into the RPM. New resources may also offer into the market as price takers or at prices that reflect their individual net costs of entering.[15] The intersection of market participant supply offers and the VRR curve sets the market price paid to all cleared capacity resources for the relevant one-year delivery period. Supply resources unable to meet their capacity commitments are subject to deficiency and penalty charges. Under this framework, RPM prices are designed to be consistent with supply-demand conditions. The RPM produces low prices when there is more than enough supply to meet resource adequacy needs and high prices when capacity supply is scarce.

FIGURE 3: ILLUSTRATIVE PJM CAPACITY SUPPLY AND DEMAND CURVES



Notes: Illustrative, not drawn to scale. See 2022/23 BRA planning parameters for specific demand curve parameters.

Historically, the PJM capacity market has been able to attract new investment and procure capacity that exceeds the reliability requirement, and at prices below the administrative estimate of Net CONE. Since the 2007/08 delivery year, 52,000 MW of new generation capacity has been attracted into the PJM capacity market; including 10,000 MW from uprates. Demand response and net import capabilities in PJM have also increased by 11,350 MW and 8,700 MW, respectively. These incremental capacity resources have been sufficient to meet increases in regional demand and replace large quantities of retirements from aging coal, nuclear, oil-fired, and high-heat rate natural gas plants.[16]

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13 "PJM Manual 18: PJM Capacity Market Revision: 46," Prepared by Capacity Market & Demand Response Operations, PJM Interconnection LLC, November 2020.

14 Newell et al. "PJM Cost of New Entry: Combustion Turbines and Combined-Cycle Plants with June 1, 2022 Online Date," Prepared for PJM Interconnect LLC by The Brattle Group, April 2018.

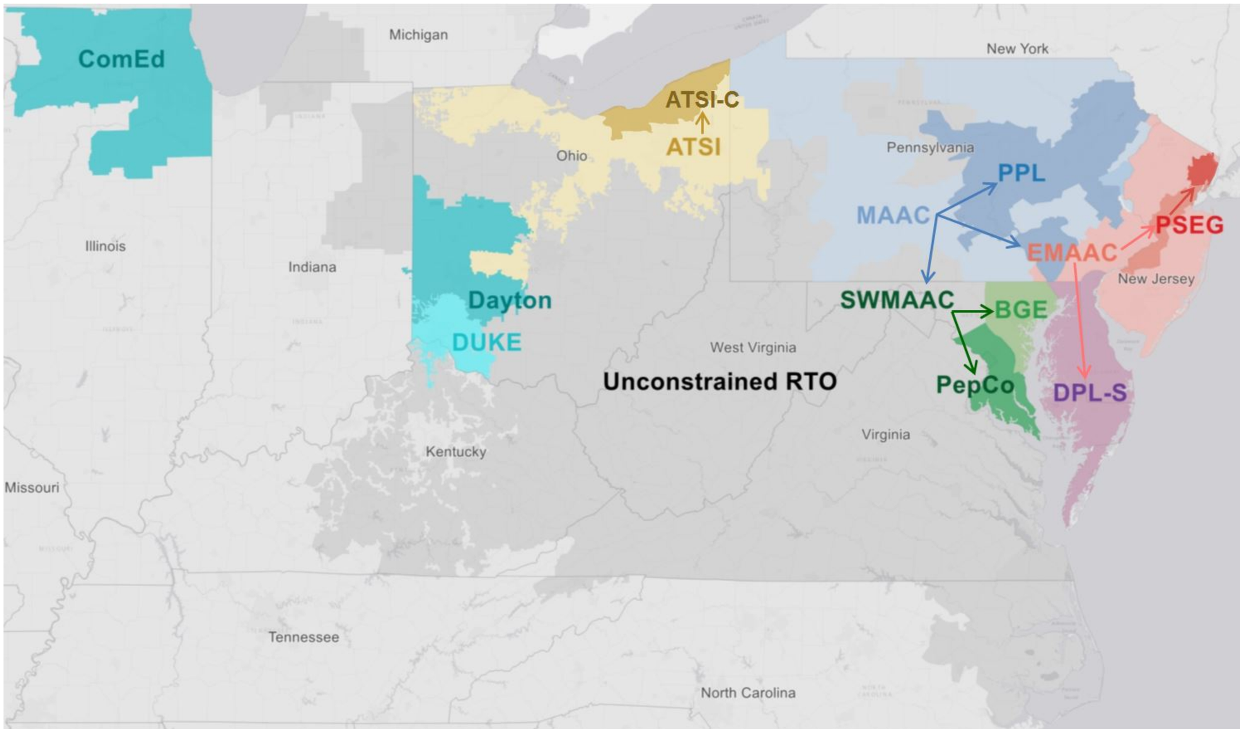
15 Seller offer prices are driven primarily by their going-forward investment and fixed costs minus any net revenues they anticipate to earn from selling other products such as energy, ancillary services, or RECs. Many capacity resources offer at a zero price if they have already come online and have few going-forward capital investments or can pre-sell most of their capacity or energy through bilateral contracts. Participants may also adjust their capacity offer price based on their long-term view of future energy and capacity prices.

16 "2021/22 RPM Base Residual Auction Results," PJM Interconnection LLC, May 2018.

HOW DOES THE CAPACITY MARKET ENSURE LOCATIONAL RESOURCE ADEQUACY FOR MARYLAND?

PJM uses the capacity market to procure capacity across the region to meet system-wide and local reliability needs at the lowest possible cost. Subregions of PJM with limited import capability due to transmission constraints are modeled as Locational Deliverability Areas (LDAs). Figure 4 shows a map of modeled LDAs in PJM.

FIGURE 4: MAP OF MODELED LOCATIONAL DELIVERABILITY AREAS IN PJM

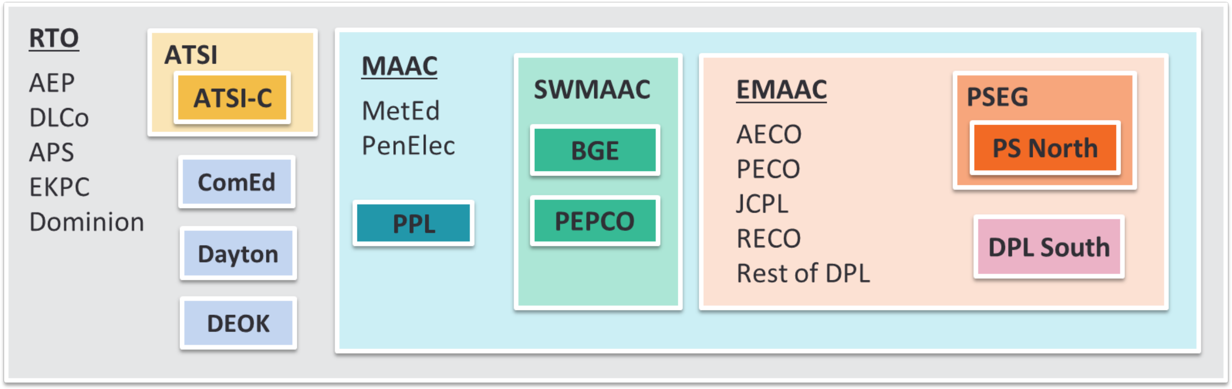


Sources and Notes: Newell et al., "Fourth Review of PJM's Variable Resource Requirement Curve," Prepared for PJM, The Brattle Group, April 19, 2018. The map represents modeled LDAs as of 2022/23.

Modeled LDAs each have a locational VRR curve, local Reliability Requirement, and locally estimated Net CONE. A "nested" LDA structure is used to reflect the transmission topology across the PJM system, in which successively smaller LDAs can procure capacity locally or from larger "parent" LDAs. Each LDA must have enough capacity procured to meet the local reliability requirements but can import a portion of that capacity from the parent LDA up to the maximum quantity that the transmission system can support or the Capacity Emergency Transfer Limit (CETL).

This complex transmission topology is illustrated in Figure 5 below. Note that modeled LDAs in the capacity market do not necessarily align with utility service territories or state boundaries. The State of Maryland comprises all or parts of seven distinct modeled LDAs, each with separate reliability parameters that must be achieved and each of which may produce distinct capacity clearing prices. The RPM auctions reflect these transmission constraints within the auction clearing by optimizing capacity imports to meet the reliability needs of all LDAs at the lowest cost. By participating in a broad regional marketplace, Maryland can save costs by importing lower-cost capacity (to the extent possible) while ensuring that sufficient local capacity will be available for reliability needs.

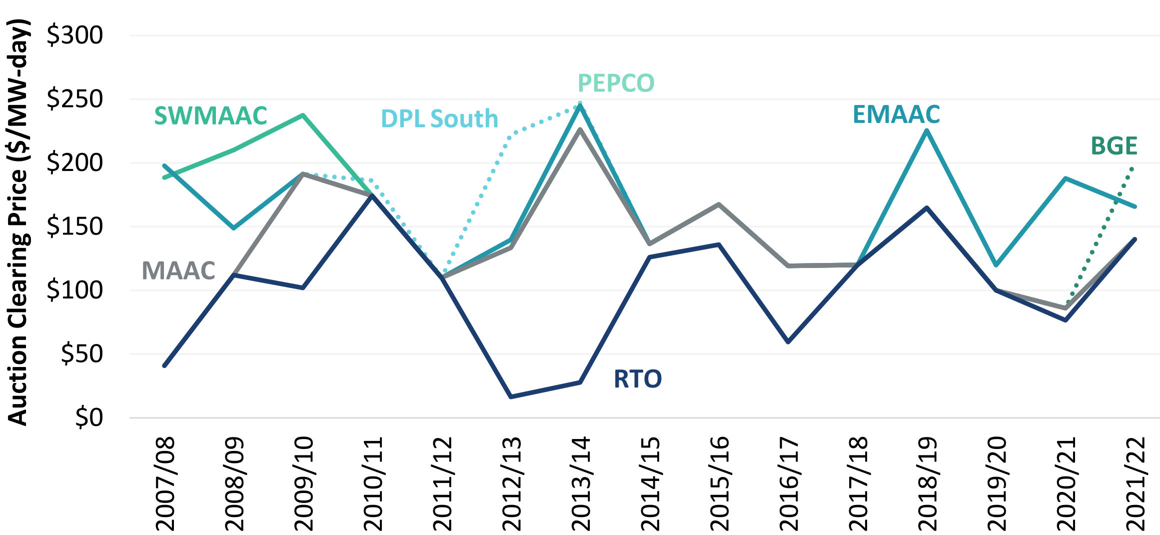
FIGURE 5: SCHEMATIC OF NESTED STRUCTURE OF LOCATIONAL DELIVERABILITY AREAS



Sources and Notes: The nested schematic is from Newell et al., "Fourth Review of PJM's Variable Resource Requirement Curve," Prepared for PJM, The Brattle Group, April 19, 2018. Each rectangle and bold label represent an LDA modeled in the 2022/23 BRA planning parameters (released in 2019, and latest as of January 2020); individual energy zones listed in non-bold without boxes are not currently modeled.

Under the RPM pricing structure, import-constrained LDAs can experience higher clearing prices relative to their parent LDAs when local reserve margins are low and due to transmission limits. This has sometimes (but not always) resulted in higher prices in the import-constrained Maryland LDAs as summarized in Figure 6. The smallest LDAs are subject to greater price volatility and occasional price spikes due to the larger price impact from small changes in supply, demand, and transmission parameters. Higher prices in constrained LDAs can serve as a signal to attract new investment in supply that is needed to support local reliability requirements, even though developing capacity resources may be more expensive in these locations.

FIGURE 6: CAPACITY CLEARING PRICES IN THE MARYLAND LDAS



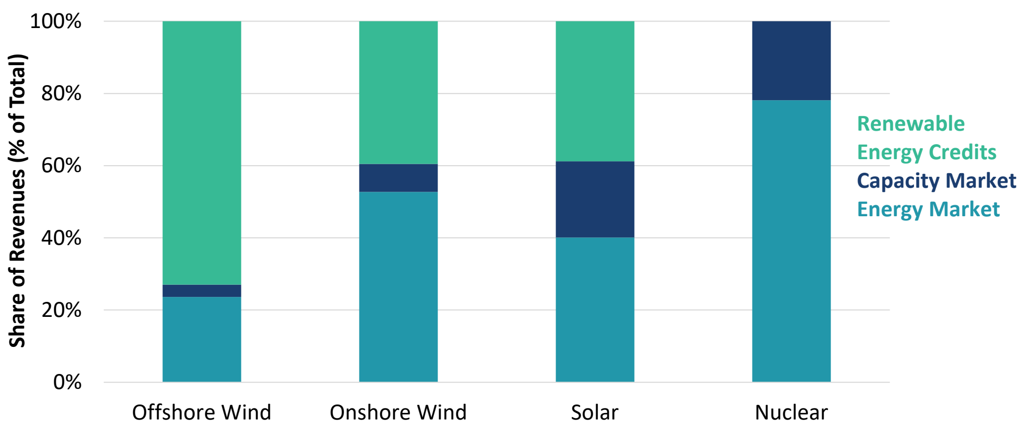
Sources and Notes: Monitoring Analytics, "State of the Market Report for PJM: Volume II, Section 5 – Capacity Market", Table 5-21: Capacity market clearing prices: 2007/08 through 2021/22 RPM Auctions, March 12, 2020.

HOW DO CLEAN ELECTRICITY MANDATES AFFECT CAPACITY MARKETS?

As of 2020, 11 out of 14 PJM states have established RPS programs to support clean energy goals.[17] While the PJM capacity market does not directly incorporate state clean energy policies, there are strong interactions between clean policy and capacity market outcomes in the interconnected regional market.

Participation in the broad PJM market is beneficial toward the efficient, cost-effective achievement of states' clean energy goals (setting aside MOPR for the moment). The wholesale electricity markets offer a ready marketplace where clean energy resources can sell energy, capacity, and (if relevant) ancillary services at a fair price. A share or even the majority of the resources' investment costs are paid for through participating in the wholesale markets, thus reducing the net cost of clean energy policy programs. For example, Figure 7 illustrates the approximate share of total resource revenues that various clean energy resources earn from the wholesale capacity and energy markets. Offshore wind, onshore wind, and solar earn anywhere from 20% to 60% of their revenues from the wholesale markets, thus requiring Maryland customers to pay only the remainder through Renewable Energy Credits (RECs) as incremental costs for pursuing clean energy goals. Worth noting given the context of MOPR, onshore and offshore wind resources earn only a small fraction of their revenues from the capacity market due to their intermittent nature and modest capacity value, meaning that the impacts of excluding them via MOPR are moderate. In contrast, solar resources earn a significant share of their total revenues from the capacity market due to relatively higher capacity value, driving an increased expense to developers (and customers) if they are excluded.

FIGURE 7: REVENUE STREAMS AVAILABLE TO CLEAN ENERGY RESOURCES



Sources and Notes: Approximate revenue streams informed by data in "2022-2023 BRA Default MOPR Floor Offer Prices for New Entry Capacity Resources with State Subsidy," PJM Interconnection, and "CONE and ACR Values – Preliminary," Monitoring Analytics, accessed February 9, 2021.

The wholesale markets further offer balancing services to complement the output profiles of intermittent resources and maintain reliability, such that the cost of integrating renewables in the PJM region has been modest to date. The "network access" approach to ensuring transmission sufficiency ensures that clean energy resources across the PJM system are simultaneously deliverable to load centers. Several

[17] "Comparison of Renewable Portfolio Standards (RPS) Programs in PJM States," Environmental Information Services, PJM Interconnection LLC, August 2020.

jurisdictions including, Maryland, Delaware, New Jersey, and Washington, DC allow RECs to be purchased across state lines to help meet their clean energy goals and access lower-cost clean energy.[18]

State policies to support clean energy resources also impact the wholesale markets, primarily by displacing fossil resources and driving lower prices in the energy and capacity markets. Most clean energy resources have zero variable or fuel cost and so offer into the energy market at a zero or negative price, thus incrementally reducing wholesale energy prices. However, intermittent renewables participating in the capacity market face unique challenges. To maintain resource adequacy, PJM assigns renewables such as wind and solar a lower capacity value because they cannot generate at their full capacity during peak load conditions. Clean energy resources supported by policy payments tend to offer their capacity into the capacity market at a low or zero price to guarantee clearing. Clean resources do not displace fossil capacity on a one-for-one MW basis, however. They tend to have lower capacity ratings, as summarized in Table 2, given their intermittency and lower average availability to meet peak system needs.

TABLE 2: CAPACITY FACTORS AND CAPACITY VALUES OF CLEAN RESOURCES

Resource Type	Capacity Factor	Capacity Value
Nuclear	94%	99%
Solar	15%	42%
Onshore Wind	30%	18%
Offshore Wind	50%	26%
Storage	n/a	40%
Hydropower	40%	95%

Sources and Notes: Nuclear capacity value and capacity factors are approximated from S&P Global Market Intelligence and 2010-2019 historical generation from EIA 923. Capacity value for solar, wind and battery storage from Default MOPR Floor Offer Prices for New Generation Capacity Resources, p. 9, PJM Market Implementation Committee, March 11, 2020. The capacity value for hydropower approximated from the 2019 PJM Reserve Requirement Study, PJM Interconnect LLC, October 2019.

The overall effect of state policies to displace other resources in the PJM markets is mostly an intended effect from state policies, as the majority of the displaced resources tend to be fossil plants (new gas plants that will not be built and aging fossil plants that will retire). However, the lower capacity and energy prices can also have the side effect of displacing other clean resources including nuclear, demand response, existing hydropower, and storage if those resources are not eligible to compete under the relevant state policy programs.

C. The Minimum Offer Price Rule and its Application to Policy Resources

The original and proper economic purpose of the MOPR is to protect the market from the exercise of buyer market power. Specifically, schemes where large net buyers or their representatives offer a small amount of uneconomic supply into the market below cost in order to artificially suppress market-clearing prices. By taking a loss on that small position, a large net buyer could then benefit from a much larger

18 "State RPS Fulfillment," Monitoring Analytics, October 2019.

short position in the market. The MOPR is designed to ensure that entities with the incentive and ability to engage in manipulative price suppression would be unable to do so by requiring their capacity market offers to reflect their full costs. Uneconomic new resources sponsored by large net buyers would fail to clear (or would set the prices at a higher level) and prevent the entity from achieving the benefits of manipulative price suppression. Symmetrical rules are imposed on large net sellers of capacity in order to prevent them from exercising economic or physical withholding.

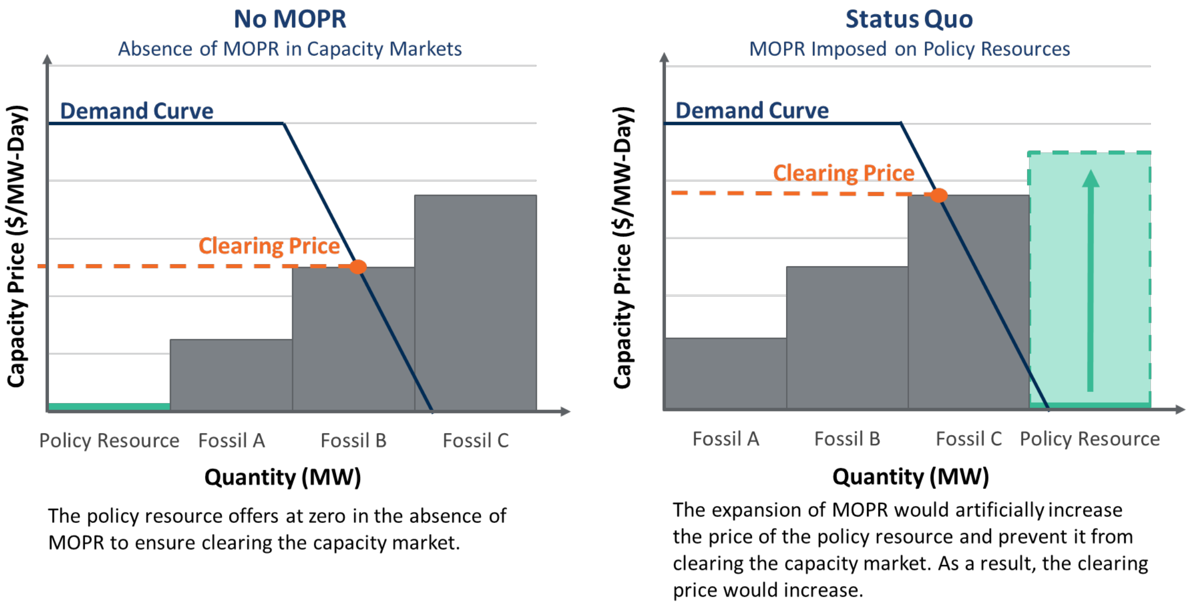
By 2011, the MOPR expanded in response to the application of state subsidies to attract natural gas capacity. In December 2019, FERC issued an order further expanding the scope of MOPR to apply to new or existing resources that receive state subsides, such as RECs or zero-emission credits (ZECs).[19] Exemptions apply only to existing resources that have previously cleared an auction or new resources that have an interconnection agreement prior to the December 2019 order. (Section II below critiques the rationale for this expansion and estimates the excess costs caused by it; here we only explain the mechanics).

Figure 8 illustrates the impact of MOPR on the ability of policy resources to clear the capacity market. The "No MOPR" scenario on the left illustrates clearing outcomes if all capacity resources are allowed to offer at their preferred offer price. Most policy resources will typically offer at a zero because these resources will be developed regardless of the capacity revenues they receive; these resources earn a large majority of their revenues through energy markets and from policy payments reflecting their environmental value. Fossil plants and other capacity resources' offers reflect the price needed to cover their net avoidable going-forward costs (that is, economic costs they will incur as a result of providing capacity in the delivery year that they would not otherwise incur). Clearing prices are set at the intersection of supply and demand, similarly to illustrative supply and demand curves in Figure 3 above.

The right-hand panel, however, illustrates the status quo case where the expanded MOPR is applied to a policy resource. The offer price of the policy resource is higher than in the No MOPR scenario and reorders the capacity market offer supply curve. As the MOPR level exceeds the capacity clearing price, the policy resource does not clear, and the market's incremental need for capacity is met by fossil resource C at higher price.

19 Federal Energy Regulatory Commission (FERC), "Order Establishing Just and Reasonable Rate," issued December 19 2019.

FIGURE 8: THE IMPACT OF MOPR ON POLICY RESOURCES



The expanded MOPR ruling initiated extensive rehearing requests and compliance filings. As a result, there have been significant delays to the PJM capacity auction schedule; the planning year 2022/23 auction that was originally scheduled for spring 2019 will now be conducted in mid-2021.[20] Auctions for the subsequent planning years will be conducted on a compressed schedule approximately every six months until the market resumes its normal schedule with a May 2024 auction for the delivery year 2027/28.

In a parallel, there are continued efforts to eliminate the MOPR through other avenues. The composition of the FERC is changing significantly and may soon have leadership and majority members that will be favorable to the elimination of MOPR on policy resources as soon as mid-2021. In the event a new FERC would be reluctant or unable to directly reverse prior decisions, they could entertain new proposals for reforming the capacity market that would achieve the same effect. Beyond FERC itself, the U.S. Court of Appeals for the Seventh Circuit is set to begin hearings on appeals to the MOPR expansion early in 2021 with the possibility of ruling as soon as late 2021.[21]

D. The Fixed Resource Requirement Alternative

Since its inception, the RPM has included provisions for a Fixed Resource Requirement (FRR) alternative that can be utilized by any qualified entities that wish to opt out of the PJM capacity market and procure capacity in a different way on behalf of their customers. The FRR was originally designed to fit the needs of vertically integrated utilities that conduct resource planning and that do not wish to have uncertainty in the quantity of capacity requirements that can be produced by the sloped demand curve.

[20] See the PJM capacity market schedule in "Update on Base Residual Auction Schedule," (Presented by PJM Interconnection to the Markets and Reliability Committee, November 19, 2020).

[21] See additional discussion of the status and outlook for the expanded MOPR from Advanced Energy Economy "MOPR and More: Where the Minimum Offer Price Rule and Related Measures Stand Going Into 2021" December 16, 2020.

Though not originally intended for this purpose, Maryland can elect to exercise the Fixed Resource Requirement (FRR) alternative to limit the impact of MOPR on policy resources contracted to Maryland customers. The FRR construct requires that sufficient capacity resources be procured to meet total and location-specific capacity requirement and remains agnostic as to how the resources are procured or at what price. This mechanism would allow Maryland to circumvent the application of MOPR on policy resources.

Entities interested in participating in the FRR alternative for the first time must notify PJM at least four months before the BRA for the first delivery year the FRR alternative will be in effect. Given the currently compressed PJM auction schedule, the deadlines for FRR election are similarly compressed and accelerated. To initiate FRR beginning with the 2024/25, 2025/26 or 2026/27 delivery year would require formal election of the FRR alternative by February 2022, September 2022 or March 2023 respectively.[22] The election for the FRR alternative requires a commitment of a minimum of five consecutive delivery years. However, FRR elections can be terminated early based on the following conditions:

- PJM establishes a separate VRR curve for an LDA encompassing the FRR service area. This exception is unlikely given that most of Maryland is already modeled within separate LDAs (e.g., BGE and PEPCO).
- A state regulatory "structural change," such as the transition to a competitive retail market.

If choosing an FRR alternative, an "FRR entity" must take responsibility for securing capacity commitments on behalf of the designated customers. Table 3 summarizes the FRR obligations for the LDAs in Maryland that would be relevant for an FRR plan in the 2022/23 delivery year. A Maryland-wide FRR would need to procure approximately 14,000 UCAP MW of capacity (second to last row), of which a minimum share must be located within each of the relevant LDAs (last row). Note that the nested LDA structure means that the locational requirements are not additive. For example, any capacity within the Potomac Electric Power Company (PEPCO) LDA would contribute toward meting the PEPCO, Southwestern Mid-Atlantic Area Council (SWMAAC), Mid-Atlantic Area Council (MAAC), and Maryland-wide capacity obligations.

The FRR entity must submit an FRR plan to PJM three years in advance of delivery (and at least four months in advance of the RPM auction) to identify the specific resources committed to serving customers. If any of the identified resources would fail to fulfill its delivery obligation or incur performance penalties, the associated penalties would be assessed to the FRR entity.

TABLE 3: MARYLAND LDA FRR OBLIGATIONS AND RESOURCE REQUIREMENTS (2022/23 DELIVERY YEAR)

			RTO	MAAC	SWMAAC	BGE	PEPCO	EMAAC	DPL-S
Total LDA									
Coincident Peak Load	*(MW)*	[1]	152,505	55,042	12,391	6,285	6,106	29,914	2,203
Forecast Pool Requirement	*(%)*	[2]	108.9%	n/a	n/a	n/a	n/a	n/a	n/a
CETL	*(UCAP MW)*	[3]	n/a	2,252	9,158	6,110	7,645	9,752	1,676
Reliability Requirement	*(UCAP MW)*	[4]	166,032	65,149	15,219	7,769	8,104	36,302	2,924
Price Responsive Demand	*(UCAP MW)*	[5]	425	425	360	170	190	65	32
EE Addback	*(UCAP MW)*	[6]	3,913	1,345	229	110	119	937	17
FRR Obligations									
Min Internal Resource Requirement	*(%)*	[7]	n/a	100.0%	44.9%	24.2%	6.9%	81.5%	52.0%
Reliability Requirement adjusted for FRR	*(UCAP MW)*	[8]	152,052	52,600	10,127	6,113	3,607	35,316	1,869
Maryland Portion of LDA									
Coincident Peak Load	*(MW)*	[9]	12,841	11,527	10,416	6,285	4,131	1,111	969
Maryland Share of Coincident Peak Load	*(%)*	[10]	8.4%	20.9%	84.1%	100.0%	67.7%	3.7%	44.0%
Price Responsive Demand	*(UCAP MW)*	[11]	313	313	299	170	129	14	14
EE Addback	*(UCAP MW)*	[12]	238	203	191	110	80	12	8
FRR Obligations									
FRR Entity UCAP Obligations	*(UCAP MW)*	[13]	**13,877**	12,412	11,206	6,768	4,438	1,207	1,048
Min Internal Resource Requirement	*(UCAP MW)*	[14]	n/a	**12,412**	**5,031**	**1,638**	**306**	**983**	**545**

Sources and notes:
[1] - [5], [8], [9] – [10]: PJM BRA Auction Results Planning Parameters from the 2022/23 Delivery Year (released in 2019, and latest as of January 2020).[1] - [5], [8], [9] – [10]: PJM BRA Auction Results Planning Parameters from the 2022/23 Delivery Year
[6]: Not available for 2022/23, so used PJM BRA Auction Results Planning Parameters from the 2021/22 Delivery Year adjusted for forecasted growth in peak load.
[7]: ([4] – [3]) / ([1] x [2])
[9] = [1] x [10]
[11] = [10] x [5] for PEPCO, BGE, DPL-S, and EMAAC; SWMAAC = PEPCO + BGE; MAAC = EMAAC + SWMAAC; RTO = MAAC
[12] = [10] x [6] for PEPCO, BGE, DPL-S, and EMAAC; SWMAAC = PEPCO + BGE; MAAC = EMAAC + SWMAAC; RTO = MAAC
[13] = ([9] – [11] + [12]) x [2]
[14] = [13] x [7]

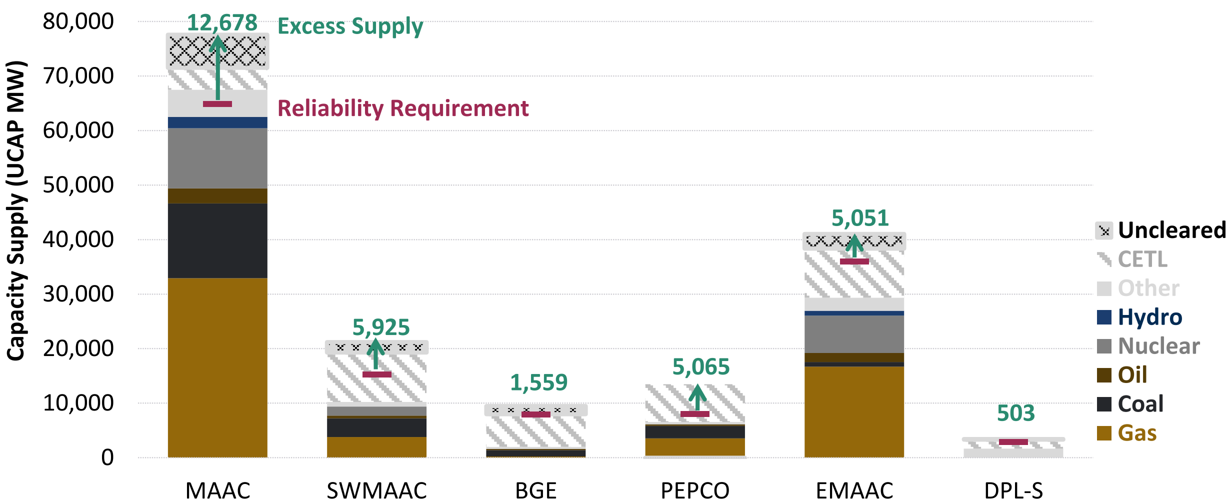
E. Structural Competitiveness of Capacity Supply

Small sub-regions of capacity markets tend to face challenges with a lack of structural competitiveness. These regions can have a relatively high cost of supply, barriers to new entry, and high ownership concentration. Maryland covers several small LDAs and thus will face some of these challenges to different degrees. Figure 9 and Figure 10 summarize the supply-demand balance and ownership share of supply resources across the Maryland LDAs. Both of these measures indicate the level of competitiveness in each

LDA. An LDA long on capacity will tend to be competitive because more supply is available to meet local needs than the minimum required and so local sellers must compete with imports. An LDA with a more fragmented ownership structure will also be more competitive. However, an LDA with a small quantity of excess supply and a single entity owning most of that supply is structurally uncompetitive. In that circumstance, a single seller could engage in economic or physical withholding, drive up local prices, and earn greater revenues on its entire portfolio of local resources. The smallest Maryland LDAs of Baltimore Gas and Electric (BGE), PEPCO, DPL-South, and SWMAAC face varying degrees of market concentration and/or tight supply, and the small size of these LDAs means that the retirement of a few large resources could tip the balance from a relatively competitive to relatively uncompetitive market structure. These locations would need to be carefully overseen from a monitoring and mitigation perspective under a Maryland FRR.

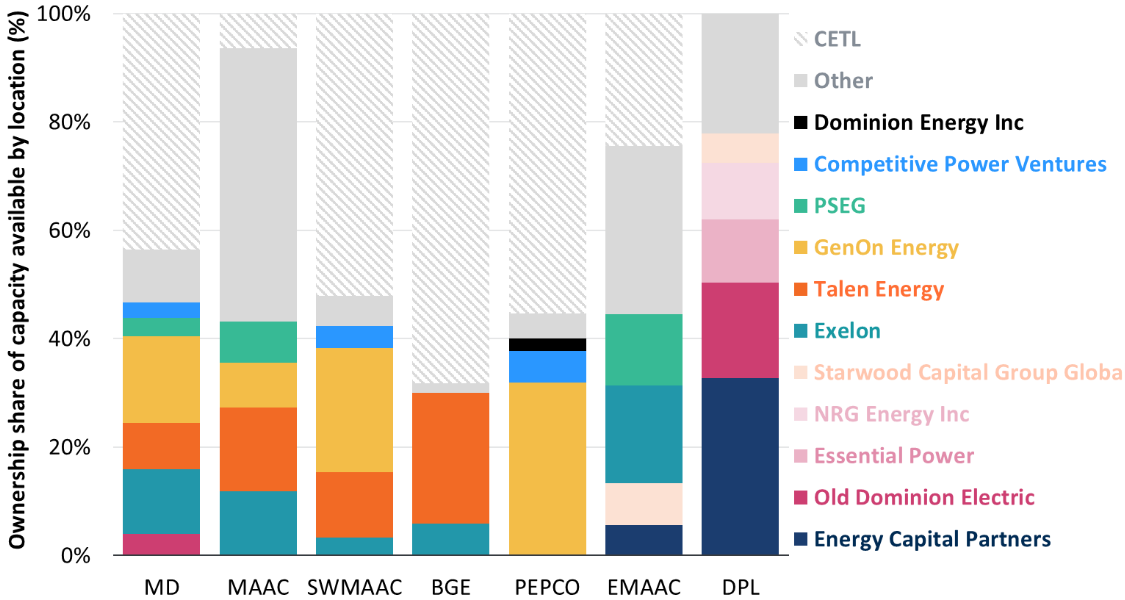
The larger LDAs including Eastern Mid-Atlantic Area Council (EMAAC), MAAC, and the portion of Allegheny Power Systems (APS) within the unconstrained RTO would not be likely to pose any market power concerns under a Maryland FRR. Maryland is a small share of total demand within these locations, each of which have supply that far exceeds Maryland demand.

FIGURE 9: CAPACITY SUPPLY AND DEMAND BALANCE



Sources and Notes: Brattle analysis based on Table 21, Monitoring Analytics, "Analysis of the 2021/22 RPM BRA: Revised," August 24, 2018 and Table 4, PJM, "2021/22 RPM BRA Results" May 23, 2018.

FIGURE 10: MARYLAND MARKET CONCENTRATION



Sources and Notes: Velocity Suite, ABB Inc., accessed January 23, 2021. The DPL zone market concentration (rather than the DPL-South LDA) is shown. Companies with market shares greater than 5% are shown.

II. Impacts of the Minimum Offer Price Rule in Maryland

A. Conflicts with State Policy Objectives

Maryland's *2019 Clean Energy Jobs Act* requires transitioning to a 50% renewable power supply by 2030, of which at least 14.5% is to be supplied by in-state solar resources and another 1,200 MW from offshore wind. The Act further requires a study of the costs of achieving a 100% clean energy supply mix by 2040.[23]

These policies reflect the public's concerns about climate change and the state's commitment to doing its share to reduce its contribution to the global problem. Absent such policies, the free market would over-produce greenhouse gases and other pollutants, since fossil-fuel-fired generators do not have to pay for the majority of the social costs that their emissions incur. It is a classic case of unpriced environmental externalities, a market failure that can only be addressed through policy mechanisms. One type of mechanism charges emitters for their emissions, through carbon taxes or cap-and-trade programs, to disfavor their production and reward non-emitters through higher market prices for energy. We and many other economists have written about the economic efficiency advantages of such an approach. However, even if carbon pricing is pursued, the political likelihood is that carbon prices may not be set high enough to support sufficient investment to meet mandated clean energy targets in the timeframe required. For

[23] Maryland State Senate, "Clean Energy Jobs," SB 516, passed on May 25 2019.

example, Regional Greenhouse Gas Initiative (RGGI) prices have been very low and are applied in only a subset of PJM states.[24] Absent a carbon price that is high enough and has a broad enough scope, Maryland and other environmentally-oriented states must use alternative means to support emissions reductions. Maryland, like other states, has used a variety of market-based approaches, long-term contracts, and other policy mechanisms to support an increasingly decarbonized supply mix.

Even though payments for clean energy attributes serve to internalize externalities and thus improve the efficiency of market outcomes, the expanded MOPR provisions consider them "subsidies" and subjects the resources to minimum offer prices. As discussed in Section I.C above, the MOPR requires policy-supported resources to offer at a price reflecting their full cost (net of energy revenues) as if they did not also receive out-of-market support reflecting their environmental value. This can prevent them from clearing the capacity market, as illustrated in Figure 8 above.

The FERC's rationale for having expanded MOPR to policy-supported resources was to "protect" prices in the competitive market from being suppressed by state-sponsored resource planning decisions. State policy-support will tend to attract incremental clean energy supply, displace fossil generation that would otherwise be built (or allow additional aging plants to retire), and reduce prevailing capacity market prices. Under FERC's theory, these lower prices amount to an artificial suppression of market prices; applying a MOPR "corrects" market prices to the higher level that would prevail absent states' policies.[25]

We disagree with this theory. In our view, state policies such as Maryland's aim to address the market failure of environmental externalities, and thus tend to guide the sector toward a more efficient outcome. Recognizing the environmental externality value of these resources, as expressed through the policy support they receive, reduces their net cost of providing capacity. Their "competitive" cost of providing capacity is thus very low or even zero as they will generally be built even if they receive no capacity payment. Imposing the MOPR on such resources and ignoring the capacity value they provide thus distorts the market, rather than correcting it. Indeed, although these resources will provide energy and contribute to supply adequacy, the MOPR causes the capacity market to procure enough non-policy resources to meet the traditional reliability requirement, as if the policy-supported resources did not exist. Excluding policy resources thus results in procuring more capacity than needed and raises prices above the level corresponding to actual supply and demand conditions. Moreover, the distortion would increase as the quantity of policy-supported resources grows. This does not make for a well-functioning market, nor one that could sustainably support investment when needed. Investors must discount a capacity price that is elevated by a controversial rule and is increasingly unstable with so much latent supply being artificially excluded. Thus, the MOPR is not a sensible policy even if one's objective is only to support competitive markets rather than to support clean energy policies.

The biggest problem with applying the MOPR to policy-supported resources is that it imposes excess costs on customers and society as a whole. It imposes costs on customers in two ways: first, by requiring customers to make higher clean energy program payments in order to bring clean resources online, since they will not earn a portion of their revenues from the capacity market; and second, by producing higher capacity prices that are paid to all clean and fossil plants that clear the capacity auction.[26] These costs might discourage Maryland from fully following through in its environmental goals. Even if not, the MOPR

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[24] Maryland, Delaware, Virginia, and New Jersey are members of RGGI. Pennsylvania is considering the possibility to join RGGI.

[25] Federal Energy Regulatory Commission (FERC), "Order Establishing Just and Reasonable Rate," issued December 19 2019.

[26] See Written Testimony Of Dr. Kathleen Spees and Dr. Samuel A. Newell, "The Economic Impacts of Buyer-Side Mitigation in New York ISO Capacity Market," November 18, 2020.

would still favor non-policy-supported resources, which are mostly fossil-fired plants, to clear the capacity market and stay online rather than retire. This uneconomic support for fossil plants runs counter to the environmental objectives underpinning the adoption of Maryland's current legislation.

To summarize, applying MOPR to policy-supported resources in Maryland can be expected to lead to the following undesirable effects:

- Limitation on the ability for clean energy resources to generate revenue and interfere with Maryland's 2030 RPS.
- The retention of uneconomic fossil-fired generation that is unnecessary for reliability, impeding Maryland's efforts to achieve transition to clean electricity.
- Higher market clearing prices exceeding the level corresponding to actual supply conditions and causing a large wealth transfer from customers to incumbent suppliers.
- An unsustainable market as these distortions become larger over time under Maryland's statutory mandate to achieve 50% renewable electricity by 2030 and explore 100% clean electricity by 2040.

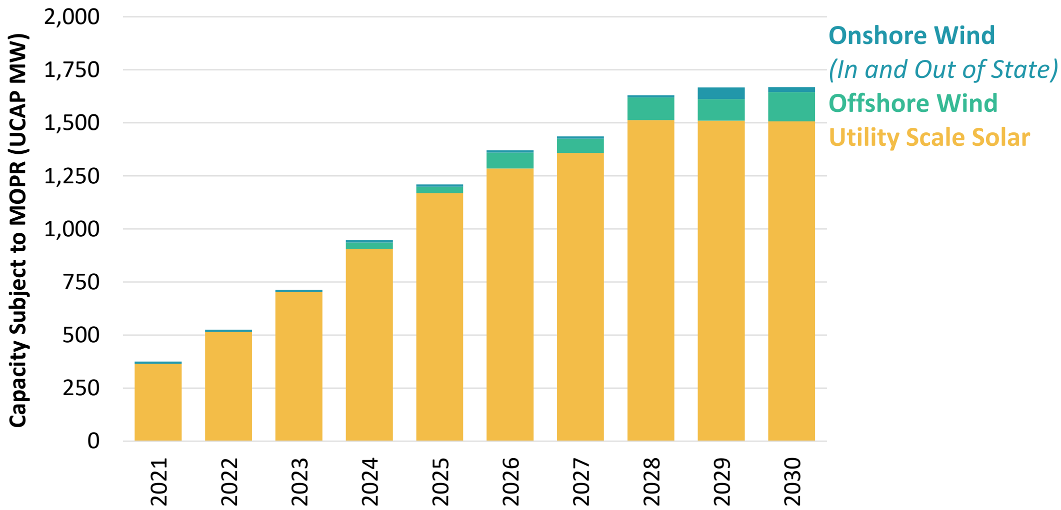
All of these challenges are amplified by the fact that several other states across the PJM region have made similarly strong commitments to clean energy including Illinois at 100% clean energy by 2050, Washington DC at 100% renewables by 2032, New Jersey at 100% clean by 2050, and Virginia at 100% renewable by 2045/2050.

B. Scale of Policy Resources Affected

The expanded scope of MOPR limits the ability for states' policy-supported renewable resources to clear the PJM capacity market. However, not all Maryland clean energy resources would be excluded by MOPR. Existing resources that previously cleared the BRA or signed interconnection agreements prior to the December 2019 order are exempt from MOPR. Resources that do not receive state subsides such as Calvert Cliffs Nuclear Facility or that do not participate in the capacity market (i.e., net-metered solar) are not subject to MOPR. Finally, resources have the opportunity to seek a unit-specific MOPR price that is lower than the PJM default MOPR price, which could enable some policy resources to clear the market even if they are subject to MOPR.

Figure 11 summarizes our estimate of the policy resources contracted to Maryland customers that will be subject to MOPR if the current rule remains in place. The total quantity of resources subject to MOPR is relatively small on a UCAP basis given the ambitious scope of Maryland's 50% renewable mandate, this is because a significant share of Maryland's anticipated clean energy resources will be eligible under the existing resource exemption, including the US Wind Project (270 ICAP MW). We assume 500 ICAP MW of Round 2 offshore wind will be developed within the applicable budget cap, reflecting current assumptions regarding the relatively high cost of building new offshore wind. New resources procured to meet the in-state solar requirement, the Skipjack offshore wind farm (120 ICAP MW), and Round 2 offshore wind procurements are assumed to be subject to MOPR. In total, the capacity subject to MOPR may grow to approximately 1,200 UCAP MW by 2025 and approximately 1,650 UCAP MW by 2030.

FIGURE 11: POLICY RESOURCES CONTRACTED TO MARYLAND CUSTOMERS SUBJECT TO MOPR



Sources and Notes: Brattle analysis based on the requirements specified in the Maryland *2019 Clean Jobs Act* and existing and proposed projects from Velocity Suite, ABB Inc., accessed January 23, 2021.

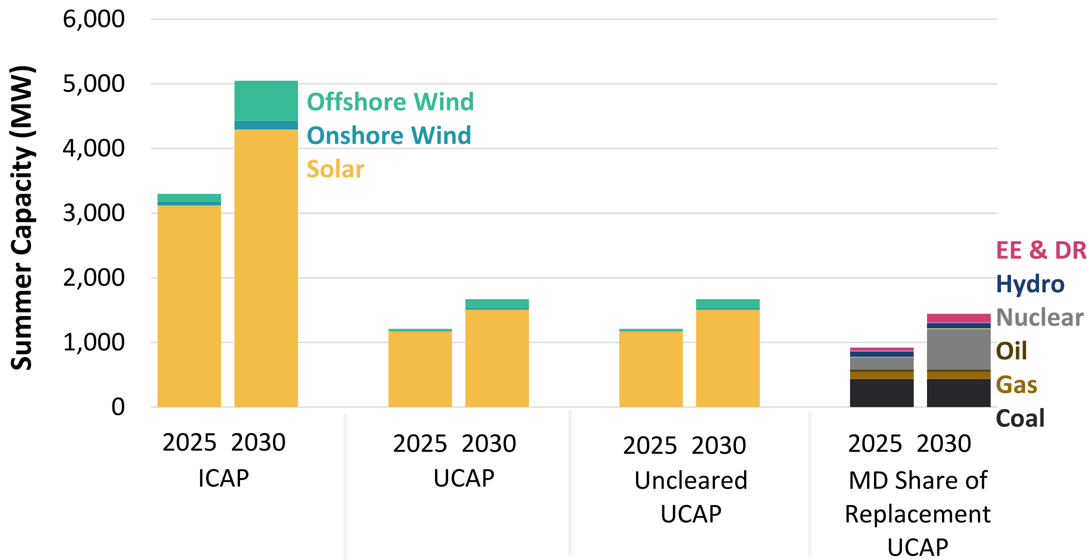
C. Impacts on Resource Mix and Customer Cost

The total quantity of resources subject to MOPR PJM-wide could be approximately 11,000 UCAP MW by 2025 and 14,000 UCAP MW by 2030. The majority of these resources are multi-unit nuclear plants earning ZECs and subject to a low or zero MOPR price and thus would be very likely to clear the capacity market. However, given current MOPR price levels (and after adjusting for projected resource cost declines), new onshore wind, offshore wind, and solar resources are unlikely to clear at projected capacity prices. Thus, on a PJM-wide basis we find that approximately 3,600 UCAP MW of policy resources are at risk of not clearing by 2025, and up to 5,800 UCAP MW by 2030.[27]

In Maryland, the MOPR will likely prevent all policy resources subjected to the MOPR from clearing the PJM capacity market. Figure 12 illustrates the contracted renewable resources subject to MOPR in Maryland in 2025 and 2030 and the market response to replace the uncleared capacity. Our analysis indicates that fossil resources are likely to replace approximately 50% of the uncleared policy resources contracted to Maryland in 2025, and 35% in 2030. Absent MOPR, these aging fossil resources would be likely to permanently retire.

[27] "2022/2023 BRA Default MOPR Floor Offer Prices for New Entry Capacity Resources with State Subsidy," PJM Interconnection LLC and "2020 Annual Technology Baseline," National Renewable Energy Laboratory.

FIGURE 12: MARYLAND CONTRACTED CAPACITY SUBJECT TO MOPR AND REPLACEMENT CAPACITY



Sources and Notes: "Maryland share of replacement UCAP" summarizes the replacement capacity resources that are uncleared under a No MOPR scenario that do clear under MOPR. It reflects Maryland's share of the incremental PJM-wide cleared capacity, calculated as the fraction of Maryland uncleared MW divided by PJM-wide uncleared MW.

Our analysis (described in further detail in section IV and in Appendix) indicates the application of MOPR to policy resources will subject Maryland customers to an additional $236 million in costs in 2025 falling to $194 million per year by 2030.[28] As outlined in Section I.C above, the application of MOPR to policy resources leads to higher capacity prices because the displaced resources subject to MOPR are replaced by more expensive resources, and fewer resources clear the capacity market overall (producing higher prices on the PJM demand curve). We estimate that average capacity prices paid by Maryland consumers would include a MOPR-driven premium of $34/MW-day in 2025 and $24/MW-day in 2030. Our estimate is consistent with or on the lower end of price impacts of MOPR presented in other studies.[29] In addition, a double payment occurs because customers are paying for capacity through the capacity market and again for renewable capacity under the Maryland RPS, further increasing the costs of MOPR.

Further, we note that the capacity market is a substantial revenue source for solar resources Maryland and across the PJM footprint, meaning that excluding solar resources from earning capacity revenues would increase the net costs of attracting these resources online. This increases the risk that solar REC prices could increase above the alternative compliance payment or exceed the applicable rate caps and

28 See reference to PSC-Brattle MOU *supra*. The Brattle model of the PJM RPM in 2025 reflects confidential supply offer data from the 2021/22 auction, adjusted for expected retirements and new entry. For 2030, we use a synthetic supply curve based on public data and estimate the long-run average avoidable net going forward costs of supplying capacity; this 2030 supply curve is more elastic, yielding relatively lower price impacts of MOPR for the same quantity of capacity excluded by MOPR. Due to the increased supply elasticity assumed in 2030 compared to in 2025, the overall costs of MOPR are lower even though the amount of capacity subject to MOPR increases.

29 For example, in MOPR/FRR Sensitivity Analyses of the 2021/22 RPM Base Residual Auction, the IMM estimated a $25-$234/MW-day cost reduction from FRR application to various quantities of supply subject to MOPR and other design structures. In a dissent to the December 19 2019 FERC Order which expanded the scope of MOPR to renewable sources, Commissioner Richard Glick stated a $40/MW-day price impact due to MOPR. In a webinar, ICF estimated $25-35/MW-day short term, $30-50/MW-day mid-term, and $50-70/MW-day long-term price effects due to implementation of MOPR with no additional FRR.

that the Maryland in-state solar carve outs may not be achieved. Under our study assumptions, we assume that solar costs decline quickly enough that the alternative compliance payment would be non-binding even in the presence of MOPR. However, if the pace of solar costs do not decline as rapidly as we assume, there is a risk that the loss of capacity revenues to Maryland solar resources could limit total achievement toward the in-state solar requirement due to applicable budget caps. For onshore and offshore wind, we anticipate that capacity revenues are too small a share of the total resource revenues to introduce a material impact on the ability to achieve legislative goals within the budget cap.[30]

III. Description of Resource Adequacy Alternatives for Maryland

There are a range of alternative market-based and planning-based approaches to supporting reliability and resource adequacy, but not all of these options are immediately available to Maryland.[31] Most importantly, given the context of this study, Maryland does not have unilateral authority to eliminate the MOPR on policy resources within the PJM capacity market. Maryland also does not have the unilateral authority to make other potentially beneficial changes to the RPM rules that would help it to better align with Maryland's clean energy mandates.

Maryland does have a range of options it could pursue independently through the FRR alternative including planning-based or auction-based approaches. The State has the option to include environmental mandates as a consideration within the FRR. These Maryland-alone FRR approaches could have a wide range of economic impacts, environmental outcomes, and implementation mechanics. We describe several options in this section, focusing on the subset that we anticipate would offer the greatest economic or environmental benefits to the State.

However, none of these Maryland-alone FRR alternatives is likely to offer the same level of benefits as a properly designed regional marketplace that aligns with State policy goals. Therefore, we discuss the elements of a regional adequacy design that would eliminate MOPR on policy resources, continue to ensure reliability, and support states' policy objectives.

A. Overview of Alternative Design Options

Table 4 below summarizes the status quo PJM capacity market and three qualitatively different approaches to achieving resource adequacy for Maryland without a MOPR applying to policy-support resources: through planning-based FRR, auction-based FRR, or an integrated clean capacity market (ICCM). In the following subsections, we describe the simplest possible approach to implementing each design in

[30] As noted above, we assume that Maryland will procure only 500 ICAP MW of the total 1,200 MW Round 2 maximum procurement goal, but the limitation on total achievement is associated with a modest overall program budget cap as compared to the procurement goal. The incremental impact from MOPR to increase program costs is unlikely to be large enough to further limit the number of projects eventually contracted.

[31] For a broader discussion of alternative resource adequacy structures beyond those that we view as available to Maryland at the present time, see Pfeifenberger et al., "A Comparison of PJM's RPM with Alternative Energy and Capacity Market Designs," Prepared for PJM Interconnection, LLC, The Brattle Group, September 2009.

Maryland, as well as the design enhancements that could improve the economic efficiency and effectiveness of each design in the context of Maryland's clean energy objectives.

TABLE 4: RELATIVE ADVANTAGES OF ALTERNATIVE RESOURCE ADEQUACY DESIGN OPTIONS

DESIGN	ADVANTAGES	DISADVANTAGES
Current PJM Capacity Market *(with MOPR on Policy Resources)*	• Regional competition • Track record of reliability at low cost • No implementation costs or risks • Market power mitigation authority • Avoid FRR lock-in period • Possibility that MOPR will be eliminated in any case within a timeframe of a few years before major costs are imposed • Maintain focus on first-best regional solution	• MOPR-driven costs • MOPR maintains more aging fossil plants that are not needed for reliability and misalign with policy objectives • MOPR is inconsistent with clean energy mandates
Planning-Based FRR	• Eliminate MOPR on policy resources & mitigate (not eliminate) MOPR price impacts • Ability to consider a wide range of policy objectives	• Lose competitive market benefits, shifting to likely less efficient planning and potential regulatory capture • Shift risk of uneconomic investments & contracts from generators to customers • Aligning FRR entity and customer interests • Potential for excess influence from FRR planning entity • Compensating FRR entity for risks • Misaligned with retail choice • Misaligned with existing market-based investments • Reduced transparency • High implementation complexity & risks • 5-year FRR lock-in period
Auction-Based FRR	• Eliminate MOPR on policy resources & mitigate (not eliminate) MOPR price impacts • Simplest FRR option • Multi-state approach could achieve most competitive benefits of a no-MOPR RPM	• Lose some regional market benefits of broader competition (unless pursuing a multi-state FRR approach) • Compensating FRR entity for risks • Medium implementation complexity & risks • 5-year FRR lock-in period
Integrated Clean Capacity Market	• Eliminate MOPR on policy resources & mitigate (not eliminate) MOPR price impacts • Greater competition among clean resources • Efficiency benefits of co-optimizing capacity and clean energy procurements • Option to accelerate clean energy achievement if prices are low • Multi-state approach could achieve most competitive benefits of a no-MOPR full RPM *plus* a regional clean energy marketplace	• Lose some regional market benefits (unless pursuing a multi-state or PJM-wide approach) • Compensating FRR entity for risks (not relevant if achieved under a PJM-wide approach) • High implementation complexity & risks

B. Status Quo RPM Capacity Market

HOW WOULD IT WORK?

The simplest option for Maryland would be to stay within the current PJM capacity market and allow private market participants to continue making resource decisions and private commitments as discussed in Section II above. Current rules would impose MOPR on an increasing quantity of policy resources committed to Maryland customers thus imposing associated costs on customers and interfering with Maryland's environmental goals.

WHAT DESIGN VARIATIONS COULD BE CONSIDERED?

Maryland does not have unilateral authority to change the design of the PJM capacity market to better accommodate State clean energy policies. It is possible, however, to influence the design through FERC proceedings, federal appeals, stakeholder processes, OPSI membership, and engagement with PJM staff. Regardless of whether Maryland chooses to pursue an FRR alternative, it would be beneficial to pursue RPM design enhancements that would better align the RPM with the needs of Maryland and other states with their environmental policies. These RPM-related enhancements could include:

- Eliminating the application of MOPR on environmental policy resources.
- Adjusting the capacity demand curve to avoid procuring excess capacity by aligning the Net CONE parameter with the true cost of new entry in the next Quadrennial review.[32]
- Considering adopting a two-season capacity market that would better enable clean energy resources that have seasonally very different capacity ratings, and would allow reduced winter procurements in the near-term (but also prepare for the possibility of higher winter loads in a long term scenario with electrified space heating).[33]
- Completing the development of an effective load carrying capability (ELCC) approach to capacity resource accreditation that more accurately measures resources' capacity value, particularly for intermittent and energy-limited resources.[34]
- Longer term, enhancing PJM's probabilistic resource adequacy modeling and its accreditation to account for flexibility-driven reliability events in addition to peak-driven reliability events.

These RPM enhancements would benefit Maryland customers if Maryland opted to continue participating in PJM's capacity market without an FRR. Even if Maryland did opt for an FRR, these enhancements would

[32] For example, one could shift the demand curve to the left while ensuring reserve margins are met. See Newell *et al.*, "Fourth Review of PJM's Variable Resource Requirement Curve," Prepared for PJM, The Brattle Group, April 19, 2018.

[33] A two-season capacity market design would enable seasonal capacity of all resource types and more accurately address seasonal capacity supply and demand in every location. This would be achieved by establishing separate reliability requirements and capacity demand curves for summer and winter needs, considering peak load and marginal cost of meeting supply in each season, thus producing efficient prices that reflect the same value per unit of avoided load shed event between seasons. See Newell et al., "Opportunities to More Efficiently Meet Seasonal Capacity Needs in PJM," Prepared for the NRDC, The Brattle Group, April 12, 2018.

[34] See "Issue Charge," PJM Interconnection, LLC, March 30, 2020 and "10.30.2020 Filing - Reliability Assurance Agreement Revisions," PJM Interconnection, LLC, October 27, 2020.

benefit Maryland customers somewhat by improving the accounting requirements that affect clean energy resources and by reducing prices in the RPM (thus indirectly reducing prices realized under an auction-based FRR).

WHAT ARE THE ADVANTAGES AND DISADVANTAGES?

There are a number of **advantages** of staying within the current PJM capacity market including:

- Path of least resistance with no implementation costs, risks, or obstacles. This approach poses none of the complexities associated with re-defining the roles and authorities of utilities, state agencies, or other entities.
- Maintaining regulatory stability for market participants.
- Maintaining the competitive benefits of participating in a broad regional marketplace (though these will be eroded over time as the scope of MOPR increases in Maryland and PJM-wide).
- Maintaining option value by deferring an FRR implementation decision until after the state gains full clarity on whether MOPR will be eliminated from the PJM market and whether a first-best regional market solution is likely to materialize.
- Maintaining state agencies' focus on other priorities, including implementation of clean energy mandates and efforts to improving the broad PJM capacity market to achieve a sustainable long-term design.

The **disadvantages** of staying within the current PJM capacity market are largely associated with the impacts of the expansive application of MOPR to policy resources, including:

- MOPR will impose excess costs on customers, with the scope of these costs growing over time along with the quantity of policy resources affected.
- MOPR will cause the uneconomic retention of existing fossil plants, counter to Maryland's and other states' environmental policy goals.
- Maryland has no authority to unilaterally change the RPM market design and cannot guarantee the success of any efforts invested in improving the design.

C. Planning-Based Fixed Resource Requirement

HOW WOULD IT WORK?

One approach to implementing an FRR in Maryland would be to designate an FRR entity and authorize it to conduct capacity planning subject to regulated cost recovery. The designated FRR entity could be a state agency, the distribution utility, an independent procurement administrator, or (more likely) some combination. The FRR entity would be selected either state-wide or individually for each distribution utility's service territory and would take responsibility for meeting the capacity needs of customers within that service territory. The processes for developing each one's FRR plan would be similar to the integrated planning activities planning activities pursued in other regulated states:

- The FRR entity would take on responsibility for developing a comprehensive resource plan that projects the full cost of electricity to customers across a range of possible outcomes and recommends a portfolio of resources and procurements for approval by a state authority.
- The recommended resource plan would account for system and local capacity needs, legislated clean energy mandates, existing contracts such as with offshore wind resources, and any other policy preferences that State regulators require to be considered such as localized pollution or employment effects.
- Interveners and commission staff would scrutinize the recommended resource plan and suggest revisions.
- The FRR entity would proceed to engage in contracts to fulfill the approved resource plan. The quantity procured to fulfill the plan would likely be lower than the quantity that would otherwise be procured within the RPM market, given that FRR entities are not subject to the sloping demand curve which has tended to procure excess quantity in recent years.
- Contracted supply resources would make a capacity commitment to the FRR entity up to the quantity that they are qualified to contribute under PJM's capacity accounting mechanisms. The FRR entity would be obligated to pay the seller for these capacity commitments at the agreed-upon price; the resource would be obligated to perform under PJM's capacity obligations.
- New policy resources that Maryland contracts under all-in bundled contracts would be prioritized for inclusion in the FRR plan to avoid the application of MOPR on these resources. These already-contracted volumes would form only a portion of the total FRR plan quantities needed, with the remainder procured from other clean and fossil capacity resources located in the relevant LDAs. Capacity resources would offer to sell into the FRR plan at the price they would otherwise expect to earn by selling their capacity into the RPM; thus prices paid for capacity in the FRR would be similar to the prevailing prices in the broader PJM market.
- The FRR entity would take responsibility for all settlements with PJM under the FERC Tariff. Any non-delivery or performance penalties caused by resources under an FRR commitment would be charged to the FRR entity (and likely should then be passed back as an assessment to the individual resource creating the penalty liability).
- The FRR entity would earn compensation for conducting the resource planning, procurement, and settlement functions, including compensation for the risks and costs associated with any bilateral contracts and would earn an approved rate of return on any required resource investments.
- Costs associated with capacity procurements and FRR entity compensation would be passed on to all end-use customers as non-bypassable charges.

If the mandate to develop an FRR plan were interpreted broadly, the implementation of a planning-based FRR would mark a significant departure from current State policies that are designed to rely on competitive forces within the wholesale market to drive efficient supply-side resource investments and enable competitive retail providers to serve end use customers. Instead, the FRR entity would take on many of the responsibilities that are currently left to individual market participants reacting to price incentives. Compared to current approaches, this planning-based FRR would create greater ability to reflect a wide range of non-price policy objectives within the resource plan, greater reliance on the technical ability of the FRR entity to engage in efficient planning and contracting, and greater reliance on State agencies to develop effective oversight. To the extent that the resource plan is implemented through longer-term contracts or bundled contracts, this would shift risks away from capacity sellers and toward customers. Both sellers and customers would enjoy more pricing stability and access to lower-cost financing under such an approach, but the costs of any uneconomic planning or contracting decisions would be borne solely by customers. Overall, a broad interpretation of planning-based FRR would be a major policy shift away from markets and toward the regulated utility model.

If the mandate to develop an FRR plan were interpreted more narrowly as the task of securing least-cost capacity for a period of no more than five years, then the implications would also be more limited. In that case, the FRR entity would not be authorized to sign contracts beyond the five-year FRR election period, would be precluded from signing bundled contracts (only capacity contracts would be considered), and would not be asked to consider factors other than capacity price in contracting decisions. Even with this more limited scope, the FRR entity would still displace the role of competitive retailers in securing capacity for their own customers and insulate certain capacity sellers from market forces for the duration of the capacity contracts. However, these effects would be limited to the five-year duration of the FRR election period, after which Maryland would be able to make a new decision regarding whether to re-enter the PJM capacity market.

WHAT DESIGN VARIATIONS COULD BE CONSIDERED?

Pursuing a planning-based FRR approach would require the State to make a number of policy choices regarding how the FRR would be implemented, including:

- **Breadth of FRR Planning Goals:** As discussed above, the most limited approach would be for the FRR entity to procure capacity to fulfill FRR planning requirements for only five years, the minimum duration of the FRR provision of PJM's tariff. A more expansive approach could allow longer-term contracts and consider a wide array of policy goals when developing a resource plan. This would mark a major shift away from reliance on the market to drive resource decisions and toward an integrated planning, however. If the State wishes to continue its policy of relying on wholesale and retail markets to achieve cost discipline and planning efficiencies, a narrow interpretation of the FRR plan would be most consistent.
- **Selection of the FRR Entity:** The PJM FRR rules align with distribution utility service territories, meaning that the utilities will likely need to have some role in assisting with data requirements and settlements. However, the utilities are not a natural party to make most resource contracting decisions in Maryland given their affiliate relationships with potential contractual counterparties.[35] Another option would be to task a State agency or a third party independent evaluator to select capacity commitments, then possibly transferring the obligations to each separate utility to manage settlements and penalties.
- **Geographic Scope of the FRR Election:** The choice to adopt an FRR plan would not necessarily need to be implemented across all of Maryland, but instead could be implemented within only a portion of the State if desired. This might suffice to avoid MOPR if most of the Maryland-contracted resources subject to MOPR could be utilized within the FRR plan of a single distribution utility area, to meet just that area's capacity needs. However, the ability to do so effectively depends on transmission constraints and their relationship to where the clean resources will be located. Given the complex transmission topology affecting Maryland and the uncertainty where new in-state solar and offshore wind will be located, it is unlikely that any single distribution area(s) could serve as a catch-all FRR entity for the State.

[35] Most notably, the affiliate relationship amongst the three large utilities Baltimore Gas and Electric (BGE), Pepco, and Delmarva Power & Light (DPL) that are owned by the same parent company Exelon that owns Maryland's largest capacity resource, the 1,756 MW Calvert Cliffs Nuclear Plant, according to S&P Global Market Intelligence.

- **How to Limit Customer Exposure to Uneconomic Contracting Choices:** Ensuring cost discipline will be a challenge under a planning-based FRR given the need to rely on the FRR entity's business judgement (and State agency oversight) to identify the most beneficial price, term, resources, and location of all capacity commitments. The FRR entity would not have a profit motive for driving down costs and so may be less likely to garner the best price as compared to the competitive market. Non-resolvable planning uncertainties will translate into risks for uneconomic contract decisions. These risks can be somewhat mitigated however if the scope of contracts is strictly limited to the five-year term, to capacity-only (not bundled) contracts, and if contracts are selected on the basis of price only rather than other considerations.
- **How to Enable Competitive Retailers:** Treating all capacity costs incurred by the FRR as non-bypassable charges would eliminate the role of competitive retailers in identifying low-cost capacity solutions on behalf of their own customers. To maintain greater consistency with retail choice, competitive retailers could be offered the opportunity to self-supply their own capacity needs by submitting resource commitments to the FRR entity in advance of any FRR commitment deadline. We note that enabling retailers in this way would be complicated and may be inconsistent with allowing the FRR entity to engage in forward or multi-year contracting.
- **How to Manage Penalty Risks:** The FRR entity responsible for settlements with PJM will face penalties if any of the FRR resources fail to deliver the promised capacity or under-perform relative to their capacity obligations. Under full RPM participation, PJM itself uses a system of credit requirements and imposes any penalties directly to individual resources' owners. In a Maryland FRR, the FRR entity would have to identify contractual means to pass these same penalty risks back to the individual resources and manage the risk of counterparty defaults (as any default on penalty payments would ultimately be passed to customers).[36]
- **How to Remunerate the FRR Entity:** The FRR entity or entities would need to be compensated for their administrative activities and for the risks they bear. Administrative activities include selecting resources within the resource plan. Risks include taking on the financial costs associated with a large number of capacity contracts (in the range of 13,000 MW and $800 million to $1 billion or more per year); and the risks of any penalties that may be assessed by PJM, to the extent that it may not be possible to fully pass on all penalties to resource owners. The State would need to determine whether a fee-for-service approach is appropriate and whether any incentive-based remuneration would be pursued as a means of achieving cost efficiency on behalf of customers.

WHAT ARE THE ADVANTAGES AND DISADVANTAGES?

The **advantages** of a planning-based FRR approach include:

- The circumvention of MOPR application on policy resources contracted to Maryland, thus avoiding the customer costs of double-paying for capacity commitments (although there are other more market-oriented ways to accomplish this, as discussed in the following section).

[36] In addition to the "financial" non-performance assessment discussed here, FRR entities also have the option to elect physical non-performance assessment prior to the delivery year. Under this option the FRR entity would be required to update its Capacity Plan in subsequent delivery years to commit additional resources, "as a penalty for those committed resources that experienced Performance Shortfalls during the Delivery Year. See PJM, "FRR Entity Physical Option for Non-Performance Assessment," May 4, 2016.

- Possible cost savings. Maryland customers could save costs indirectly in two additional ways. First, by reducing the quantity of capacity procured to the FRR minimum (rather than the greater quantity that would be procured by the sloping demand curve). And second, by causing the overall PJM-wide capacity price to fall as Maryland will enable some resources to circumvent MOPR and take more demand than supply out of the capacity market. This reduction in the PJM-wide capacity price could indirectly benefit Maryland customers by reducing the price that must be paid to attract capacity resources away from RPM and into the FRR plan. However, these savings do not guarantee customer savings overall since the FRR plan will likely provide less competitive benefits and pose greater risks of uneconomic contracts and resource investments that would have to be borne by customers.
- The ability to consider other policy objectives beyond just price when selecting resources to include within the FRR plan, such as environmental, health, or employment effects.

The **disadvantages** of a planning-based FRR approach include:

- A shift away from the broad regional market and the competitive benefits provided. Inconsistency with State policies that have favored reliance on competitive, market-based approaches to driving the resource mix.
- Correspondingly shifted risks of uneconomic FRR contracting or investment decisions from generators to customers.
- Inconsistency with Maryland's policy to enable competitive retailers to serve customers through their own supply plans (rather than relying on a regulated entity to make supply decisions).
- Complexity, cost, and incentives challenges associated with properly selecting, incentivizing, and remunerating the FRR entity or entities.
- Reduced ability to implement effective market monitoring and mitigation in the primarily bilateral capacity arrangements (particularly in small, concentrated LDAs). Seller market power could become a concern for buyers; buyer market power could become a concern for sellers.
- Some distribution utilities that might be considered as FRR entities have unregulated generation affiliates that they might be tempted to favor. Such affiliate transactions produce poor incentives from a customer perspective, given that both parties to the contract wish for a higher price (while customers wish for a lower price).
- Being locked in to a five-year FRR election period, which presents the possibility of regret (if FRR planning costs are higher than anticipated or if the broader PJM market achieves the beneficial reforms needed for a first-best solution without MOPR).
- Partially undermine the performance and effectiveness of pricing signals for capacity within the Maryland LDAs (and to a lesser extent within the broader PJM capacity market). The elimination of the sloping demand curve for Maryland customers would forgo some of the price stabilization benefits, with the greatest effects realized in the Maryland LDAs and a lesser effect realized system wide. There would also be additional regulatory uncertainties imposed on capacity resources participating in both RPM and the FRR given the lack of clarity on the structure under which they would be remunerated over a typical asset life, though the five-year lock-in period would mitigate the effects.
- Reduced transparency as compared to a centralized market.
- High implementation complexity and costs, both for the regulator and the FRR entities.

D. Auction-Based Fixed Resource Requirement

HOW WOULD IT WORK?

An auction-based approach to implementing an FRR would have some similarities with the planning-based approach described in Section III.C but would utilize a competitive auction format to procure the quantity of capacity needed to meet Maryland's FRR plan. In its simplest form, the auction-based FRR would be implemented as follows:

- Each year the FRR entity would publish the parameters of a capacity procurement auction, clarifying the quantity of capacity that it would seek to procure on behalf of Maryland customers including the minimum share of total capacity that would need to be procured within each applicable LDA.
- As under the planning-based FRR, a portion of the FRR plan would be met by resources otherwise subject to the MOPR that are contracted on behalf of Maryland customers (to the extent that State agencies have the authority to direct this commitment under contract terms).
- The FRR entity would conduct a competitive auction to procure the remaining needed capacity from any PJM-qualified capacity resource in the relevant LDAs, with the FRR auction being indifferent to whether the underlying capacity resource is clean or fossil. Policy resources subject to MOPR would likely offer into the FRR auction at a low price given that they would be unlikely to earn capacity payments by selling into PJM's RPM auction. Other capacity resources would offer at prices near the expected price in the upcoming RPM auction (reflecting the opportunity cost of not selling into the PJM market). However, there would be concerns about market power, particularly if Maryland has less authority than PJM does to mitigate market power, as discussed below.
- The FRR procurement would be a single round, uniform price auction, and could produce higher prices in any LDAs for which the minimum capacity requirements are more costly to fulfill.
- The FRR entity would make a payment commitment to the cleared capacity resources and submit these cleared resources to PJM within the FRR plan. Any capacity resources that fail to clear the Maryland FRR auction would be able to offer their capacity into the subsequent BRA.
- The FRR entity would interact directly with PJM for the purposes of penalty settlements, passing any associated costs on to the individual resources.

Similar to the planning-based FRR, the auction-based approach would create an opportunity to enable resources contracted for policy purposes, and subject to MOPR, to provide capacity within the PJM footprint. This applies whether the policy resource is contracted on behalf of Maryland's customers or those of other states. The auction-based approach would maintain some advantages of the competitive PJM market including the ability to utilize market forces to procure capacity at least cost, pricing transparency, and reliance on unbundled energy, ancillary services, and capacity prices to drive resource entry and exit. Further, the one-year-at-a-time, capacity-only commitments limit the scope of cost exposure to Maryland customers. Even if FRR auction prices were to clear at an uneconomic high level in one year or in one LDA due to a design flaw or the exercise of market power, the realized high price would not be locked in over any multi-year contract terms, and any structural problems causing the uneconomic prices could be addressed in future auctions (they would not be locked in over a multi-year contract term). Oversight and compensation of the FRR entity would be far less challenging than under a planning-based FRR given that the auction procedures would be strictly delineated and approved by State authorities (minimizing the role of expert judgement or misaligned incentives in resource selection).

However, the simplest version of a Maryland-only FRR auction has a number of challenges that could make it unattractive as a permanent resource adequacy structure for the State. Maryland is a relatively small share of the PJM market and is broken into even smaller locational sub-markets for capacity, some of which have significant market concentration. This limits the scope of competition that could be achieved in a Maryland-only FRR auction. Market monitoring and mitigation would be more feasible in an auction format than in a bilateral planning-based approach but would still be more challenging due to the need to allow offers reflective of the opportunity cost of not participating in the RPM auction. The elimination of the sloping capacity demand curve could save some costs in the short term but would expose Maryland to the challenges of a vertical demand curve if maintained over a longer time period. Particularly in the smallest LDAs, the vertical demand curve in Maryland could produce higher price volatility, greater exposure to locational reliability shortfalls (or associated FRR penalties), and greater exposure to exercise of market power. Overall, the higher price volatility would produce a less attractive investment climate and so may produce less favorable outcomes over the long term as new resources are needed or existing resources need reinvestment to continue operating; based on current market conditions the BGE LDA appears most likely to face these small-submarket challenges in the near term but other LDAs could face similar challenges over time. The Maryland LDAs representing a small share of much larger PJM capacity regions would face fewer such challenges as the small volume of demand could be served by a wider array of resources and at a potentially more stable price informed by expectations in the subsequent BRA.

WHAT DESIGN VARIATIONS COULD BE CONSIDERED?

The simplest possible auction-based FRR format described here may be possible to refine in ways that would improve performance, though these enhancements also increase complexity, create a greater likelihood of implementation flaws, and at times present other trade-offs. Potential design variations include:

- **Choices Common to All FRR Variations.** As discussed above under the planning-based FRR variation, the auction-based FRR would need to establish the appropriate FRR entity, mechanisms for enabling competitive retailers, remuneration for the FRR entity, and approach to managing penalty risk.
- **Monitoring and Mitigation.** At a minimum, any FRR plan should include some means of reviewing market structure, auction competitiveness, and the potential for exercise of market power. An auction-based approach offers greater opportunities to implement effective controls on the exercise of market power, to the extent that a state agency has the authority to implement them. If Maryland has the authority, it would be beneficial to impose a capacity must-offer requirement and appropriate capacity offer caps on suppliers within the smallest import-constrained LDAs (BGE, Pepco, SWMACC, and DPL-South). The offer caps would need to be high enough to reflect all resource net going forward costs (including the expected opportunity cost of not selling capacity into the subsequent RPM auction).
- **LDA Sloping Demand Curves.** To the extent that the FRR auction would be utilized to support resource adequacy over an investment or reinvestment cycle, a sloping demand curve would benefit the sustainability of the design. Adopting a well-designed curve for the smallest LDAs within Maryland (SWMAAC, Pepco, BGE, and DPL-South) could provide a more sustainable basis for investments and maintaining locational reliability. For the portions of Maryland that can be served from resources in

EMAAC, MAAC and Rest of RTO, the interaction with the broader market will provide this price-stabilizing benefit even if Maryland maintains a vertical demand curve under the FRR auction.[37]

- **RPM-Derivative Pricing.** Most sellers in the FRR auction would likely offer at their opportunity cost of not selling capacity in the subsequent RPM auction. However, sellers will not know the upcoming RPM clearing price and so would have some uncertainty as to the best offer price in the Maryland FRR. If sellers guess systematically low, Maryland customers could benefit from a one-off discount to their capacity payments. If sellers guess systematically high (particularly in any constrained sub-LDAs), Maryland customers may have to pay an uneconomically high price for that one year. The "RPM-derivative pricing" concept proposed in the context of the New Jersey resource adequacy docket would seek to reduce this problem by accepting offer prices expressed as a percentage of the subsequent RPM price, thus protecting customers from uneconomic high prices (but also forgoing the possible benefits of low-price FRR outcomes). We note that this concept poses other complexities and challenges that would need to be addressed before being further considered in Maryland, particularly as associated with locational price differences and resources that have a minimum absolute payment needed to take a capacity commitment.[38]
- **Multi-State FRR Auction.** If Maryland were to consider an auction-based FRR as a permanent resource adequacy design, it would be beneficial to consider whether a multi-state FRR auction could become possible. Particularly if pursued alongside other states representing demand in the same LDAs, Maryland could increase access to the competitive benefits of a broader regional marketplace and mitigate challenges associated with operating a smaller sub-market.

WHAT ARE THE ADVANTAGES AND DISADVANTAGES?

The **advantages** of an auction-based FRR approach include:

- Circumvent MOPR on Maryland policy resources and mitigate some (but not all) of the costs of MOPR, similar to the other FRR options.
- Simplest possible approach to implementing FRR, reducing the risk of design flaws, especially if borrowing most auction rules from the PJM RPM.
- Reliance on a well-designed competitive auction approach maintains some of the benefits of the PJM capacity market including transparency, use of market forces to incentivize cost discipline, and auction format designed to attract a least-cost set of capacity commitments.
- If pursued through a multi-state FRR auction and with design enhancements such as sloped demand curves and comprehensive market monitoring and mitigation, an FRR alternative could form a sustainable long-term resource adequacy structure. If utilized broadly enough, the multi-state FRR could offer most or all of the competitive benefits of a no-MOPR PJM capacity market.

The **disadvantages** of an auction-based FRR approach include:

- Similar to other FRR options, implementation costs and challenges associated with managing penalty risks, settlements, and selecting an FRR entity (though fewer challenges than under a planning-based

[37] We do note that maintaining a vertical demand curve in these locations would make Maryland a bit of a free rider in terms of its ability to lean on the broader RTO market to pay for the price-stabilizing benefits of the system demand curve.

[38] See the full description of the RPM derivative pricing concept in "Independent Market Monitor Report on PSEG FRR 2.0, NJBPU Investigation of Resource Adequacy Alternatives," IMM, November 23, 2020.

approach, given the more prescriptive nature of the procurement that minimizes reliance on the FRR entity's business judgement).

- Losing the benefits of regional competition from participating in the broad PJM marketplace (unless Maryland identifies a way to pursue a multi-state FRR auction).
- Inefficiencies associated with capacity price uncertainties between the FRR auction and the RPM auction (potentially exposing customers to somewhat higher capacity prices in the FRR auction if potential sellers overestimate expected RPM auction prices).
- Challenges in preventing the exercise of market power in small concentrated LDAs.
- Challenges in addressing price volatility and supporting efficient price formation in small LDAs due to small sub-market size, lumpy nature of capacity investments, and lack of a sloping demand curve.
- Lock in to the five-year FRR commitment period, which may become unattractive if the MOPR is eventually eliminated from the PJM market.
- Implementation cost and complexity (though less complicated than a planning-based or ICCM-based FRR); developing the auction-based FRR into a more sustainable long-term design may further increase complexity.

E. Integrated Clean Capacity Market

HOW WOULD IT WORK?

The Integrated Clean Capacity Market (ICCM) is a resource adequacy alternative that is under active consideration by New Jersey and the New England region as a means of eliminating the MOPR on policy resources and better aligning the capacity market with state decarbonization policy goals.[39,40] The ICCM would build on the successes of the current capacity market with a new resource adequacy construct designed to meet both capacity and clean energy policy goals in a single procurement auction. The auction would procure two separate products: (1) capacity, denominated in UCAP MW and differentiated by location as in today's capacity market; and (2) renewable energy credits (RECs) or clean energy attribute credits (CEACs), denominated in MWh of clean energy attributes that can contribute toward Maryland's renewable portfolio standard. It could be implemented for a single state or a group of states.

Adapting the ICCM concept into Maryland's context, the design could be implemented as follows:

- A Maryland-alone ICCM could be unilaterally pursued under the FRR election option, under similar implementation choices as discussed under the prior two FRR design options. An FRR entity would need to be identified to implement procurement auction procedures, likely an independent entity that is not affiliated with any Maryland capacity resources, clean energy resources, or utilities.
- A multi-state or PJM-wide ICCM would achieve greater efficiencies by maintaining access to the broadest regional competition for both capacity and clean energy needs. This could be implemented

39 See the "Investigation of Resource Adequacy Alternatives Docket No. EO20030203," Prepared for State of New Jersey Board of Public Utilities, The Brattle Group, January 2021.

40 See Spees, "The Integrated Clean Capacity Market: A Design Option for New England's Grid Transition," October 1, 2020.

either under a multi-state FRR or through collaboration with PJM in enhancing or replacing the current RPM design.

- PJM would continue to establish the total and locational capacity requirements as well as resources' accreditation for meeting these requirements (all in UCAP terms), as under current FRR procedures.
- Maryland would establish its own MWh quantities of RECs to be procured within the ICCM, consistent with State legislative mandates to achieve up to 50% renewable procurement by 2030 and considering program budgets, State carve-outs for in-state solar and offshore wind resources, and other policies. Vertical or sloping demand curves for clean energy can be established based on clean energy mandates and program budgets and would be set independently from the total and locational demand curves for capacity. See additional discussion of design variations related to clean energy demand procurement below.
- Similar to the simpler auction-based FRR, the FRR auction administrator would conduct a single joint auction to gain resource commitments three years prior to the delivery year. Unlike in the current RPM or simpler auction-based FRR, the ICCM would procure two separate products at two distinct prices for meeting the capacity needs (in UCAP MW, defined by PJM) and the clean energy needs (in REC MWh, defined by Maryland).
- Fossil resources, demand response, storage, and energy efficiency would be eligible to sell capacity only. Renewable resources (and possibly nuclear) would be eligible to sell both capacity and RECs up to the maximum resource rating. Clean energy resources would thus earn two revenue streams from the auction, one from each product.
- Resources would offer a total revenue requirement based on the minimum payment needed to make a resource commitment in the ICCM. Clean energy resources would be assumed to be indifferent as to whether payments are earned from capacity sales or REC sales (as long as total revenues exceed the resource offer price).[41] Capacity-only resources, including fossil resources, would offer only capacity value under the current offer price format of $/MW-day UCAP.
- The auction clearing process would select the least-cost resource mix to meet both capacity and clean energy needs, setting prices based on the marginal cost of supply for each product.[42]
- Existing and future contracts for clean energy and capacity resources would be pre-committed within the ICCM and thus avoid MOPR application, subject to contractual obligations (similar to the other FRR design options).
- Customers and competitive retailers would be allowed to self-supply their capacity and REC obligations within the ICCM (similar to the enabling provisions for competitive retailers under the auction-based FRR).

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41 For example, a 100 MW installed capacity (ICAP) solar resource could be eligible to sell as much as 42 UCAP MW of capacity and 131,400 MWh of CEACs (based on a 42% capacity derating and 15% energy capacity factor). The resource might offer at $61/kW-year in ICAP terms, a price at which the resource is willing to sell its entire resource eligibility of 42 UCAP MW of capacity plus 131,400 MWh of CEACs. A low capacity price would require a relatively higher CEAC price in order for the resource to earn sufficient revenue and clear the market (and vice versa: a low CEAC price would require a higher capacity price before the resource would clear).

42 Specifically, the auction format would be a uniform-price, single-round auction. Procurements would utilize a surplus-maximizing objective function that optimizes resource selection and sets prices for each product based on the incremental cost of supply or shadow price on each auction constraint (these are standard practice as utilized in the current RPM and the auction-based FRR approach).

- Cleared capacity resources would be submitted to PJM as comprising the FRR plan, with the FRR entity taking responsibility for all PJM-assessed capacity penalties. Costs would be passed on to Maryland customers of the relevant capacity zones (no settlements would be assessed to competitive retailers to the extent that they had self-supplied capacity).
- Cleared clean energy resources would be required to fulfill their REC delivery obligations within the delivery year, with procurement costs passed on to Maryland customers in proportion to energy consumption (no settlements would be assessed to customers or competitive retailers to the extent they had self-supplied clean energy procurements).

HOW WOULD DEMAND FOR CLEAN ENERGY BE EXPRESSED?

Demand for clean energy would be expressed as either a vertical or sloping demand curve for the MWh of RECs that are to be procured on behalf of Maryland customers in the relevant delivery year. The following Figure 13 provides an illustrative example of how demand for clean energy could be expressed in Maryland for the year 2030 as consistent with State law, though there are a number of implementation variations to consider.

The demand and treatment of clean energy resources in in the ICCM could be represented as follows:

- **Total State Clean Energy Demand:** Maryland's total demand for clean energy (blue line) would be based on the total renewable energy mandate of 50% by 2030; together with existing nuclear supply (which is not eligible for clean energy payments), the total State clean energy target is 72% by 2030. A downward-sloping demand curve could be consistent with this target, with an illustrative curve here based on three demand curve points: (a) *a "target" point* at a quantity consistent with the 50% RPS goal (72% total clean energy) and target price based on the estimated cost of developing new clean energy resources, net of their anticipated energy and capacity revenues, or the "clean net cost of new entry" (Clean Net CONE); (b) *price cap* at 1.5x the Clean Net CONE and 5% below the target quantity; and (c) *a foot point* at 100% clean energy and a price of zero. The sloping curve would offer benefits including price stabilization and the ability to accelerate clean energy achievement if this can be accomplished at low cost.[43]
- **Nuclear:** Consistent with current Maryland legislation, existing nuclear would not be eligible to receive clean energy payments (but would be eligible to earn capacity payments). If at some point the State wished to incorporate nuclear resources into the ICCM, it would become an eligible resource to contribute to clean energy mandates and to earn CEAC payments, and the total clean energy procurement target would be increased by a commensurate amount. CEAC prices paid to nuclear resources could be capped at a lower level than the payments awarded to other supply resources (which would preserve some price competition between nuclear and renewable supply resources while preventing payments in excess of any total program budget).
- **In-State Solar Carve-out:** The 14.5% in-state solar carve-out would be reflected as a separate carve-out demand curve within the ICCM. Prices for in-state-solar RECs (SRECs) would clear at higher prices if that is required to attract sufficient supply, similar to how SREC prices can trade at a price premium

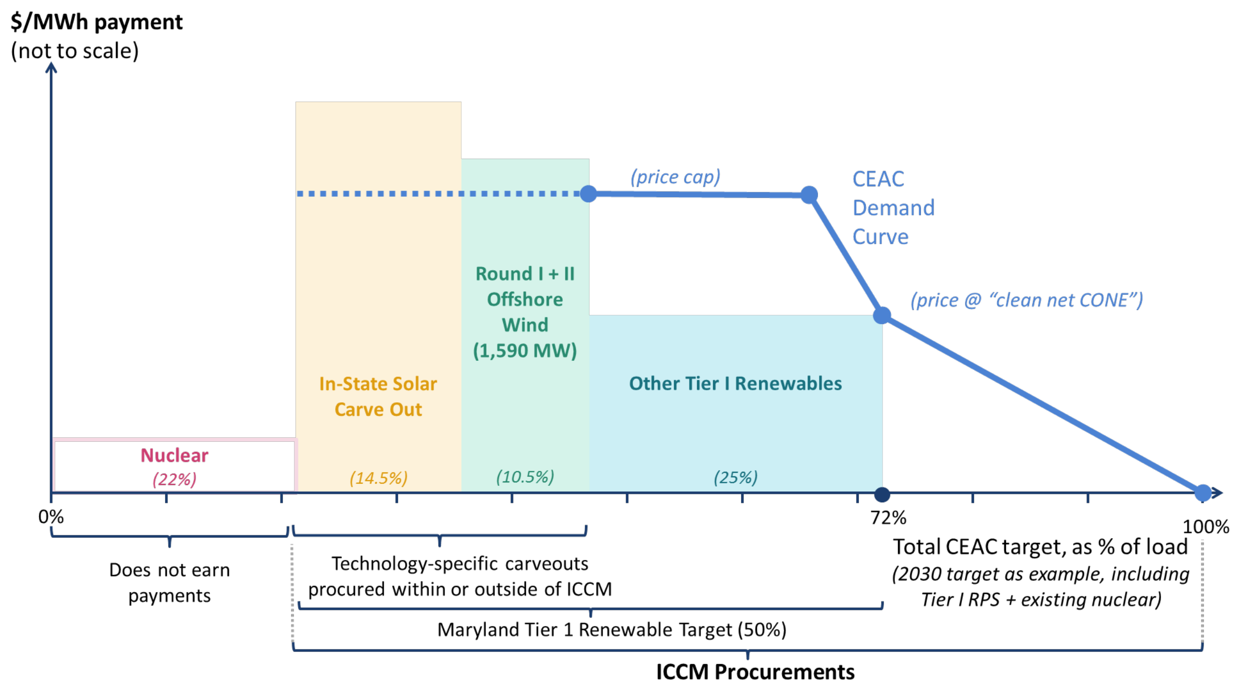
[43] See additional discussion of how a state demand curve for clean energy under the ICCM could be developed in Appendix B.1-B.2 here, and in "Investigation of Resource Adequacy Alternatives Docket No. EO20030203," Prepared for State of New Jersey Board of Public Utilities, The Brattle Group, January 2021.

relative to other Tier 1 REC prices. Retailers' private contracts for in-state solar resources would be accommodated as self-supply for SREC (and, if relevant, also for capacity) within ICCM auctions.

- **Offshore Wind:** Offshore wind could continue to be procured through State solicitations as today, with procured quantities utilized as self-supply within the ICCM auctions. This approach would allow the offshore wind resources to contribute to capacity needs and would reduce the net volume of RECs procured from other resources in the ICCM auction.
- **Other Tier 1 REC Resources:** Other clean energy resources such as onshore wind and solar that are qualified to produce Tier 1 RECs in Maryland could fulfill the remaining total clean energy demand consistent with the clean energy demand curve (with increasing quantities at lower prices).
- **Storage, Energy Efficiency and Demand Response:** These capacity-only clean resources would participate as capacity resources in the ICCM but would not earn REC payments.

Together, these approaches would enable Maryland to meet its clean energy requirements within an auction-based format alongside capacity requirements.

FIGURE 13: ILLUSTRATIVE 2030 MARYLAND DEMAND CURVE FOR CLEAN ENERGY WITHIN THE ICCM



WHAT DESIGN VARIATIONS COULD BE CONSIDERED?

If Maryland were to pursue an ICCM approach, we assume that the concept would be intended as a long-term sustainable resource adequacy design for the Maryland, multiple states, or the PJM region. Thus, the design would need to include the components of a permanent, sustainable FRR construct as described above, plus the elements of a long-term sustainable clean energy procurement mechanism. Some of the design variations that could be considered include:

- **Regional Scope, Governance, and Implementation.** A Maryland-alone or multi-state ICCM could be implemented under the current PJM Tariff rules for an FRR. As with other FRR structures, this would necessitate establishing an independent auction administrator and FRR entities to engage in settlements with PJM. A multi-state or PJM-wide ICCM could also be pursued as a regional solution to MOPR-related conflicts that could ultimately be implemented by PJM and replace the current RPM structure. The Maryland-alone approach would offer the control and certainty to State policymakers, whereas a broad regional scope would offer the greater economic and environmental benefits.

- **Price Lock-in for New Resources.** A multi-year price lock-in, such as for a 7-12-year term might be offered to provide price certainty on RECs for new resources.
- **Choices Relevant for a Long-term Sustainable Resource Adequacy Structure.** As discussed relevant to the auction-based FRR, there are a few challenges associated with developing a long-term sustainable resource adequacy design particularly as associated with small capacity areas. Robust monitoring and mitigation and well-designed sloping demand curves would help to address some of these challenges. A broader regional footprint would further support market sustainability.
- **Demand Curve for Clean Energy.** As described above, the demand curve for clean energy would need to be adapted to ensure that it conforms with state legislation and policy priorities including program budget caps, existing contracts, and appetite to procure greater quantities of clean energy if prices are low.

WHAT ARE THE ADVANTAGES AND DISADVANTAGES?

The **advantages** of an ICCM approach include:

- Similar to the other FRR options, circumvent MOPR on Maryland policy resources and mitigate the costs of MOPR.
- Similar to the auction-based FRR approach, maintain efficiency benefits of competitive auctions for capacity needs.
- Achieve enhanced competition and efficiency gains among clean energy resources.
- Efficiency benefits of co-optimizing capacity and clean energy procurements.
- Option to use clean energy demand curves to accelerate carbon abatement achievement if the cost of doing so is low.
- If pursued over a multi-state or RTO-wide approach, provide the broad competitive benefits of a regional no-MOPR capacity market plus a regional clean energy marketplace.

The **disadvantages** of an ICCM approach include:

- Exiting the PJM capacity market would forgo some of the benefits of participating in a broad regional capacity market, unless ICCM is pursued through a multi-state or RTO-wide approach. A Maryland-alone design poses greater risks of higher prices that could be caused by implementation challenges across multiple small capacity LDAs (similar to other FRR options).
- If pursuing a multi-state or regional approach, Maryland would have less control over design specifics (but could retain control over key parameters such as the quantity of clean energy procured through the ICCM).
- High implementation complexity.

IV. Economic Assessment of Resource Adequacy Alternatives

To assess the economic implications of alternative resource adequacy structures for Maryland, we utilized a model that replicates the outcomes of the PJM capacity auction under the status quo design and after any assumed design changes. We estimated the potential impacts of the various design scenarios on capacity costs, payments for clean energy, patterns of retirement and new entry, and resource supply mix in the years 2025 and 2030. In particular, we evaluated the implications for Maryland consumers under the following alternative resource adequacy scenarios:

- **Status Quo:** Maryland stays in PJM capacity market and pays the cost of MOPR on policy resources.
- **No-MOPR RPM:** Maryland stays in PJM capacity market, but MOPR is eliminated from application to state-supported clean energy resources.
- **Best-Case Auction-Based FRR:** Maryland leaves the PJM capacity market and conducts its own FRR capacity auction with the most optimistic best-case competitive pricing outcomes achieved in each respective capacity zone. In particular, we assume suppliers of capacity not subject to MOPR are willing to sell capacity in the Maryland FRR auction at prices no higher than what they would receive in the PJM market, *and* that they are perfectly able to predict their opportunity costs of not participating in the PJM market with no uncertainty.[44]
- **IMM-Assumed Pricing for FRR:** Maryland leaves the PJM capacity market, but implements the FRR under an FRR design that results in higher pricing outcomes in line with the assumptions developed by the Independent Market Monitor (IMM) in a prior analysis of a Maryland FRR.[45] These realized FRR prices we assume would be driven by some combination of sequential-auction pricing uncertainty, lack of supply participation, exercise of market power, design flaws, and/or implementation issues. Following the IMM, we assume prices reach the level of Net CONE times the balancing ratio (equal to 78% based on the PJM 2022/23 parameters).
- **Maryland-Only ICCM:** Maryland elects the FRR option and conducts its own ICCM to procure both capacity and clean energy attributes on behalf of customers under a competitive procurement approach. Other states remain in the PJM capacity market.
- **PJM-Wide ICCM:** The entire PJM region adopts an ICCM as an evolution of the current capacity market, achieving the competitive benefits of a no-MOPR full RPM plus a regional clean energy marketplace.

To estimate costs and resource mix under each of these alternative design structures, we utilize a model of the PJM capacity market that replicates locational clearing outcomes and prices. We utilize offer data from the PJM 2021/22 BRA to estimate potential outcomes, as updated to reflect future conditions anticipated by 2025 and 2030.[46] Additional modeling assumptions and results are included in Appendix.

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[44] Note that certain FRR auction structures could make it more likely to achieve this outcome, such as a design in which resources were able to express their offer prices as a percentage of the eventual PJM RPM base auction clearing prices (though the existence of multiple LDAs in Maryland limit the ability to achieve exactly this result aligned with perfect-foresight, best-case pricing).

[45] Monitoring Analytics, "Potential Impacts of the Creation of Maryland FRRs," April 16, 2020.

[46] See reference to PSC-Brattle MOU *supra*.

A. Customer Costs across Design Alternatives

Figure 14 compares the results of our Maryland customer cost analysis across the six scenarios examined in both 2025 and 2030. We find that the best-case outcome under a competitive FRR leads Maryland customers to save approximately 80% of the cost of MOPR. There are two primary drivers of these savings: (1) customers pay for roughly 3% less capacity under the FRR, because Maryland must only procure the reliability requirement, whereas under the current RPM, more capacity is procured due to the downward sloping demand curve; and (2) the FRR allows thousands of MW of resources that cannot clear due to MOPR in the PJM RPM to provide capacity to Maryland. This unlocks not only the Maryland-subsidized resources to supply capacity, but also enables MOPR-excluded policy resources from other states to sell their capacity to Maryland customers. This effectively increases the supply of capacity across the PJM footprint, lowering capacity prices both the RPM capacity market and the Maryland FRR. This produces cost savings for Maryland customers and other PJM customers alike.

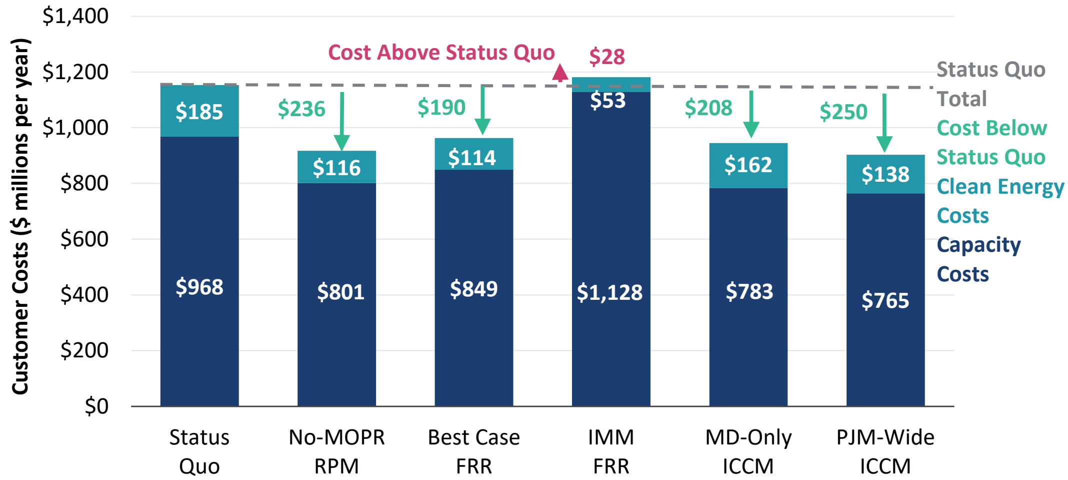
The substantial cost savings under a “Best-Case FRR” depends on the willingness of non-MOPR capacity suppliers to sell into the Maryland FRR auction at competitive prices. Non-MOPR capacity sellers should rationally offer at the anticipated price in the upcoming BRA (as they would not be willing to accept a lower price to serve Maryland than to sell into the full PJM market). If sellers could predict RPM prices perfectly or the auction could be constructed to exactly reflect sellers’ true opportunity costs, then prices would converge between the FRR auction and subsequent BRA; we assume FRR prices will have only a 5% premium over RPM outcomes in this case. There are also a number of plausible scenarios under which higher prices than the idealized Best Case FRR could materialize under a Maryland FRR. Higher prices could arise from suppliers offering at prices above later-realized RPM prices due to uncertainties, lack of supply participation, localized market power, or other FRR implementation challenges. If these outcomes were to produce higher prices near the levels previously assumed by the IMM, customer costs could increase (rather than decrease) under an FRR. Under this scenario, the cost savings achieved by avoiding MOPR on policy resources are more than offset by the higher capacity payments that exceed the pricing that would be available in the broader PJM market. If left unaddressed or locked in under long-term contracts under a planning-based FRR approach, then a poorly-design or poorly-implemented FRR could cost the same or significantly more than staying within the RPM and accepting the costs of MOPR. These pricing risks highlight the importance of thoughtful design of an auction-based FRR and avoiding any lock-in of potentially unfavorable prices.

If Maryland elected the FRR and designed a single-state ICCM to procure both capacity and RECs, cost savings could be similar to those seen under the Best-Case FRR and No-MOPR RPM. In addition to these cost savings, Maryland could also achieve the benefits of accelerated clean energy procurements under an ICCM design if implemented with a downward-sloping demand curve for RECs. This additional new entry would further reduce capacity prices in both the PJM RPM and FRR auctions. The cost savings from further-reduced capacity payments would roughly offset the additional REC payments necessary to incentivize additional renewable entry. However, this design is subject to some of the same challenges of other Maryland-alone FRR cases as relates to pricing of the capacity product. Careful implementation of the new Maryland-only ICCM would be necessary to mitigate such potential outcomes.

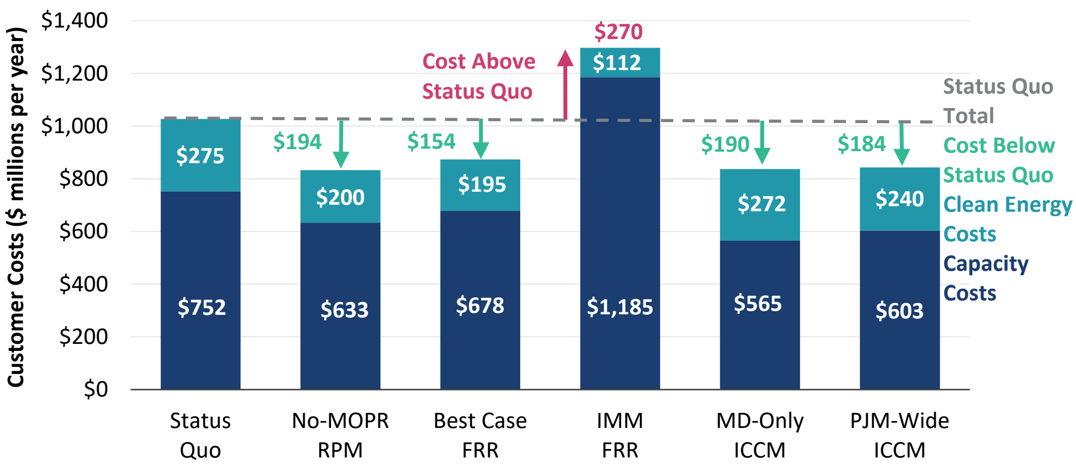
While not a design that Maryland can unilaterally implement, a PJM-wide ICCM would mitigate much of the risks of undesirable outcomes under the FRR scenarios. Costs to Maryland could be somewhat higher in a PJM-wide ICCM than under a Maryland-only ICCM, primarily because Maryland would procure more capacity by participating in the market with a downward sloping demand curve for capacity.

FIGURE 14: MARYLAND CUSTOMER COSTS BY DESIGN ALTERNATIVE

PANEL A: 2025 MARYLAND CUSTOMER COSTS



PANEL B: 2030 MARYLAND CUSTOMER COSTS



Notes: Clean energy resource costs include payments to new onshore wind, offshore wind, and utility-scale solar resources in excess of their energy and capacity revenues. Capacity costs include Maryland's share of PJM capacity costs (when participating in the PJM auction) or the Maryland FRR cost (when not).

B. Implications for Resource Mix and Clean Energy Goals

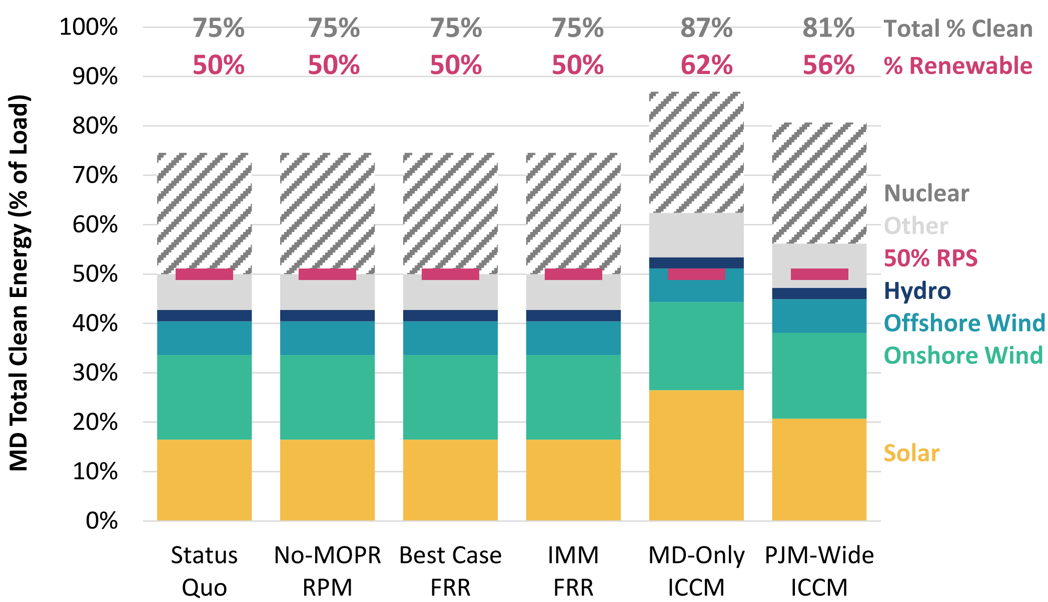
As discussed in Section II.C, we find that the exclusion of Maryland clean energy resources under MOPR could result in the maintaining of fossil and nuclear resources across the PJM footprint that might otherwise retire. However, we do not find that these factors would cause the uneconomic retention of fossil resources located within Maryland itself. Under our study assumptions, we anticipate that most fossil resources within Maryland will continue to clear the capacity or FRR structure under all scenarios analyzed either because they are needed to meet localized transmission constraints or because they remain cost-effective relative to prevailing market prices. While these fossil resources may continue to stay in operational status for capacity or reliability reasons, their generation output and associated emissions will continue to decline as more renewable supply is developed. If the pace of solar costs do not decline as rapidly as we assume in our analysis, there is also a risk that the loss of capacity revenues to Maryland solar resources could limit total achievement toward the in-state solar requirement due to applicable budget caps.

Maryland's clean energy mix (as opposed to installed capacity mix) also changes across a subset of the alternative resource adequacy structures. The volume of clean energy resources procured toward Maryland's clean energy goals does not vary across the Status Quo, No-MOPR RPM, Best Case FRR, or IMM FRR as summarized in Figure 15, as the clean energy additions are chosen to exactly meet the total RPS target, offshore wind procurements, and in-state solar carve-out. Under these scenarios, total renewable supply is equal to 50% of Maryland load (75% if including nuclear generation).

Both the Maryland-Only ICCM and PJM-Wide ICCM design scenarios procure substantially more clean energy due to the introduction of a downward-sloping demand curve that can accelerate clean energy procurement. By 2030 a Maryland-alone ICCM could attract sufficient incremental new clean resources to increase Maryland's share of load served by renewables to 62% by 2030 (or 87% including both renewables and nuclear supply).

Under a PJM-Wide ICCM, Maryland's clean energy procurement also exceeds the RPS targets, achieving 56% renewable (81% total clean including nuclear) by 2030. Under a broad regional approach, the entire PJM footprint achieves a faster pace of renewable deployment, increasing PJM-wide clean energy from 54% of load (in the Status Quo and FRR cases) up to 65% of load under a PJM-wide ICCM. These higher levels of renewable deployment tend to reduce the capacity value of the intermittent renewable supply. This, in turn, causes the marginal cost of the clean energy attribute to increase, so Maryland procures somewhat less clean energy with a downward sloping demand curve than it would under a Maryland-alone ICCM.

FIGURE 15: SHARE OF MARYLAND LOAD MET BY CLEAN ENERGY BY SCENARIO (2030)
(INCLUDES NEW AND EXISTING CLEAN ENERGY RESOURCES)



Notes: "Other" clean energy includes Landfill Gas, Municipal Solid Waste, Agriculture Waste, Black Liquor, Other Biomass Gas, Wood/Waste Solids, and Geothermal currently providing RECs to meet Maryland RPS target.

List of Acronyms

APS	Allegheny Power Systems
BGE	Baltimore Gas and Electric
BRA	Base Residual Auction
CETL	Capacity Emergency Transfer Limits
CETO	Capacity Emergency Transfer Objective
CEAC	Clean Energy Attribute Credit
ICCM	Control, Communication and Metering
DPL	Delmarva Power & Light
ELCC	Effective Load Carrying Capability
EMAAC	Eastern Mid-Atlantic Area Council
FERC	Federal Energy Regulatory Commission
FRR	Fixed Resource Requirement
FCEM	Forward Clean Energy Market
ICCM	Integrated Clean Capacity Market
IRM	Installed Reserve Margin
LDA	Locational Deliverability Area
LSE	Load-Serving Entity
MD	Maryland
MAAC	Mid-Atlantic Area Council
MOPR	Minimum Offer Price Rule
MW	Megawatt
Net ACR	Net Avoidable Cost Rate
Net CONE	Net Cost of New Entry
OPSI	Organization of PJM States, Inc.
PJM	PJM Interconnection
PEPCO	Potomac Electric Power Company
RGGI	Regional Greenhouse Gas Initiative
RTO	Regional Transmission Organization
RPM	Reliability Pricing Model
REC	Renewable Energy Credit
RPS	Renewable Energy Portfolio Standard
SREC	Solar Renewable Energy Certificate
SWMAAC	Southwestern Mid-Atlantic Area Council
MEA	Maryland Energy Administration
UCAP	Unforced Capacity
VRR	Variable Resource Requirement
ZEC	Zero-Emission Credit

Appendix: Modeling Details

Our modeling approach incorporates a number of study assumptions that may impact results. Though price and other outcomes are subject to a number of uncertainties, we have applied consistent assumptions across all studied scenarios.

Supply Offers. Our model of the PJM region in 2025 reflects confidential supply offer data from the 2021/22 auction received from PJM, adjusted for announced retirements and new entry.[47] For 2030, we have updated this supply curve based on public data and estimate the long-run average avoidable net going forward costs of supplying capacity, which yields a more elastic 2030 supply curve.[48] Consistent with recent market experience, we assume that new entry of gas combined cycle and renewable resources can be attracted at prices 20% below the administrative estimate of the net cost of new entry (Net CONE), with new resource costs projected to decline consistent with National Renewable Energy Laboratory (NREL) projections.[49] Our approach produces outcomes with greater price differences in 2025 than in 2030 can be caused by the same quantity of supply or demand changes. Our approach accounts for the fact that in the short-term capacity prices can be quite sensitive, with large prices changes driven by relatively small changes in supply or demand. However, over the longer term, extreme pricing impacts will tend to be moderated by supply exit (in the case of persistent low prices) and new entry (in the case of persistent high prices).

Demand and Transmission Parameters. We assume that policy-supported resources must to offer at least the default MOPR price when subject to MOPR. The capacity demand curve reflects the 2022/23 PJM RPM demand curve, updated to 2025/26 and 2030/31 conditions to account for changes in peak demand by LDA and anticipated changes in Net CONE. Capacity emergency transfer limits (CETL) into each LDA are assumed to stay constant throughout the study period.

Auction-Based FRR Options. The various FRR options are modeled as sequential auctions, with PJM resources offering into the FRR auction at their economic costs, including opportunity costs of not clearing the subsequent PJM BRA. In the Best-Case FRR and Maryland-Only ICCM cases we assume suppliers project RPM revenues with near perfect foresight (leading to only a 5% price premium in FRR clearing prices relative to the RPM prices in most LDAs). In the IMM-Assumptions FRR case we assume that FRR prices are set at the balancing ratio times Net CONE.[50] Capacity demand curves in the FRR are vertical at the Maryland reliability requirement.[51]

Maryland-Only ICCM. In the Maryland-Only ICCM, we assume the present offshore wind and in-state solar carve-outs to the RPS remain in place as today. In addition, we define a new demand curve for the clean energy attribute as discussed in Section III.E that reflects demand for the incremental (non-carveout) clean energy needed to meet the RPS at a $/MWh reference price given by the expected cost of new clean entry, net of energy and capacity revenues. Solar and onshore wind are assumed to be able to provide

47 See reference to PSC-Brattle MOU *supra*.

48 Monitoring Analytics, "CONE and ACR Values – Preliminary," January 28, 2020.

49 "2020 Annual Technology Baseline," National Renewable Energy Laboratory.

50 Assumption derived from the IMM study of FRR implementation in Maryland. Monitoring Analytics, "Potential Impacts of the Creation of Maryland FRRs," April 16, 2020.

51 We adjust the reliability requirement for energy efficiency and price-responsive demand in accordance with PJM's accounting for these factors in the determination of RPM demand curves.

clean energy and capacity, though the capacity value of both is assumed to decline as penetration increases. The demand curve slopes down to a point reflecting 100% clean energy at $0/MWh price. As in the simple FRR cases, we assume that capacity subject to MOPR inn the rest of the PJM footprint can also offer capacity at non-MOPR prices, subject to limits by LDA of the amount of local capacity needed to meet the FRR requirement.

PJM-Wide ICCM. In the PJM-Wide ICCM, we assume the capacity and clean energy attribute markets are co-optimized across the PJM footprint. We assume states' offshore wind and solar carve-outs are maintained, with additional generic clean energy available from either solar or onshore wind, whichever is most economic (considering both their clean energy value and capacity value at the prevailing clean and capacity prices). The PJM-wide demand curve for clean energy is implemented similarly to the one developed for Maryland and applies only to states that have already adopted renewable portfolio standards.

Table 5 provides a summary of prices, costs, and quantities procured across study years and alternative market design scenarios.

TABLE 5: SUMMARY OF ECONOMIC RESULTS ACROSS SCENARIOS

		2025						2030					
		Status Quo	No-MOPR RPM	Best Case FRR	IMM FRR	MD Only ICCM	PJM-Wide ICCM	Status Quo	No-MOPR RPM	Best Case FRR	IMM FRR	MD Only ICCM	PJM-Wide ICCM
Capacity													
Cleared UCAP MW	*(UCAP MW)*	14,042	14,162	13,740	13,740	13,740	14,279	13,943	14,037	13,472	13,472	13,472	14,114
Uncleared MD MOPR Resources	*(UCAP MW)*	1,210	0	0	0	0	0	1,669	0	0	0	0	0
Average MD Capacity Price	*($/MW-day)*	$189	$155	$169	$225	$156	$147	$148	$124	$138	$241	$115	$117
Capacity Costs	*($ Millions/yr)*	$968	$801	$849	$1,128	$783	$765	$752	$633	$678	$1,185	$565	$603
Contracts and Clean Energy													
Renewable Energy Supply	*(% of Load)*	40%	40%	40%	40%	43%	42%	50%	50%	50%	50%	62%	56%
Clean Energy Supply	*(% of Load)*	65%	65%	65%	65%	68%	66%	75%	75%	75%	75%	87%	81%
Contracts and Clean Energy Costs	*($ Millions/yr)*	$185	$116	$114	$53	$162	$138	$275	$200	$195	$112	$272	$240
Total Maryland Customer Costs	***($ Millions/yr)***	**$1,153**	**$917**	**$963**	**$1,181**	**$945**	**$903**	**$1,027**	**$833**	**$873**	**$1,297**	**$837**	**$843**
Costs Above (Below) Status Quo	*($ Millions/yr)*	*n/a*	*($236)*	*($190)*	*$28*	*($208)*	*($250)*	*n/a*	*($194)*	*($154)*	*$270*	*($190)*	*($184)*

Notes: Monetary values reported in nominal dollars.

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