

Final Draft 2017 Inventory of Renewable Energy Generators

KEVIN PORTER AND LAURA MILLER, EXETER ASSOCIATES, INC.

PRESENTATION TO MARYLAND RPS WORK GROUP

DAVIDSON, MARYLAND

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Overview

- Findings
- Summary of Comments on Preliminary Draft
- Comments Addressed and Not Addressed
- Results, Solar Carve-Out and Non-Carve-Out Tier 1
- Results, High Capacity Factor Wind and Solar
- Results, 50 percent RPS in Maryland
- Caveats

Purpose of the Final Draft of the Renewable Energy Inventory

- Purpose of report is to estimate the quantity of proposed, planned and operating generation resources in PJM that are eligible for the PJM states' (inclusive of Maryland) RPS policies, and to assess how much, if any, generation capacity would need to be developed to meet the requirements of the Maryland RPS and other state RPS policies.

Findings of the Final Draft of the Renewable Energy Inventory

- Final Draft report projects a shortfall of non-solar carve-out Tier 1 RECs in PJM (except for 2018 and 2030), but adequate supplies of solar and Tier 2 RECs.
 - As discussed later, the analysis is based on several assumptions that if not realized, will affect the results, perhaps considerably.
 - Final Draft report indicates that changing the eligible resources for the non-carve-out Tier 1 category in Maryland would only represent a change to the renewable portfolio “balance” of PJM states with RPS policies, with the exception of black liquor.
 - Other than Maryland, states in PJM generally do not include black liquor as an eligible technology in their RPS policies.* If it was no longer eligible in Maryland, then additional Tier 1 non-carve out RECs would be necessary.
- * Black liquor is eligible as a Tier 1 resource in Pennsylvania but only for in-state resources, and as a Tier 2 resource in the District of Columbia.

Summary of Comments from Previous Draft

- Report's basic finding that there is a shortage of Tier 1 non-solar carve-out RECs currently within PJM was questioned:
 - All states are meeting their RPS targets.
 - Tier 1 REC prices within PJM are low.
- Recommendations to adjust report's methodology in several respects:
 - Take a PJM-wide perspective in estimating demand and supply for RPS policies within PJM and not limit analysis only to generators registered for the Maryland RPS.
 - Incorporate "excess solar" over and above the solar carve-out requirements as a non-carve-out Tier 1 requirements.
 - Re-evaluate the methodology for forecasting future capacity additions of on-shore wind.
 - Reconsider the capacity factors for wind and solar.
 - Do not include states with voluntary RPS targets (Indiana and Virginia).
 - Correct some data errors for generation and load in various states.

Comments Addressed from Previous Draft

- Take a PJM-wide perspective in estimating demand and supply for RPS policies within PJM and not limit analysis only to generators registered for the Maryland RPS. ✓
- Use “excess solar” from carve-outs be used to fulfill non-carve-out Tier 1 requirements. ✓
- Re-evaluate the methodology for adding new on-shore wind capacity. ✓
- Reconsidered the capacity factors for wind. ✓
- Removed states in PJM with voluntary RPS targets (Indiana and Virginia). ✓
- Incorporated New Jersey’s updated RPS requirements. ✓
- Correct some data errors for generation and load in various states. ✓

Comments Addressed from Previous Draft – In Detail

- Take a PJM-wide perspective in estimating demand and supply for RPS policies within PJM and not limit analysis only to generators registered for the Maryland RPS. ✓
- Incorporate “excess solar” over and above state solar carve-out requirements as a compliance option for non-carve-out Tier 1. ✓
- Re-evaluate the methodology for adding incremental capacity of on-shore wind.
 - Used historical annual wind capacity increases in GATS rather than the PJM interconnection queue ✓
 - Assumed a 50 percent reduction in new on-shore wind capacity within PJM after the PTC expires in 2021.
- Reconsider the capacity factors for wind and solar. ✓
 - Reviewed EIA and GATS data to calculate historical capacity factors.
 - The capacity factor for on-shore wind was increased from 26 percent to 30 percent.
 - Solar was left unchanged at 16 percent in the report, *but* a high wind and solar capacity factor scenario was added.

Comments Not Incorporated

- Incorporate RECs banking.
- Eliminate Illinois from RPS demand calculations.
- Incorporate utility announcements for adding renewable energy capacity.
- Account for pending initiatives in the District of Columbia and New Jersey
 - New Jersey—development of an Energy Master Plan to meet a 100 percent clean energy target by 2050.
 - District of Columbia—Legislation introduced to increase the D.C. RPS to 100 percent by 2050.

Electric Generating Capacity Factors Estimated for PJM

Generator Type	PJM Capacity Factor
Biomass	84%
Black Liquor	84
Geothermal	80
Hydroelectric	45
Methane (mixed fuel)	55
Solar PV	16
Solar Thermal	25
Waste-to-Energy	27
Wind – Land-based	30
Wind – Offshore ^[i]	39

Note: See Appendix B for full derivation methodology.
^[i] This was not used for the two Maryland-specific projects; those projections were based directly on Maryland PSC Order No. 88192.

Non-carve-out Tier 1 Projected Projects in PJM by Technology 2018-2030

Estimated Capacity (MW)

Year	Wind	Offshore Wind	Hydro	Qualifying Biomass	Methane	Other ^[i]	TOTAL
2017 ^[ii]	8,262	--	2,698	387	811	1,426	13,584
2018	8,987	--	2,728	392	836	1,426	14,369
2019	9,712	--	2,758	397	861	1,426	15,154
2020	10,437	--	2,788	402	886	1,426	15,939
2021	10,799	248	2,818	407	911	1,426	16,610
2022	11,162	248	2,848	412	936	1,426	17,032
2023	11,524	368	2,878	417	961	1,426	17,575
2024	11,887	368	2,908	422	986	1,426	17,997
2025	12,249	368	2,938	427	1,011	1,426	18,420
2026	12,612	368	2,968	432	1,036	1,426	18,842
2027	12,974	368	2,998	437	1,061	1,426	19,265
2028	13,337	368	3,028	442	1,086	1,426	19,687
2029	13,699	368	3,058	447	1,111	1,426	20,110
2030	14,062	368	3,088	452	1,136	1,426	20,532
Average Annual Growth Rates							
2018-2024	4.77%	0.00%	1.07%	1.24%	2.79%	0.00%	3.82%
2024-2030	2.84%	0.00%	1.01%	1.15%	2.39%	0.00%	2.22%
2018-2030	3.80%	0.00%	1.04%	1.19%	2.59%	0.00%	3.02%

^[i] Includes black liquor, geothermal, and waste-to-energy, which are not expected to experience market growth.
^[ii] The 2017 Inventory Database capacity data were used for 2017.

Estimated Generation (GWh)

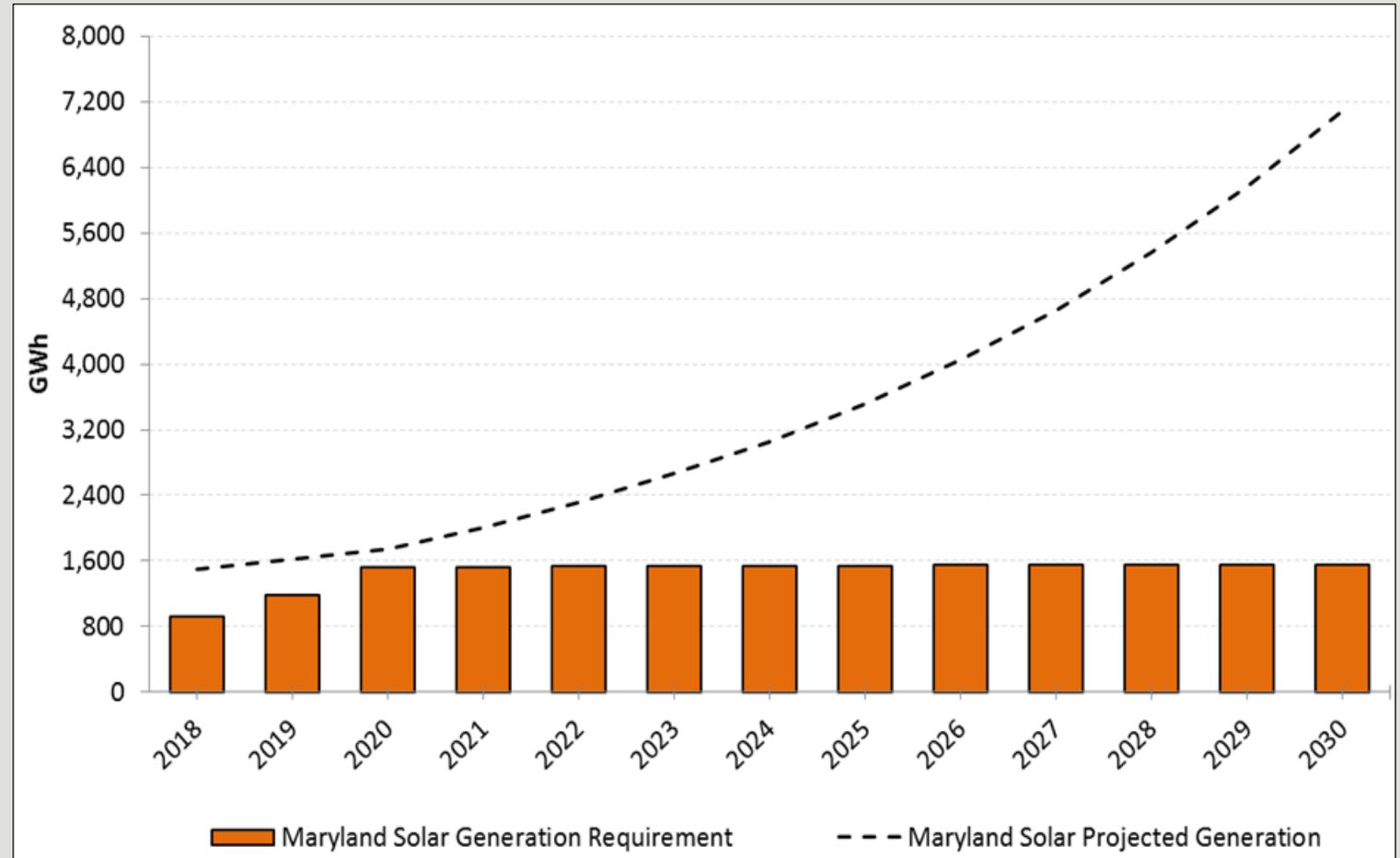
Year	Wind	Offshore Wind	Hydro	Qualifying Biomass	Methane	Other ^[i]	TOTAL
2017 ^[ii]	21,712	--	10,637	2,851	3,905	5,842	44,948
2018	23,617	--	10,756	2,888	4,026	5,842	47,128
2019	25,522	--	10,874	2,925	4,146	5,842	49,309
2020	27,428	--	10,992	2,961	4,267	5,842	51,490
2021	28,380	914	11,110	2,998	4,387	5,842	53,632
2022	29,333	914	11,229	3,035	4,508	5,842	54,860
2023	30,286	1,369	11,347	3,072	4,628	5,842	56,544
2024	31,238	1,369	11,465	3,109	4,749	5,842	57,772
2025	32,191	1,369	11,583	3,145	4,869	5,842	59,000
2026	33,144	1,369	11,702	3,182	4,989	5,842	60,228
2027	34,096	1,369	11,820	3,219	5,110	5,842	61,456
2028	35,049	1,369	11,938	3,256	5,230	5,842	62,685
2029	36,001	1,369	12,056	3,292	5,351	5,842	63,913
2030	36,954	1,369	12,175	3,329	5,471	5,842	65,141
Average Annual Growth Rates							
2018-2024	4.77%	0.00%	1.07%	1.24%	2.79%	0.00%	3.45%
2024-2030	2.84%	0.00%	1.01%	1.15%	2.39%	0.00%	2.02%
2018-2030	3.80%	0.00%	1.04%	1.19%	2.59%	0.00%	2.73%

^[i] Includes black liquor, geothermal, and waste-to-energy, which are not expected to experience market growth.
^[ii] The 2017 Inventory Database capacity data and capacity factors were used for 2017.

Maryland Solar Carve-out

- Maryland is expected to meet and exceed its solar carve-out requirements.
- Maryland is projected to be in excess of its solar carve-out requirement by 222 GWh by 2020 and by 5,523 GWh by 2030.

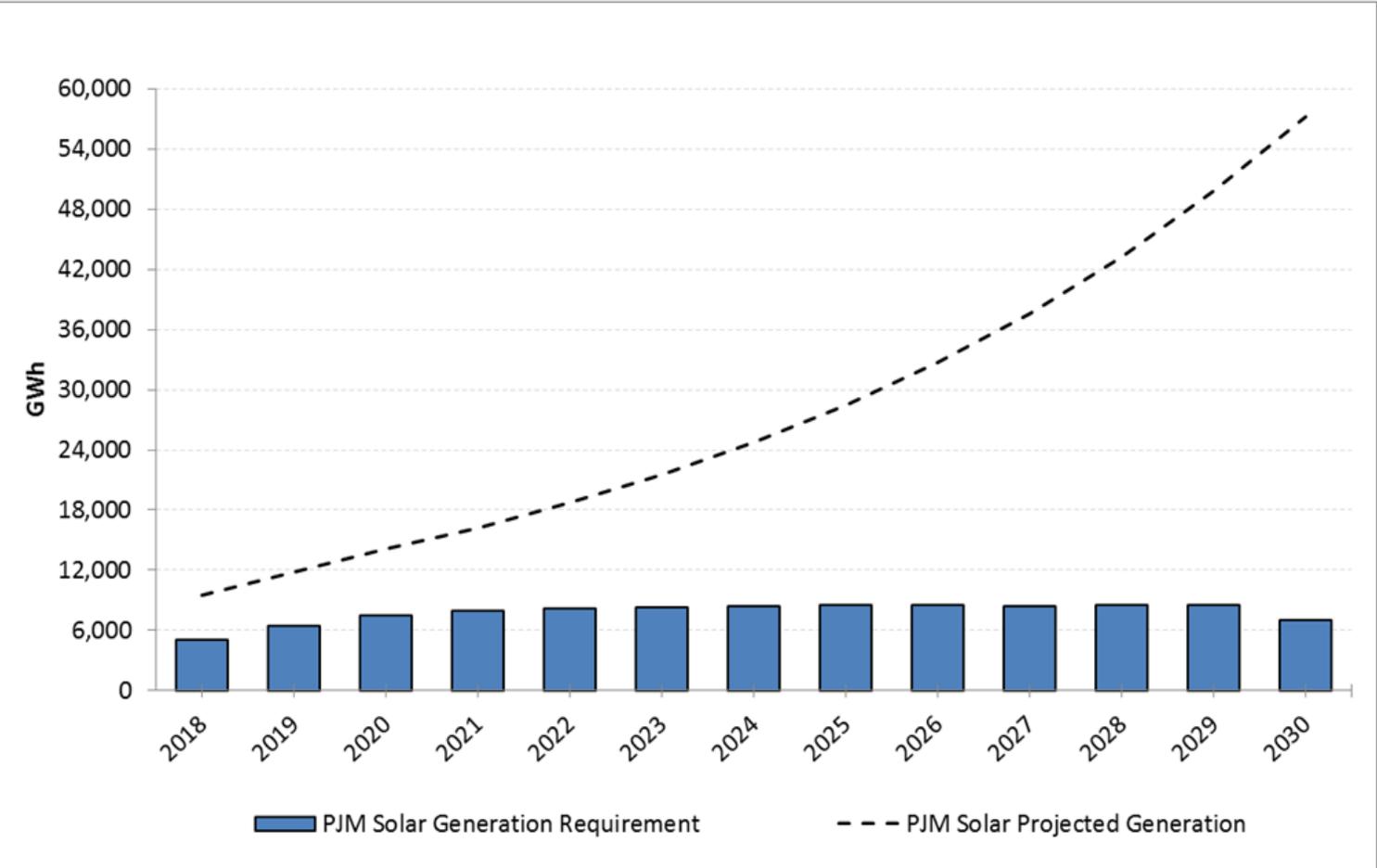
Solar RPS Requirements in Maryland Compared to Projected Solar Energy Generation in Maryland (2018-2030) (GWh)



Solar Carve-outs in PJM

- Provided for information only, as most states in PJM with solar carve-outs require solar to be located in that state.

Solar RPS Requirements in PJM Compared to Projected Solar Energy Generation (2018-2030) (GWh)



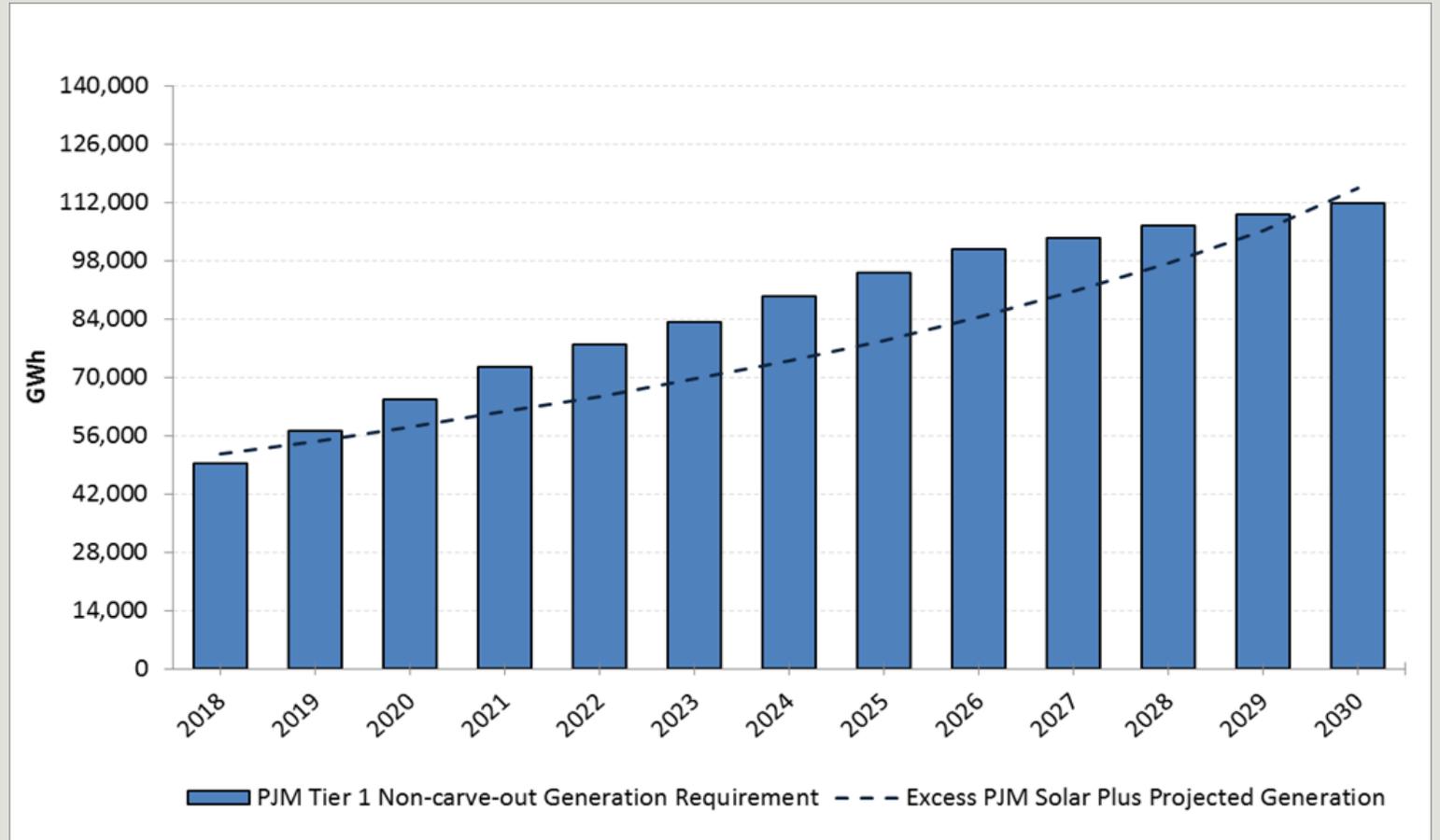
Non-carve-out Tier 1 RPS Requirements in PJM Compared to Projected PJM Renewable Energy Generation (2018-2030) (GWh)

Year	Generation Requirement	Projected Generation	Excess Solar	Net
2018	49,354	47,128	4,408	2,182
2019	57,207	49,309	5,365	(2,532)
2020	64,797	51,490	6,633	(6,674)
2021	72,394	53,632	8,331	(10,431)
2022	77,820	54,860	10,562	(12,398)
2023	83,347	56,544	13,154	(13,649)
2024	89,324	57,772	16,331	(15,220)
2025	95,132	59,000	19,914	(16,218)
2026	100,697	60,228	24,186	(16,283)
2027	103,467	61,456	29,154	(12,856)
2028	106,341	62,685	34,740	(8,916)
2029	109,052	63,913	41,178	(3,961)
2030	111,799	65,141	50,187	3,529

- Projected deficit peaks in 2026, then turns into a surplus in 2030.
- For 2026, deficit amounts to roughly 5-7 GW of wind (if met only with wind) or 7-12 GW of solar (if met only with solar).

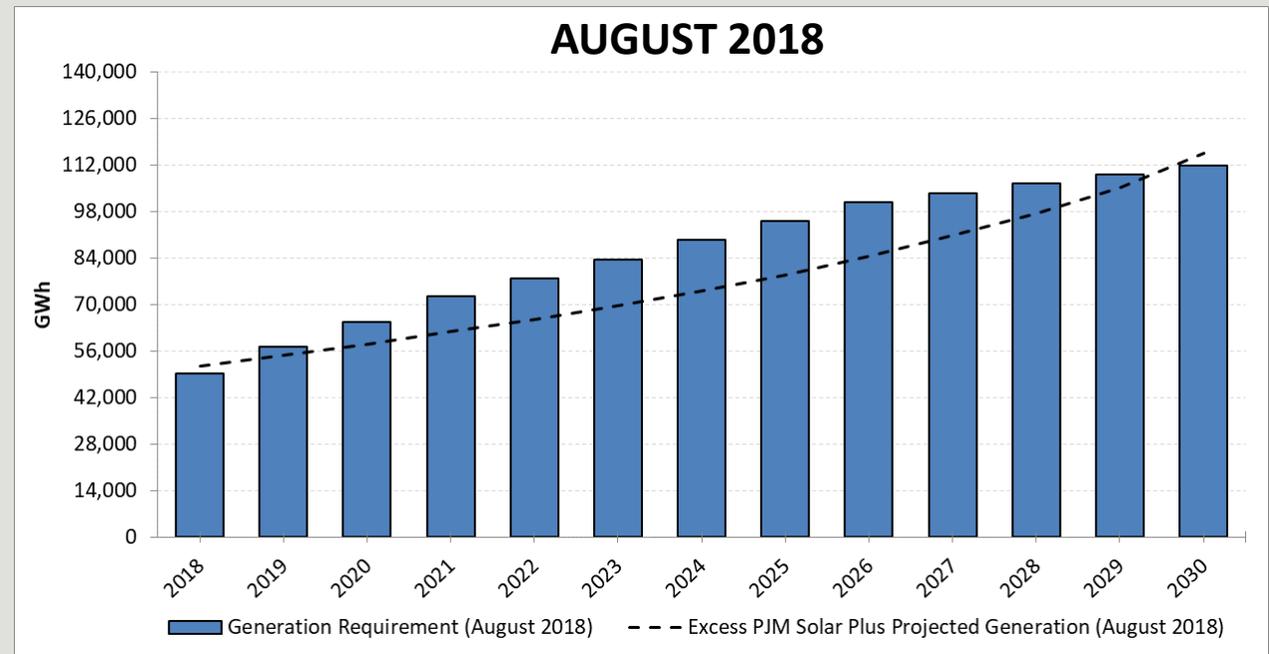
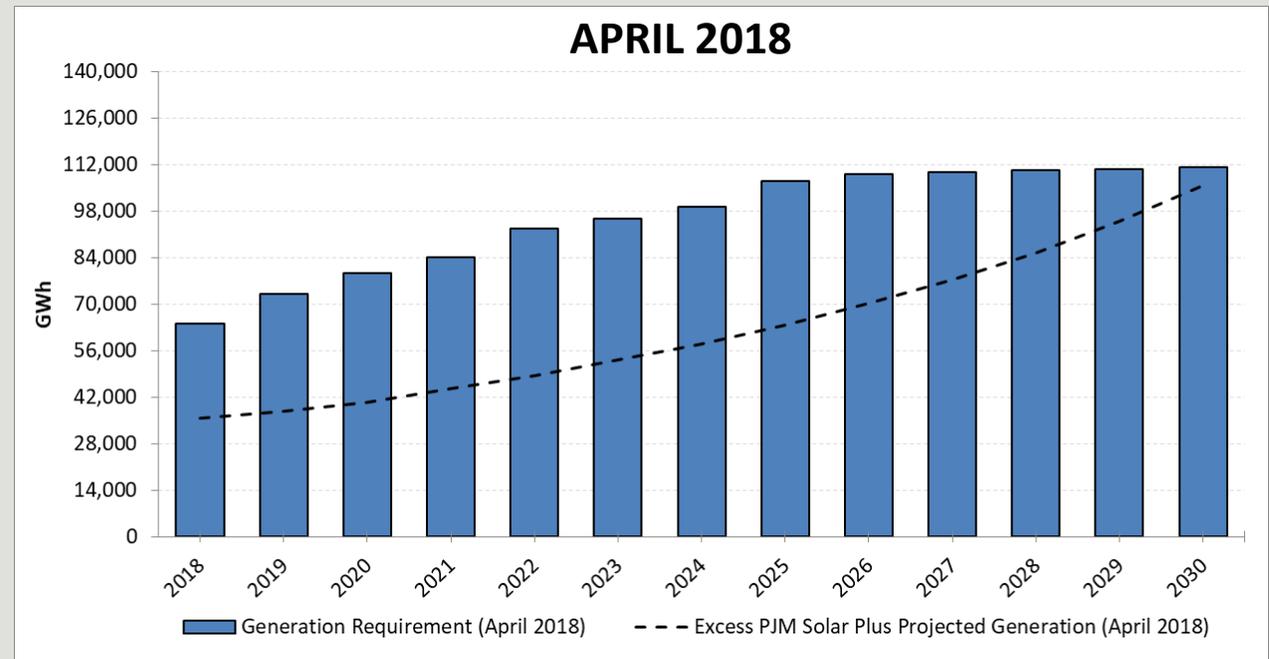
Non-carve-out
Tier 1 RPS
Requirements in
PJM Compared to
Projected PJM
Renewable Energy
Generation (2018-
2030) (GWh)

Non-carve-out Tier 1 RPS Requirements in PJM Compared to Projected Available PJM Renewable Energy Generation (2018-2030) (GWh)



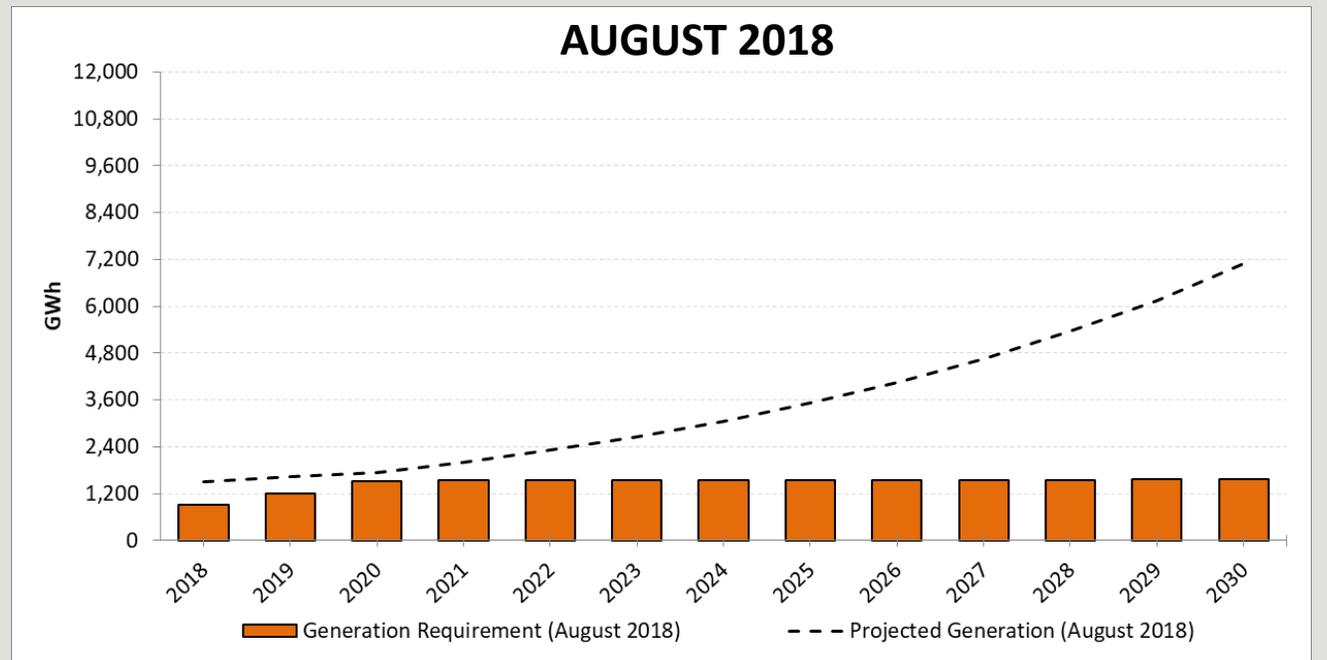
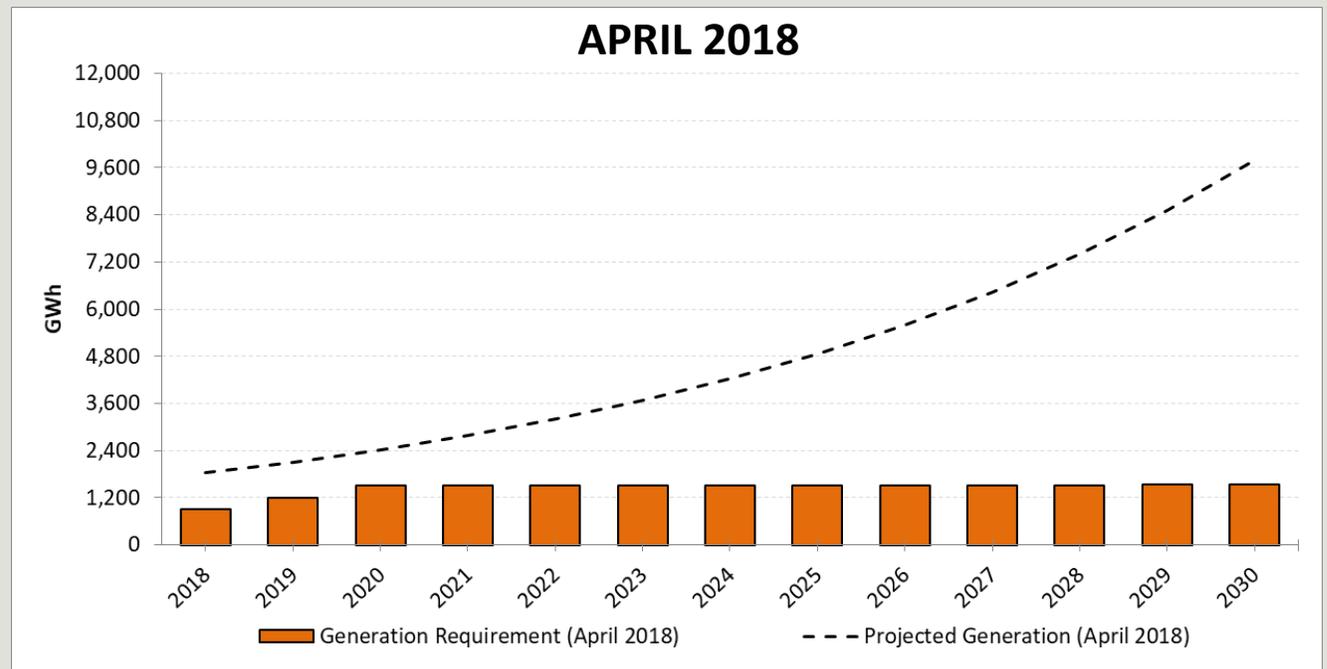
Comparison of Results: April and August 2018

PJM Non-carve-out Tier 1 Generation Requirements, surpluses and shortages by year



Comparison of Results: April and August 2018

Maryland Solar Generation Requirements, surpluses by year



Alternative Scenario – 50% Maryland RPS by 2030

- An increase in the Maryland RPS requirement will put upward pressure on Maryland REC prices, making it more economical to apply RECs from other states to Maryland.
- An increase in Maryland REC prices will in turn increase REC prices in other PJM states with an RPS. With an overall increase, renewable energy projects that may have been unprofitable at lower REC prices may become profitable, resulting in an increase in the amount of RECs in the market.

Scenario for 50 Percent Maryland RPS Requirement by 2030, by Percentages

Year	Tier 1 Solar	ORECs	Non-carve-out Tier 1	TOTAL
2018 ^[i]	1.50%	0.00%	14.30%	18.30%
2019	1.95	0.00	18.45	20.40
2020	2.50	0.00	22.50	25.00
2021	2.75	1.33	24.55	28.63
2022	3.00	1.33	26.60	30.93
2023	3.25	1.98	28.66	33.89
2024	3.50	1.98	30.71	36.19
2025	3.75	1.98	32.76	38.49
2026	4.00	1.98	34.81	40.79
2027	4.25	1.98	36.86	43.09
2028	4.50	1.98	38.92	45.40
2029	4.75	1.98	40.97	47.70
2030	5.00	1.98	43.02	50.00

^[i] The 2018 total includes 2.5 percent for the final year of Tier 2 compliance.

Alternative Scenario – 50% Maryland RPS by 2030 Impact on Non-carve-out Tier 1

- Including all PJM RPS requirements, there would be insufficient resources within PJM to satisfy non-carve out Tier 1 requirements.
- Here again, deficit of non-carve-out RECs peaks in 2026 and declines by 2030.
- For 2026, projected deficit equivalent to roughly 8-11 GW of wind (if only met with wind) or 11-19 GW (if only met with solar)

**Non-carve-out Tier 1 RPS Requirements in PJM Assuming a Maryland
50% RPS Requirement (2018-2030) (GWh)**

Year	RPS Generation Requirements in PJM (a)	Projected Supply of RPS-eligible Generation in PJM (b)	Excess PJM Solar (Assuming 5% Solar Carve-out in Maryland) (c)	Difference between Projected RPS Requirements and Generation (b)+(c)-(a)
2018	49,354	47,128	4,380	2,182
2019	57,207	49,309	5,337	(2,532)
2020	64,797	51,490	6,605	(6,674)
2021	74,463	53,632	8,151	(12,653)
2022	81,150	54,860	10,228	(16,035)
2023	88,346	56,544	12,666	(19,108)
2024	95,601	57,772	15,688	(22,113)
2025	102,689	59,000	19,115	(24,547)
2026	109,538	60,228	23,258	(26,052)
2027	113,599	61,456	28,070	(24,072)
2028	117,767	62,685	33,498	(21,585)
2029	121,778	63,913	39,777	(18,088)
2030	125,830	65,141	48,628	(12,061)

High Wind and Capacity Factor Scenario

Non-carve-out Tier 1 in PJM.
Assume solar has a 25 percent capacity factor and wind has a 35 percent capacity factor.

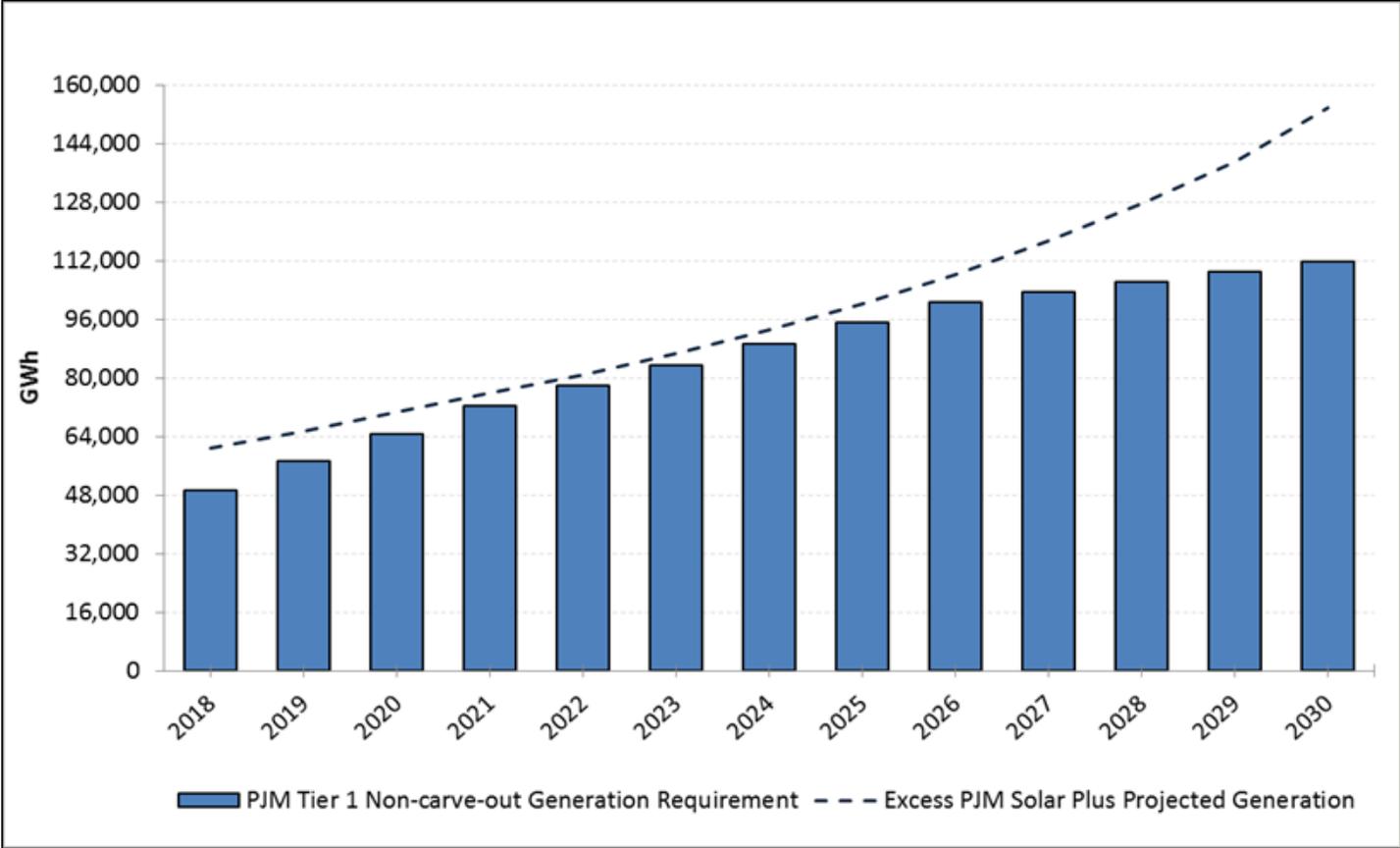
Non-carve-out Tier 1 RPS Requirements in PJM Compared to Projected Available PJM Renewable Energy Generation (2018-2030) (GWh)

Year	Generation Requirement	Projected Generation	Excess Solar ^[i]	Net
2018	49,354	51,065	9,752	11,463
2019	57,207	53,563	12,015	8,371
2020	64,797	56,061	14,588	5,852
2021	72,394	58,362	17,479	3,447
2022	77,820	59,749	21,082	3,011
2023	83,347	61,591	25,253	3,497
2024	89,324	62,978	30,245	3,899
2025	95,132	64,365	35,914	5,147
2026	100,697	65,752	42,586	7,641
2027	103,467	67,139	50,314	13,986
2028	106,341	68,526	59,074	21,259
2029	109,052	69,913	69,162	30,023
2030	111,799	71,300	82,369	41,870

High Wind and Capacity Factor Scenario, cont.

Non-carve-out Tier 1 in PJM, assume solar has a 25 percent capacity factor and wind has a 35 percent capacity factor

Non-carve-out Tier 1 RPS Requirements in PJM Compared to Projected Available PJM Renewable Energy Generation (2018-2030) (GWh)



Caveats

- It is assumed states in PJM will not change their existing RPS policies, and states without a RPS continue to not have an RPS.
- Projected capacity additions by technology could differ than what was assumed in this report.
- This report limits future offshore wind capacity to the two projects approved by the Maryland PSC. However, substantially more offshore wind capacity could be developed if initiatives such as New Jersey's goal of 3,500 MW of offshore wind by 2030 is successful.
- Certain utility initiatives to add more renewable energy were not included in the Inventory.

Caveats (cont'd)

- Higher load growth than projected would increase the demand for RPS-eligible generation within PJM.
- Largely followed what the Maryland RPS classifies as eligible technologies, which excludes certain non-renewable technologies such as natural gas cogeneration and bituminous coal that qualify as Tier 1 resources in other states.
- Only eligible resources and demand within PJM states were assessed, but renewable resources that are located outside of PJM are also eligible to meet non-carve-out Tier 1 requirements in PJM. In 2016, 13.9 percent of non-carve-out Tier 1 requirements in Maryland were met using outside-of-PJM resources.
- The capacity factors of certain technologies could be higher or lower than what is assumed in this report, such as the 30 percent capacity factor for wind and the 16 percent capacity factor for solar.

Next Steps

- Please provide comments by September 7th.
- PPRP/Exeter will review comments and revise the report.