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September 15, 2020

BY ELECTRONIC FILING

Mr. Joel H. Peck, Clerk
c/o Document Control Center
State Corporation Commission
Tyler Building — First Floor
1300 East Main Street
Richmond, Virginia 23219

RE: Commonwealth of Virginia *ex rel.* State Corporation Commission in re: Virginia Electric & Power Company's Integrated Resource Plan filing pursuant to Virginia Code § 56-597 *et seq*.

Case No. PUR-2020-00035

Dear Mr. Peck,

Please find attached for filing in the above-captioned case the Direct Testimony of Jason Frost on behalf of the Sierra Club. Mr. Frost's testimony is filed in public version only. Please do not hesitate to contact me if you have any questions regarding this filing.

Thank you,

Evan Dimond Johns
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COMMONWEALTH OF VIRGINIA
STATE CORPORATION COMMISSION

APPLICATION OF

VIRGINIA ELECTRIC AND POWER COMPANY

Case No. PUR-2020-00035

In re: Virginia Electric and Power Company's Integrated Resource Plan filing pursuant to Virginia Code § 56-597 et seq.

DIRECT TESTIMONY OF JASON FROST

ON BEHALF OF THE SIERRA CLUB

September 15, 2020

Summary of the Direct Testimony of Jason Frost

As Dominion acknowledges in its 2020 IRP, FERC's MOPR Order renders "the capacity market revenues for most new resources, including those from self-supply entities . . . uncertain." Because that uncertainty affects the costs to ratepayers of Dominion's resource decisions throughout the planning period, Dominion states that it is "continuing to evaluate the MOPR Order and the FRR alternative." My testimony describes the PJM Minimum Offer Price Rule (MOPR), its potential impact on Dominion's future clean energy resources, the Fixed Resource Requirement (FRR) alternative to the PJM capacity market and the MOPR and how and why Dominion should evaluate the costs and benefits of the FRR alternative to determine whether selection of the FRR is in the best interest of ratepayers.

The MOPR will increase the costs of meeting state clean energy goals and require Dominion to retain unnecessary legacy fossil fuel powered generation by not counting renewable capacity. The FRR presents a way to avoid the negative impacts of the MOPR and can reduce consumer costs by avoiding the need to pay for legacy fossil fuel capacity that is no longer needed. Different clean energy resources will be impacted by the MOPR in different ways, but costs to ratepayers will increase when any renewable or storage resources are not counted toward Dominion's capacity supply.

I recommend that the Commission require Dominion to conduct a full cost-benefit analysis of the FRR alternative relative to continued participation in the PJM capacity market and a comprehensive assessment of the impacts of the MOPR on Resource Plans A-D in its 2020 IRP. Dominion should select the FRR alternative if it finds that the FRR reduces costs to ratepayers. I also recommend that the Commission open a docket specifically to address Dominion's FRR and MOPR analysis. This will give interested parties and the Commission an opportunity to file comments and present testimony on Dominion's analysis.

Table of Contents

1. INTRODUCTION AND QUALIFICATIONS

Q. Please state your name, business address, and position.

A. My name is Jason Frost and I am an Associate with Synapse Energy Economics, Incorporated ("Synapse"). My business address is 485 Massachusetts Avenue, Suite 3, Cambridge, Massachusetts 02139.

Q. Please describe Synapse Energy Economics.

A. Synapse is a research and consulting firm specializing in energy and environmental issues, including electric generation, transmission and distribution system reliability, ratemaking and rate design, electric industry restructuring and market power, electricity market prices, stranded costs, efficiency, renewable energy, environmental quality, and nuclear power.

Synapse's clients include state consumer advocates, public utilities commission staff, attorneys general, environmental organizations, federal government agencies, and utilities.

Q. Please summarize your work experience and educational background.

A. At Synapse, I work on numerous topics with focuses on wholesale electricity market issues, electric system modeling, and multi-sector decarbonization pathways. I have participated in the NEPOOL stakeholder process for ISO New England for a year and half. As part of this work, I evaluated ISO New England's Energy Security Improvements proposal, Forward Capacity Auction parameters and load requirements,

electrification impacts on the load forecast, and Offer Review Trigger Prices in the Forward Capacity Auction. I have also worked on wholesale market issues in PJM, specifically focusing on the Minimum Offer Price Rule (MOPR), its impacts on state clean energy policies and consumer costs, and the potential of the Fixed Resource Requirement (FRR) alternative to help meet state clean energy goals at lower costs. I co-authored a guide for state decision makers called *The Fixed Resource Requirement Alternative to PJM's Capacity Market*. I have also conducted benefit-cost analysis modeling comparing the MOPR and the FRR alternative to assist a PJM state consumer advocate office.

In addition to my work on wholesale electricity markets, I have run the EnCompass capacity expansion model to develop resource plans to compare with utility IRPs. I have also developed models to understand the impacts of transportation and building electrification on the electric grid and on economy-wide greenhouse gas emissions.

I hold a Bachelor of Science in Physics from Stanford University in Stanford, California.

A copy of my current resume is attached as Exhibit JF-1.

Q. On whose behalf are you testifying in this case?

A. I am testifying on behalf of Sierra Club.

Q. Have you testified previously before the State Corporation Commission of Virginia?

A. No.

Q. What is the purpose of your testimony in this proceeding?

A. As Dominion acknowledges in its IRP, FERC's MOPR Order renders "the capacity market revenues for most new resources, including those from self-supply entities . . . uncertain."[1] Because that uncertainty affects Dominion's resource decisions throughout the planning period, Dominion states that it is "continuing to evaluate the MOPR Order and the FRR alternative." [2] The purpose of my testimony is to present information about that alternative to the PJM capacity market, describe the costs and benefits that the Company should consider when evaluating the FRR, and recommend a timeline for when the Company should decide to elect the FRR.

Q. Please identify the documents and filings on which you base your opinions.

A. My findings rely upon FERC's December 2019 order and PJM's March 2020 compliance filing to FERC regarding the expansion of the MOPR to state subsidized resources, Advanced Energy Economy's report *Understanding FERC's 'Minimum Offer Price Rule' Order*, Farmer and Gramlich's report *Whether to FRRexit:*

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1 Virginia Electric & Power Company's Report of its Integrated Resource Plan (May 1, 2020) at 15 (hereinafter 2020 Plan).

2 *Id.* at 16.

Information states need on the costs and benefits of departing the PJM capacity construct, and Dominion's 2020 Plan.

2. OVERVIEW OF TESTIMONY AND CONCLUSIONS

Q. Please summarize your primary conclusions.

A. My primary conclusion is that the MOPR has the potential to impact compliance with the Virginia Clean Economy Act (VCEA), keep fossil fuel generation online longer, and unnecessarily increase ratepayer costs. The magnitude of these impacts will depend on the ability of different types of renewable capacity to clear the market under the MOPR. Any renewables not clearing the market may cause ratepayers to pay more for Dominion to meet its requirements under the VCEA. The FRR alternative presents a way to avoid the negative impacts of the MOPR. However, a comprehensive quantitative analysis is needed to fully evaluate both the costs and risks associated with the MOPR and whether the FRR alternative would reduce costs for ratepayers.

Q. Please summarize your primary recommendations.

A. I recommend that the Commission require Dominion to conduct a full cost-benefit analysis of the FRR alternative relative to continued participation in the PJM capacity market and a comprehensive assessment of the impacts of the MOPR on Resource Plans A-D in its 2020 IRP. This analysis should address whether Dominion's solar resources will be able to clear the Reliability Pricing Model (RPM), which will have a significant impact on the cost of the RPM under the MOPR. Dominion should select the FRR alternative if it finds that the FRR reduces costs to ratepayers.

I also recommend that the Commission open a docket specifically to address Dominion's FRR and MOPR analysis. This will give interested parties and the Commission an opportunity to file written comments and present testimony on Dominion's analysis.

3. PJM'S MINIMUM OFFER PRICE RULE

Q. What is PJM's Minimum Offer Price Rule?

A. The Minimum Offer Price Rule (MOPR) sets price floors below which resources cannot offer capacity into the PJM Base Residual Auction (BRA), which determines capacity prices and obligations in the PJM capacity market, the RPM. As originally established, the MOPR was designed to ensure that net buyers of capacity were not able to use market power to artificially drive down the capacity prices and distort the market. Historically, the MOPR was only applied to new, natural gas-fired resources.[3] However, in December 2019, FERC ordered PJM to extend the MOPR to all new and existing capacity resources that receive state subsidies, including those owned by vertically integrated utilities and included in state regulated rate base.[4] The order includes exemptions for certain types of existing resources.

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3 *PJM Interconnection*, Docket No. ER11-2875, Order Accepting Proposed Tariff Revisions Subject to Conditions and Addressing Related Complaint, 135 FERC ¶ 61022 (April 12, 2011) at 2, 141, 153.

4 *See generally PJM Interconnection*, Docket No. ER18-178 (Consolidated), Order Establishing Just and Reasonable Rate, 169 FERC ¶ 61022 (December 19, 2019).

Q. What resources will be subject to the MOPR?

A. The expansion of the MOPR is broad reaching. FERC's ruling applies the MOPR to all new capacity resources that receive or are eligible to receive "State Subsidies." FERC includes an expansive definition of the term "Subsidy" in its Order that includes nearly all state policy tools used to promote the development of renewable energy and demand-side resources. This includes programs such as renewable portfolio standards (RPS) and associated Renewable Energy Credit (REC) markets as well as procurement mandates and targets (such as those for offshore wind), including those that are part of a utility Integrated Resource Plan.[5]

Q. Are there any exemptions to the MOPR?

A. Yes. The FERC order exempts most existing resources[6] from the MOPR, except nuclear units, provided they meet one of the following criteria:

(a) have successfully cleared an annual or incremental capacity auction prior to the date of the order (December 19, 2020);

(b) have an executed interconnection construction service agreement on or before the date of the order; or

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5 Advanced Energy Economy, *Understanding FERC's 'Minimum Offer Price Rule' Order: A Primer on FERC's December 2019 Order Impacting PJM's Capacity* (January 2020) at 3, available at https://info.aee.net/hubfs/Federal%20Policy%20(2018-2020)/PJM%20MOPR%20Explainer%2001_20.pdf (hereinafter AEE Primer).

6 For example, existing renewables, demand response, energy efficiency, storage resources, and self-supply resources owned by vertically-integrated utilities.

(c) have an unexecuted interconnection construction service agreement filed by PJM for the resource with the Commission on or before the date of this order.[7]

PJM's March 2020 compliance filing adopts these main exceptions and further proposes clarification that certain state and local programs should not be categorized as a "subsidy" under MOPR. Specifically, PJM's filing exempts several key categories of potential "state subsidies:"

1. The Regional Greenhouse Gas Initiative (RGGI) or any other state action that imposes a tax or assesses a charge utilizing the parameters of a regional program on a given set of resources notwithstanding the tax or cost having indirect benefits on resources not subject to the tax or cost;
2. Any state-directed default service procurement plan competitively procured without regard to resource fuel type;
3. Any voluntary and arm's length bilateral transaction, such as voluntary transactions for RECs; and
4. Any revenues for providing capacity as part of an FRR Capacity Plan or through bilateral transactions with FRR Entities.[8]

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7 AEE Primer, *supra* note 5, at 4.

8 *PJM Interconnection*, FERC Docket No. EL18-178 (Consolidated), Compliance Filing Concerning the Minimum Offer Price Rule, Request for Waiver of RPM Auction Deadlines, and Request for an Expedited Comment Period (March 18, 2020), available at https://pjm.com/directory/etariff/FercDockets/4443/20200318-er18-1314-003.pdf (hereinafter March 18 Filing).

Q. What is the resource-specific exemption?

A. PJM also proposed a resource-specific exemption (also referred to as a Unit-Specific Exemption) from the MOPR in its March 18, 2020 compliance filing. If approved by FERC, this exemption would allow subsidized new resources to bid into the capacity market at their actual cost and avoid the price floor. This would allow for capacity resources to offer a lower price than the PJM-calculated MOPR floor price into the RPM to increase its chances of clearing the market. Once a resource clears an auction, it is then allowed to participate in future auctions as an existing resource and therefore exempt from the MOPR going forward.

To qualify for this exemption, a resource will need to justify a capacity market offer price lower than the MOPR. This offer must be based on a capacity resource's specific attributes, such as actual project costs, expected revenues, asset life, etc. and will be subject to approval by the PJM Independent Market Monitor.

While this option requires significant upfront work by the developer, it provides an opportunity to receive long-term capacity revenue for a new renewable resource.

Q. What is the current status of PJM's compliance with FERC's MOPR order?

A. In March 2020, PJM submitted a compliance filing to FERC describing how it proposed to implement FERC's MOPR order. The filing included illustrative net cost of new entry (Net CONE) values for each resource type. These values are used as each

technology's floor price under the MOPR.[9] On April 16, 2020, FERC required PJM to file an additional compliance filing on several areas for which PJM had sought clarification. On June 1, 2020, PJM submitted a second compliance filing to FERC that further amended the application of the MOPR in the PJM capacity market.[10] PJM's compliance filings are now before FERC. PJM cannot move forward with its next capacity auction to procure capacity for the 2022-2023 delivery year until FERC acts on PJM's compliance filings.

Q. Are there any alternatives to participation in PJM's capacity market under the MOPR?

A. Yes, a load serving entity (LSE)—including an investor-owned utility like Dominion—can choose to meet PJM's resource adequacy requirements through the Fixed Resource Requirement (FRR) alternative to PJM's capacity market. Through an FRR election, an LSE commits to acquiring adequate capacity to meet PJM's forecast of its loads plus a PJM-determined reserve margin for a period of at least five years. After selecting the FRR alternative, an LSE no longer purchases capacity through the PJM capacity market. Similarly, resources that contribute capacity to the LSE's FRR portfolio do not offer their capacity into the capacity market. Importantly, some PJM

9 Whether FERC accepts these offer floors will affect the ability of renewable resources to participate in the RPM as well as RPM clearing prices.

10 *PJM Interconnection*, FERC Docket No. EL18-178 (Consolidated), Second Compliance Filing Concerning Application of the Minimum Offer Price Rule (June 1, 2020), available at https://pjm.com/directory/etariff/FercDockets/4571/20200601-er18-1314-006.pdf.

capacity market rules, including the MOPR, do not apply to the FRR alternative. Thus, an LSE is free to utilize capacity resources of any technology type to fulfill its FRR obligations, as long as it acquires enough total capacity and does not violate transmission constraints.

Q. What are the benefits of the FRR alternative?

A. The primary benefit of the FRR is that it creates a pathway for states to compensate new renewable energy and storage resources for capacity. This can avoid the need for ratepayers to pay twice for capacity. If the capacity from new renewable resources receiving state incentives is not counted toward PJM's capacity requirement, then consumers may end up paying twice for capacity: once for unnecessary fossil generation through the RPM and once in the form of higher incentive costs for renewable resources needed to meet state clean energy goals.

The FRR also allows LSEs to procure enough capacity to meet PJM's required reserve margin. The RPM has a sloped demand curve and typically procures excess capacity beyond the required reserve margin. This additional capacity can increase the total capacity cost paid by LSEs. The FRR alternative can therefore reduce the amount of capacity Dominion has to acquire to meet PJM's reliability requirements.

Another benefit of the FRR is the portfolio-level physical compliance option for meeting capacity obligations.[11] Under this framework, individual resources are not penalized based on performance during severe grid conditions. Instead, the LSE is required to procure additional resources in the next year if its portfolio of resources does not perform as required. This can reduce the risk for individual renewable resources participating in the capacity market.

4. IMPLICATIONS OF THE MOPR FOR DOMINION

Q. Did Dominion do any analysis of the MOPR or the FRR alternative in its 2020 Plan?

A. Dominion did not analyze the impact of the MOPR or the FRR alternative as part of its 2020 Plan. Dominion states in its IRP that "[t]he Company is continuing to evaluate the FERC MOPR Order and the FRR alternative" and that "it has made no decision at this time" as to whether it will ultimately seek to select the FRR alternative.[12]

Q. In your opinion, should Dominion have performed this analysis in its 2020 Plan?

A. Yes. In my opinion, Dominion's 2020 Plan should have included a quantitative and comprehensive analysis of both the benefits and costs of the FRR alternative as well as the impacts of the MOPR on Dominion's Resource Plans A-D. The FRR can reduce

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11 Miles Farmer & Robert Gramlich, *Whether to FRRexit: Information States Need on the Costs and Benefits of Departing the PJM Capacity Construct* (May 2020), available at https://gridprogress.files.wordpress.com/2020/05/whether-to-frrexit-paper7.pdf.

12 2020 Plan at 16.

the impact of the MOPR on ratepayers and compliance with the VCEA and should have been accounted for in Dominion's preferred resource plan, if the Company finds that it will reduce costs to ratepayers.

Q. What are some of the potential implications for the MOPR on Dominion's resource mix?

A. The MOPR adds a barrier to participation in the capacity market for all new renewable resources and forces these resources to ignore revenue from state programs (including renewable portfolio standards) when setting capacity offer prices. This can slow renewable generation development, increase greenhouse gas emissions, and increase costs for ratepayers.

The VCEA requires Dominion to procure increasing amounts of renewable energy over time and to retire all fossil-fueled generation by 2045.[13] If Dominion cannot receive capacity credit and compensation for these resources, it would be forced to continue to purchase or maintain unnecessary fossil fuel-powered generation. This will keep polluting resources online longer than they otherwise would be and will waste ratepayer money on infrastructure that is no longer needed. In addition, denying clean energy resources access to capacity revenue could make it more difficult for Virginia to meet its clean energy goals and would put more pressure on other revenue sources (such as renewable energy credits, or RECs) to fund renewable energy investments.

13 Virginia Code § 56-585.5 B 3.

The MOPR could result in customers paying for capacity twice: once in the form of capacity payments to unnecessary legacy generation and a second time in the form of higher REC prices (or other revenues) to support clean resources that are prevented from receiving capacity market revenues.

Q. How will the MOPR impact renewable resources and battery storage?

A. MOPR reduces the likelihood that renewable resources can clear in the RPM and be compensated for the capacity they supply. The magnitude of the impact of the MOPR on each type of renewable energy resource varies, as these resources depend on different combinations of energy, capacity, REC, and other revenues. Resources that are qualified to provide greater amounts of capacity and that are unlikely to clear the RPM under MOPR will face the most severe impacts.

Q. How much capacity can renewable resources and battery storage offer into the RPM?

A. Because renewable resources generate power intermittently, PJM discounts their nameplate capacity in determining how much capacity they can supply into the RPM, based on the amount of power they tend to produce during PJM's peak load hours, which occur in the summer. These discount factors are called capacity credits. Resources with greater capacity credits are eligible to offer more capacity into the market and therefore receive greater capacity compensation for the same amount of nameplate capacity. Solar energy depends the most on capacity revenue in PJM due to its relatively high summer peak capacity credit of 60 percent of nameplate capacity

(for single axis tracking solar generators). Onshore wind has a higher capacity factor and therefore earns more energy and REC revenue, but it receives a capacity credit of only 17.6 percent. This makes onshore wind much less dependent on capacity revenues and reduces the impact of the MOPR on onshore wind relative to the impact on solar. Offshore wind, with a capacity credit of 26 percent, is eligible for more capacity revenue than onshore wind, but is also less impacted by the MOPR than solar.

Q. How likely is each type of renewable or storage resource to clear the RPM under the MOPR?

A. Resources will only be able to clear future BRAs under the MOPR if they can offer capacity at a price less than or equal to the clearing price of the auction. The MOPR prevents new resources from offering capacity at lower prices than their price floors, so resources with lower price floors are more likely to be able to clear the RPM. PJM presented illustrative price floors for each type of resource in its March 2020 compliance filing, and resources may be able to receive lower resource-specific floor prices if they present costs lower than PJM's assumptions. The illustrative floor price for single axis tracking solar is $175/MW-day.[14] For comparison, the clearing price of the most recently completed BRA for the 2021/2022 delivery year, held in May 2018, was $140/MW-day. Solar may be able to clear the RPM if resource-specific floor prices are below the ultimate clearing prices of future auctions. Offshore wind and battery storage have much higher illustrative price floors of $3,146/MW-day and

14 March 18 Filing at 64.

$1,040/MW-day, respectively. These resources are less likely to be able to clear the market under the MOPR.[15]

Q. What will the impacts of the MOPR be on Dominion's generation portfolio?

A. The MOPR will impact many of Dominion's new solar, offshore wind, and battery storage resources in upcoming BRAs. Prior to 2023, the impact of the MOPR on Dominion's resource mix in Plans A-D in the 2020 Plan will depend primarily on the ability of solar to clear the RPM. Solar accounts for a large fraction of Dominion's proposed new utility scale renewable resources through 2035 (14,820 MW of solar out of 22,346 MW of total renewable and storage resources) and it benefits more from capacity revenues than other renewable resources due to its high capacity credit. The ability of solar to clear the capacity market will have a very large impact on the costs to ratepayers of the MOPR.

Dominion's resource plans include new offshore wind and battery storage resources coming online in 2026 that will also be impacted by the MOPR and that will likely seek to participate in the RPM beginning in 2023 due to the typical three year lead time between the BRAs and the corresponding capacity delivery years. Offshore wind and battery storage resources are unlikely to clear in the capacity market, which will lead to significant lost capacity revenue for Dominion and ultimately its ratepayers.

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15 *Id.*

If the capacity that any of these future renewable resources supply is not counted in the RPM, they will be unable to displace legacy fossil fuel resources that are no longer needed or allowed under the VCEA. In order to assess the full impacts of the MOPR, Dominion must perform a comprehensive assessment of the impacts of the MOPR on Plans A-D in its 2020 Plan.

Q. When would Dominion need to select the FRR option?

A. Dominion has the option to select the FRR alternative prior to each BRA. The BRA typically occurs in the second quarter three years in advance of its associated delivery year for capacity, but the schedule has been impacted by FERC's MOPR order and the auction for the 2022/2023 delivery year has not yet occurred. However, once Dominion selects the FRR, it cannot re-enter the capacity market for five years.

Q. What analysis should Dominion provide in support of its decision?

A. Dominion should present a full cost-benefit analysis comparing the capacity market under the MOPR with the FRR alternative, including the net present value revenue requirement under each alternative. Benefits of the FRR should include reduced fossil fuel generation capacity purchases due to the ability to count renewable capacity in the FRR. Another benefit the Company should consider is the ability to procure less capacity, as the PJM capacity market typically acquires capacity in excess of the PJM required reserve margin. An important component of this analysis should be an evaluation of the ability of solar resources to clear the RPM, as that will significantly impact the magnitude of the impacts of the MOPR. Dominion should make a decision

to elect the FRR if doing so will save its ratepayers money, after performing a cost-benefit analysis of electing the FRR option.

5. CONCLUSIONS AND RECOMMENDATIONS

Q. Please summarize your conclusions.

A. The MOPR represents a challenge to achieving state clean energy goals, retiring unnecessary fossil fuel generation resources, and taking advantage of the low costs of renewable energy resources, but it will not impact all renewable resources equally. New solar, offshore wind, and battery storage resources will all be impacted by the MOPR. Utility scale solar generation resources tend to benefit more from capacity revenue than both onshore and offshore wind resources, so if these resources are excluded from the RPM by the MOPR ratepayers could face significant costs. The exact impact of the MOPR on solar resources is somewhat uncertain because it is unclear if they will be able to clear in the capacity market despite the MOPR. Offshore wind and battery storage, however, are unlikely to be able to clear the capacity market based on PJM's illustrative floor prices for those technologies. If any of these resources are unable to clear the capacity market, fossil fuel generation capacity will be unnecessarily retained, and ratepayer costs will increase. The FRR alternative provides a way to avoid these impacts, and it should be closely considered as Dominion brings more new renewable resources online.

Q. Please summarize your recommendations.

A. I recommend that the Commission require Dominion to conduct a full cost-benefit analysis of the FRR alternative relative to continued participation in the PJM capacity market and a comprehensive assessment of the impacts of the MOPR on Resource Plans A-D in its 2020 IRP. This analysis should address whether Dominion's solar resources will be able to clear the RPM, which will have a significant impact on the cost of the RPM under the MOPR. Dominion should select the FRR alternative if it finds that the FRR reduces costs to ratepayers.

I also recommend that the Commission open a docket specifically to address Dominion's FRR and MOPR analysis. This will give interested parties and the Commission an opportunity to submit comments and present testimony on Dominion's analysis.

Q. Does this conclude your direct testimony?

A. Yes.

INDEX OF EXHIBITS

EXHIBIT JF-1

RESUME OF JASON FROST

Jason Frost, Associate

Synapse Energy Economics I 485 Massachusetts Avenue, Suite 3 I Cambridge, MA 02139 I 617-453-7043
jfrost@synapse-energy.com

PROFESSIONAL EXPERIENCE

Synapse Energy Economics Inc., Cambridge, MA. *Associate,* June 2020 – Present, *Research Associate*, August 2018 – June 2020.

- Participates in NEPOOL stakeholder process for New England's wholesale electricity market and evaluates ISO and stakeholder proposed rule changes.
- Evaluates the impacts of the Minimum Offer Price rule in PJM on renewable and storage resources and customer costs.
- Topic Area Manager for Transportation.
- Co-developer of EV-REDI, a model to calculate the emissions and electricity demand impacts of electric vehicle adoption.
- Conducts quantitative modeling of transportation, building, and electric sector decarbonization pathways.
- Conducts a wide range of other energy and transportation sector analysis on rate design for electric vehicles, electric grid resource plans, and other topics.

Lawrence Berkeley National Laboratory, Berkeley, CA. *Materials Science Researcher*, June 2017 – June 2018

- Developed software to accelerate discovery of improved thermoelectric materials for solid state conversion of heat to electricity under the guidance of Dr. Anubhav Jain.
- Implemented a new integration algorithm to more correctly calculate particle mobility.

Stanford University Department of Electrical Engineering, Stanford, CA. *Intern*, Summer 2016

- Searched for materials with rapidly changing dielectric functions and little loss, infinitely anisotropic materials, and permittivity near zero materials.

MIT Kavli Institute for Astrophysics and Space Research, Cambridge, MA. *Intern*, Summer 2015

- Modeled polarization laboratory experiments in Python.
- Modeled atmospheric absorption of soft X-rays and matched quasar jet data with theory.
- Co-authored two papers that have been published.

EDUCATION

Stanford University, Stanford, CA: Bachelor of Science in Physics, 2018.

- Researched optimization of on-campus electric vehicle charging and quantified the resulting benefits. Co-authored paper submitted for publication.

SKILLS

- Programming languages: Python, Julia, C, Matlab
- EnCompass power sector planning software
- Linear and nonlinear optimization

PUBLICATIONS

Goldberg, D., J. Frost, D. Hurley, K. Takahashi. 2020. *New England Electrification Load Forecast*. Synapse Energy Economics for E4TheFuture.

Chang, M., J. Frost, C. Lane, S. Letendre, PhD. 2020. *The Fixed Resource Requirement Alternative to PJM's Capacity Market: A Guide for State Decision-Making*. Synapse Energy Economics for the State Energy & Environmental Impact Center at the NYU School of Law.

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Allison, A., R. Wilson, D. Glick, J. Frost. 2018. *Comments on South Africa 2018 Integrated Resource Plan.* Synapse Energy Economics for Centre for Environmental Rights.

Resume updated September 2020

CERTIFICATE OF SERVICE

In accordance with the Commission's Order Requiring Electronic Service in Case No. CLK-2020-00007, I certify that on or before September 15, 2020, I sent the foregoing by electronic mail to:

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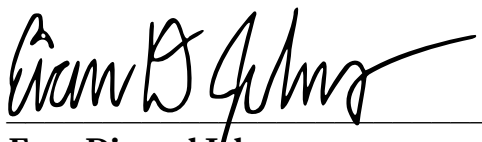

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