PJM Tier I Inventory & Forecasting

Updates to Eligible Supply, Capacity Factors, and Addition Assumptions in response to PPRP RPS Study Group report by Exeter Associates

June 8, 2018

MDV-SEIA

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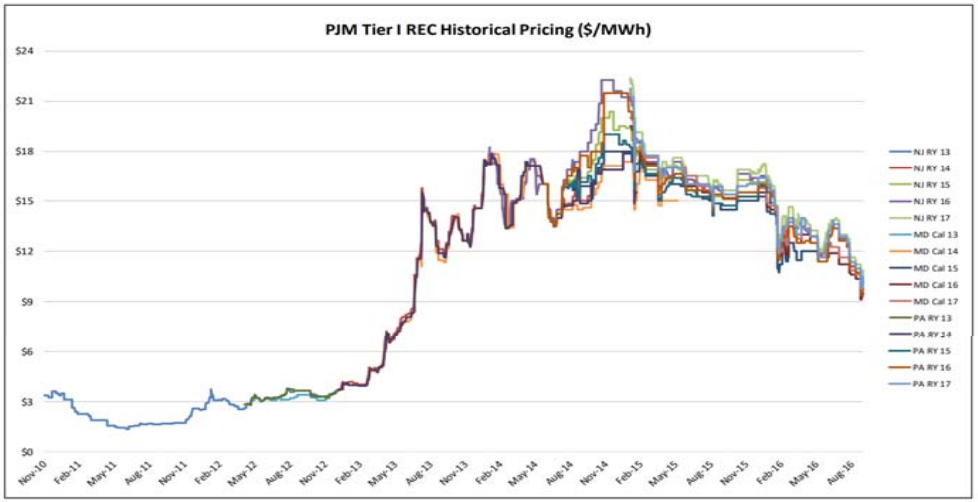
EXECUTIVE SUMMARY

Tier 1 REC Pricing Does Not Support Conclusion of PJM Undersupply

- Exeter concludes that the PJM Tier I Market is currently undersupplied and will need aggressive addition rates (46% annual growth rate) to avoid perpetual undersupply
- On its face, this conclusion is not supported by what we observe in the price history of Tier I RECs across PJM RPS programs, which have been trading well below ACP values[1] for the past 5+ years through the present day. This would not be the case if the market was truly undersupplied.



1: MD ACPs are currently set at $37.50/MWh per http://programs.dsireusa.org/system/program/detail/1085
2: Chart Source: http://karbone.com/wp-content/uploads/2017/05/PJM-Tier-I-Presentation-for-Morningstar-10.04.16.pdf

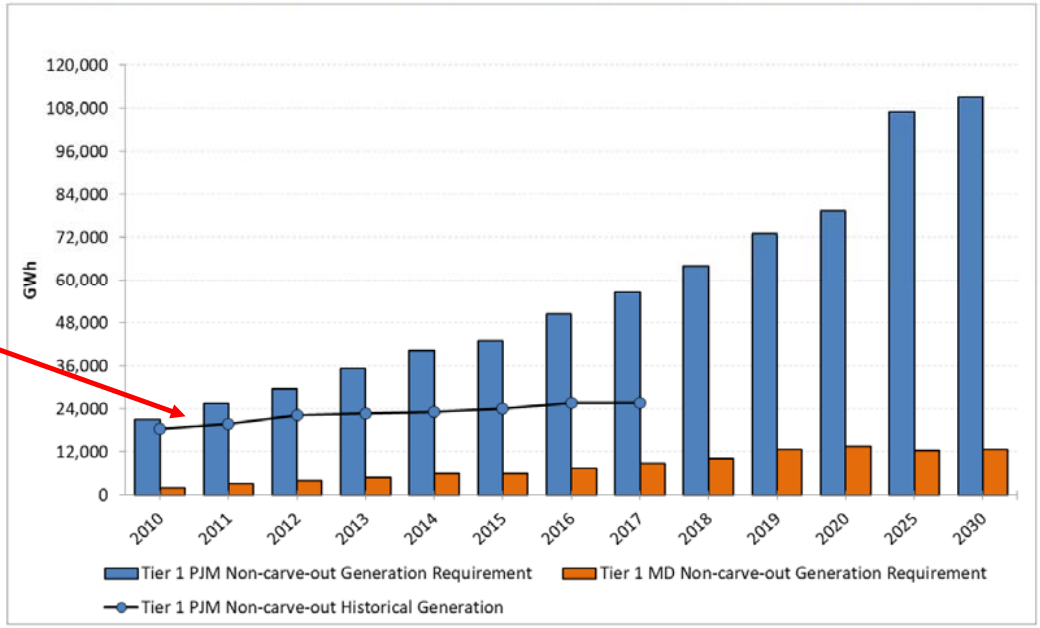
Tier 1 REC Pricing Does Not Support Conclusion of PJM Undersupply

- Figure IV-1 from the Exeter report shows that the Tier I PJM Non-carve-out Historical Generation (in GWh) is well below the Tier I PJM Non-carve-out Generation Requirement. This represents an "undersupplied" market that would be trading close to ACP levels.

This line represents Exeter's estimate of Tier 1 supply (i.e. Exeter's "Tier 1 Inventory").

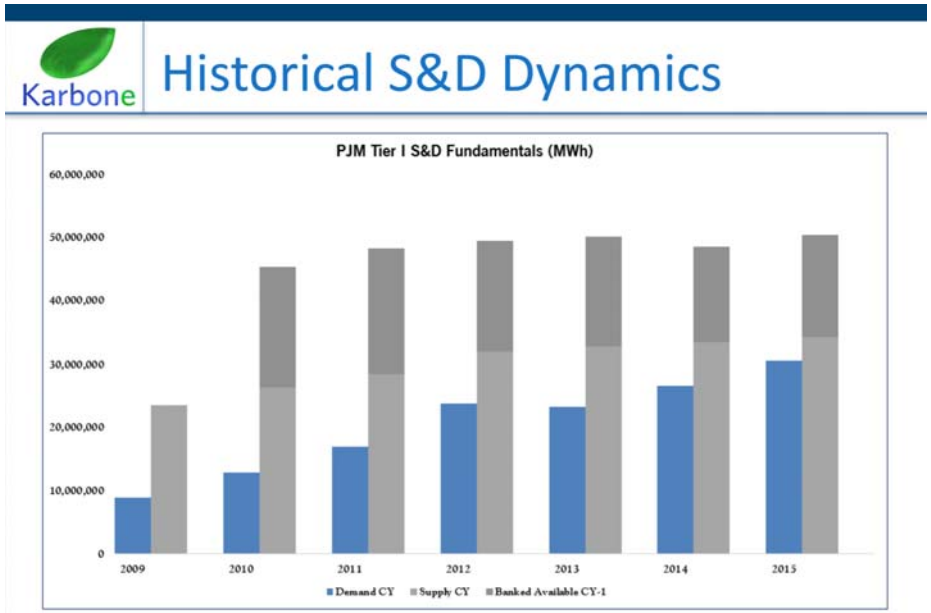
According to this estimate, Tier 1 demand (shown by the blue bars) far exceeds supply, and PJM Tier 1 RECs are under-supplied.

Figure IV-1. Non-carve-out Tier 1 Generation Required by the RPS in Maryland and PJM



Tier 1 Undersupply Assessment Not Shared by Other 3rd Party Analysts

- Other 3rd party reports show that the PJM Tier I market has not been undersupplied but rather has sufficient eligible generation to meet RPS demand across all RPS states
- This presentation explores the causes and implications of this inconsistency and presents MDV-SEIA's analysis of Tier I supply (i.e. inventory) and Tier 1 Demand through 2030



1: Chart Source: http://karbone.com/wp-content/uploads/2017/05/PJM-Tier-I-Presentation-for-Morningstar-10.04.16.pdf

Exeter Solar Growth Scenario is Ignored in the Report's Narrative and Conclusion; Solves Undersupply

- Table VII-4 of Exeter report estimates ~68,000,000 GWh of Tier 1 solar across PJM by 2030 (vs. **0 Wh** in the base-case analysis that drives the report's narrative)
- The implications of this scenario is only included in a table in the report and otherwise not included in the narrative or conclusions. For example, conclusions about the need for imports from outside of PJM to meet RPS demand or challenges in replacing Tier 1 supply from Black Liquor are not supported by a Tier 1 inventory that assumes steady Tier 1 solar additions through 2030.
- Including even a fraction of this solar Tier 1 volume along with realistic wind growth assumptions would **reverse undersupply narrative and conclusions in the report.**

Issues Identified with Exeter Inventory Analysis & Methodology

- Exeter's approach to summing the eligible Tier I resources appears to only capture the Tier I MWhs that were registered in MD (~8.8 GW of Tier 1 generators per Table II-2) in PJM GATS
- This approach, however, does not include the Tier I resources that (i) are eligible as Tier I in MD, but chose to register in other states where they sold their RECs and did not register in MD or (ii) are Tier I resources that are eligible in other states but are not eligible in MD
- To properly sum the eligible Tier I supply potential across PJM, all Tier I eligible MWhs that have the potential of being retired as a Tier I REC in any PJM state should be included (~16.5 GW)
- Other related issues identified include the use of historical NCFs that are lower than average historical NCFs
- These issues in Exeter's methodology results in a conclusion of significant undersupply that is not supported by observable market dynamics (ex. Tier 1 pricing well below ACPs) and not borne out by analysis conducted by MDV-SEIA

MDV-SEIA Analysis Addresses Issues with Exeter Methodology & Assumptions

- Correcting methodological errors in Exeter's analysis results in ~58,000 GWh of eligible Tier I supply vs 55,650 GWh of PJM-wide Tier I demand in 2017
- Scenario analysis using a range of more appropriate assumptions results in continued PJM RPS market balance through 2030
- Conclusions:

  1) Exeter's analysis as shown in Table II-2 of eligible resources is missing significant volume of Tier I eligible resources

  2) Exeter's capacity factors for utility-scale solar and wind as they are low relative to historic data and industry trends/projections

  3) Future supply additions used by Exeter to support report's conclusions are puzzlingly inconsistent with any credible range (ex. 0 MWh Tier 1 solar additions, 78 MW/year wind additions, etc.) and should be adjusted to reflect wind additions that at least track historic additions (ex. 800 MW/y) and solar additions more in line with 3rd party forecasts and utility plans (ex. Dominion Virginia 2018 IRP)

PART 1:
TIER 1 INVENTORY

Tier 1 Inventory: What's eligible as a Tier I Resource?

- Understanding the eligible Tier 1 Resources across PJM is a complex undertaking as each state has different eligibility rules

Comparison of Renewable Portfolio Standards (RPS) Programs in PJM States

	NJ	MD	DC	PA	DE
Class I or Tier I Renewable Energy Sources	Class I renewable sources: • solar technologies • photovoltaic technologies • wind Energy • fuel cells powered by renewable fuels • geothermal technologies • wave or tidal action • methane gas from landfills or a biomass facility, provided that the biomass is cultivated and harvested in a sustainable manner. • In-state hydroelectric facilities <3 MW placed in service after 7/23/2012	Tier 1 Renewable sources: (1) solar and solar water heat; (2) wind; (3) qualifying biomass; (4) methane from a landfill or wastewater treatment plant; (5) geothermal; (6) ocean; (7) a fuel cell powered by methane or biomass; (8) a small hydroelectric plant (9) poultry litter incineration facilities in Maryland. in Maryland (11) certain geothermal heating and cooling systems and biomass systems that generate thermal energy	Tier 1 Renewable sources: (1) solar (including solar thermal); (2) wind; (3) qualifying biomass (>65% efficiency); (4) methane from a landfill or wastewater treatment plant; (5) geothermal; (6) ocean, including Energy from waves, tides, currents, and thermal differences; and (7) a fuel cell that produces electricity from a tier 1 renewable source under item (3) or (4) of this subsection.	Tier I alternative Energy sources: (1) Solar photovoltaic and solar thermal energy. (2) Wind power. (3) Low-impact hydropower. (4) Geothermal Energy. (5) Biologically derived methane gas. (6) Fuel cells. (8) Coal mine methane.	Electricity derived from: a. solar; b. wind; c. ocean; d. geothermal; e. fuel cell capable of being powered by Renewable Fuels; f. combustion of gas from the anaerobic digestion of organic material; g. small hydroelectric facility (30 megawatts or less); h. sustainable biomass, excluding waste to energy;

https://www.pjm-eis.com/~/media/pjm-eis/documents/rps-comparison.ashx

Tier 1 Inventory: What's eligible as a Tier I Resources?

- The "Renewable Generators Registered in GATS" database displays all of the generators that are registered across PJM by fuel type, location, (i.e. 8,301 MW of wind located in PJM states, 9,747 MW of wind located in PJM and bordering states) and where they're registered as Tier I RECs
- As a practice, individual generators often, but not always, register with more than one RPS in which they are eligible
  - Ex. a wind project located in OH could choose to register its MWhs as eligible Tier 1 RECs in PA, MD, DE, NJ, OH, and IL….or it could choose to only register it's Tier 1 MWhs in DE, for example
- The Exeter approach did not include all Tier I eligible generators, but rather only those that registered in MD. This results in an under-estimate of Tier 1 supply that is eligible for the Maryland RPS.
  - In the example above, the OH wind project registered only in DE was not included in their summation of eligible Tier I resources

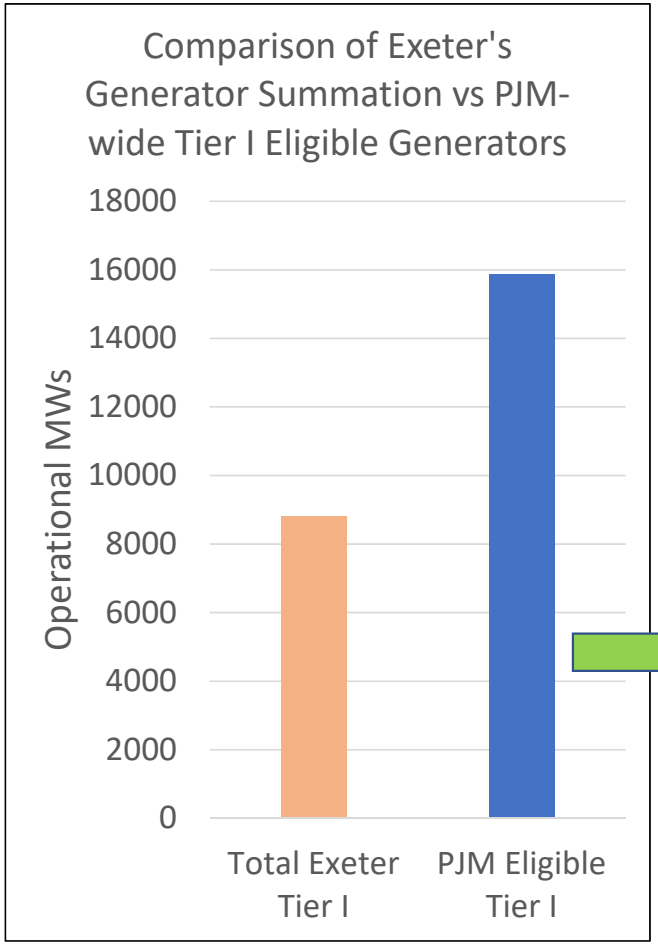
Tier 1 Inventory: The Tier 1 Fungibility Dynamic

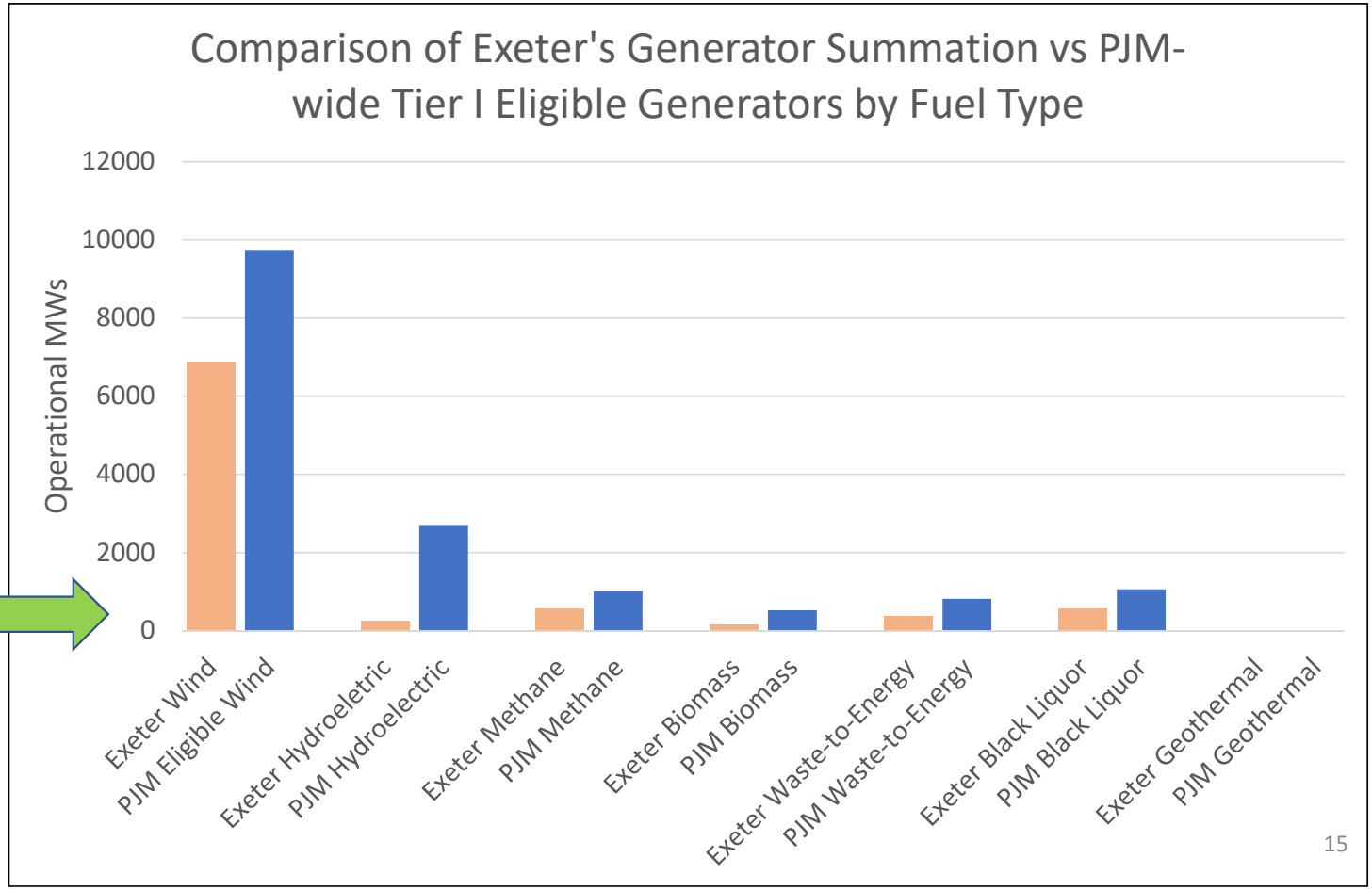
- Further, since each state RPS has different eligibility requirements for Tier 1 RECs, but all Tier 1 RECs participate in the same combined Tier 1 market, Tier 1 resources that qualify in New Jersey's RPS but not Maryland's will impact Tier 1 supply in both markets
- This "fungibility" is the result of the fact that there is significant overlap in eligibility criteria across PJM RPS programs
  - Ex. The Maryland RPS allows Black Liquor but the DC RPS does not. However, the supply of Black Liquor Tier 1 RECs retired each year for Maryland's RPS means the identical number of RECs from a common eligible resource like wind is available to DC that would otherwise have been retired in MD. In effect, any inventory of PJM Tier 1 RECs for a DC RPS inventory would include Black Liquor in the summation of supply.
- By applying Maryland RPS eligibility criteria to all PJM resources, the Exeter approach failed to account for this fungibility dynamic. This contributes to Exeter's under-estimate of Tier 1 supply.

Tier 1 Inventory: MDV-SEIA's Methodology

- To determine the volume of PJM Tier 1 RECs while accounting for the methodological errors raised on the previous slides, the following approach was employed:
  1. Use the "Renewable Generators Registered in GATS" database as the source of each unique generator that is Tier I eligible in ***any*** PJM RPS state
  2. Assign a Capacity Factor to each Tier I eligible generator using historic data
  3. Use #1 and #2 to calculate the annual MWh of Tier I RECs that each PJM registered renewable generator can produce
  4. For non-traditional Tier I resources (i.e. coal-bed methane, other biogases, etc), look to historic "as-retired" volume of MWhs to arrive at the supply potential of the non-traditional Tier I resource

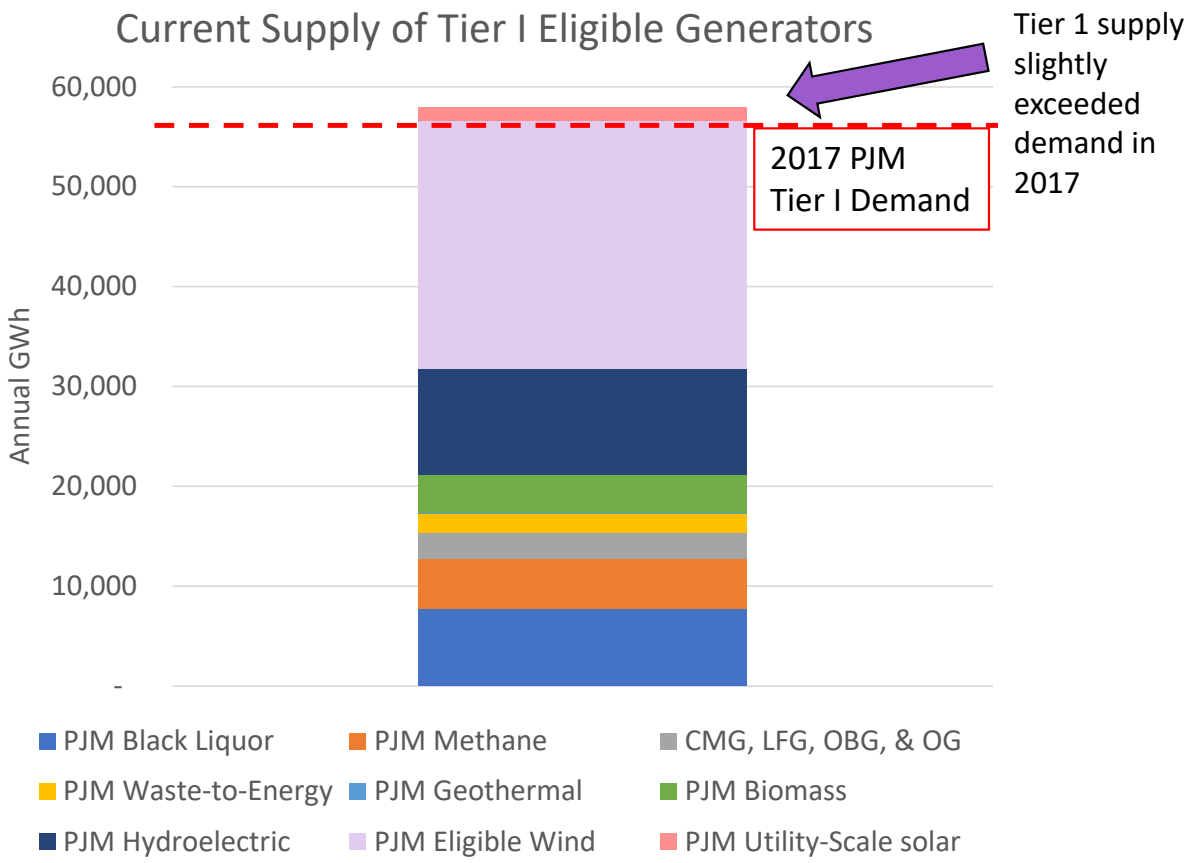
Tier 1 Inventory: Result of MDV-SEIA Analysis





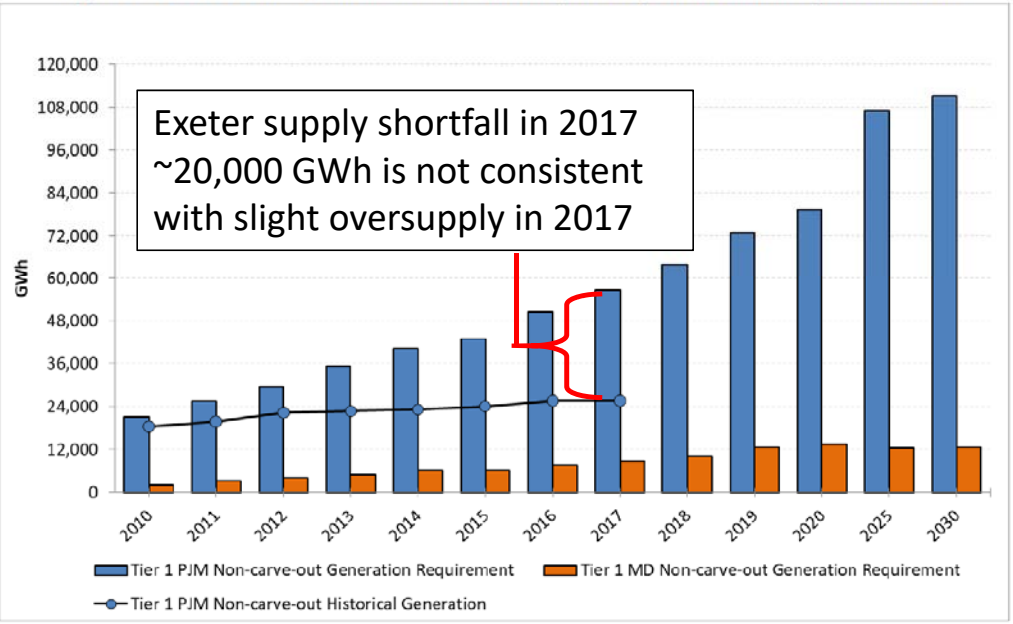
Tier 1 Inventory: Result of MDV-SEIA Analysis

- Using Exeter's aggregate RPS demand tabulation:
  - 2017 PJM Tier I demand: **55,650 GWh**
- MDV-SEIA's PJM Tier 1 inventory methodology estimates slight oversupply in PJM in 2017
- This is consistent with stable PJM Tier 1 prices in 2017 in the $6-$12/MWh range vs. ACPs in the $30+ range
- This observation is inconsistent with Exeter's under-supply estimates which show significant undersupply in 2017



Tier 1 Inventory:
Revisiting Exeter's Inventory Conclusion

Figure IV-1. Non-carve-out Tier 1 Generation Required by the RPS in Maryland and PJM



Exeter's approach concludes that the Tier I Generation Requirement (at ~55,000 GWh) exceeds the Historical Generation (at ~33,000 GWh). If this were the case, Tier I REC prices would have been at or near ACP levels in 2017 across PJM, which was not the case.

PART 2:
PROJECTING TIER 1 SUPPLY

Issues Identified with Exeter Forecast Analysis

1) Addition rates of wind and utility-scale solar are very low

- The growth rate assumptions driving Exeter's conclusions are at odds with: (i) historic wind and solar addition rates, (ii) planned addition announcements in IRPs, (iii) the volume under development in the PJM queue (iv) third party projections and (v) elements of Exeter's own report (ex. Table VI-6, Table VII-4, etc).

2) Capacity Factors are lower than market data

- Wind historic capacity factors have averaged 29% in PJM and the industry expects higher capacity factors, closer to 35% on average, as rotor diameters continue to grow and technology continues to improve
- Similarly, PJM Tier I solar will likely continue the trend towards single-axis tracking with the bulk of Tier 1 solar growth in large sunny states like NC, VA, and OH with average capacity factors around 25% over the next decade. As a reference, DOM's 2018 IRP includes a 26% CF for utility-scale solar in VA.[1]

1: https://www.dominionenergy.com/library/domcom/media/about-us/making-energy/2018-irp.pdf, Appendix 5A

Looking forward: Wind Additions 2018-2030

Addition Rate Assumptions - Wind

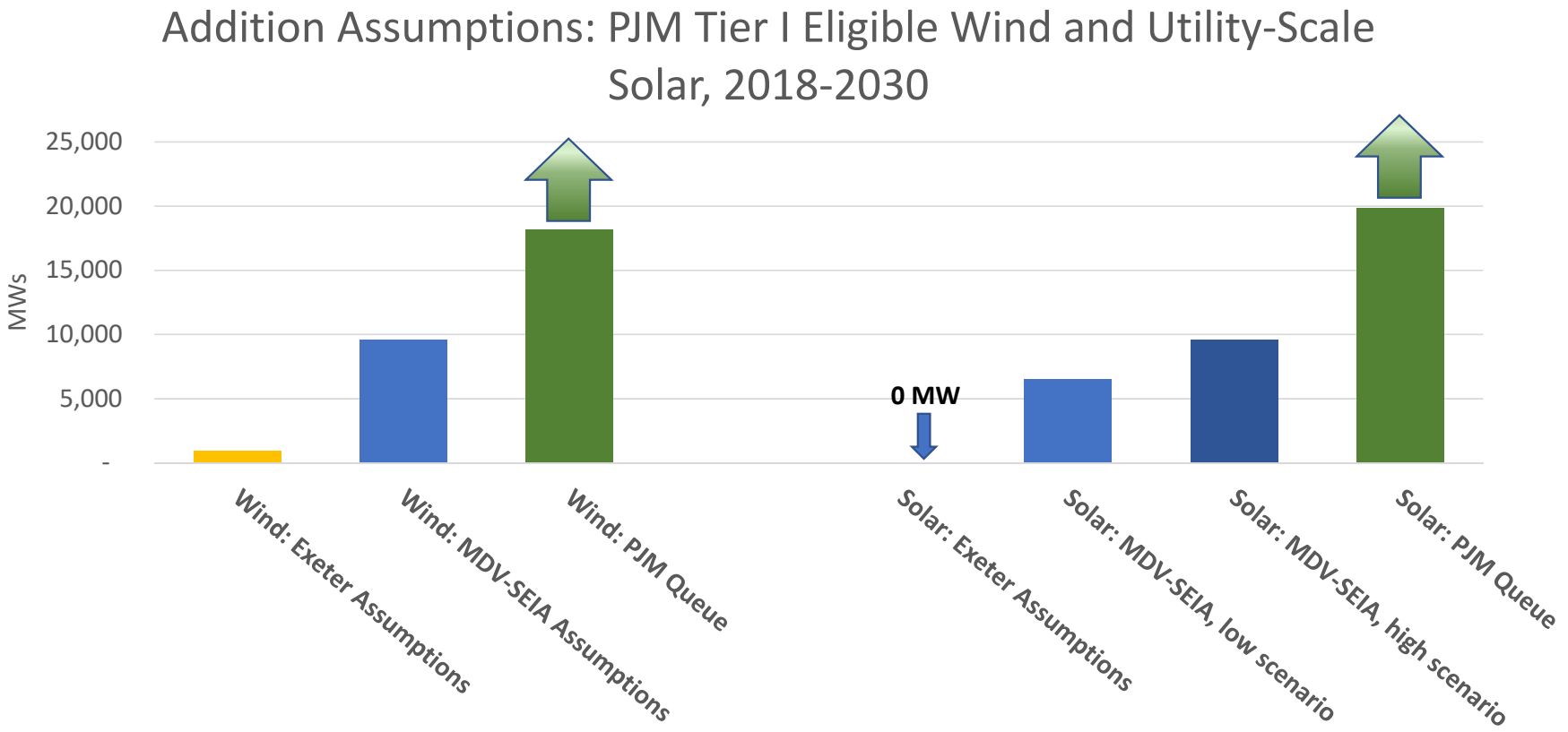
- Exeter's analysis assumed 940 MW of total wind additions from 2018-2030 (or **78 MW/year**)
- Historic additions over the last 10 years have been roughly **800 MW/y** year in PJM
- The PJM queue for wind projects under development currently shows ~18,000 MW of wind projects under study, engineering, or construction in PJM
- It is reasonable to assume that there will be a continued addition rate of 800 MW/y of PJM Tier I eligible wind over the next decade

Looking forward: Solar Additions 2018-2030

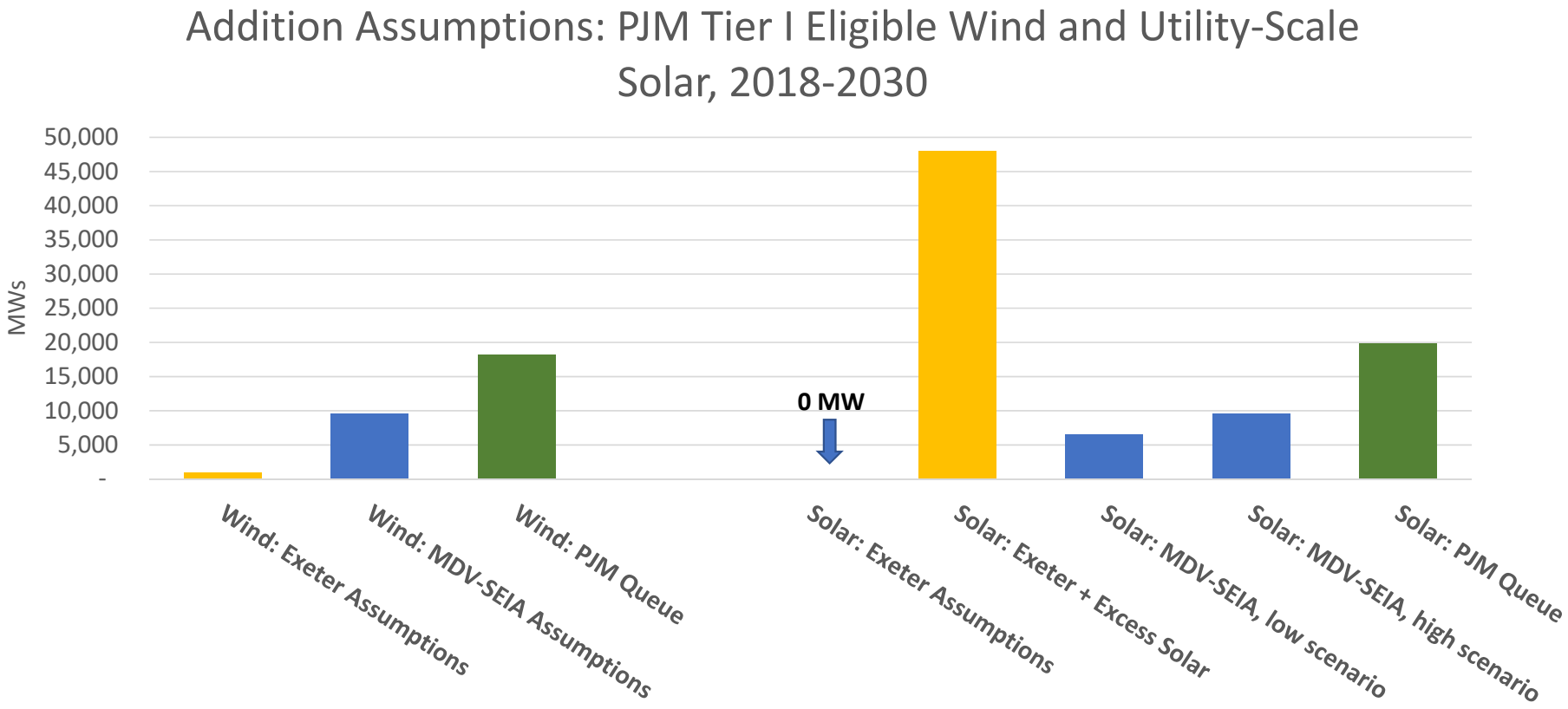
Addition Rate Assumptions - Solar

- Exeter's solar additions are assumed to fulfill RPS carve-out demand and **0 MW** of utility-scale solar additions to serve Tier I non-carve-out demand
- In practice, however, there are currently ~640 MW of non-carve-out operational solar across VA, NC, and OH currently supplying Tier I RECs
- Build cost improvements along with support from Tier I REC pricing have driven numerous utilities to forecast robust solar additions, much of which will supply non-carveout Tier I RECs
  - Ex. Dominion forecasts 480 MW/y of solar additions over the next 10 years in Virginia
  - Ex. Appalachian Power plans on adding 750 MW by 2030 in Virginia
  - Ex. AEP OH plans on adding 400 MW in 2021 alone
- There are currently ~20,000 MW of solar projects under study, engineering or construction in PJM, most of which will be eligible as Tier 1 resources.
- Lastly, Exeter's own report includes a table VI-6 entitled *"Estimated Capacity of Total Solar Projects in PJM (2018-2030) (MW)"* in which they estimates the potential for ~55GW of solar capacity by 2030, generating 77,000 GWh annually.

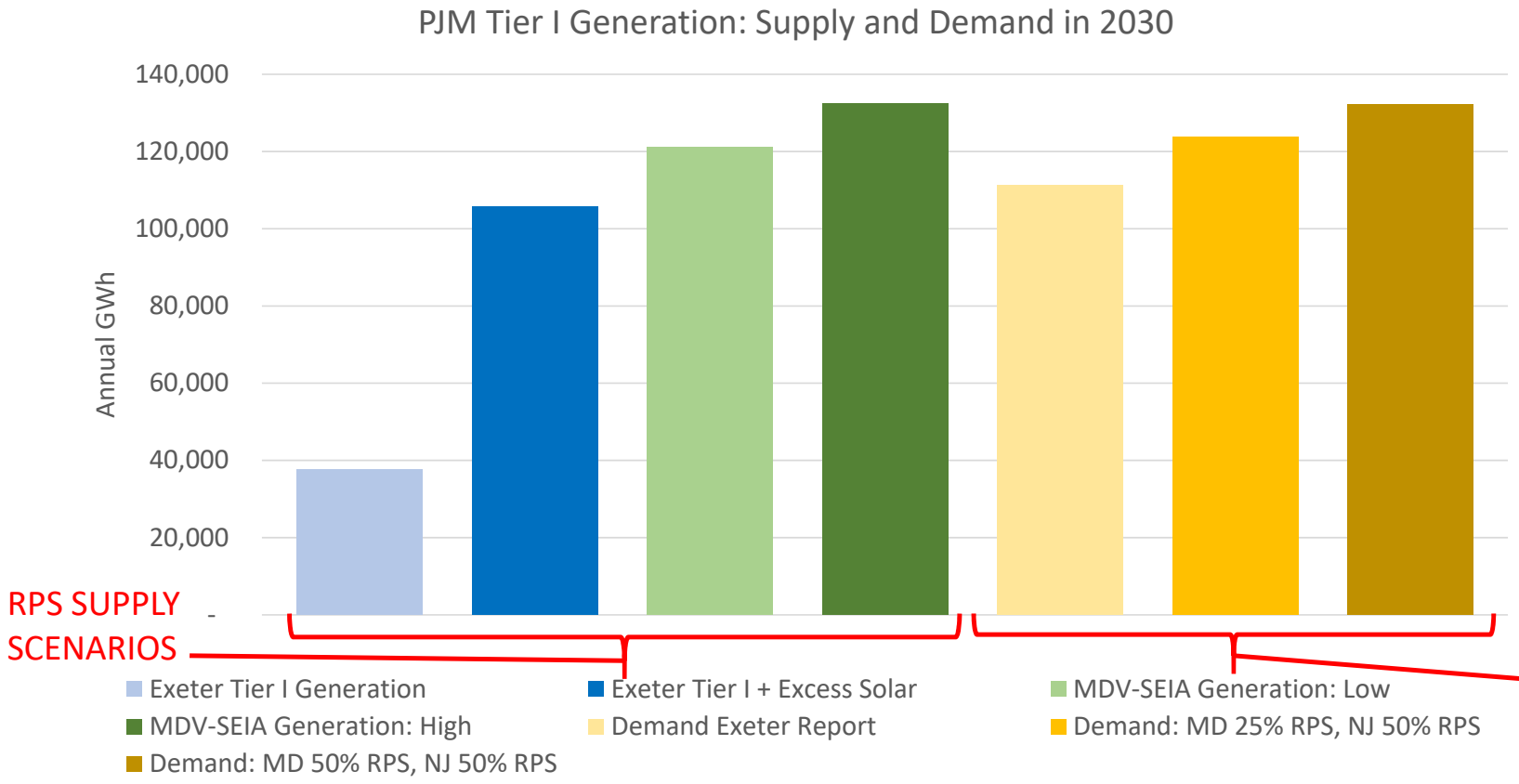
Tier 1 Additions Assumptions in Context: Exeter vs MDV-SEIA vs PJM Queue



For Undersupply Narrative to Hold, Expected Tier 1 Solar Additions Must Be Ignored



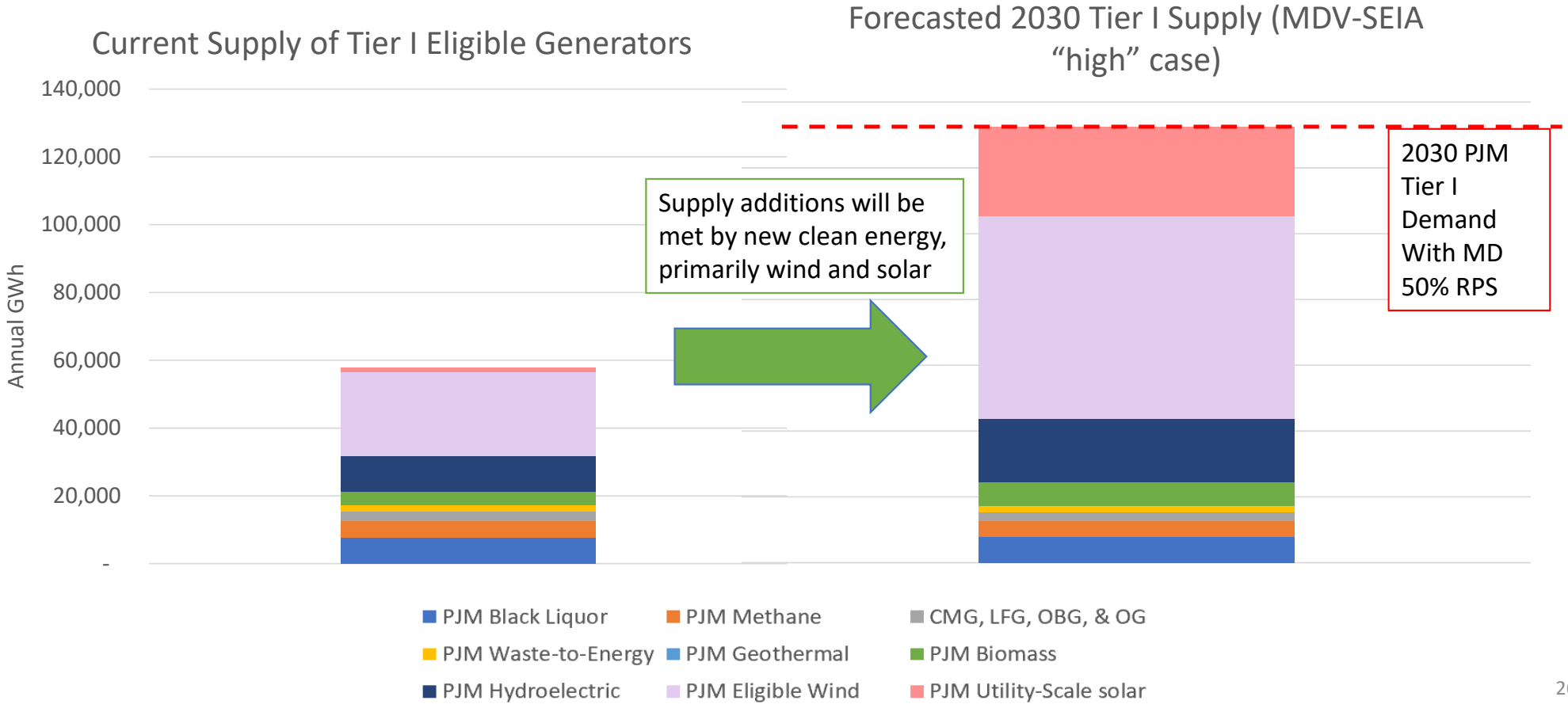
Analysis Indicates Sufficient Supply to Meet NJ & MD RPS Increases



MDV-SEIA Low vs. High scenarios assume different rates of solar and wind growth well below current PJM queue activity. Both scenarios also assume lower biomass growth rate assumptions vs. Exeter's report

CONCLUSIONS

New Wind and Solar Additions Through 2030 Adequate to Meet Tier 1 Demand Including MD 50% RPS



Conclusion: Tier 1 Undersupply Unlikely Even With NJ & MD RPS Expansion

Exeter's Conclusion

- The PJM Tier I market is undersupplied and will require 46% annual growth rate to satisfy RPS demand
- This conclusion is flawed for three reasons:
  1) The supply of eligible Tier I resources is incorrect
  2) The capacity factors are lower than market data indicates
  3) The addition rates are far too low for wind and solar

MDV-SEIA's Conclusion

- The current PJM Tier I RPS construct is working to incent new clean energy to come online (as seen by the 8 GW of wind that has come online over the past 10 yrs)
- Proper inclusion of eligible Tier I resources along with reasonable addition rates that will be further driven by RPS demand results in Tier I market balance even with the addition of the NJ 50% RPS and the MD 50% RPS