Maryland Power Plant Research Program

# 2017 INVENTORY OF RENEWABLE ENERGY GENERATORS ELIGIBLE FOR THE MARYLAND RENEWABLE ENERGY PORTFOLIO STANDARD

## ~PRELIMINARY DRAFT~

**MARCH 2018**

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**Prepared for:**

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**POWER PLANT RESEARCH PROGRAM**

**MARYLAND DEPARTMENT OF NATURAL RESOURCES**

**MARCH 2018**

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# Acknowledgments

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# Table of Contents

# Table of Contents (cont'd)

# List of Tables

# List of Tables (cont'd)

# List of Figures

# List of Acronyms

| | |
|---|---|
| ACP | Alternative Compliance Payment |
| AEC | Alternative Energy Credit |
| AEPS | Alternative Energy Portfolio Standard (OH) |
| CPS | Clean Energy Portfolio Standard (IN) |
| CY | Compliance Year |
| DG | Distributed Generation |
| EIA | U.S. Energy Information Administration |
| EY | Energy Year |
| FERC | Federal Energy Regulatory Commission |
| GATS | Generation Attribute Tracking System |
| GWh | Gigawatt-hour |
| HB | House Bill |
| IOU | Investor-owned Utility |
| IPL | Industrial Process Load |
| ISO | Independent System Operator |
| ITC | Investment Tax Credit |
| kW | Kilowatt |
| LFG | Landfill Gas |
| LSE | Load-serving Entity |
| MISO | Midcontinent Independent System Operator |
| MW | Megawatt |
| MWh | Megawatt-hour |
| OREC | Offshore Wind Renewable Energy Credit |
| OpenEI | Open Energy Information |
| NREL | National Renewable Energy Laboratory |
| PJM | PJM Interconnection, LLC |
| PPRP | Power Plant Research Program |
| PSC | Maryland Public Service Commission |
| PV | Photovoltaic |
| REC | Renewable Energy Credit |
| REPS | Renewable Energy and Energy Efficiency Portfolio Standard (NC) |
| RPS | Renewable Energy Portfolio Standard |
| RTO | Regional Transmission Organization |
| SREC | Solar Renewable Energy Credit |
| SB | Senate Bill |

# Abstract

The *2017 Inventory of Renewable Energy Generators Eligible for the Maryland Renewable Energy Portfolio Standard* (2017 Inventory Report) is the third comprehensive effort by the Maryland Department of Natural Resources, Power Plant Research Program (PPRP) since 2006 to determine whether there is sufficient operating and planned renewable energy generating capacity within PJM Interconnection, LLC (PJM) to meet Maryland's Renewable Energy Portfolio Standard (RPS) requirements established under the 2004 Maryland Renewable Energy Portfolio Standard and Credit Trading Act. The 2017 Inventory Report quantifies resources that are eligible to meet current Maryland RPS requirements and assesses the additional renewable energy generating capacity needed to meet future requirements.

The purpose of this report is to provide a comprehensive assessment as to whether Maryland can reasonably meet its RPS requirements in coming years following the changes to the Maryland RPS and other PJM states' RPS requirements, and the changes in proposed, planned, and operating renewable energy capacity. This edition also takes into consideration the impact each RPS category has on the whole, as well as what might be expected to occur with an increase in the Maryland RPS.

# Executive Summary

The *2017 Inventory of Renewable Energy Generators Eligible for the Maryland Renewable Energy Portfolio Standard* (2017 Inventory Report) is the third comprehensive effort by the Maryland Department of Natural Resources, Power Plant Research Program (PPRP) since 2006 to determine whether there is sufficient renewable generation capacity within PJM Interconnection, LLC (PJM) to meet Maryland's Renewable Energy Portfolio Standard (RPS) requirements first established under the 2004 Maryland Renewable Energy Portfolio Standard and Credit Trading Act. The previous update, published in 2012, concluded that: "…Maryland's solar generation capacity must grow substantially…to meet Tier 1 solar set-aside requirements for 2022"; "…compliance with non-solar [non-carve-out] Tier 1 generation requirements will require a modest year-over-year rate of growth in eligible generation"; and "…no new Tier 2 generators will be needed to meet Maryland or other Tier 2 RPS standards in PJM."[1]

Since the last update in 2012, the Maryland General Assembly has amended the Maryland RPS several times. These amendments include:

- Adding offshore wind, solar water-heating, thermal energy from biomass systems that primarily use animal waste, and geothermal heating and cooling as eligible technologies;
- Creating carve-outs for offshore wind within Tier 1;
- Changing the geographic eligibility of facilities to exclude renewable energy credits (RECs) from states adjacent to PJM, absent an accompanying delivery of electricity into PJM;
- Increasing the percentage requirement for Tier 1 resources and accelerating the schedule; and
- Recategorizing waste-to-energy systems as Tier 1 resources from their former classification as Tier 2 resources.

The 2017 Inventory Report reflects all changes to the Maryland RPS since May 2012. The current requirements of the Maryland RPS are displayed in Table ES-1.

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[1] *2011 Inventory of Renewable Energy Generators Eligible for the Maryland Renewable Energy Portfolio Standard*; Maryland Department of Natural Resources, Power Plant Research Program, February 2012, http://msa.maryland.gov/megafile/msa/speccol/sc5300/sc5339/000113/014000/014735/unrestricted/20120571e.pdf, p. i.

**Table ES-1. Maryland RPS – Percentage of Renewable Energy Required**

| Year | Tier 1 Total | Solar (subset Tier 1)[a] | Offshore Wind (subset Tier 1)[b] | Tier 2 Total[c] |
|---|---|---|---|---|
| 2006 | 1% | 0% | 0% | 2.5% |
| 2007 | 1 | 0 | 0 | 2.5 |
| 2008 | 2.005 | 0.005 | 0 | 2.5 |
| 2009 | 2.01 | 0.01 | 0 | 2.5 |
| 2010 | 3.025 | 0.025 | 0 | 2.5 |
| 2011 | 5 | 0.05 | 0 | 2.5 |
| 2012 | 6.5 | 0.1 | 0 | 2.5 |
| 2013 | 8.2 | 0.25 | 0 | 2.5 |
| 2014 | 10.3 | 0.35 | 0 | 2.5 |
| 2015 | 10.5 | 0.5 | 0 | 2.5 |
| 2016 | 12.7 | 0.7 | 0 | 2.5 |
| 2017 | 13.1 | 1.15 | 0 | 2.5 |
| 2018 | 15.8 | 1.5 | 0 | 2.5 |
| 2019 | 20.4 | 1.95 | 0 | -- |
| 2020 | 25 | 2.5 | 0 | -- |
| 2021[d] | 25 | 2.5 | ~1.33 | -- |
| 2022 | 25 | 2.5 | ~1.33 | -- |
| 2023+ | 25 | 2.5 | ~2.0 | -- |

[a] Solar requirement began in compliance year 2008.

[b] The offshore wind carve-out by law could be a maximum of 2.5 percent beginning in 2017; however, only the approved offshore RECs (ORECs) have been included here. Other PJM members do not have an equivalent category.

[c] Tier 2 requirement sunsets at the end of compliance year 2018.

[d] According to Maryland Public Service Commission (PSC) Order No. 88192, Table 2, "Offshore Wind Component of the RPS Obligation for Purchasers of ORECs." (The percentage fluctuates annually because the ORECs are based on MWh and energy sales every year.)

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*Source:* Maryland Code, Public Utilities § 7-703, http://codes.findlaw.com/md/public-utilities/md-code-public-util-sect-7-703.html.

Eight PJM states (Delaware, Illinois, Maryland, Michigan, New Jersey, North Carolina, Ohio, and Pennsylvania) and the District of Columbia have mandatory RPS requirements. Indiana and Virginia have developed voluntary renewable energy goals. Numerous changes in these policies and in the amount of proposed, planned, and operating renewable energy capacity warrant a new assessment of renewable energy projects to gauge current and future resources needed to meet state RPS requirements within PJM.[2]

This report uses data contained in the PJM Generation Attribute Tracking System (GATS) to produce a dataset of available renewable energy capacity that would qualify under the Maryland RPS. The dataset is supplemented with geophysical, capacity, and generation data acquired from the U.S. Department of Energy's (DOE's) U.S. Energy Information Administration (EIA). Additional research including state RPS requirements (see Appendix A) and electricity sales projections were also incorporated into this database, which is referred to throughout this document as the 2017 Inventory Database.

Analysis of the 2017 Inventory Database determined the current availability of renewable resources and the amount of growth needed to satisfy not only Maryland's RPS but also the RPS requirements of other states in PJM. Maryland's Tier 1 RPS requirement allows its electric suppliers to source ocean energy, landfill gas, biomass, onshore and offshore wind, solar, solar water heating, and fuel cells (fueled by Tier 1 resources) from anywhere within PJM or from outside of PJM if the associated energy is delivered into PJM.[3] Geothermal electric, geothermal heat pumps, municipal solid waste, and poultry litter plants must also be located within Maryland and interconnected to the distribution grid. Tier 1 RECs may also be used to fulfill Tier 2 requirements. Of the Maryland RPS requirements, compliance with the non-carve-out Tier 1 category appears to represent the only potential challenge. Available data indicate that if all PJM states with RPSs, including the voluntary goals established in Indiana and Virginia, were to meet their RPS requirements with PJM resources, PJM would experience a nearly 31,000 gigawatt-hour (GWh) deficit (i.e., 55 percent) in 2017 non-carve-out Tier 1 generation. Relying on those same parameters, non-carve-out Tier 1 generation will need to grow at approximately 46 percent annually beginning in 2017 to meet future PJM (inclusive of Maryland) RPS requirements out to 2020 if all PJM states, including Maryland, rely only on PJM renewable resources to meet RPS requirements. This suggests that a significant portion of PJM RPS compliance will be met from qualifying resources outside of PJM.

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[2] See Appendix A for specific state RPS information.

[3] Solar resources may be used for compliance with the basic Tier 1 requirements. For purposes of this report and analysis, it is assumed that all in-state solar installations will be used to meet the Maryland solar carve-out. Solar facilities located outside of Maryland are expected to be used to comply with other state solar carve-out or solar-specific requirements. States without a solar carve-out might have solar installations that could contribute to compliance with Tier 1 requirements in Maryland or other PJM states; however, this is anticipated to be a *de minimis* amount. Therefore, the solar carve-out resources are accounted for separately from Maryland non-carve-out Tier 1, despite the fact that they could qualify under either category.

The Maryland RPS has two carve-outs; one for solar and one for offshore wind. The Maryland Tier 1 solar carve-out requires that solar be connected to the distribution grid in Maryland to be eligible for compliance; for purposes of this report, these solar projects will be considered in-state. Solar capacity will need to grow by approximately 4 percent annually (every year from 2017 through 2020) to meet future Maryland solar requirements. Maryland is on pace to meet its current and future solar carve-out requirements, based on anticipated new capacity projected using a 15 percent growth rate.

Eligible offshore wind facilities that are located on the continental shelf between 10 and 30 miles off the coast of Maryland in a U.S. Department of the Interior (DOI) designated leasing zone potentially qualify for the Tier 1 offshore wind carve-out pending Maryland Public Service Commission (PSC) approval. On May 11, 2017, the PSC issued Order No. 88192 approving two offshore wind energy projects—the US Wind, Inc. project was approved for 248 megawatts (MW) (of a total 750-MW planned project), and the Skipjack Offshore Energy, LLC project was approved for 120 MW.

Maryland could potentially meet Tier 2 requirements with in-state resources through its final requirement year of 2018, but there are also Tier 2 generation options available from within PJM. Some states, particularly Pennsylvania, allow additional resources such as pumped storage hydropower and waste coal to qualify as Tier 2 eligible; these resources do not qualify for Tier 2 in Maryland, but they increase the total pool of eligible resources available for various state RPS requirements in PJM.

If Maryland's RPS is increased to require that the percentage of energy sourced from renewable energy resources is greater than that represented in Maryland's existing RPS, Maryland, as well as the other PJM states with RPSs, will need to procure a greater portion of non-carve-out Tier 1-eligible RECs from outside PJM since there will be insufficient Tier 1 RECs from within PJM to meet the increased requirement based on projections of new renewable resource development in PJM. If the solar carve-out in Maryland's RPS were to be doubled from 2.5 percent by 2020 to 5.0 percent by 2030, Maryland is expected to be able to meet that added requirement with in-State solar resources; that is, in-State solar development in Maryland can be expected to accommodate even a significant increase in the solar carve-out requirement.

If Maryland were to further restrict resource eligibility for Tier 1 resources; for example, by eliminating the eligibility of RECs sourced from black liquor or wind, without any corresponding reduction in the RPS percentage requirements, added pressure may be placed on Maryland to procure RECs for RPS compliance from outside-of-PJM resources since there are insufficient

PJM non-carve-out Tier 1 (or equivalent) resources expected to be developed to allow reliance on only PJM resources.

It should be noted that the changes to the Maryland RPS related to Tier 1 eligibility may permit other PJM states to employ RECs that would have otherwise been Maryland-eligible for their own RPS compliance, thereby freeing up RECs from those states for Maryland compliance. To the degree that other PJM states with RPSs can employ the RECs that were previously Maryland-eligible, the pressure on Maryland to rely on RECs imported into PJM would be reduced.

This concept applies to all of the Tier 1 categories except black liquor, which other PJM states do not recognize as an eligible Tier 1 resource. If black liquor were to be redefined as ineligible for Maryland Tier 1 RPS compliance, there would be a reduced supply of non-carve-out Tier 1 generation (that could not be replaced with other generation from the PJM non-carve-out Tier 1 "pool"). Consequently, elimination of wind or small hydro as Maryland-eligible renewable resources accepted for Tier 1 compliance in other PJM sates would result in no meaningful changes in REC prices or the ability of PJM sates to meet their RPS requirements from PJM renewable resources. Elimination of the eligibility of black liquor, however, would result in tighter supply conditions in PJM since no other PJM states consider black liquor as an eligible Tier 1 RPS resource, and hence Maryland's exclusion of black liquor would reduce the pool of Tier 1 RECs in PJM.

Finally, it needs to be recognized that the market for RECs is highly complex due to similarities (and differences) in the RPS eligibility requirements among states (technologies and locations), differences in alternative compliance payments (ACPs), and differences in the "shelf life" of RECs in different states. With changes in RPS requirements over time, and the expected shortfall of PJM non-carve-out Tier 1 resources to fully meet the RPS requirements of the PJM states with RPSs, there will be upward pressure on REC prices in Maryland and other PJM states. Those higher REC prices will induce additional renewable resource development, changes in REC sales among the states based on differentials in REC prices, and increased imports of RECs into PJM based on more favorable economics associated with higher REC prices. Market dynamics, therefore, can be expected to resolve much, if not all, of the potential shortfalls in non-carve-out Tier 1 renewable resource availability over time.

# I. Introduction

## A. Purpose of Report

An RPS requires that a portion of the electricity sold by a load-serving entity (LSE) in a given state comes from eligible renewable energy sources. Maryland is one of 29 states, and the District of Columbia, with an RPS.

PPRP published the first *Inventory of Renewable Energy Resources Eligible for the Maryland Renewable Energy Portfolio Standard* in 2006 (2006 Inventory Report). The purpose of the 2006 Inventory Report was to determine the quantity of proposed, planned, and operating resources eligible for the Maryland RPS, and to assess how much, if any, additional renewable energy capacity would need to be constructed to meet the requirements of the Maryland RPS and of other states within PJM that have RPS policies.[4] In February 2012, PPRP published the *2011 Inventory of Renewable Energy Generators Eligible for the Maryland Renewable Energy Portfolio Standard* (2011 Inventory Report) to reflect changes to the Maryland RPS, other PJM states' RPS policies, and renewable energy capacity. The current report, the *2017 Inventory of Renewable Energy Generators Eligible for the Maryland Renewable Energy Portfolio Standard* (2017 Inventory Report), revisits the RPS requirements of Maryland and other states within PJM in light of continued growth in renewable energy capacity, modified standards, and changed market conditions.

## B. Maryland's Renewable Energy Portfolio Standard

The Maryland RPS has experienced significant changes since its inception in 2006. Tier categories and percentage requirements have changed, schedules have been accelerated, and alternative compliance payments (ACPs) have been modified.[5] Table I-1 lists categories of facilities that are currently eligible under Tier 1 and Tier 2 of the Maryland RPS.

[4] Jim McVeigh, Joseph Cohen, Kevin Porter, Christina Mudd, and Michael Lee, *Inventory of Renewable Energy Resources Eligible for the Maryland Renewable Energy Portfolio Standard*, Maryland Department of Natural Resources, Power Plant Research Program, 2006, https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/PB2006110517.xhtml, 14.

[5] Details regarding the legislative history of the Maryland RPS requirements can be found in Appendix D.

**Table I-1. Maryland RPS – Tier 1 and Tier 2 Classifications**

| | |
|---|
| **Tier 1 Eligible Facilities** |
| Solar PV and solar thermal systems (located within Maryland for the carve-out) that produce electric power, and solar water-heating systems constructed after June 1, 2011 |
| Land-based and offshore wind |
| Qualifying biomass[a] |
| Methane from the anaerobic decomposition of organic materials in a landfill or a wastewater treatment plant |
| Geothermal including energy generated through geothermal exchange from or thermal energy avoided by groundwater or a shallow ground source |
| Ocean including energy from waves, tides, currents, and thermal differences |
| Fuel cells powered by methane or biomass |
| Hydroelectric plants under 30 MW licensed by FERC or exempt from licensing |
| Poultry litter-to-energy within Maryland |
| Waste-to-energy (including blast furnace gas and refuse-derived fuels) within Maryland |
| **Tier 2 Eligible Facilities** |
| Hydroelectric plants other than pumped storage hydropower |

PV = photovoltaic; FERC = Federal Energy Regulatory Commission

[a] Qualifying biomass is: a non-hazardous, organic material that is available on a renewable or recurring basis; waste material that is segregated from inorganic waste material; and is derived from any of the following sources:

1. Excluding old-growth timber, any of the following forest-related resources:
   a. Mill residue, except sawdust and wood shavings
   b. Pre-commercial soft wood thinning
   c. Slash, brush, or yard waste
   d. Pallets, crates, or dunnage
2. Agricultural and silvicultural sources, including tree crops, vineyard materials, grains, legumes, sugar, and other crop byproducts or residues.
3. Gas produced from the anaerobic decomposition of animal waste or poultry waste.
4. A plant that is cultivated exclusively for purposes of being used as a Tier 1 or Tier 2 renewable resource to produce electricity.

*Source:* Maryland Code, Public Utilities § 7-703, http://codes.findlaw.com/md/public-utilities/md-code-public-util-sect-7-703.html.

### B.1. *Changes to Maryland RPS Requirements Subsequent to the Previous Inventory Update*

In 2012, the Maryland General Assembly passed Senate Bill (SB) 791 and House Bill (HB) 1187. Together, these bills accelerated the Maryland RPS solar carve-out compliance requirements beginning in 2013, moved the 2 percent solar requirement from 2022 to 2020, and allowed measurements of solar water-heating energy production for qualified in-home water heaters.[6] Also in 2012, the enactment of SB 652 and HB 1186 qualified eligible geothermal heating and cooling systems commissioned on or after January 1, 2013 as Tier 1 resources.

Additionally, in May 2012, SB 1004 and HB 1339 qualified thermal energy associated with biomass systems that primarily use animal waste as Tier 1 resources, effective January 1, 2013.

In 2013, Maryland enacted HB 226, which created a carve-out for offshore wind in Tier 1 of the Maryland RPS. Beginning in 2017, this bill allows qualified offshore wind generation to count toward the RPS up to a maximum of 2.5 percent of retail electricity sales. As a carve-out, this generation counts towards the overall Tier 1 requirement.[7] HB 226 defines qualified offshore wind projects as those located on the outer continental shelf, in an area of the ocean designated for leasing by the U.S. Department of the Interior (DOI), and between 10 and 30 miles off the Maryland coast. The projects must also interconnect to the PJM grid at the Delmarva Peninsula and be approved by the Maryland PSC.[8]

In February 2017, the Maryland General Assembly passed HB 1106, which increased the solar carve-out to 2.5 percent and overall Tier 1 requirements to 25 percent by 2020.[9] Throughout this report, the timeframe for the presented figures is through 2030; this is for illustration purposes only, as the Tier 1 requirements (in percentage terms) in Maryland plateau in 2020. Table I-2 illustrates the percentage requirements of the Maryland RPS by year and by tier.

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[6] See Maryland Public Utilities Article (PUA) § 7-701(q), http://codes.findlaw.com/md/public-utilities/md-code-public-util-sect-7-701.html.

[7] The Maryland PSC sets the actual amount, which may not exceed 2.5 percent.

[8] General Assembly of Maryland, HB 0226, *Maryland Offshore Wind Energy Act of 2013*, March 23, 2013, http://mgaleg.maryland.gov/2013RS/bills/hb/hb0226e.pdf.

[9] HB 1106 became law as the passage was an override of a gubernatorial veto. See http://mgaleg.maryland.gov/2016RS/bills/hb/hb1106e.pdfl.

**Table I-2. Maryland RPS – Percentage of Renewable Energy Required**

| Year | Tier 1 Total | Solar (subset Tier 1)[a] | Offshore Wind (subset Tier 1)[b] | Tier 2 Total[c] |
|---|---|---|---|---|
| 2006 | 1% | 0% | 0% | 2.5% |
| 2007 | 1 | 0 | 0 | 2.5 |
| 2008 | 2.005 | 0.005 | 0 | 2.5 |
| 2009 | 2.01 | 0.01 | 0 | 2.5 |
| 2010 | 3.025 | 0.025 | 0 | 2.5 |
| 2011 | 5 | 0.05 | 0 | 2.5 |
| 2012 | 6.5 | 0.1 | 0 | 2.5 |
| 2013 | 8.2 | 0.25 | 0 | 2.5 |
| 2014 | 10.3 | 0.35 | 0 | 2.5 |
| 2015 | 10.5 | 0.5 | 0 | 2.5 |
| 2016 | 12.7 | 0.7 | 0 | 2.5 |
| 2017 | 13.1 | 1.15 | 0 | 2.5 |
| 2018 | 15.8 | 1.5 | 0 | 2.5 |
| 2019 | 20.4 | 1.95 | 0 | -- |
| 2020 | 25 | 2.5 | 0 | -- |
| 2021[d] | 25 | 2.5 | ~1.33 | -- |
| 2022 | 25 | 2.5 | ~1.33 | -- |
| 2023+ | 25 | 2.5 | ~2.0 | -- |

[a] Solar requirement began in compliance year 2008.

[b] The offshore wind carve-out by law could be a maximum of 2.5 percent beginning in 2017; however, only the approved offshore renewable energy credits (ORECs) have been included here. Other PJM members do not have an equivalent category.

[c] Tier 2 requirement sunsets at the end of compliance year 2018.

[d] According to Maryland PSC Order No. 88192, Table 2, "Offshore Wind Component of the RPS Obligation for Purchasers of ORECs." (The percentage fluctuates annually because the ORECs are based on MWh and energy sales every year.)

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*Source:* Maryland Code, Public Utilities § 7-703, http://codes.findlaw.com/md/public-utilities/md-code-public-util-sect-7-703.html.

For the purposes of this report, when the term "Tier 1 requirements" is used, the understanding will be that the offshore wind and solar carve-outs are included. Tier 1 solar requirements will be specific to the solar carve-out, and Tier 1 offshore wind requirements will be specific to the offshore wind carve-out. There will be instances when the portion of Tier 1 that is exclusive of the solar and offshore wind carve-outs will be assessed, and the term "non-carve-out Tier 1 requirements" will be used.[10]

### B.2. *Alternative Compliance Payment*

To show compliance with the Maryland RPS, LSEs must retire the appropriate number of renewable energy credits (RECs) in a tracking account in the PJM Generator Attribute Tracking System (GATS). A REC is a certificate demonstrating one megawatt-hour (MWh) of energy output from a certified renewable energy generator.[11] If the electricity supplier does not retire the required number of RECs, it must pay an ACP for each REC that it is short for a given compliance period. Alternatively, electricity suppliers might pay the ACP in lieu of submitting RECs. Most states in the PJM region with RPS requirements have instituted ACPs. In Maryland, funds generated from the ACP provide grants and loans for the construction of Tier 1 resources. The ACP amounts differ from state to state and influence the market price for RECs by driving competition for renewable energy sources in the region. Electricity suppliers in states with a high ACP are willing to pay more—up to the ACP amount—for RECs. Table I-3 shows the ACP levels for each state in the PJM region as of mid-2017, as well as the geographic footprint of eligible facilities according to each state's RPS.[12,13]

[10] Offshore wind is not anticipated to be used to fulfill RPS requirements until, at the earliest, the year 2021. This is based on a Maryland PSC Order approving offshore wind renewable energy credits (ORECs) that was issued on May 11, 2017. For this reason, potential offshore wind generation is not included as fulfilling Tier 1 requirements through 2020.

[11] A renewable energy generator (such as a wind farm) receives one REC for every one MWh of electricity it produces. A recognized certifying agency gives each REC a unique identification number. The renewable electricity can then be fed into the electrical grid, while the accompanying REC can be sold separately on the open market.

[12] "PJM Program Information," PJM Environmental Information Services, https://www.pjm-eis.com/program-information.aspx.

[13] Please see Appendix A for more information on RPS requirements for other PJM states.

**Table I-3. Alternative Compliance Payments in PJM**

| State | RPS Geographic Footprint | Alternative Compliance Payments |
|---|---|---|
| Maryland | The source must be: (1) located in the PJM region; or (2) outside the area described in item (1) but in a control area that is adjacent to the PJM service territory, if the electricity is delivered into the PJM service territory.[a]<br><br>Solar must come from within the State to meet the solar carve-out requirement. | Tier 1 (non-carve-out) – $37.50/MWh for non-carve-out shortfalls in 2017 and beyond.<br><br>Tier 1 (Solar) – $195/MWh for solar shortfalls in 2017; $175/MWh in 2018; $150/MWh in 2019; $125/MWh in 2020; $100/MWh in 2021; $75/MWh in 2022; $60/MWh in 2023; $50/MWh in 2024 and beyond.<br><br>Tier 1 IPL – $2.00/MWh for IPL shortfalls in 2017 and beyond.<br><br>Tier 2 – $15/MWh in 2017 until the sunset of the standard in 2018.<br><br>Tier 2 IPL – There are no fees for Tier 2 IPL shortfalls. |
| Delaware | A generation unit must be: (1) in the PJM region or located outside the PJM region with the ability to import into the PJM region; and (2) tracked through the PJM market settlement system.[b] | 1st deficient year: $25/MWh for non-carve-out; $400/MWh for solar.<br><br>2nd deficient year: $50/MWh for non-carve-out; $450/MWh for solar.<br><br>Subsequent years: $80/MWh for non-carve-out; $500/MWh for solar. |
| District of Columbia | Eligible resources must be located: (1) in the PJM region; (2) in a state that is adjacent to the PJM region; or (3) outside the PJM region or adjacent state in a control area that is adjacent to the PJM region if the electricity from either is delivered into the PJM region.[c] | For compliance years 2009-2018:<br><br>Tier 1 – $50/MWh<br><br>Tier 2 – $10/MWh<br><br>Solar – $500/MWh in 2016-2023; $400/MWh in 2024-2028; $300/MWh in 2029-2032; and $50/MWh in 2033 and beyond.[d] |
| Illinois | Eligible resources must be located within Illinois. If there are insufficient, cost-effective in-state resources, resources can be procured from adjoining states, and if these are also not cost-effective, resources can be procured from other regions of the country.[e] | For compliance year June 2017 – May 2018, the estimated ACP for LSEs in the Ameren territory is $1.8054/MWh; $1.8917/MWh in the ComEd territory; and $1.2415/MWh for MidAmerican.[f]<br><br>Illinois has not yet established an ACP beyond 2018. |
| Indiana | Indiana utilities participating in the voluntary Clean Energy Portfolio Standard must obtain 50% of qualifying energy from within the state.[g] | Indiana has voluntary goals and no ACP. |
| Kentucky | There is no RPS.[h] | There is no ACP. |

**Table I-3. Alternative Compliance Payments in PJM (cont'd)**

| State | RPS Geographic Footprint | Alternative Compliance Payments |
|---|---|---|
| Michigan | Electricity must be generated in Michigan or outside the state in the retail electric customer service territory of any provider that is not an alternative electric supplier.[i] | There are various regulatory actions based on electric provider type.[j]<br><br>Rate-regulated providers: The electric provider must purchase sufficient RECs to meet the standard; the costs of such RECs are not recoverable from ratepayers if the Michigan PSC finds that the provider does not make a good-faith effort to meet the standard.<br><br>Municipalities and member-regulated cooperatives: The attorney general (or cooperative member) may commence a civil action for injunctive relief.<br><br>Alternative electric suppliers: The state may revoke licenses, issue orders to cease and desist, and charge fines between $5,000 and $50,000. |
| New Jersey | Electricity must be generated within or delivered into the PJM region. For both Class I and Class II facilities, renewable energy delivered into the PJM region must be generated at a facility that was constructed on or after January 1, 2003.[k] | Non-carve-out ACP is $50/MWh.<br><br>Solar ACPs are as follows:[l]<br><br>Energy Year (EY) 2017: $315/MWh<br>EY 2018: $308/MWh<br>EY 2019: $300/MWh<br>EY 2020: $293/MWh<br>EY 2021: $286/MWh<br>EY 2022: $279/MWh<br>EY 2023: $272/MWh<br>EY 2024: $266/MWh<br>EY 2025: $260/MWh<br>EY 2026: $253/MWh<br>EY 2027: $250/MWh<br>EY 2028: $239/MWh |
| North Carolina | Utilities may use unbundled RECs from out-of-state renewable energy facilities to meet up to 25% of the RPS.[m] | The state has no ACP; however, the North Carolina Utilities Commission may assess penalties if utilities fail to comply.[n] |
| Ohio | Utilities must meet at least 50% of the renewable energy requirement with in-state facilities, and the remaining 50% with resources that can be shown to be deliverable into the state.[o] | The ACP is $45/MWh for non-carve-out. The Public Utilities Commission of Ohio adjusts the ACP annually, but it will never be less than $45/MWh.<br><br>The solar ACP was $300/MWh in 2014 through 2016, reduced every two years thereafter through 2026 by $50/MWh to a minimum of $50/MWh.[p] |

**Table I-3. Alternative Compliance Payments in PJM (cont'd)**

| State | RPS Geographic Footprint | Alternative Compliance Payments |
|---|---|---|
| Pennsylvania | Sources must be located inside the geographical boundaries of Pennsylvania or within the service territory of any regional transmission organization that manages the transmission system in any part of the Commonwealth.[q] | The ACP is $45/MWh for non-carve-out.<br><br>For solar PV, the ACP is valued at 200% times the sum of: (1) the market value of solar alternative every credits (AECs) for the reporting period; and (2) the levelized value of up-front rebates received by sellers of solar AECs.[r] |
| Tennessee | There is no RPS.[s] | There is no ACP. |
| Virginia | Electricity must be generated or purchased in Virginia or in the PJM region.[t] | There are voluntary goals and no ACP. |
| West Virginia | HB 2001, effective January 27, 2015, repealed the Alternative and Renewable Energy Portfolio standard. There is no RPS.[u] | There is no ACP. |

IPL = industrial process loads; LSE = load-serving entity; PV = photovoltaic

[a] "PJM Program Information – Maryland," PJM Environmental Information Services, https://www.pjm-eis.com/program-information/maryland.aspx.

[b] "PJM Program Information – Delaware," PJM Environmental Information Services, https://www.pjm-eis.com/program-information/delaware.aspx.

[c] "Program Information – District of Columbia," PJM Environmental Information Services, https://www.pjm-eis.com/program-information/district-of-columbia.aspx.

[d] "Law 21-154, Renewable Portfolio Standard Expansion Amendment Act of 2016," Code of the District of Columbia, effective October 8, 2016, http://www.dcregs.dc.gov/Gateway/NoticeHome.aspx?noticeid=6249921.

[e] "PJM Program Information – Illinois," PJM Environmental Information Services, https://www.pjm-eis.com/program-information/illinois.aspx.

[f] "Notice of 2017-2018 Estimated ACP Rates Revised as of 2017-04-10," RPS Alternative Compliance Payment Notices, Illinois Commerce Commission, April 10, 2017, https://www.icc.illinois.gov/electricity/RPSCompliancePaymentNotices.aspx.

[g] "Clean Energy Portfolio Standard – Indiana," Database of State Incentives for Renewables & Efficiency®, North Carolina Clean Energy Technology Center, last updated November 20, 2015, http://programs.dsireusa.org/system/program/detail/4832.

[h] Jocelyn Durkay, "State Renewable Portfolio Standards and Goals," National Conference of State Legislators, December 28, 2016, http://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx.

[i] Clean, Renewable, and Efficient Energy Act 295 of 2008, Section 460.1029: Renewable energy system location; requirements, Michigan Legislature, effective October 6, 2008, http://legislature.mi.gov/doc.aspx?mcl-460-1029.

[j] Clean, Renewable, and Efficient Energy Act 295 of 2008, Section 460.1053: Failure to meet renewable energy credit standard by deadline; civil action; contested case; final order, Michigan Legislature, effective October 6, 2008, http://legislature.mi.gov/doc.aspx?mcl-460-1053..

[k] "PJM Program Information – New Jersey," PJM Environmental Information Services, https://www.pjm-eis.com/program-information/new-jersey.aspx.

[l] "Renewables Portfolio Standard," Database of State Incentives for Renewables & Efficiency®, North Carolina Clean Energy Technology Center, last updated May 20, 2015, http://programs.dsireusa.org/system/program/detail/564.

[m] North Carolina General Assembly, Chapter 62 of the North Carolina General Statutes, § 62-133.8 – Renewable Energy and Energy Efficiency Portfolio Standard, Public Utilities Act, 1963, http://www.ncleg.net/enactedlegislation/statutes/html/bychapter/chapter_62.html.

[n] "Renewable Energy and Energy Efficiency Portfolio Standard," Database of State Incentives for Renewables & Efficiency®, North Carolina Clean Energy Technology Center, last updated September 23, 2016, http://programs.dsireusa.org/system/program/detail/2660.

**Table I-3. Alternative Compliance Payments in PJM (cont'd)**

[o] "PJM Program Information, Ohio," PJM Environmental Information Services, https://www.pjm-eis.com/program-information/ohio.aspx.
[p] Ohio Revised Code Title 49, Chapter 4928.64, Electric distribution utility to provide electricity from alternative energy resources, effective July 31, 2008, http://codes.ohio.gov/orc/4928.64.
[q] "PJM Program Information, Pennsylvania," PJM Environmental Information Services, https://www.pjm-eis.com/program-information/pennsylvania.aspx.
[r] "Alternative Energy Portfolio Standard – Pennsylvania," Database of State Incentives for Renewables & Efficiency®, North Carolina Clean Energy Technology Center, last updated August 24, 2016, http://programs.dsireusa.org/system/program/detail/262.
[s] Jocelyn Durkay, "State Renewable Portfolio Standards and Goals," National Conference of State Legislators, December 28, 2016, http://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx.
[t] "PJM Program Information – Virginia," PJM Environmental Information Services, https://www.pjm-eis.com/program-information/virginia.aspx.
[u] " PJM Program Information – West Virginia," PJM Environmental Information Services, https://www.pjm-eis.com/program-information/west-virginia.aspx

The variations in ACP levels can lead to widely differing prices for Tier 1 and Tier 2 RECs and competition for RECs within the region. LSEs may request from the Maryland PSC a one-year delay from complying with the solar carve-out of the Maryland RPS if the cost of purchasing solar RECs (SRECs) is equal to or exceeds one percent of the LSE's revenue. This provision also holds true for Tier 1 RECs, except that the costs of purchasing Tier 1 RECs must be 10 percent or more of the LSE's revenue.

## C. Related Maryland Regulations Affecting Renewable Development

In addition to the Maryland RPS, there are two policy initiatives created by Maryland legislation and administered by the Maryland PSC that further enable renewable energy development. Net metering has been in place since 2005, and a Community Solar Energy Generating System Pilot Program is in the early stages of implementation.

### C.1. *Net Metering*

As defined by the National Renewable Energy Laboratory (NREL), net metering is: "a metering and billing arrangement designed to compensate distributed energy generation (DG) system owners for any generation that is exported to the utility grid."[14] Net metering has encouraged the growth of renewable energy development because the producer of the energy has a guaranteed purchaser of the energy, and in many cases such as in Maryland, the energy must be purchased at the full retail rate, including delivery charges.

[14] National Renewable Energy Laboratory, Net Metering, https://www.nrel.gov/technical-assistance/basics-net-metering.html.

In Maryland, as with the RPS, net metering has changed over time. In 2007, the net metering not-to-exceed capacity was raised to 1,500 MW. As of the latest net metering status report (2017) issued by the Maryland PSC,[15] net metering capacity had reached 461 MW, thus the Maryland PSC concluded that no policy changes were necessary at that time. Solar projects represent the majority of net-metered projects. Between June 2015 and June 2016 (the latest information available), solar net-metered capacity increased from 236 to 460 MW, while wind net-metered capacity decreased from 1.2 to 0.5 MW, and biomass net-metered capacity decreased from 1.4 to 0.3 MW.[16]

### C.2. *Community Solar Energy Generating System Pilot Program*

The Community Solar Energy Generating System Pilot Program is a three-year pilot program that became law on May 12, 2015, and recently entered the implementation phase.[17] The intent of Maryland HB 1087: *Electricity – Community Solar Energy Generating System Program* is to facilitate the purchase of solar energy by customers that: (1) rent; (2) do not have sufficient area to install solar generation; (3) do not have sufficient solar resources; or (4) may not be able to otherwise afford solar. Participating customers purchase (or lease) a share of the solar project; the proportional project output is treated as if the project (on a proportional basis) is located behind the customer's meter. The law also encourages the use of brownfields for the development of solar projects. The program consists of three categories of projects, each of which has a capacity limit designation: brownfield/grayfield/industrial area (approximately 58 MW); open (approximately 77 MW); and low-to-moderate income (approximately 59 MW).

Applications for the first of three rounds of projects were required between April 10 and May 5, 2017; those applications are being reviewed as an "initial batch," and then further applications will be considered on a first-come, first-served basis. There is a 194-MW capacity limit for the three-year program. For the first round of applications in 2017, 40 percent of the capacity (77 MW) is allocated; year two (2018) also has 40 percent of the capacity allocated; and in year three (2019), 20 percent of the capacity (40 MW) is allocated.

[15] Maryland PSC, *Report on the Status of Net Energy Metering in the State of Maryland*, August 2017, http://www.psc.state.md.us/wp-content/uploads/Final-2016-Net-Metering-Report.pdf.
[16] Ibid.
[17] Community solar programs capitalize on net metering in that a solar project under this program may use aggregate net metering of participating customers.

The pilot program is being implemented by four Maryland utilities: Baltimore Gas and Electric Company (BGE), Potomac Electric Power Company (Pepco), Potomac Edison, and Delmarva Power and Light (Delmarva). At the conclusion of the three-year pilot, the Maryland PSC is required to provide a report on the program to the Maryland General Assembly.

## D. The Role of Market Factors in Renewable Energy Development

As noted previously, each MWh generated by a qualifying renewable energy project will also generate a REC. For the RECs from a particular renewable energy project to be eligible to satisfy the RPS requirements of a particular state, the project itself would need to be approved as eligible by the state's relevant regulatory authority. In Maryland, the PSC approves the eligibility of renewable energy projects for meeting the Maryland RPS consistent with the eligibility requirements spelled out in the statute. The project owner could also apply to other states for approval as an eligible renewable energy source for meeting RPS requirements. While a REC may be eligible to be used for compliance in more than one state, the REC that is used to demonstrate RPS compliance can only be used once and in one state, and is retired once compliance is shown for a particular state.

There is an active market for the sale/purchase of RECs, with trades typically occurring as bilateral transactions. RECs, however, are sometimes bundled with the energy output of a renewable energy project, such that the purchaser of the energy from, for example, a wind power project would also receive the RECs associated with the production of wind energy from the project. A single price could be agreed upon for the bundled energy/REC product and neither the energy nor the RECs would be priced on a stand-alone basis.

Multiple reporting organizations provide market data related to RECs sales and include not only current-year REC prices but also REC prices for future years, typically two to four years out. A renewable energy project owner, therefore, could sell RECs that would be produced in future years at an agreed-upon price. Typically, future REC prices are reported only a few years into the future, since the market begins to lose liquidity for RECs products much further out in time.

Separate RECs markets exist for each product for each jurisdiction. For example, separate prices are reported for Maryland Tier 1, Tier 2, and solar carve-out RECs.[18] Similarly, there are separate prices for each of the products in each of the states in PJM (and in other Regional

[18] While ORECs may reduce demand for other non-carve-out Tier 1 RECs, they are different in that they are not market-driven, but set by the Maryland PSC. Other PJM states do not have any products comparable to ORECs.

Transmission Organizations and Independent System Operators [RTOs and ISOs]). These markets, however, are highly complex due to the interrelationships among the various markets. Most of the states within PJM have mandatory RPS policies in place,[19] and there are important differences among state RPS policies in terms of the percentages of renewable energy required in any specific year and the types of technologies eligible to meet the RPS requirements. Additionally, the specification of the geographic restrictions on project eligibility differ among the various state RPS policies. A further complicating factor is that satisfaction of a state's RPS may be accomplished either through the purchase of qualifying RECs or through an ACP. The ACPs differ among the states and also differ for different types of renewables; for example, in states with a solar carve-out, the ACPs for solar RPS compliance tend to be higher than the ACPs for Tier 1 (or analogous classification) renewable energy.

The ACPs effectively function as a cap on the price of the RECs.[20] The ACP represents the maximum amount that a renewable energy generator, that is, a RECs supplier, could expect to sell RECs for on the market. Since there are transaction costs associated with the purchase of RECs, a retail energy supplier needing to satisfy an RPS obligation would only be willing to pay a price slightly below the ACP. Because the price of RECs is affected by the level of the ACP, and because RECs from a particular project may be eligible to meet RPS requirements in multiple states, the ACP levels in one state can affect the market price of RECs in other states.

An additional consideration that should be recognized is that not all RECs are purchased to meet RPS requirements. A firm may purchase RECs over and above the level required for satisfaction of the relevant state RPS to market itself as an environmentally friendly company, or to comply with corporate goals for renewable energy or reduction of carbon dioxide ($CO_2$) emissions. Additionally, government organizations may purchase RECs above the amount needed to meet the respective state's RPS requirement to satisfy environmental or other policy goals.

These factors, taken together, affect the price of the RECs predominantly from the demand side. From the supply side, state RPS requirements define the eligibility of particular resources and—in combination with the eligibility requirements of other states, geographic eligibility provisions, and the period of time over which RECs can be used to satisfy the state RPS

[19] The following PJM states do not have mandatory RPS requirements in place: Indiana, Kentucky, Tennessee, Virginia, and West Virginia.

[20] If a retail energy supplier, for example, can meet its RPS obligation through payment of an ACP of $20, the supplier would be unwilling to purchase RECs for $25.

policies—help determine the quantity of RECs available in the state during any particular compliance year. Supply is also affected by cost considerations that relate to capital cost requirements, financing costs, and federal and state tax incentives.

As noted above, the supply of RECs is related to the time period over which the RECs can be used. RECs produced in one year may be used to satisfy state RPS requirements in future years based on banking provisions contained in state RPS policies. For example, in Maryland, a REC generated in one year can be used to satisfy the RPS requirement in that year, the following (second) year, or the third year. Consequently, the owner of RECs may decide to delay the sale of RECs based on a belief that future REC prices will increase as the percentage requirements for renewable energy in a particular state increase. Alternatively, if the potential seller believes that REC prices will decline in the future, or wishes to hedge against the potential for prices declining in the future, the RECs would be sold and retired in the same year the RECs were created in order to satisfy state RPS obligations. The purchaser of the RECs, however, may opt to hold those RECs until a future date based on different perceptions about market movements.

Just as RECs generated in one year can affect prices in future years, RECs generated in prior years can affect current-year REC prices. RECs generated in prior years, either in excess of RPS requirements or withheld from retirement due to expectations of higher market prices, may need to be sold and retired to avoid expiration.

A final factor affecting the quantity of RECs in the market, the demand for RECs, and ultimately the price for RECs, is the recognition that the legislation that defines the RPS parameters can be modified over time. These factors include the percentage of renewables required in each year, which types of generation resources are eligible to meet the various classes of renewables that are defined, the shelf-life of the RECs, the geographic eligibility, and the levels of the ACP. In Maryland, the RPS legislation has been changed four times since the RPS was originally established. Furthermore, the price of RECs in Maryland can be affected by changes in the RPS regulations in other states.

The market for RECs also affects decisions regarding construction of new renewable generating facilities. Higher prices for particular categories of RECs signal to developers that there is a relatively tight market and, to the extent that developers may perceive those market conditions to prevail over a reasonably long period of time, new project development can be spurred. Conversely, relatively low REC prices can signal at least a temporary glut and may induce developers to put certain renewable energy projects on hold or perhaps cancel projects that would have proceeded under more favorable conditions.

The above discussion suggests that the REC markets are interrelated and complex. The function of these markets, both historically and in the future, will determine the degree to which Maryland will be successful in achieving its renewable energy goals.

# II. Renewable Energy Facilities in PJM

As of December 31, 2017, the GATS contains information about 167,907 electric generating units. Of these entries, 165,841 are in the PJM control area and 2,066 units were found to be located outside PJM.[21] There were 387 facilities in the PJM control area removed from consideration due to the following reasons: not qualifying as Maryland-eligible, considered as secondary facilities, or considered as duplicate facilities.[22] The remaining entries were aggregated by EIA facilities code (if this unique identifier was available) for a total of 165,452 unique generating facilities. Of these facilities in PJM, 165,159 are Tier 1 solar-qualifying, 282 are Tier 1-qualifying (exclusive of solar), and 11 are eligible for Tier 2 compliance based upon Maryland RPS requirements. For those facilities with more than one fuel source, the capacity associated with renewable energy was prorated based on historical generation by fuel source and the contribution of renewable resources.[23] Some facilities utilize more than one renewable energy technology, and the database lists them under the qualifying technology with the highest proportion of the facility's generation. The database does not identify any qualifying wastewater-treatment biogas, operational offshore wind, or poultry litter-to-energy electric plants.

The GATS data described above were used to produce an inventory of available renewable energy resources that would qualify as eligible for Maryland RPS compliance, with supplemental geophysical and capacity utilization data acquired from the EIA. The specifics of individual state RPS policies within PJM are described in Appendix A, and sales projections (used to determine future RPS requirements as described in the beginning of Section III) were also included.[24]

Table II-1 shows a summary of the number of Maryland PSC-certified renewable energy facilities, broken out by tier and by solar and non-carve-out, by state in PJM meeting the

[21] There are two facilities outside of the PJM control area that are certified for the Maryland Tier 1 non-carve-out category; both are wind facilities (Tatanka Wind Farm in North Dakota and Farmer City Wind Farm in Missouri) with a combined capacity of 326 MW.

[22] It is assumed that the costs to transmit eligible generation from outside of PJM are too high to warrant using that generation for compliance with the Maryland RPS. Historically, minimal generation from sources outside PJM has been used for compliance.

[23] Generation data are typically not available for smaller, methane-based plants (e.g., those utilizing internal combustion generators). It is expected that the renewable share of methane capacity may be overstated owing to the extensive cofiring or fuel-switching between natural gas and diesel fuels.

[24] For detailed information on the data collection methodology employed in this analysis, refer to Appendix B.

Maryland Tier 1 and Tier 2 requirements.[25] Table II-2 and Table II-3 break down the information by technology.

**Table II-1. Renewable Energy Generating Facilities in PJM Certified as Eligible for Maryland RPS Compliance (as of EOY 2017)[a]**

| | Tier 1 | | Tier 2 |
|---|---|---|---|
| State | No. of Solar Carve-out Facilities | No. of Non-carve-out Facilities | No. of Facilities |
| Maryland | 54,973 | 101 | 1 |
| Delaware | 4,511 | 4 | -- |
| District of Columbia | 3,352 | -- | -- |
| Illinois | 832 | 38 | -- |
| Indiana | 49 | 11 | -- |
| Kentucky | 122 | 6 | -- |
| Michigan | 7 | 6 | -- |
| New Jersey | 80,002 | 6 | -- |
| North Carolina | 86 | 3 | 2 |
| Ohio | 2,343 | 22 | 1 |
| Pennsylvania | 16,275 | 39 | 3 |
| Tennessee | 4 | 1 | -- |
| Virginia | 2,198 | 36 | 1 |
| West Virginia | 405 | 9 | 3 |
| **TOTAL:** | **165,159** | **282** | **11** |

[a] There is no column for the offshore wind carve-out, as there are no operational facilities as of December 31, 2017. The facilities in other states are categorized by Maryland Tier 1 and Tier 2 eligibility, as further explained in Section III.

25 In most instances, the capacity listed is the nameplate capacity. However, for multi-fuel plants, the capacity has been adjusted to reflect the ratio of renewable fuels to non-renewable fuels in an effort to avoid overstating the amount of Tier 1 capacity installed. Additionally, in some instances, the GATS nameplate capacity is different than other documented nameplate capacity figures as published by EIA or state Certificate of Public Convenience and Necessity (CPCN) records. When required, researchers contacted the generator owners to determine an approximate capacity value.

**Table II-2. Existing Generation Capacity and Number of Installed Units in PJM That Are Certified as Tier 1 under the Maryland RPS (as of EOY 2017)**

| State | MW/ No. of Units | Tier 1 Facility Category | | | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Solar | Wind | Hydro-electric[a] | Methane[b] | Qualifying Biomass | Waste-to-Energy | Black Liquor | Geo-thermal | |
| Maryland | MW | 975 | 180 | 20 | 23 | 4 | 258 | 30 | 2 | **1,492** |
| | No. | 54,973 | 7 | 2 | 10 | 2 | 4 | 1 | 75 | **55,074** |
| Delaware | MW | 97 | -- | -- | 9 | -- | -- | -- | -- | **106** |
| | No. | 4,511 | -- | -- | 4 | -- | -- | -- | -- | **4,515** |
| District of Columbia | MW | 45 | -- | -- | -- | -- | -- | -- | -- | **45** |
| | No. | 3,352 | -- | -- | -- | -- | -- | -- | -- | **3,352** |
| Illinois | MW | 55 | 2,719 | 20 | 129 | -- | -- | -- | -- | **2,924** |
| | No. | 832 | 17 | 3 | 18 | -- | -- | -- | -- | **870** |
| Indiana | MW | 11 | 1,701 | 8 | -- | -- | -- | -- | -- | **1,721** |
| | No. | 49 | 9 | 2 | -- | -- | -- | -- | -- | **60** |
| Kentucky | MW | 12 | -- | -- | 16 | 5 | -- | -- | -- | **33** |
| | No. | 122 | -- | -- | 5 | 1 | -- | -- | -- | **128** |
| Michigan | MW | 5 | -- | 15 | 3 | -- | -- | -- | -- | **23** |
| | No. | 7 | -- | 5 | 1 | -- | -- | -- | -- | **13** |
| New Jersey | MW | 2,211 | 8 | 11 | 50 | -- | -- | -- | -- | **2,280** |
| | No. | 80,002 | 1 | 1 | 4 | -- | -- | -- | -- | **80,008** |
| North Carolina | MW | 784 | 208 | -- | -- | -- | -- | 124 | -- | **1,116** |
| | No. | 86 | 1 | -- | -- | -- | -- | 2 | -- | **89** |
| Ohio | MW | 172 | 418 | -- | 71 | -- | -- | 51 | -- | **713** |
| | No. | 2,343 | 6 | -- | 15 | -- | -- | 1 | -- | **2,365** |
| Pennsylvania | MW | 321 | 997 | 95 | 144 | -- | -- | 83 | -- | **1,640** |
| | No. | 16,275 | 13 | 7 | 17 | -- | -- | 2 | -- | **16,314** |
| Tennessee | MW | 0 | -- | -- | -- | -- | -- | 49 | -- | **49** |
| | No. | 4 | -- | -- | -- | -- | -- | 1 | -- | **5** |
| Virginia | MW | 431 | -- | 29 | 111 | 140 | 124 | 239 | -- | **1,074** |
| | No. | 2,198 | -- | 13 | 16 | 2 | 1 | 4 | -- | **2,234** |
| West Virginia | MW | 4 | 652 | 58 | -- | -- | -- | -- | -- | **714** |
| | No. | 405 | 5 | 4 | -- | -- | -- | -- | -- | **414** |
| **TOTAL:** | **MW** | **5,124** | **6,884** | **257** | **557** | **149** | **382** | **576** | **2** | **13,930** |
| | **No.** | **165,159** | **59** | **37** | **90** | **5** | **5** | **11** | **75** | **165,441** |

Note: Totals may not equal sum of components due to independent rounding.

[a] Hydroelectric for Tier 1 (Tier 1-Hydro) includes all power generating facilities with less than 30 MW that were constructed at a dam that was in operation prior to 2004.

[b] Methane from the anaerobic decomposition of organic materials in a landfill or a wastewater treatment plant.

**Table II-3. Existing Generation Capacity and Number of Installed Units in PJM That Are Certified as Tier 2 under the Maryland RPS (as of EOY 2017)**

| | MW/ No. of Units | Tier 2 Facility Category Hydroelectric[a] | TOTAL |
|---|---|---|---|
| Maryland | MW | 531 | **531** |
| | No. | 1 | **1** |
| North Carolina | MW | 278 | **278** |
| | No. | 2 | **2** |
| Ohio | MW | 47 | **47** |
| | No. | 1 | **1** |
| Pennsylvania | MW | 501 | **501** |
| | No. | 3 | **3** |
| Virginia | MW | 8 | **8** |
| | No. | 1 | **1** |
| West Virginia | MW | 159 | **159** |
| | No. | 3 | **3** |
| **TOTAL:** | **MW** | **1,525** | **1,525** |
| | **No.** | **11** | **11** |

Note: PJM states with no Tier 2 eligible facilities certified in Maryland under Tier 2 include: Delaware, Illinois, Indiana, Kentucky, Michigan, New Jersey, and Tennessee; the District of Columbia also has no Tier 2 eligible facilities.

[a] Hydroelectric for Tier 2 includes all hydroelectric facilities (other than those less than 30 MW) that were constructed at a dam that was in operation prior to 2004.

# III. RPS Requirements in PJM

The renewable electricity generation required to meet a state's RPS requirement is typically based on a percentage of the sales of electricity within each particular state. To estimate future RPS requirements, it is necessary to project the sales of electricity within the PJM region and apply them to the RPS percentage requirements for Maryland and other PJM states.[26]

The retail sales projections for Maryland were calculated separately from the other states (and the District of Columbia) within PJM for this analysis; rather than using PJM projections, the Maryland PSC *Ten-Year Plan (2016-2025) of Electric Companies in Maryland* (Plan) was used as a source for the Maryland-specific figures. The "Net of DSM (Demand Side Management)" retail sales projections for 2016-2025 for Maryland-only service areas were provided in the Plan; then, the annual growth rate was calculated based on the 2020-2025 retail sales projections (0.2 percent per year), and was then applied to 2025 retail sales projections to calculate the projections each year from 2026 to 2030. In addition, the calculated retail sales projections for Maryland were compared to the PJM 2017 *Load Forecast Report* to determine if the two approaches had consistent results. The PJM Load Forecast showed growth rates for Maryland that were similar to the Plan data. For example, the PJM 2017 *Load Forecast Report* includes 15-year annual growth rates (2017-2032) for BGE at 0.0 percent, and at 0.2 percent for Pepco. Prior to applying the RPS percentages for Maryland to determine the projected RPS requirements, a 1.9 percent downward adjustment was made in the retail sales projections to account for industrial process load (IPL) sales, which are exempt from the RPS requirements. The 1.9 percent figure is an estimate based on historical Maryland PSC data for 2013-2015.

For the remaining states and the District of Columbia, the 2017 Inventory Report uses historical data from Form EIA-826 – Monthly Electric Utility Sales and Revenue Report with State Distributions, and annualized growth rates obtained from the Midcontinent Independent System Operator's (MISO's) *2016 MISO Independent Load Forecast Report* and PJM's 2017 *Load Forecast Report* to forecast electricity sales for each utility through 2030. Respective zonal growth rates were also obtained from the PJM 2017 *Load Forecast Report* to project total retail sales for each PJM member.

There are several states in which only a portion of the electricity supply system is within the PJM control area. In these cases, an electric utility or an RTO, such as MISO, might serve the

[26] In Maryland, the current RPS percentage requirements for Tier 1 peak in 2020; however, for illustrative purposes, this report extends the timeframe considered to 2030.

remaining portions of the state located outside of PJM. Table III-1 presents the estimated amount of electric consumption within the PJM region, including the portion consumed by states located in more than one ISO.[27] This study assumes that for states with only partial PJM service, the RPS requirement is directly proportional to the amount of service supplied. For example, in Michigan, PJM is estimated to provide approximately 7 percent of the total electrical demand. Accordingly, this analysis assumes that 7 percent of Michigan's RPS requirements will be derived from the PJM system, and 93 percent of the Michigan renewable energy requirement would stem from sales outside of the PJM region. Likewise, only those renewable resources located within the PJM-controlled portions of the PJM states are available for meeting the PJM states' RPS requirements.

**Table III-1. Electric Power Consumption within PJM and Proportion Supplied by PJM (2017)**

| State | Total Consumption (GWh) | Proportion Supplied by PJM | |
|---|---|---|---|
| | | Percent | GWh |
| Maryland | 60,788 | 100.0% | 60,788 |
| Delaware | 11,034 | 100.0 | 11,034 |
| District of Columbia | 11,381 | 100.0 | 11,381 |
| Illinois | 140,119 | 74.7 | 104,595 |
| Indiana | 98,213 | 25.0 | 24,597 |
| Kentucky | 73,094 | 57.0 | 41,627 |
| Michigan | 103,440 | 7.2 | 7,476 |
| New Jersey | 74,751 | 100.0 | 74,751 |
| North Carolina | 134,214 | 7.6 | 10,240 |
| Ohio | 147,558 | 100.0 | 147,558 |
| Pennsylvania | 144,672 | 100.0 | 144,672 |
| Tennessee | 97,192 | 4.5 | 4,413 |
| Virginia | 112,758 | 99.7 | 112,425 |
| West Virginia | 31,856 | 100.0 | 31,856 |
| **TOTAL:** | **1,241,070** | -- | **787,414** |

GWh = gigawatt-hour

[27] The portion of electric supply estimated as sourced from the PJM region is based on the ratio of population in the counties served by PJM to the state's total population.

Each of the states within the PJM region and the District of Columbia have different RPS standards. These varying standards, for the most part, align very well with Maryland's RPS standards. For the three states with an RPS that did not align well with Maryland's RPS, the following assumptions were made:

- The Michigan RPS sets an overall renewable target. It does not specify the percent requirement of any particular renewable resource. For purposes of this analysis, the Michigan RPS is assumed to align with Maryland Tier 1 values (i.e., there is no specific breakout for Tier 1 solar carve-out or Tier 2 resources). This may overstate competition for Tier 1 resources among Michigan LSEs.

- Pennsylvania and Ohio allow certain non-renewable resources to qualify for RPS compliance. The blanket RPS targets for these states were assumed to align in total with Maryland tiers. These assumptions may overstate competition for Tier 1 and Tier 2 resources.

Table III-2 presents the percentage of the electricity supply in each PJM state and the District of Columbia that is required by its RPS. While not every jurisdiction's RPS is mandatory, as noted in Table III-2 and Table III-3, this analysis took a conservative approach and assumed that the voluntary goals that are in place for Virginia and Indiana would be met. The individual state percentages have been aligned to track with Tier 1 and Tier 2 of the Maryland RPS where possible. The RPS standards from those states without tiers are included as Tier 1.

**Table III-2. RPS Requirements in PJM Aligned to Maryland Tiers[a]**

| | 2017 | 2018 | 2019 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|
| **Maryland** | | | | | | |
| Tier 1 Solar | 1.15% | 1.50% | 1.95% | 2.50% | 2.50% | 2.50% |
| ORECs | 0.00 | 0.00 | 0.00 | 0.00 | ~2.00 | ~2.00 |
| Non-carve-out Tier 1 | 14.45 | 16.80 | 20.95 | 22.50 | 20.50 | 20.50 |
| Tier 2 | 2.50 | 2.50 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Delaware** | | | | | | |
| Tier 1 Solar | 1.50 | 1.75 | 2.00 | 2.25 | 3.50 | 3.50 |
| Non-carve-out Tier 1 | 14.50 | 15.75 | 17.00 | 17.75 | 21.50 | 21.50 |
| Tier 2 | | | | | | |
| **District of Columbia** | | | | | | |
| Tier 1 Solar | 0.98 | 1.15 | 1.35 | 1.58 | 2.85 | 4.50 |
| Non-carve-out Tier 1 | 12.52 | 14.35 | 16.15 | 18.42 | 23.15 | 37.50 |
| Tier 2 | 1.50 | 1.00 | 0.50 | 0.00 | 0.00 | 0.00 |
| **Illinois** | | | | | | |
| Tier 1 Solar | 0.78 | 0.87 | 0.96 | 1.05 | 1.50 | 1.50 |
| Non-carve-out Tier 1[b] | 13.00 | 14.50 | 16.00 | 17.50 | 25.00 | 25.00 |
| Tier 2 | | | | | | |
| **Indiana[c]** | | | | | | |
| Tier 1 Solar | | | | | | |
| Non-carve-out Tier 1 | 4.00 | 4.00 | 7.00 | 7.00 | 10.00 | 10.00 |
| Tier 2 | | | | | | |
| **Michigan** | | | | | | |
| Tier 1 Solar | | | | | | |
| Non-carve-out Tier 1 | 10.00 | 10.00 | 12.50 | 12.50 | 15.00 | 15.00 |
| Tier 2 | | | | | | |
| **New Jersey** | | | | | | |
| Tier 1 Solar | 3.00 | 3.20 | 3.29 | 3.38 | 3.83 | 4.10 |
| Non-carve-out Tier 1 | 10.49 | 12.33 | 14.18 | 16.03 | 17.88 | 17.88 |
| Tier 2 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 |
| **North Carolina** | | | | | | |
| Tier 1 Solar | 0.14 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |
| Non-carve-out Tier 1[b] | 5.86 | 9.80 | 9.80 | 9.80 | 12.30 | 12.30 |
| Tier 2 | | | | | | |
| **Ohio** | | | | | | |
| Tier 1 Solar | 0.15 | 0.18 | 0.22 | 0.26 | 0.46 | 0.50 |
| Non-carve-out Tier 1 | 3.35 | 4.32 | 5.28 | 6.24 | 11.04 | 12.00 |
| Tier 2 | | | | | | |
| **Pennsylvania** | | | | | | |
| Tier 1 Solar | 0.29 | 0.34 | 0.39 | 0.44 | 0.50 | 0.50 |
| Non-carve-out Tier 1 | 5.71 | 6.16 | 6.61 | 7.06 | 7.50 | 7.50 |
| Tier 2 | 8.20 | 8.20 | 8.20 | 8.20 | 10.00 | 10.00 |
| **Virginia[c]** | | | | | | |
| Tier 1 Solar | | | | | | |
| Non-carve-out Tier 1 | 7.00 | 7.00 | 7.00 | 7.00 | 15.00 | 15.00 |
| Tier 2 | | | | | | |

[a] The offshore wind carve-out, by law, could be a maximum of 2.5 percent beginning in 2017; however, only the approved ORECs have been included here. Other PJM members do not have an equivalent category.
[b] The alignment to the Maryland categories means that non-carve-out is specific to Maryland; these states have their own carve-outs contained in this category.
[c] The voluntary programs were included to reflect the possibility that the RPS targets are met; the inclusion of these programs results in a conservative approach to the data analysis.

The RPS requirement in gigawatt-hours (GWh) within the PJM region can be calculated by multiplying the RPS percentage requirement for each state and the District of Columbia by its consumption.  Table III-3 provides the projected renewable energy consumption in GWh within the PJM region.  Maryland's 2020 solar RPS requirement equals about 29 percent of the total solar requirements within the PJM region, and Maryland's non-carve-out Tier 1 requirements amount to 19 percent of the PJM region requirements.

**Table III-3. Actual and Projected RPS Requirements in PJM Aligned to Maryland Tiers (GWh)[a]**

| | ACTUAL | PROJECTED | | | | |
|---|---|---|---|---|---|---|
| | 2017 | 2018 | 2019 | 2020 | 2025 | 2030 |
| **Maryland** | | | | | | |
| Tier 1 Solar | 699 | 912 | 1,185 | 1,518 | 1,518 | 1,527 |
| ORECs | | | | | 1,369 | 1,369 |
| Non-carve-out Tier 1 | 8,784 | 10,218 | 12,730 | 13,658 | 12,457 | 12,538 |
| Tier 2 | 1,520 | 1,520 | | | | |
| **Delaware** | | | | | | |
| Tier 1 Solar | 166 | 193 | 221 | 248 | 384 | 387 |
| Non-carve-out Tier 1 | 1,600 | 1,740 | 1,876 | 1,953 | 2,357 | 2,378 |
| Tier 2 | | | | | | |
| **District of Columbia** | | | | | | |
| Tier 1 Solar | 112 | 131 | 154 | 180 | 324 | 514 |
| Non-carve-out Tier 1 | 1,425 | 1,634 | 1,838 | 2,095 | 2,632 | 4,283 |
| Tier 2 | 171 | 114 | 57 | | | |
| **Illinois** | | | | | | |
| Tier 1 Solar | 816 | 912 | 1,008 | 1,102 | 1,583 | 1,595 |
| Non-carve-out Tier 1 | 13,597 | 15,203 | 16,794 | 18,373 | 26,376 | 26,589 |
| Tier 2 | | | | | | |
| **Indiana[b]** | | | | | | |
| Tier 1 Solar | | | | | | |
| Non-carve-out Tier 1 | 984 | 999 | 1,773 | 1,791 | 2,684 | 2,829 |
| Tier 2 | | | | | | |
| **Michigan** | | | | | | |
| Tier 1 Solar | | | | | | |
| Non-carve-out Tier 1 | 748 | 756 | 960 | 971 | 1,202 | 1,254 |
| Tier 2 | | | | | | |
| **New Jersey** | | | | | | |
| Tier 1 Solar | 2,243 | 2,395 | 2,462 | 2,526 | 2,857 | 3,064 |
| Non-carve-out Tier 1 | 7,838 | 9,223 | 10,607 | 11,978 | 13,338 | 13,362 |
| Tier 2 | 1,869 | 1,871 | 1,871 | 1,868 | 1,865 | 1,868 |
| **North Carolina** | | | | | | |
| Tier 1 Solar | 14 | 21 | 21 | 21 | 21 | 22 |
| Non-carve-out Tier 1 | 600 | 1,012 | 1,016 | 1,016 | 1,294 | 1,327 |
| Tier 2 | | | | | | |
| **Ohio** | | | | | | |
| Tier 1 Solar | 221 | 266 | 325 | 385 | 682 | 745 |
| Non-carve-out Tier 1 | 4,943 | 6,384 | 7,808 | 9,229 | 16,370 | 17,881 |
| Tier 2 | | | | | | |
| **Pennsylvania** | | | | | | |
| Tier 1 Solar | 424 | 493 | 566 | 643 | 725 | 725 |
| Non-carve-out Tier 1 | 8,256 | 8,932 | 9,590 | 10,234 | 10,876 | 10,880 |
| Tier 2 | 11,863 | 11,890 | 11,896 | 11,892 | 14,501 | 14,506 |
| **Virginia[b]** | | | | | | |
| Tier 1 Solar | | | | | | |
| Non-carve-out Tier 1 | 7,870 | 7,971 | 8,027 | 8,027 | 17,378 | 17,862 |
| Tier 2 | | | | | | |

[a] The offshore wind carve-out, by law, could be a maximum of 2.5 percent beginning in 2017; however, only the approved ORECs have been included here. Other PJM members do not have an equivalent category.
[b] The voluntary programs were included to reflect the possibility that the RPS targets are met; the inclusion of these programs results in a conservative approach to the data analysis.

# IV. Projected Renewable Energy Requirements in PJM and Maryland

## A. Electricity Generation Capacity Factors

The capacity factor of an electric generating unit is measured as the ratio of the actual energy output (MWh) over a period of time to the output at full nameplate capacity over that same period.[28] For example, a 100-MW wind farm that produces 262,800 MWh of energy in a given year has a capacity factor of 30 percent.[29] Generating units generally do not run at full capacity for many reasons, including unforced outages, scheduled outages for routine maintenance, insufficient demand, or economic factors (i.e., the units are idled when electric demand is low or the market price is too low to make generation economical). In addition, the capacity factors of renewable generators are decreased when their resources (wind, sunlight, or water) or fuel sources (biomass, municipal waste) are reduced or not available. Table IV-1 shows the capacity factors that were used in this analysis for the relevant renewable energy technologies.

**Table IV-1. 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 | 26 |
| Wind – Offshore[a] | 39 |

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

[28] Capacity factor should not be confused with "capacity credit," which is a measure of the unit's expected, dispatchable capacity during periods of peak demand. Currently, PJM grants wind facilities a capacity credit of 13 percent of nameplate capacity for reliability purposes and capacity market participation. Wind facilities may apply for a higher capacity credit if they can provide production data to justify a higher value.

[29] Using 8,760 hours in a year, a 100-MW plant continuously operating at full capacity would generate 876,000 MWh. 262,800 MWh / 876,000 MWh = .30, or 30 percent capacity factor.

The PJM region is not characterized by the best solar or wind resources compared to other regions of the U.S.; capacity factors for solar and wind in PJM are lower than average solar and wind capacity factors nationwide. The PJM capacity factors shown above in Table IV-1 are approximate and based on a combination of the national values as reported by the NREL Open Energy Information (OpenEI) Transparent Cost Database and capacity factors derived from EIA data for renewable energy units within PJM when reasonable sample sizes were available.[30,31]

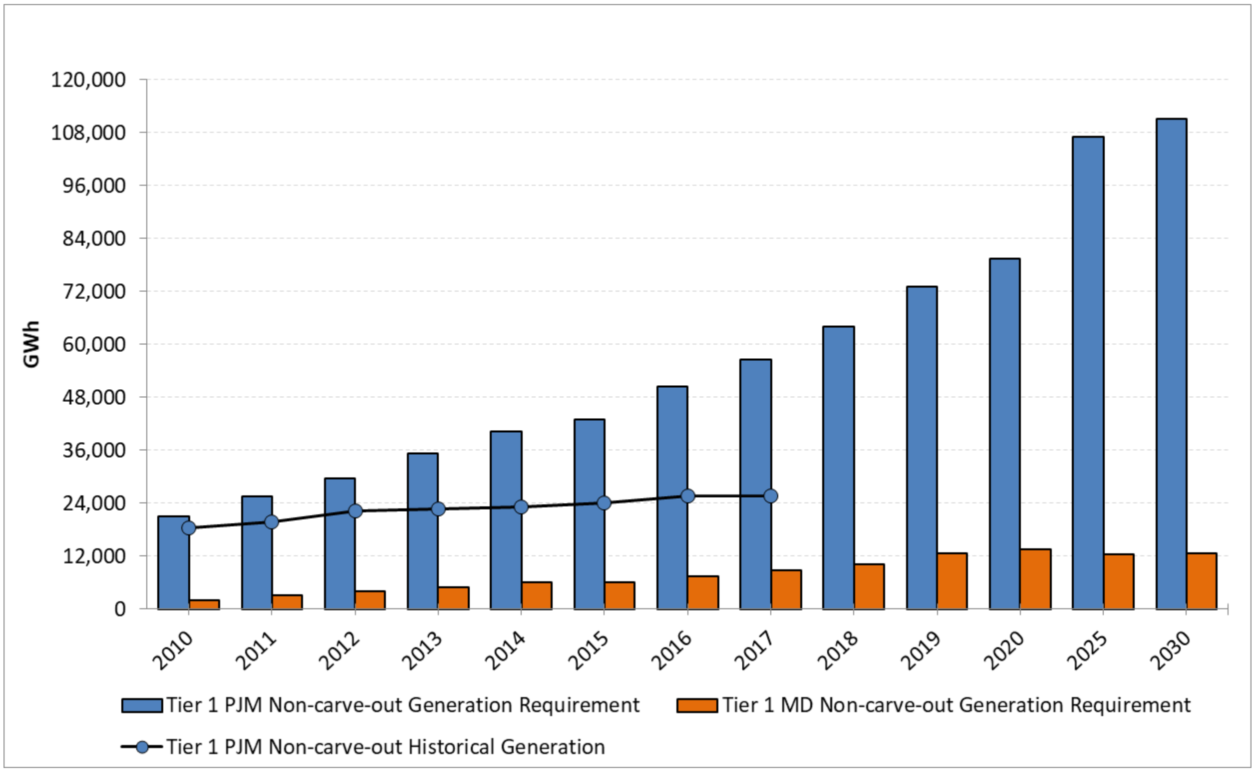
## B. Projected Tier 1 RPS Requirements in Maryland and PJM

The 2017 Inventory Database contains 8,806 MW of nameplate, non-carve-out Tier 1 capacity from 282 individual plants, excluding solar resources.[32,33] These plants in the PJM control area produced nearly 25,625 GWh of energy in 2017, assuming the capacity factors listed above in Table IV-1. Figure IV-1 shows this estimated generation by non-carve-out Tier 1 resources, along with the generation required for RPS compliance in Maryland and PJM as a whole; however, this figure should only be reviewed with a clear understanding of how it was developed. Considerations to keep in mind include the following:

- The analysis was restrictive in terms of generation estimates, including only those resources that are Maryland-Certified under Maryland's non-carve-out Tier 1 requirements.
- The analysis was all-encompassing in terms of PJM aggregate requirements, including voluntary RPS goals in Indiana and Virginia and Tier 1 requirements in other states that may be met with non-Maryland certified resources, such as coal mine methane in Pennsylvania.

[30] "Transparent Cost Database: Capacity Factor," Open Energy Information, National Renewable Energy Laboratory, http://en.openei.org/apps/TCDB/#blank.
[31] Appendix B describes the derivation of the PJM capacity factors.
[32] These data reflect all existing capacity as opposed to capacity that has Maryland Renewable Certification.
[33] Although solar is eligible for meeting Maryland's non-carve-out Tier 1 requirements, it is anticipated that the vast majority of Maryland solar installations will be used to meet the Maryland solar carve-out, or other solar requirements in PJM, and thus will be unavailable for meeting the remaining Tier 1 requirement.

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



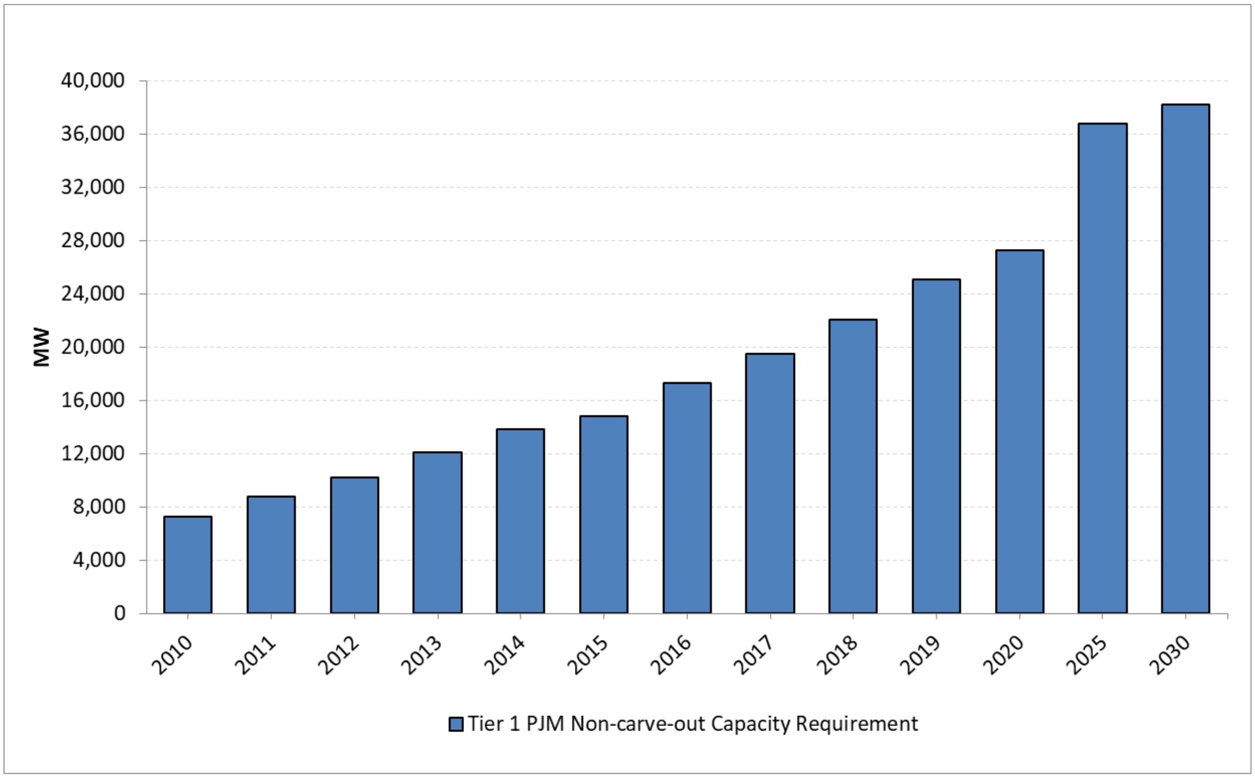

The RPS requirement in Maryland for non-carve-out Tier 1 in 2020 is estimated to be 13,658 GWh. The estimate for non-carve-out Tier 1 RPS requirements in PJM for 2020 is 79,325 GWh, which includes the Maryland requirement. To meet the requirements for all PJM states with RPSs, the amount of generation from non-carve-out Tier 1 resources within PJM will need to increase by approximately 46 percent annually from 2017 through 2020 if those requirements were to be met exclusively by PJM resources.[34] The high growth rate required between 2017 and 2020 indicates that a significant portion of the aggregate PJM RPS requirement will be met with resources located outside PJM (e.g., MISO and the New York ISO [NYISO]). Relying on compliance RECs from outside of PJM is consistent with the RPS requirements of all PJM states with RPSs in place.

Using Maryland's eligibility requirements for non-carve-out Tier 1 generation, nearly 61 percent of current Tier 1 generation in PJM comes from wind, which has an assumed capacity factor of 26 percent for onshore generation (see Table IV-1). The rest of PJM's non-carve-out Tier 1 generation typically has higher capacity factors than onshore wind, such that the overall

[34] Because resources used to fulfill non-carve-out Tier 1 requirements may come from PJM, no consideration is given in this report to attempt to meet these requirements entirely within Maryland.

weighted average resource capacity factor is approximately 33 percent in PJM. Assuming that the mix of Tier 1 resources remains constant; i.e., a 33 percent capacity factor is used, Figure IV-2 shows the total nameplate capacity that would need to be in place to meet the RPS non-carve-out Tier 1 requirements in PJM. Note that the capacity requirement need not be located within PJM.[35,36]

**Figure IV-2. Non-carve-out Tier 1 Capacity Required by the RPSs of PJM States**




Note: The non-carve-out Tier 1 RPS requirements for Maryland peak in 2020 and then plateau; however, other PJM states have requirements that continue to increase after 2020, which could affect the renewables market.

These required capacity calculations are based on a weighted average capacity factor for renewables as described above. The mix of resources relied upon in Maryland to meet its RPS requirement sheds light on the development of the weighted average capacity factor. Drawing from annual RPS reports from the Maryland PSC, Figure IV-3 presents the RECs retired per calendar year to meet non-carve-out Tier 1 requirements for the State.

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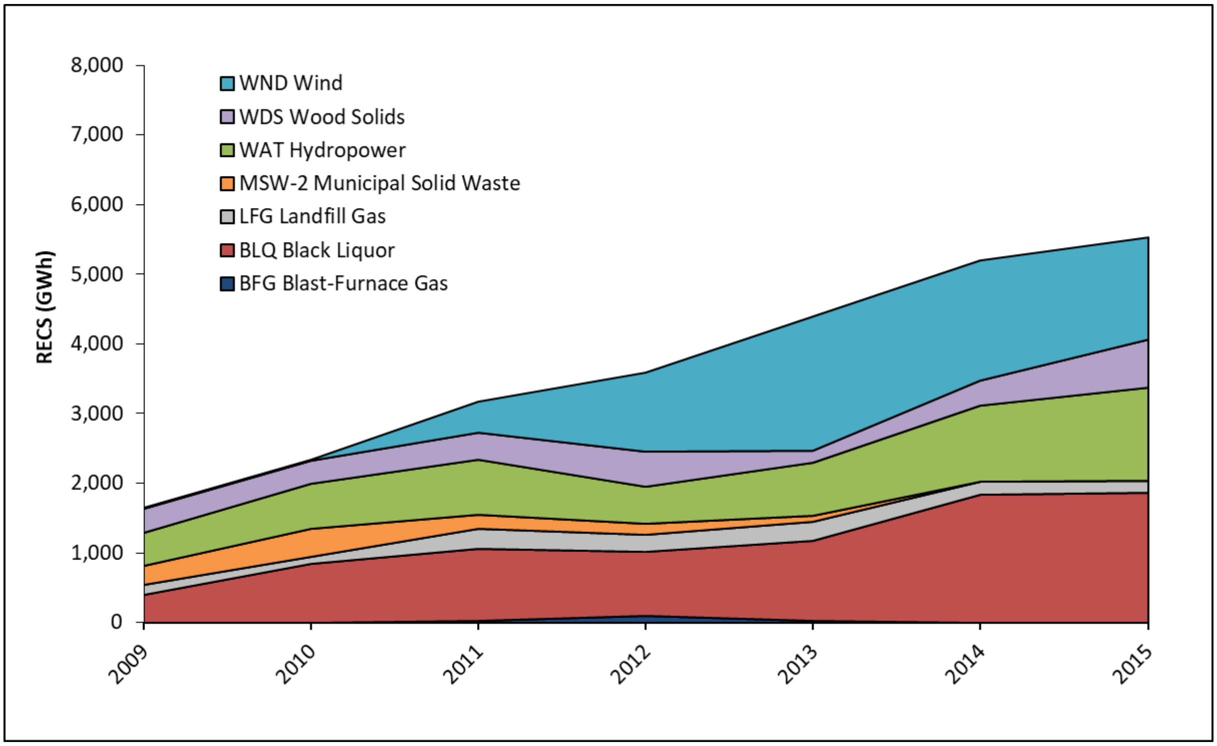
[35] As previously addressed, solar resources from outside of Maryland, but within PJM, may be used to fulfill the non-carve-out Tier 1 requirements; however, this is not anticipated. Including solar in the calculations for the weighted average capacity (and, subsequently, the capacity needed to meet the RPS) is the technically correct approach, and results in a conservative estimate of capacity needed to meet the RPS requirements due to the low capacity factor of solar.

[36] Renewable resources from outside of PJM may be used to fulfill Maryland non-carve-out Tier 1 requirements if the renewable generation is transmitted into PJM.

As shown in Figure IV-3, black liquor, hydroelectric, and wind, together, represent the majority of renewable generation used to meet the Maryland non-carve-out RPS requirement in 2015.

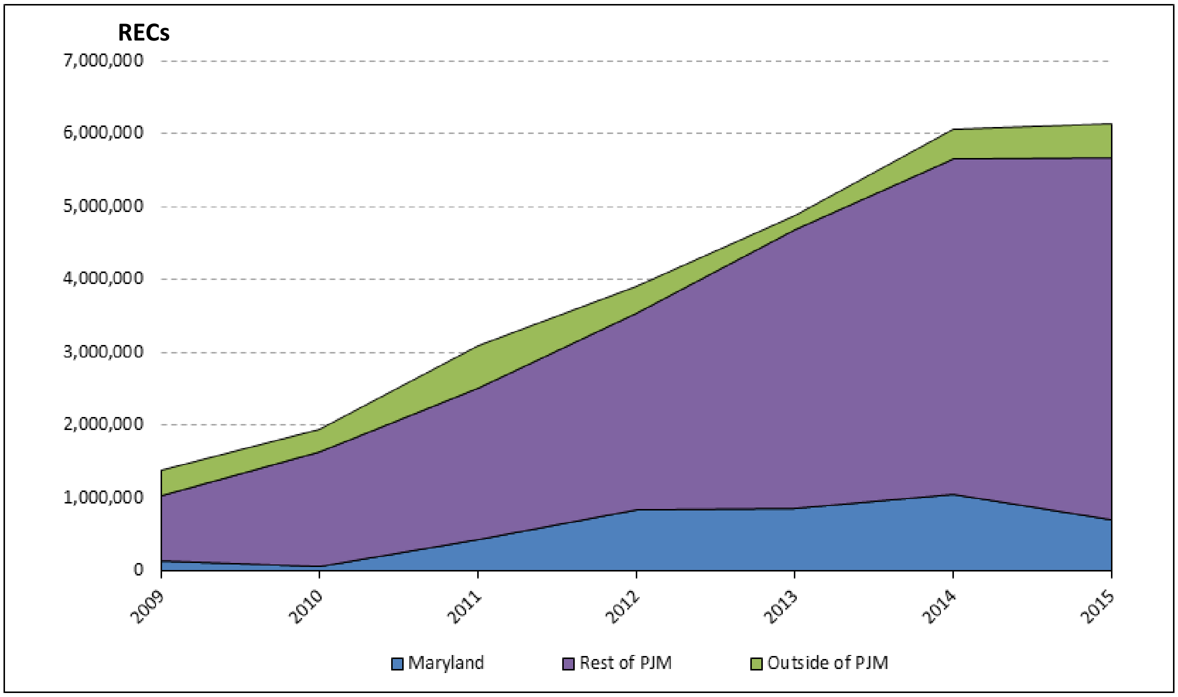
**Figure IV-3. RECs Retired for Non-carve-out Tier 1 RPS Compliance by Resource in Maryland (2009-2015)**




*Source:* Maryland PSC Annual RPS Reports for Calendar Years 2009-2015.

Figure IV-4 illustrates the location of resources used to meet the non-carve-out Tier 1 requirements in Maryland from 2009-2015. A significant portion of these requirements for Maryland was met using out-of-state resources, with only a small percentage of outside-of-PJM resources were relied upon in those years. With increasing requirements in coming years resulting from the prescriptions of the Maryland RPS, heavier reliance on outside-of-PJM resources may be needed to comply with the Maryland RPS.

**Figure IV-4. RECs Retired for Non-carve-out Tier 1 RPS Compliance in Maryland by Location (2009-2015)**

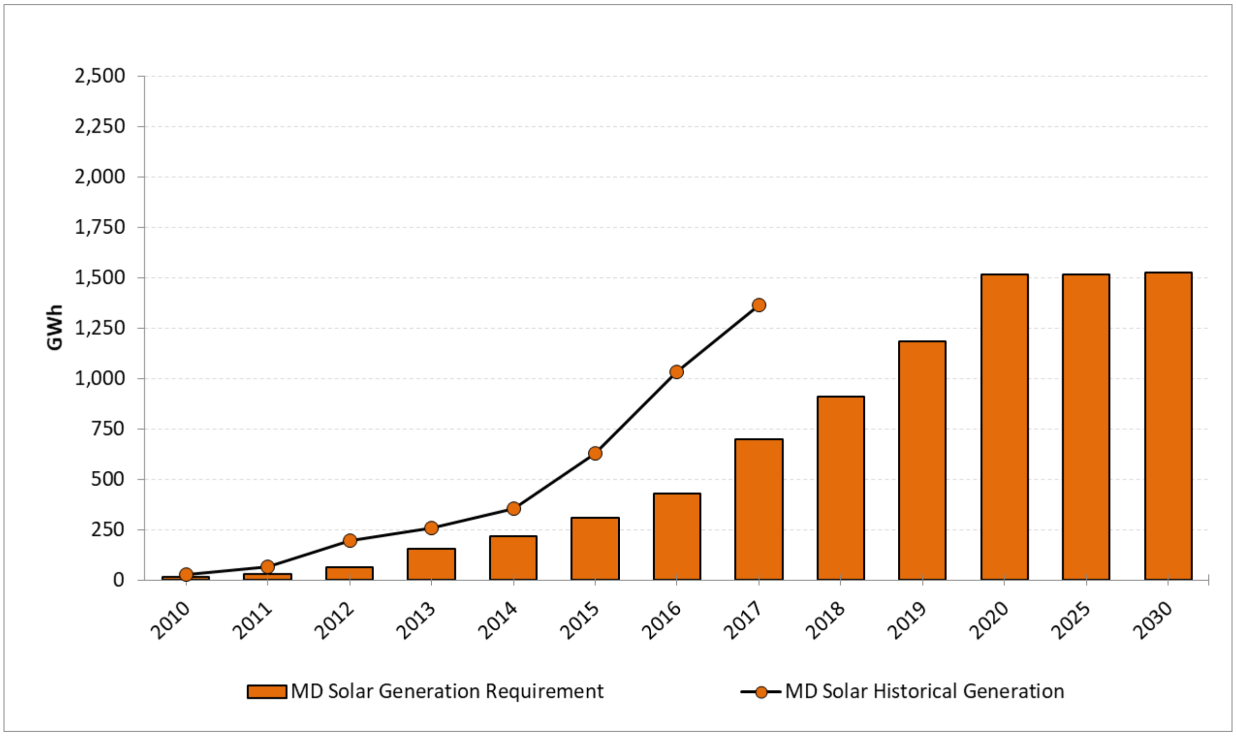



*Source:* Maryland PSC Annual RPS Reports for Calendar Years 2009-2015.

## C. <u>Projected Tier 1 Solar Carve-out RPS Requirements in Maryland and PJM</u>

In 2007, Maryland enacted a carve-out for solar energy within Tier 1, which the State legislature further amended in 2010 and 2012, and then again in 2017 when the 2 percent requirement was increased to 2.5 percent by 2020. Figure IV-5 shows the projected Tier 1 solar generation output needed to meet RPS requirements in Maryland.

**Figure IV-5. Solar Generation Required by the Maryland Solar RPS**




The 2017 Inventory Database includes 54,973 solar projects installed in Maryland for 975 MW of electric generating capacity. Given a 16 percent capacity factor, these Maryland solar units generated an estimated 1,367 GWh in 2017—approximately 2.2 percent of Maryland's 2017 electric consumption, and more than double Maryland's 2016 solar RPS requirement (i.e., 1.15 percent). Maryland consumes 7.7 percent of the electricity generated in the PJM region and currently produces 19 percent of the PJM region's solar electric power.

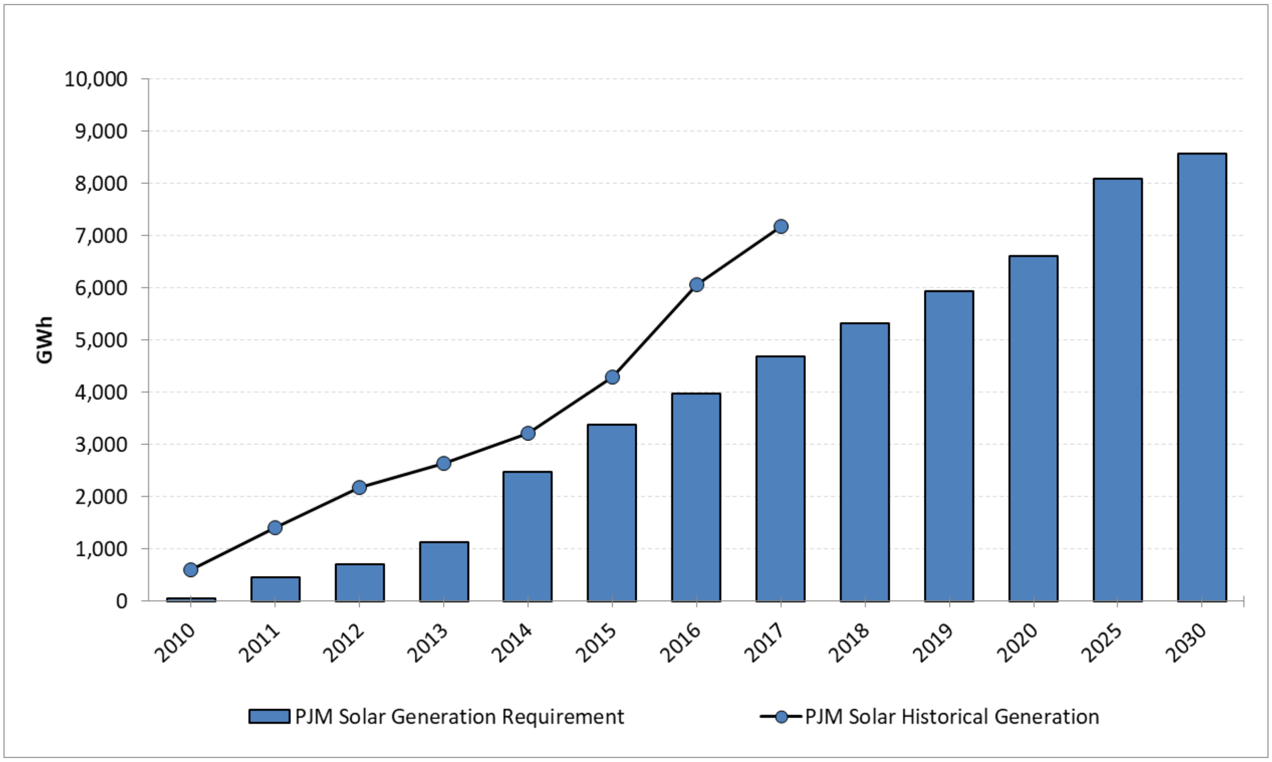
The Maryland RPS carve-out for solar-generated power in 2020 is estimated to be 1,518 GWh (refer to Table III-3), which must be met using in-state solar resources. Maryland's in-state solar generation must grow by approximately 4 percent annually between 2017 and 2020 in order to meet the 2020 Maryland Tier 1 solar RPS requirement of 2.5 percent.[37]

The 2017 Inventory Database lists 5,123 MW of nameplate solar capacity from 165,159 units in the PJM control area. Assuming a 16 percent capacity factor, these solar units generated an estimated 7,182 GWh of energy in 2017. The RPS requirements of states within PJM for solar-generated power in 2020 are estimated to be 6,621 GWh (see Figure IV-6). The ability of other states in PJM to meet their respective solar RPS requirements is included here for

[37] See Section V for more information on historical net metering data as reported by the Maryland PSC.

informational purposes, though there is not a direct connection to Maryland being able to meet its solar RPS requirement (as that must be met from in-state resources exclusively).

**Figure IV-6. Solar Generation Required for the Solar RPSs of PJM States**




Using a capacity factor of 16 percent for solar energy, Figure IV-7 estimates the total solar nameplate capacity that would need to be installed to meet the projected RPS energy requirements in both Maryland and PJM. Maryland itself requires an additional 108 MW of solar capacity between 2017 and 2020 to meet its 2020 requirement.[38]

[38] See Appendix C for an analysis of the projected sizes of solar projects.

**Figure IV-7. Installed Solar Nameplate Capacity Required to Meet RPS Demand in Maryland and PJM**

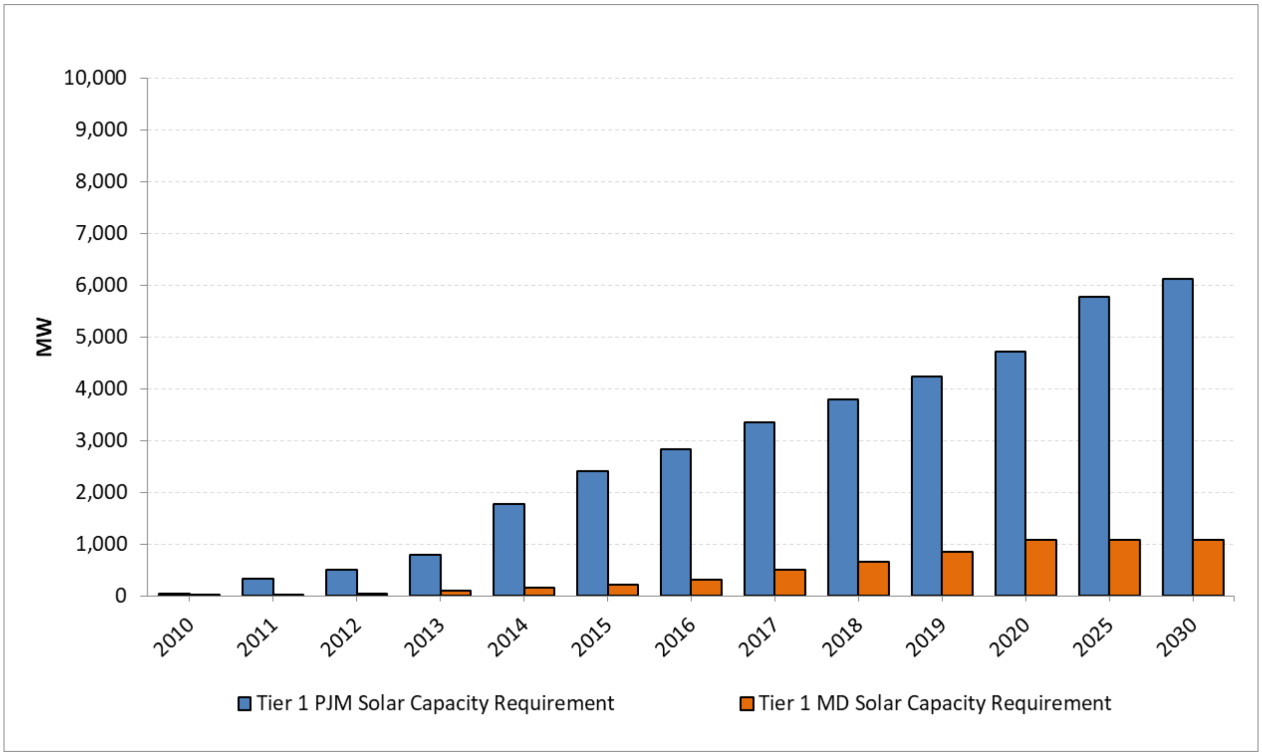
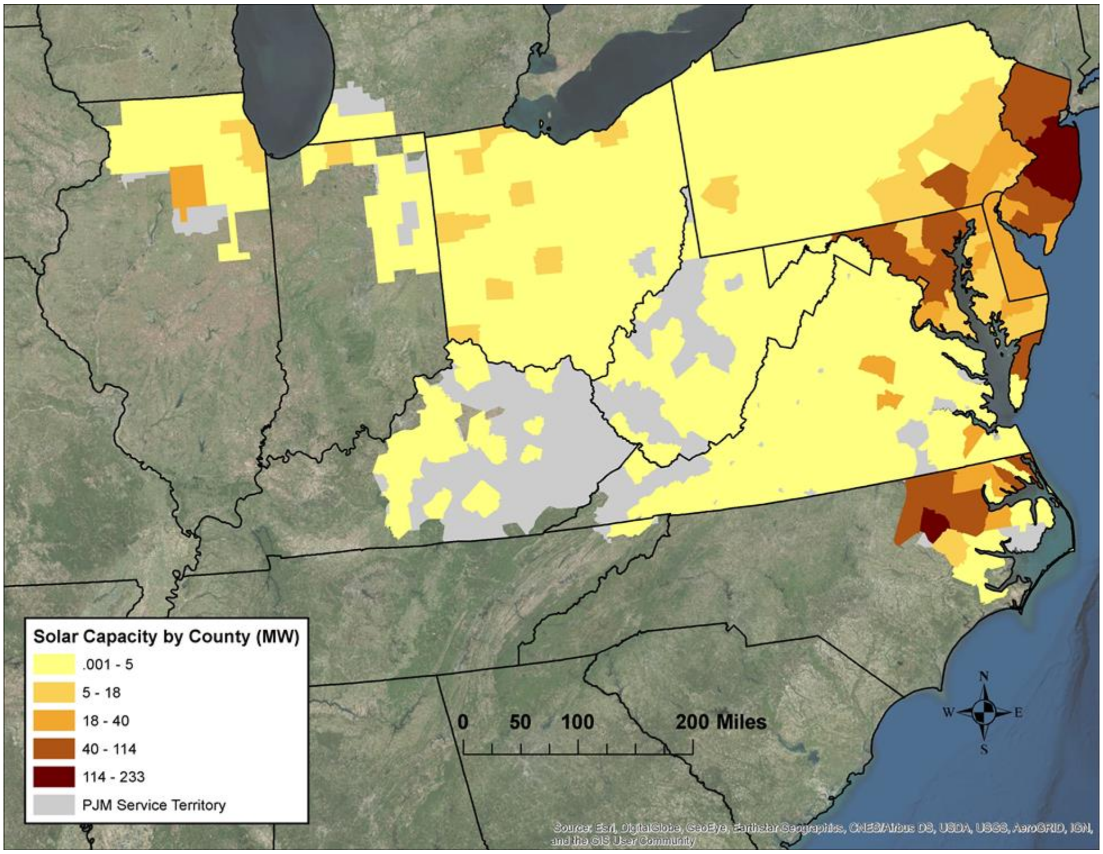



Figure IV-8 shows the distribution of solar generation units installed in the PJM control area. New Jersey by far has the most solar generating capacity in PJM and currently accounts for 48 percent of PJM's total solar generation. The reason New Jersey solar projects represent such a large portion of the PJM solar portfolio is a result of New Jersey state policy measures implemented to support the market, specifically: solar ACPs that are set high enough to provide an incentive for market development ($308/MWh in energy year [EY] 2018, declining to $239/MWh in EY 2028); a high solar carve-out requirement (escalating to 4.1 percent by 2027); and a long banking life for SRECs (five years).

**Figure IV-8.  Solar Capacity in PJM (2017)**




## D. Tier 2 RPS Requirements in Maryland and PJM

The Maryland RPS requires that 2.5 percent of electricity sales from LSEs come from Tier 2 resources through 2018, after which the requirement expires. The 2017 Inventory Database contains 1,537 MW of Tier 2 nameplate capacity from 11 units in PJM.[39] Using the capacity factors shown in Table IV-1, Tier 2 resources produced an estimated 6,059 GWh of energy in 2017; with an estimated 2,092 GWh of that total generated at the 531-MW Conowingo hydro plant in Maryland.[40] As discussed in more detail below, there is enough generation in PJM to meet Tier 2 requirements in Maryland through the scheduled expiration of the Tier 2 requirement in 2018, as well as in other states within PJM.

The only eligible Tier 2 resource in Maryland is large hydro. The 2.5 percent requirement is approximately 1,520 GWh in 2018, meaning that the Conowingo hydro plant could potentially

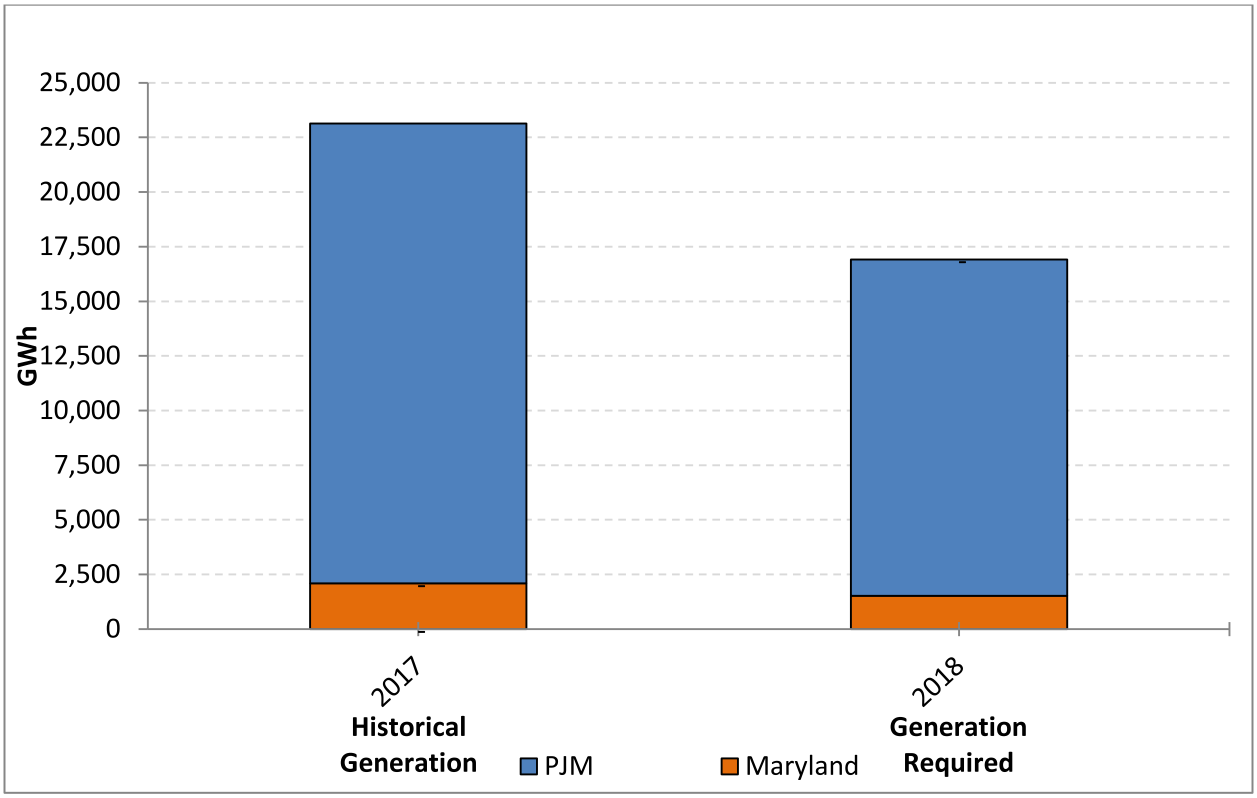
[39] These data reflect all existing capacity as opposed to capacity that has Maryland renewable certification.

meet the Maryland Tier 2 requirement on its own; historically, however, the Tier 2 requirements (in terms of RECs retired) have been fulfilled by multiple projects in multiple states. In 2015, RECs from the Conowingo hydro plant fulfilled 63 percent of the total Tier 2 RECs retired in Maryland; the remainder were from other plants located out of state (though within PJM).[41]

Pennsylvania, New Jersey, and the District of Columbia also have Tier 2 requirements in their respective RPS policies; however, compared to Maryland's Tier 2, there are more eligible resources. For example, waste coal, pumped storage hydropower, and energy efficiency all qualify as Tier 2 resources under the Pennsylvania RPS.

Figure IV-9 illustrates Tier 2 generation in Maryland and PJM for 2017, and the total Tier 2 RPS requirement for 2018, reinforcing the finding that there will be sufficient resources for Maryland (and PJM) compliance with Tier 2 requirements.

**Figure IV-9. PJM and Maryland Tier 2 2017 Generation Compared to 2018 RPS Requirements**




[41] Maryland PSC RPS Report, January 2017, http://www.psc.state.md.us/wp-content/uploads/RPS-Report-2017.pdf, 20.

# V. Projects in the PJM Queue

To determine whether there will be sufficient renewable energy generation to fulfill RPS obligations in Maryland, the first source of data to consider is the PJM Interconnection Queue (PJM queue), which tracks proposed generating projects. Federal Energy Regulatory Commission (FERC) regulations and PJM operating rules require that these projects undergo a series of studies to determine whether they can safely interconnect to the PJM grid. Table V-1 displays the sum of nameplate capacity of renewable generation projects that PJM's queue lists as under construction or active (meaning requisite studies are being performed for projects that fall under either category) from 2011 through 2017. The total capacity of all renewable projects listed in the PJM queue for those years is 34,448 MW, of which onshore and offshore wind power account for 38 percent, or 13,172 MW. It is important to note that the PJM queue does not reflect behind-the-meter projects, such as residential solar systems.[42] The PJM queue is always changing, with new projects requesting interconnection and other projects dropping out for a myriad of reasons, such as difficulties in siting the project or obtaining project financing.

[42] Behind-the-meter projects are addressed in Section VI.

## Table V-1. Nameplate Capacity of Active and Under-construction Tier 1 Renewable Energy Projects in the PJM Queue (MW)

| Energy Source | State | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Total in Queue (2011-2017) | Estimated in Service for 2018 |
|---|---|---|---|---|---|---|---|---|---|---|
| Utility Scale Solar | DC | | | | | | | | -- | **44.9** |
| | DE | | | | | 6.0 | 229.2 | 100.0 | **335.2** | **177.6** |
| | IL | | | | | | 25.0 | 1,119.9 | **1,144.9** | **330.1** |
| | IN | | | | | | 400.0 | 570.0 | **970.0** | **243.8** |
| | KY | | | | | | 180.0 | 20.0 | **200.0** | **60.3** |
| | MD | 20.0 | 22.0 | | 193.0 | 65.3 | 934.9 | 140.4 | **1,375.6** | **1,305.3** |
| | MI | | | | | | | 100.0 | **100.0** | **28.6** |
| | NC | | | | 274.9 | 625.7 | 946.9 | 1,153.0 | **3,000.5** | **1,504.1** |
| | NJ | 28.9 | | 7.1 | | 16.2 | 51.9 | 28.6 | **132.7** | **2,243.2** |
| | OH | 3.4 | | | | 135.0 | 1,985.5 | 2,984.5 | **5,108.4** | **1,398.2** |
| | PA | | | | | | 83.0 | 257.5 | **340.5** | **402.9** |
| | TN | | | | | | | | -- | -- |
| | VA | | | | 8.5 | 183.4 | 3,916.6 | 3,825.7 | **7,934.2** | **2,335.1** |
| | WV | | | | | | 5.0 | 30.0 | **35.0** | **12.2** |
| Solar; Storage | NJ | | | | | | 0.6 | | **0.6** | **0.1** |
| | OH | | | | | | | 200.0 | **200.0** | **48.0** |
| | PA | | | | | | | 100.0 | **100.0** | **24.0** |
| | VA | | | | | | | 45.0 | **45.0** | **10.8** |
| Storage; Solar | NC | | | | | | | 110.0 | **110.0** | **26.4** |
| | VA | | | | | | 85.0 | | **85.0** | **20.4** |
| | WV | | | | | | | 19.9 | **19.9** | **4.8** |
| Methane; Solar | MD | | | | | | | 11.6 | **11.6** | **2.8** |
| **Subtotal:** | | **52.3** | **22.0** | **7.1** | **476.4** | **1,031.6** | **8,843.6** | **10,816.1** | **21,249.1** | **10,223.7** |
| Wind | IL | 187.5 | | | 350.0 | 150.0 | 1,058.4 | 1,476.1 | **3,222.0** | **2,816.0** |
| | IN | 1,500.0 | | | | 375.0 | 624.2 | 1,030.0 | **3,529.2** | **1,807.2** |
| | MD | 150.0 | | | | | | | **150.0** | **184.8** |
| | NC | | | 300.3 | | 130.0 | | | **430.3** | **220.9** |
| | NJ | | | | | | 200.0 | | **200.0** | **13.5** |
| | OH | | | 18.0 | | 100.0 | 494.8 | 1,906.6 | **2,519.4** | **493.9** |
| | PA | | | 70.0 | 298.0 | 90.0 | 641.1 | 255.8 | **1,354.9** | **1,037.2** |
| | VA | | 72.0 | | | | 96.6 | 180.0 | **348.6** | **10.5** |
| | WV | | | | 224.3 | 50.6 | | 160.0 | **434.9** | **665.3** |
| Wind; Storage | IL | | | | | | | | **240.0** | **7.2** |
| | PA | | | | | | | | **90.0** | **2.7** |
| | WV | | | | | | 141.3 | | **141.3** | **4.2** |
| **Subtotal**: | | **1,837.5** | **72.0** | **388.3** | **872.3** | **895.6** | **3,496.4** | **5,096.5** | **12,660.6** | **7,263.5** |
| Offshore Wind | DE | | | | | 499.6 | | | **499.6** | -- |
| | MD | | | | | | | | -- | -- |
| | VA | | | 12.0 | | | | | **12.0** | -- |
| **Subtotal**: | | | | **12.0** | | **499.6** | | | **511.6** | -- |
| Hydro | IL | | | | | | | | -- | **20.0** |
| | IN | | | | | | | | -- | **8.2** |
| | MD | | | 0.4 | | | | 15.0 | **15.4** | **26.0** |
| | MI | | | | | | | | -- | **15.2** |
| | NJ | | | | | | | | -- | **11.0** |
| | OH | | | | | | | | -- | -- |
| | PA | | | | | | | | -- | **94.6** |
| | VA | | | | | | | 7.5 | **7.5** | **32.2** |
| | WV | | | | | | | | -- | **58.1** |
| **Subtotal**: | | | | **0.4** | | | | **22.5** | **22.9** | **265.2** |
| Biomass | MD | | | | | | 4.0 | | **4.0** | **5.7** |
| | KY | | | | | | | | -- | **5.0** |
| | TN | | | | | | | | -- | -- |
| | VA | | | | | | | | -- | **139.9** |
| **Subtotal**: | | | | | | | **4.0** | | **4.0** | **150.6** |
| **TOTAL:** | | **1,889.8** | **94.00** | **407.8** | **1348.7** | **2426.8** | **12,344.0** | **15,937.1** | **34,448.2** | **17,903.0** |

*Source:* "Generation Queues: Active (ISA, WMPA, etc.)," PJM, [http://www.pjm.com/planning/generation-interconnection/generation-queue-active.aspx](http://www.pjm.com/planning/generation-interconnection/generation-queue-active.aspx).

Because not all projects in the PJM queue ultimately result in an operational energy generating facility, assumptions based on technology were made to determine what percent of projects that enter the queue reach in-service status. The calculations are based on a weighted average of percent-in-service of projects by technology taken from the years 2012 through 2014, as those years represent more consistent market activity, having fewer fluctuations than the data from 2015 and 2016. Based on this approach, the estimates of PJM queue projects that will reach the in-service status are presented in Table V-2.

**Table V-2. Estimated In-service Projects in the PJM Queue by Technology (2012-2014)**

| Technology | Percent In Service |
|---|---|
| Biomass | 48% |
| Hydropower | 37 |
| Solar | 24 |
| Solar; Storage | 24 |
| Storage; Solar | 24 |
| Methane; Solar | 24 |
| Wind | 3 |
| Wind; Storage | 3 |

Using these percentages, the column labeled "Estimated in Service for 2018" in Table V-1 reflects the estimated 5,490 MW that will go online in 2018. Applying the capacity factors from Table IV-1, it is estimated that 8,060 GWh of renewable energy from new projects will be available in 2018, composed of an estimated: 7,148 GWh solar; 865 GWh wind; 33 GWh hydro; and 14 GWh biomass.

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# VI. Projected Future Renewable Capacity and Generation in PJM

Projected future renewable capacity and generation in PJM is based on the actual 2017 GATS data (supplemented by EIA data), the projects estimated to be in service from the 2018 PJM queue as described in Section V, and, for the years 2019 through 2030, a technology-specific growth rate. Projections begin in 2018 by combining the 2017 GATS data and estimated in-service projects from the PJM queue; the remaining years are based on technology-specific growth rates applied to the 2018 figures.[43] As in other areas of the 2017 Inventory Report, generation data are based on capacity data and, in this case, capacity projections. The GATS data are assumed to be inclusive of net metering projects, which are therefore included in the growth projections.[44] Historical net metering data are provided in Table VI-1 for reference. This analysis addresses only non-carve-out Tier 1 and solar RPS categories, as projections for the Tier 2 requirement (which expires in 2018) were deemed unnecessary.

**Table VI-1. Installed Net Metering Solar Capacity in Maryland (2010-2016) (MW)**

| Reporting Year[a] | Installed Solar Capacity | Increase from Prior Year |
|---|---|---|
| 2010 | 13 | -- |
| 2011 | 31 | 18 |
| 2012 | 56 | 25 |
| 2013 | 100 | 44 |
| 2014 | 142 | 42 |
| 2015 | 236 | 94 |
| 2016 | 460 | 224 |

[a] 2010 data is as of January 2010; the remaining reporting years' data is as of the end of June.

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*Source:* Maryland Public Service Commission State of Net Metering Reports, 2010-2016.

[43] For biomass and hydro, the growth is based on average annual capacity growth between 2012 and 2016 for years with capacity going into service; for the wind growth calculation, the period was extended to start in 2009 to incorporate the early growth of the wind market. Biomass annual growth is assumed to be 76.9 MW, hydro annual growth is estimated to be 15.8 MW, and 76.88 MW of capacity is added annually for wind.

[44] In 2016, 99.8 percent of the net metering was from solar, with the small remainder from wind and biomass resources. Source: Maryland PSC, *Report on the Status of Net Energy Metering in the State of Maryland*, August 2017, http://www.psc.state.md.us/wp-content/uploads/Final-2016-Net-Metering-Report.pdf.

Non-carve-out Tier 1 renewable energy projects have an estimated capacity growth rate from 2018 through 2030 of 1.95 percent. Table VI-2 presents the estimated capacity for the non-carve-out Tier 1 projects in PJM from 2018 through 2030, broken down by technology; Table VI-3 shows the corresponding energy generation for the same time period.[45]

**Table VI-2. Estimated Capacity of Non-carve-out Tier 1 Projects in PJM by Technology (2018-2030) (MW)**

| Year | Wind | Offshore Wind | Hydro | Biomass | Other[a] | TOTAL |
|---|---|---|---|---|---|---|
| 2018 | 7,264 | -- | 265 | 151 | 1,517 | **9,196** |
| 2019 | 7,340 | -- | 281 | 228 | 1,517 | **9,366** |
| 2020 | 7,417 | -- | 297 | 304 | 1,517 | **9,536** |
| 2021 | 7,494 | 248 | 313 | 381 | 1,517 | **9,953** |
| 2022 | 7,571 | 248 | 328 | 458 | 1,517 | **10,123** |
| 2023 | 7,648 | 368 | 344 | 535 | 1,517 | **10,412** |
| 2024 | 7,725 | 368 | 360 | 612 | 1,517 | **10,582** |
| 2025 | 7,802 | 368 | 376 | 689 | 1,517 | **10,751** |
| 2026 | 7,879 | 368 | 392 | 766 | 1,517 | **10,921** |
| 2027 | 7,955 | 368 | 407 | 843 | 1,517 | **11,091** |
| 2028 | 8,032 | 368 | 423 | 920 | 1,517 | **11,260** |
| 2029 | 8,109 | 368 | 439 | 997 | 1,517 | **11,430** |
| 2030 | 8,186 | 368 | 455 | 1,073 | 1,517 | **11,599** |
| **Average Annual Growth Rates** | | | | | | |
| 2018-2024 | 1.03% | -- | 5.24% | 26.27% | 0.00% | **2.37%** |
| 2024-2030 | 0.97% | 0.00% | 3.98% | 9.81% | 0.00% | **1.54%** |
| 2018-2030 | -- | -- | 4.61% | 17.75% | 0.00% | **1.95%** |

[a] Includes black liquor, geothermal, methane, and waste-to-energy, which are based on PJM GATS and not expected to experience market growth.

[45] As previously noted, the Tier 1 non-carve-out analysis focuses on PJM as a whole because Maryland does not have state-specific requirements for this category.

**Table VI-3. Estimated Generation of Non-carve-out Tier 1 Projects in PJM by Technology (2018-2030) (GWh)**

| Energy Source | Wind | Offshore Wind | Hydro | Biomass | Other[a] | TOTAL |
|---|---|---|---|---|---|---|
| 2018 | 16,543 | -- | 1,045 | 1,108 | 7,840 | **26,538** |
| 2019 | 16,718 | -- | 1,108 | 1,674 | 7,840 | **27,341** |
| 2020 | 16,894 | -- | 1,170 | 2,240 | 7,840 | **28,144** |
| 2021 | 17,069 | 914 | 1,232 | 2,806 | 7,840 | **29,861** |
| 2022 | 17,244 | 914 | 1,295 | 3,372 | 7,840 | **30,664** |
| 2023 | 17,419 | 1,369 | 1,357 | 3,938 | 7,840 | **31,923** |
| 2024 | 17,594 | 1,369 | 1,419 | 4,503 | 7,840 | **32,726** |
| 2025 | 17,769 | 1,369 | 1,481 | 5,069 | 7,840 | **33,529** |
| 2026 | 17,944 | 1,369 | 1,544 | 5,635 | 7,840 | **34,333** |
| 2027 | 18,119 | 1,369 | 1,606 | 6,201 | 7,840 | **35,136** |
| 2028 | 18,294 | 1,369 | 1,668 | 6,767 | 7,840 | **35,939** |
| 2029 | 18,469 | 1,369 | 1,731 | 7,333 | 7,840 | **36,742** |
| 2030 | 18,644 | 1,369 | 1,793 | 7,899 | 7,840 | **37,546** |
| **Average Annual Growth Rates** | | | | | | |
| 2018-2024 | 1.03% | -- | 5.24% | 26.27% | 0.00% | **3.55%** |
| 2024-2030 | 0.97% | 0.00% | 3.98% | 9.81% | 0.00% | **2.32%** |
| 2018-2030 | -- | -- | 4.61% | 17.75% | 0.00% | **2.93%** |

[a] Includes black liquor, geothermal, methane, and waste-to-energy, which are based on PJM GATS and not expected to experience market growth.

Note that over time, the generation portfolio changes substantially, as described below:

- There is a small, steady increase in wind generation.
- Biomass resources show an increase in generation over the 12-year period.
- There is no increase in generation contemplated from "other" resources.
- Hydropower represents approximately 4 to 5 percent of the renewable generation portfolio over the 12-year period.[46]
- Offshore wind becomes a part of the portfolio in 2021 and bumps up in 2023.[47]

[46] Hydropower growth is typically through upgrades to current projects.
[47] The approved offshore wind projects are anticipated to be operational in 2020 and 2023; adding 913,845 MWh in 2020 and an additional 455,482 MWh in 2023.

Projections for solar capacity and generation were calculated in the same way as non-carve-out Tier 1 estimates—2017 GATS capacity data were added to 2018 estimated in-service capacity from the PJM queue to derive the 2018 projections,[48] to which a growth rate was then applied for years 2019 through 2030. For solar generation, a conservative growth rate of 15 percent was applied, based on one-half of the average annual growth rate of solar generation in PJM from 2014 through 2017. Uncertainties that may affect future solar market growth include influences such as: the federal Investment Tax Credit (ITC),[49] a planned increase in tariffs on imported solar panels, and anticipated continued decreases in the costs of solar panels. Table VI-4 presents the estimated capacity for solar projects in Maryland from 2018 through 2030; Table VI-5 presents the corresponding estimated generation for the same time period.[50]

**Table VI-4. Estimated Capacity of Total Solar Projects in Maryland (2018-2030) (MW)**

| Year | Utility-scale Solar |
|---|---|
| 2018 | 1,305 |
| 2019 | 1,501 |
| 2020 | 1,726 |
| 2021 | 1,985 |
| 2022 | 2,283 |
| 2023 | 2,625 |
| 2024 | 3,019 |
| 2025 | 3,472 |
| 2026 | 3,993 |
| 2027 | 4,592 |
| 2028 | 5,281 |
| 2029 | 6,073 |
| 2030 | 6,984 |

[48] The PJM queue had over 400 potential solar projects as of January 2018. This includes all active PJM queue projects not fully in service or withdrawn.
[49] Growth is anticipated to continue through the reduction of the ITC from the current 30 percent ITC level to 10 percent for commercial installations in 2022, and the expiration of the ITC for residential installations, also in 2022.
[50] As previously noted, the Tier 1 non-carve-out analysis focuses on PJM as a whole because Maryland does not have state-specific requirements for this category.

**Table VI-5. Estimated Generation of Total Solar Projects in Maryland (2018-2030) (GWh)**

| Year | Utility-scale Solar |
|---|---|
| 2018 | 1,830 |
| 2019 | 2,104 |
| 2020 | 2,420 |
| 2021 | 2,782 |
| 2022 | 3,200 |
| 2023 | 3,680 |
| 2024 | 4,232 |
| 2025 | 4,867 |
| 2026 | 5,597 |
| 2027 | 6,436 |
| 2028 | 7,401 |
| 2029 | 8,512 |
| 2030 | 9,788 |

For the Maryland RPS requirements, in-state solar is the primary consideration. However, PJM solar capacity and generation projections are included here as an indication of what is anticipated in the broader market. Table VI-6 presents the estimated capacity for solar projects in PJM from 2018 through 2030; Table VI-7 presents the estimated generation for the same time period.

**Table VI-6. Estimated Capacity of Total Solar Projects in PJM (2018-2030) (MW)**

| Year | Utility-scale Solar |
|---|---|
| 2018 | 10,224 |
| 2019 | 11,757 |
| 2020 | 13,521 |
| 2021 | 15,549 |
| 2022 | 17,881 |
| 2023 | 20,563 |
| 2024 | 23,648 |
| 2025 | 27,195 |
| 2026 | 31,274 |
| 2027 | 35,966 |
| 2028 | 41,361 |
| 2029 | 47,565 |
| 2030 | 54,699 |

**Table VI-7. Estimated Generation of Total Solar Projects in PJM (2018-2030) (GWh)**

| Year | Utility-scale Solar |
|---|---|
| 2018 | 14,330 |
| 2019 | 16,479 |
| 2020 | 18,951 |
| 2021 | 21,793 |
| 2022 | 25,062 |
| 2023 | 28,822 |
| 2024 | 33,145 |
| 2025 | 38,117 |
| 2026 | 43,834 |
| 2027 | 50,409 |
| 2028 | 57,971 |
| 2029 | 66,667 |
| 2030 | 76,667 |

# VII. Comparison of Projected Availability of Renewable Energy and RPS Category Requirements

Reviewing the results of the analysis as presented in Sections V and VI of the 2017 Inventory Report, the projected availability of renewable energy can now be compared to projected RPS requirements to determine future surpluses or shortages of renewable energy needed for RPS compliance.

It is evident that there is sufficient non-carve-out Tier 1 generation in PJM to meet Maryland RPS requirements through 2030. There is not, however, sufficient non-carve-out Tier 1 generation in PJM for all of the PJM states with RPS policies similar to Maryland's to meet their respective RPS requirements. For example, as shown in Table VII-1, in 2020 an estimated 79,000 GWh would be required for all PJM states to meet their non-carve-out Tier 1 RPS requirements; however, only 28,000 GWh are projected to be available from PJM resources.

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

| Year | Generation Requirement | Projected Generation | Difference |
|---|---|---|---|
| 2018 | 64,072 | 26,538 | **(37,535)** |
| 2019 | 73,019 | 27,341 | **(45,678)** |
| 2020 | 79,325 | 28,144 | **(51,181)** |
| 2021 | 83,998 | 29,861 | **(54,137)** |
| 2022 | 92,820 | 30,664 | **(62,155)** |
| 2023 | 95,559 | 31,923 | **(63,636)** |
| 2024 | 99,215 | 32,726 | **(66,489)** |
| 2025 | 106,964 | 33,529 | **(73,434)** |
| 2026 | 109,098 | 34,333 | **(74,765)** |
| 2027 | 109,592 | 35,136 | **(74,456)** |
| 2028 | 110,214 | 35,939 | **(74,275)** |
| 2029 | 110,641 | 36,742 | **(73,899)** |
| 2030 | 111,183 | 37,546 | **(73,637)** |
| **Average Annual Growth Rates** | | | |
| 2018-2024 | 7.56% | 3.55% | -- |
| 2024-2030 | 1.92% | 2.93% | -- |
| 2018-2030 | 4.70% | 2.32% | -- |

For all the PJM states with RPS policies to meet their non-carve-out Tier 1 RPS requirements in 2020 from PJM resources, available renewable energy generation in PJM would have to have an annual growth rate (from 2017 to 2020) of approximately 46 percent. However, based on this analysis, the projected annual growth rate for these years is 3 percent. This rate of required growth in PJM renewable generation does not recognize the potential for reliance on outside-of-PJM renewable generation to be relied upon to meet a portion of the renewable energy requirements for PJM states with RPSs. Additionally, market dynamics that would serve to provide incentives for renewable project developers to construct qualifying new projects both inside PJM and in other RTOs/ISOs are not represented, which would serve to diminish the gaps between required generation and eligible generation over time.

A potential renewable resource that may become more abundantly available in the future is offshore wind. The two offshore wind projects that have been approved by the Maryland PSC have been included in this analysis. However, other large projects are in the planning/discussion phases, including: an additional 500 MW in Maryland and a potential new project in New Jersey. As noted, renewable resources located outside of PJM, but which are Maryland certified, are also eligible to meet non-carve-out Tier 1 requirements. In 2015, 7.7 percent of non-carve-out Tier 1 requirements in Maryland were met using outside-of-PJM resources, and that number is growing. With higher Maryland RECs prices resulting from a potential gap between supply and requirements, the percentage of renewable energy imported from outside of PJM is expected to increase.

The results for the solar comparison differ significantly from the non-carve-out Tier 1 comparison; results indicate that both Maryland and other members of PJM will meet their solar RPS requirements.[51] This is due in part to the rapid development of the market within the last few years. For example, according to GATS, there was a doubling of solar capacity within PJM between 2014 and 2016. Maryland, however, is expected to generate sufficient solar energy in 2018 to meet and surpass its 2020 requirements (see Table VII-2).

Table VII-2 shows Maryland solar generation—required and generated (in-State)—for 2018 through 2030. As seen in Table VII-2, Maryland is expected to significantly exceed its solar generation requirements throughout this time period. Note that any solar generation above

[51] For solar capacity and generation, a growth rate of 15 percent was applied, based on one-half the average annual growth rate for PJM from 2014-2017.

and beyond the Maryland solar carve-out requirements could be applied to non-carve-out Tier 1 requirements. The data contained in Table VII-2 are displayed graphically in Figure VII-1.

**Table VII-2. Solar RPS Requirements in Maryland Compared to Projected Solar Energy Generation in Maryland (2018-2030) (GWh)**

| Year | Generation Requirement | Projected Generation | Difference |
|---|---|---|---|
| 2018 | 912 | 1,830 | **917** |
| 2019 | 1,185 | 2,104 | **919** |
| 2020 | 1,518 | 2,420 | **902** |
| 2021 | 1,515 | 2,782 | **1,268** |
| 2022 | 1,515 | 3,200 | **1,685** |
| 2023 | 1,515 | 3,680 | **2,165** |
| 2024 | 1,518 | 4,232 | **2,714** |
| 2025 | 1,518 | 4,867 | **3,349** |
| 2026 | 1,520 | 5,597 | **4,077** |
| 2027 | 1,522 | 6,436 | **4,914** |
| 2028 | 1,526 | 7,401 | **5,876** |
| 2029 | 1,526 | 8,512 | **6,985** |
| 2030 | 1,527 | 9,788 | **8,261** |

**Figure VII-1. Solar RPS Requirements in Maryland Compared to Projected Solar Energy Generation in Maryland (2018-2030) (GWh)**

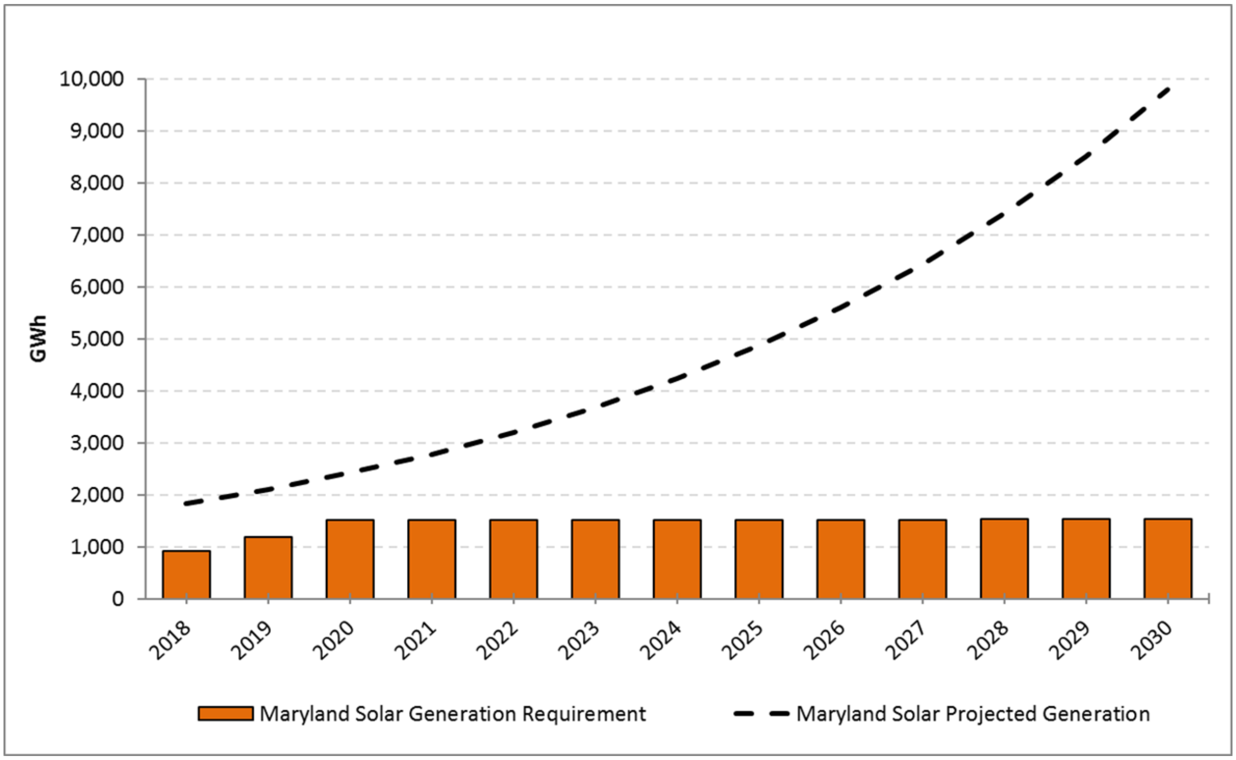


Table VII-3 shows the solar RPS requirements in PJM (for states with RPSs with solar carve-outs) and projected solar energy generation in PJM for 2018 through 2030. As seen in Table VII-3, the aggregate solar generation requirements in PJM are projected to be significantly exceeded throughout the period.

**Table VII-3. Solar RPS Requirements in PJM Compared to Projected Solar Energy Generation (2018-2030) (GWh)**

| Year | Generation Requirement | Projected Generation | Difference |
|---|---|---|---|
| 2018 | 5,323 | 14,330 | **9,006** |
| 2019 | 5,941 | 16,479 | **10,538** |
| 2020 | 6,621 | 18,951 | **12,330** |
| 2021 | 6,975 | 21,793 | **14,819** |
| 2022 | 7,260 | 25,062 | **17,803** |
| 2023 | 7,546 | 28,822 | **21,275** |
| 2024 | 7,817 | 33,145 | **25,329** |
| 2025 | 8,093 | 38,117 | **30,024** |
| 2026 | 8,083 | 43,834 | **35,751** |
| 2027 | 8,252 | 50,409 | **42,158** |
| 2028 | 8,427 | 57,971 | **49,544** |
| 2029 | 8,532 | 66,667 | **58,135** |
| 2030 | 8,580 | 76,667 | **68,087** |

The data from Table VII-3 are illustrated in Figure VII-2.

**Figure VII-2. Solar RPS Requirements in PJM Compared to Projected Solar Energy Generation (2018-2030) (GWh)**

The shortfall in available non-carve-out Tier 1 PJM generation to meet RPS requirements in PJM and in Maryland can be met, in part, with excess solar generation, that is, solar generation in excess of the solar carve-outs in the PJM states.

Table VII-4 provides a breakdown of the quantities of solar generation that could potentially be available to meet non-carve-out Tier 1 requirements, as well as the expected shortfall for non-carve-out Tier 1 resources.

**Table VII-4. Potential Generation of Solar to Meet Deficit of Non-carve-out Tier 1 RPS Requirements in PJM (2018-2030) (GWh)**

| Year | Deficit | Excess PJM Solar | Remaining Deficit |
|---|---|---|---|
| 2018 | (37,535) | 9,006 | **(28,528)** |
| 2019 | (45,678) | 10,538 | **(35,140)** |
| 2020 | (51,181) | 12,330 | **(38,852)** |
| 2021 | (54,137) | 14,819 | **(39,319)** |
| 2022 | (62,155) | 17,803 | **(44,353)** |
| 2023 | (63,636) | 21,275 | **(42,361)** |
| 2024 | (66,489) | 25,329 | **(41,160)** |
| 2025 | (73,434) | 30,024 | **(43,411)** |
| 2026 | (74,765) | 35,751 | **(39,014)** |
| 2027 | (74,456) | 42,158 | **(32,298)** |
| 2028 | (74,275) | 49,544 | **(24,732)** |
| 2029 | (73,899) | 58,135 | **(15,764)** |
| 2030 | (73,637) | 68,087 | **(5,550)** |

# VIII. Potential Impacts of Changes to Maryland RPS Goals

Legislation has been introduced in the Maryland General Assembly in recent years to increase the RPS goals above and beyond those contained in HB 1106. Table VIII-1 presents one example of gradually increased RPS percentage requirements that would reach 50 percent by 2030; note that this does not include Tier 2.[52]

**Table VIII-1. Scenario for 50 Percent Maryland RPS Requirement by 2030, by Percentages**

| Year | Tier 1 Solar | ORECs | Non-carve-out Tier 1 | TOTAL |
|---|---|---|---|---|
| 2018 | 1.77% | 0.00% | 16.51% | **18.28%** |
| 2019 | 2.04 | 0.00 | 18.72 | **20.76** |
| 2020 | 2.31 | 1.33 | 20.93 | **24.57** |
| 2021 | 2.58 | 1.33 | 23.14 | **27.04** |
| 2022 | 2.85 | 1.33 | 25.35 | **29.52** |
| 2023 | 3.12 | 1.98 | 27.56 | **32.65** |
| 2024 | 3.38 | 1.98 | 29.76 | **35.13** |
| 2025 | 3.65 | 1.98 | 31.97 | **37.61** |
| 2026 | 3.92 | 1.98 | 34.18 | **40.09** |
| 2027 | 4.19 | 1.98 | 36.39 | **42.56** |
| 2028 | 4.46 | 1.98 | 38.60 | **45.04** |
| 2029 | 4.73 | 1.98 | 40.81 | **47.52** |
| 2030 | 5.00 | 1.98 | 43.02 | **50.00** |

Taking the percentages from Table VIII-1 and applying them to the total retail sales projections produces the RPS requirements that would be in place with a hypothetical 50 percent RPS goal, as shown in Table VIII-2. The ORECs requirement in Table VIII-2 reflects the offshore wind generation included in Maryland's current RPS, and as authorized by the Maryland PSC, without modification.

[52] Tier 2 is assumed to be expiring at the end of 2018, consistent with the current RPS.

**Table VIII-2. Scenario for 50 Percent Maryland RPS Requirement by 2030 (GWh)**

| Year | Tier 1 Solar | ORECs | Non-carve-out Tier 1 | TOTAL |
|---|---|---|---|---|
| 2018 | 1,076 | -- | 10,041 | **11,117** |
| 2019 | 1,239 | -- | 11,374 | **12,612** |
| 2020 | 1,401 | -- | 12,704 | **14,104** |
| 2021 | 1,562 | 914 | 14,020 | **16,495** |
| 2022 | 1,725 | 914 | 15,359 | **17,997** |
| 2023 | 1,888 | 1,369 | 16,698 | **19,955** |
| 2024 | 2,055 | 1,369 | 18,074 | **21,499** |
| 2025 | 2,218 | 1,369 | 19,410 | **22,998** |
| 2026 | 2,385 | 1,369 | 20,777 | **24,531** |
| 2027 | 2,552 | 1,369 | 22,150 | **26,070** |
| 2028 | 2,723 | 1,369 | 23,557 | **27,649** |
| 2029 | 2,888 | 1,369 | 24,918 | **29,176** |
| 2030 | 3,055 | 1,369 | 26,285 | **30,709** |

As stated previously, there would theoretically be sufficient resources within PJM for Maryland to comply with non-carve-out Tier 1 requirements, even given a doubling of the requirement, but there would be substantial competition for non-carve-out Tier 1 resources because the other PJM jurisdictions would all be vying for the same Tier 1 resources to meet their own requirements. Alternatively stated, Maryland cannot meet its own RPS requirements from PJM renewable resources concurrent with other PJM states also fulfilling their RPS requirements with PJM resources. For purposes of these calculations, it is assumed that other PJM jurisdictions maintain their current levels of RPS requirements through 2030.

Fundamentally, an increase in the Maryland RPS requirement from 25 percent in 2020 to 50 percent in 2030 would represent significant challenges to Maryland meeting the increased goal. Based on available and projected PJM renewable resources, Maryland, as well as other PJM states, would need to look beyond PJM to secure the necessary RECs to meet their respective RPS requirements.

As we noted in Chapter IV, market dynamics will affect the degree to which Maryland (and other PJM states with RPSs) will be able to meet the renewable energy requirements from PJM and outside-of-PJM resources. With an increase in the Maryland RPS requirement, Maryland RECs prices will face upward pressure, and RECs that would have otherwise been used to satisfy the RPS requirements in other states will find it more economic to be applied to the Maryland RPS. This, of course, will result in upward pressure on REC prices in other PJM states since those states will be competing with Maryland for those same RECs. With an increase in REC prices, renewable energy projects that were unprofitable at lower REC prices may become profitable, thus increasing the total amount of RECs available in the market to meet the higher Maryland requirements. Additionally, projects located outside of PJM will find that sales of renewable energy into PJM will become more attractive, thus increasing the pool of available RECs from sources external to PJM. In short, the complex interrelationships of REC prices, project development, ACP levels, and power supply imports from other RTOs/ISOs will affect the degree to which Maryland would be able to meet a higher RPS requirement or whether the requirement would ultimately be met, at least for a period of time, with payment of ACPs in lieu of the retirements of Maryland-eligible RECs.

Table VIII-3 presents the increased RPS requirement as it would apply to the non-carve-out Tier 1 category for Maryland, along with the total (i.e., increased) deficit in generation requirements for PJM.

**Table VIII-3. Tier 1 Non-carve-out RPS Requirement in PJM Compared to Maryland Current and 50% RPS Requirement by 2030 (GWh)**

| Year | Generation Requirement | Projected Generation | Difference in Maryland Tier 1 Non-carve-out Current RPS and 50% RPS Requirement | Difference |
|---|---|---|---|---|
| 2018 | 64,072 | 26,538 | (177) | **(37,358)** |
| 2019 | 73,019 | 27,341 | (1,356) | **(44,322)** |
| 2020 | 79,325 | 28,144 | (954) | **(50,227)** |
| 2021 | 83,998 | 29,861 | 1,192 | **(55,329)** |
| 2022 | 92,820 | 30,664 | 2,531 | **(64,686)** |
| 2023 | 95,559 | 31,923 | 4,263 | **(67,899)** |
| 2024 | 99,215 | 32,726 | 5,614 | **(72,103)** |
| 2025 | 106,964 | 33,529 | 6,953 | **(80,388)** |
| 2026 | 109,098 | 34,333 | 8,305 | **(83,070)** |
| 2027 | 109,592 | 35,136 | 9,660 | **(84,116)** |
| 2028 | 110,214 | 35,939 | 11,034 | **(85,310)** |
| 2029 | 110,641 | 36,742 | 12,389 | **(86,288)** |
| 2030 | 111,183 | 37,546 | 13,747 | **(87,384)** |

Table VIII-4 compares a 5 percent solar carve-out generation requirement with projected solar generation. As shown in Table VIII-4, projected solar generation in Maryland is expected to exceed this hypothetical revised solar requirement throughout the 2018 through 2030 period.

**Table VIII-4. Scenario for 5 Percent Maryland RPS Requirement for Solar Compared to Projected Maryland Solar Energy Generation (2018-2030) (GWh)**

| Year | 5% Solar Carve-out Generation Requirement | Projected Generation | Difference |
|---|---|---|---|
| 2018 | 1,076 | 1,830 | **753** |
| 2019 | 1,239 | 2,104 | **865** |
| 2020 | 1,401 | 2,420 | **1,019** |
| 2021 | 1,562 | 2,782 | **1,221** |
| 2022 | 1,725 | 3,200 | **1,475** |
| 2023 | 1,888 | 3,680 | **1,792** |
| 2024 | 2,055 | 4,232 | **2,177** |
| 2025 | 2,218 | 4,867 | **2,648** |
| 2026 | 2,385 | 5,597 | **3,212** |
| 2027 | 2,552 | 6,436 | **3,884** |
| 2028 | 2,723 | 7,401 | **4,679** |
| 2029 | 2,888 | 8,512 | **5,623** |
| 2030 | 3,055 | 9,788 | **6,733** |
| **Average Annual Growth Rates** | | | |
| 2018-2024 | 11.39% | 15.00% | -- |
| 2024-2030 | 6.83% | 15.00% | -- |
| 2018-2030 | 9.09% | 15.00% | -- |

# IX. Potential Impacts of Changes to the RPS Categories

This section of the 2017 Inventory Report addresses Maryland's ability to comply with the RPS given hypothetical changes to the resources eligible for Tier 1 compliance. Tier 2 is not addressed here as Tier 2 expires in 2018. Furthermore, this analysis does not address either the solar or offshore wind carve-outs.[53]

The non-carve-out Tier 1 eligible resources that have historically seen the greatest use for compliance—black liquor, small hydroelectric, and wind—are the focus of this section. Landfill gas (LFG), municipal solid waste (MSW), and wood waste solids (WDS) have been used in smaller amounts, but consistently over time; while blast furnace gas (BFG) resources have been used minimally for compliance.[54] Because LFG, MSW, WDS, and BFG contribute only minimally to non-carve-out Tier 1 compliance, the implications of these resources no longer being eligible to meet the Maryland non-carve-out Tier 1 RPS requirements are not being addressed since any potential impact would be correspondingly minimal. The focus of this section is placed on black liquor, land-based wind, and small hydroelectric.

While the black liquor category of Tier 1 has historically seen substantial use for RPS compliance in Maryland, it is not anticipated, in terms of recent market trends, that additional black liquor sources will go into service.[55] Historically, there has been a steady increase in the use of black liquor for RPS compliance, from 390,726 MWh in 2009 to 1,858,203 MWh in 2015 (or approximately 30 percent of Tier 1 requirements in that year) as the RPS Tier 1 percentages have increased over time. The RECs from black liquor, according to the 2015 RPS report from the Maryland PSC, originate primarily from outside of Maryland: Virginia (59.8 percent); Tennessee (12.6 percent); North Carolina (9.7 percent); Ohio (8.3 percent); Pennsylvania (6.0 percent); and Maryland (3.5 percent). The historical increases in the percentage of black liquor used for non-carve-out Tier 1 requirements are not expected to continue; with limited anticipated growth in that market, and increasing RPS percentages, the percentage that black liquor contributes to meeting the overall RPS requirements is not expected to increase from current levels.

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[53] The solar carve-out reaches a peak of 2.5 percent in 2020 and remains at that level. Offshore wind compliance is stated in Maryland PSC Order No. 88192 as 53 percent of the offshore wind carve-out in 2020 for the U.S. Wind project; and 25.9 percent of the 2023 requirement for the Skipjack project. Combined, the projects will reach 1.98 percent of the RPS requirement. See: http://www.marylandoffshorewind.com/qa.html.

[54] See Figure IV-3.

[55] Black liquor generates electricity at paper mills located throughout PJM. Additional development of paper mills, or expansion of current paper mills, is not anticipated to be substantial based on market conditions and trends.

Maryland is the only state in PJM that includes black liquor as an eligible Tier 1 resource. As a consequence, if Maryland were to modify the Tier 1 eligibility criteria to exclude black liquor, Maryland would need to replace black liquor with other renewable resources from the pool of available resources in PJM (or potentially outside PJM) that meet Maryland's eligibility requirements. To a large degree, Maryland's Tier 1 requirements, exclusive of black liquor, are similar to the Tier 1 eligibility requirements in other PJM states, with some exceptions. Regardless, were Maryland to eliminate black liquor as a Tier 1 resource, the impact would be to increase the gap between PJM generation and PJM RPS requirements by the amount of black liquor being used by Maryland as a Tier 1 resource. Alternatively stated, the degree to which Maryland relies on black liquor to meet it Tier 1 RPS requirement is the degree to which the PJM states with RPSs will need to, in the aggregate, increase imports into PJM to meet their collective requirement.

Table IX-1 shows the comparison between projected PJM RPS requirements for Tier 1-eligible RECs and generation of Tier 1-eligible RECs in PJM under the current Maryland RPS requirements (i.e., with black liquor eligible to meet Tier 1 requirements) and under hypothetical Maryland RPS requirements that exclude black liquor from Tier 1 eligibility. As shown on Table IX-1, the gap in being able to meet the RPS requirements for the aggregate of PJM states with PJM resources increases by 4,200 GWh per year, which is PJM generation from black liquor sources. Because black liquor generation is not anticipated to increase over time, this differential remains constant through the forecast period given the projection that electric generation from black liquor will not be increasing over the period 2018 through 2030.

**Table IX-1. Comparison of Projected PJM Non-carve-out Tier 1 Generation and Maryland Requirements Eliminating Black Liquor (2018-2030) (GWh)**

| Year | PJM Non-carve-out Tier 1 Generation Requirement (a) | Projected PJM Non-carve-out Tier 1 Generation (Including Black Liquor) (b) | Difference (c) = (a – b) | Projected Generation (Minus Black Liquor) (d) | Difference (e) = (a – d) | Change in the Difference (f) = (e – c) |
|---|---|---|---|---|---|---|
| 2018 | 64,072 | 26,538 | 37,535 | 22,297 | 41,775 | 4,240 |
| 2019 | 73,019 | 27,341 | 45,678 | 23,101 | 49,918 | 4,240 |
| 2020 | 79,325 | 28,144 | 51,181 | 23,904 | 55,421 | 4,240 |
| 2021 | 83,998 | 28,947 | 55,051 | 24,707 | 59,291 | 4,240 |
| 2022 | 92,820 | 29,750 | 63,069 | 25,510 | 67,309 | 4,240 |
| 2023 | 95,559 | 30,554 | 65,005 | 26,314 | 69,245 | 4,240 |
| 2024 | 99,215 | 31,357 | 67,858 | 27,117 | 72,098 | 4,240 |
| 2025 | 106,964 | 32,160 | 74,804 | 27,920 | 79,044 | 4,240 |
| 2026 | 109,098 | 32,963 | 76,134 | 28,723 | 80,375 | 4,240 |
| 2027 | 109,592 | 33,767 | 75,825 | 29,527 | 80,065 | 4,240 |
| 2028 | 110,214 | 34,570 | 75,645 | 30,330 | 79,885 | 4,240 |
| 2029 | 110,641 | 35,373 | 75,268 | 31,133 | 79,508 | 4,240 |
| 2030 | 111,183 | 36,176 | 75,006 | 31,936 | 79,246 | 4,240 |

The elimination of black liquor as a resource eligible to meet the Maryland Tier 1 RPS will result in a decrease of supply of RECs to meet the overall RPS requirements in PJM and consequently result in increases in the price of RECs relative to what they would otherwise be. As noted in previous sections of this report, the increase in REC prices will induce market responses in the form of increases in renewable project development as marginal projects not previously economic would become economic with the availability of additional revenue associated with the increased REC prices. Additionally, generation from outside of PJM will find that the economics associated with the sale of power and RECs in PJM are more attractive than they were previously, and thereby increase the number of RECs available for use to satisfy the RPS requirements of the states within PJM.

The analysis conducted with respect to the impacts related to the elimination of black liquor as an eligible Maryland Tier 1 resource is different with respect to consideration of eliminating onshore wind power as an eligible Maryland Tier 1 resource. Because other states in PJM accept RECs sourced from wind power projects as eligible to satisfy Tier 1 requirements, the wind-related RECs no longer acceptable by Maryland would simply be used by other states in

PJM, thereby freeing Tier 1 RECs from other Maryland-eligible sources (e.g., qualifying biomass, landfill gas, small hydroelectric) that were relied upon by the other states. In essence, the allocation of RECs from various widely accepted sources would change but the overall number of RECs available to meet Tier 1 requirements in PJM would not. Maryland's mix of RECs used to meet its Tier 1 requirements would change, and the approximately 24 percent of compliance RECs used to meet the Maryland Tier 1 requirement in 2015 (the last year for which such data are available) would be replaced by RECs from alternative Tier 1 sources. As a result, there would be no significant changes in the pricing of RECs in PJM, nor would there be any change in the overall gap between the aggregate PJM Tier 1 RPS requirement and the amount of Tier 1 generation coming from PJM. This would be the case as long as the amount of wind-sourced Tier 1 RECs no longer used by Maryland to meet its RPS requirements were less than the number of Tier 1-eligible RECs available in PJM from other renewable resources and used by other states. Alternatively stated, if there are sufficient Tier 1 RECs in PJM sourced from generation other than wind to fully replace the wind-sourced RECs that would be no longer acceptable in Maryland following a hypothetical change in the Tier 1 eligibility criteria, then:

- There would be no impacts to the RECs markets in Maryland or PJM;
- The price of Tier 1 RECs in PJM and in Maryland would be unaffected;
- There would be no additional incentives to develop new renewable projects in PJM over and above the incentives that existed prior to Maryland's change in Tier 1 eligibility related to wind-sourced generation;
- There would be no additional incentives for generators outside of PJM to increase imports into PJM compared to those that existed prior to Maryland's change in Tier 1 eligibility related to wind-sourced generation; and
- The magnitude of the gap between PJM renewable generation and renewable energy needed to meet RPS requirements would be unchanged.

Table IX-2 shows the amount of wind energy that Maryland is projected to use to meet its Tier 1 RPS requirements between 2018 and 2030. Additionally, Table IX-2 shows the amount of non-wind Tier 1 resources available in PJM to contribute to the satisfaction of RPS requirements in the PJM states with RPSs in place. As seen from Table IX-2, in each year of the projection period, the amount of energy sourced from wind that Maryland is projected to use to meet its Tier 1 RPS requirement is well below the amount of energy generated in PJM from other (non-wind and non-solar) sources, thereby facilitating modifications of the compliance portfolios of the various PJM states with RPSs to absorb wind-sourced energy that would no longer be used by Maryland (due to a modification in the RPS Tier 1 eligibility requirements) and thereby free non-wind Tier 1 energy previously used by those states to allow Maryland to substitute for wind-sourced compliance.

**Table IX-2. Comparison of Projected PJM Tier 1 Generation (Minus Wind and Solar) and Maryland Reliance on Wind Generation for RPS Compliance (2018-2030) (GWh)**

| Year | Projected PJM Tier 1 Generation (Minus Wind and Solar) | Maryland RPS Met by Wind Generation | Difference |
|---|---|---|---|
| 2018 | 9,994 | 1,510 | **8,484** |
| 2019 | 10,622 | 1,525 | **9,097** |
| 2020 | 11,250 | 1,541 | **9,710** |
| 2021 | 12,792 | 1,556 | **11,236** |
| 2022 | 13,421 | 1,572 | **11,849** |
| 2023 | 14,504 | 1,588 | **12,917** |
| 2024 | 15,132 | 1,604 | **13,529** |
| 2025 | 15,760 | 1,620 | **14,141** |
| 2026 | 16,389 | 1,636 | **14,752** |
| 2027 | 17,017 | 1,653 | **15,364** |
| 2028 | 17,645 | 1,669 | **15,975** |
| 2029 | 18,273 | 1,686 | **16,587** |
| 2030 | 18,901 | 1,703 | **17,198** |

The circumstances associated with the elimination of wind-sourced resources to meet the Tier 1 RPS requirements in Maryland would equally apply to the rescission of Maryland Tier 1 eligibility for small hydroelectric. Given that other states in PJM allow the use of this resource to meet their Tier 1 (or equivalent) requirements, the elimination of this resource from participation in the satisfaction of the Maryland RPS would have no significant implications for RECs prices in Maryland or elsewhere in PJM or in the ability of any of the PJM states having an RPS to meet its RPS obligations relative to circumstances without the Maryland RPS eligibility modifications regarding small hydro.

# Appendix A. Overview of Renewable Portfolio Standards

## 1. Summary of State RPS Policies

To add context to the Maryland and PJM state RPS policies, Table A-1 displays all of the states in the country with such standards, the dates by which their requirements must be met, and the dates the standards were enacted (or updated). For more information on a particular state's RPS, see Table A-2.

**Table A-1. Summary of State RPS Policies**

| State | Renewable Energy Requirements | Year Requirements Must Be Met | Date Enacted (or Updated) |
|---|---|---|---|
| Arizona | 15% overall*<br>4.5% DG †† | 2025 | 2001 (2005, 2006) |
| California | 50% overall | 2030 | 2002 (2003, 2006, 2009, 2010, 2011, 2012, 2015, 2017) |
| Colorado | 30% (IOUs)*†<br>3% DG<br>(1.5% customer-sited) | 2020 | 2004 (2006, 2010, 2013, 2014, 2015) |
| Connecticut | 27% overall | 2020 | 1998 (2007, 2011, 2013, 2015) |
| Delaware | 25% overall*<br>3.5% solar PV | 2025 | 2005 (2007, 2011, 2013) |
| Hawaii | 100% overall | 2045 | 2004 (2009) |
| Illinois | 25% overall<br>1.5% solar PV<br>0.25% DG<br>18.75% wind | 2026 | 2007 (2009, 2010, 2011) |
| Indianaº | 10% overall† | 2025 | 2011; 2012 |
| Iowa | 105 MW overall | | 1983 (1991, 2003, 2007) |
| Kansasº | 20% overall | 2020 | 2009 (2010, 2015) |
| Maine | 40% overall | 2017 | 1999 (2006, 2007, 2009, 2011) |
| Maryland | 25% overall<br>2.5% solar electric | 2020 | 2004 (2007, 2008, 2010, 2011, 2012, 2013, 2016, 2017) |
| Massachusetts | 15% (new resources) / 6.03% (existing resources)<br>400 MW solar PV | 2020 / 2016 | 1997 (2009, 2011, 2013) |
| Michigan | 15% overall*†<br>3.2 multiplier for solar electric | 2021 | 2008 (2016, 2017) |
| Minnesota | 26.5% (IOUs) / 31.5% (Xcel Energy)<br>1.5% solar electric<br>0.15% solar PV and DG | 2025<br>2020 | 2007 (2009, 2013, 2014) |
| Missouri | 15% overall<br>0.3% solar electric | 2021 | 2008 (2010, 2013) |
| Montana | 15% overall | 2015 | 2005 (2013) |

**Table A-1. Summary of State RPS Policies (cont'd)**

| State | Renewable Energy Requirements | Year Requirements Must Be Met | Date Enacted (or Updated) |
|---|---|---|---|
| Nevada | 25% overall*<br>1.5% solar electric<br>2.4 multiplier for solar PV †† | 2025 | 2013 |
| New Hampshire | 24.8% overall<br>0.3% solar electric | 2025<br>2014 | 2007 (2008, 2012, 2014, 2015, 2016, 2017) |
| New Jersey | 20.38% non-carve-out + 4.1% solar electric | 2020<br>2027 | 1999 (2005, 2010, 2011, 2012, 2015, 2017) |
| New Mexico | 20% (IOUs)<br>4% solar electric<br>0.6% DG | 2020 | 2002 (2007, 2014, 2015) |
| New York | 50% overall<br>0.58% customer-sited†† | 2030<br>2015 | 2004 (2005, 2010, 2013, 2015, 2016) |
| North Carolina | 12.5% (IOUs)<br>0.2% solar electric †† | 2021<br>2018 | 2007 (2008, 2009, 2010, 2011, 2014) |
| North Dakotaº | 10% overall | 2015 | 2007 |
| Ohio | 12.5% overall<br>0.5% solar electric | 2026 | 2008 (2009, 2010, 2014, 2017) |
| Oklahomaº | 15% overall | 2015 | 2010 (2015) |
| Oregon | 50% overall* (large utilities)<br>20 MW solar PV (2.0 multiplier) | 2040<br>2025 | 2007 (2008, 2010, 2016) |
| Pennsylvania | 18% overall†<br>0.5% solar PV | 2021 | 2004 (2007, 2009, 2016) |
| Rhode Island | 38.5% overall | 2035 | 2004 (2009, 2014, 2016) |
| South Carolinaº | 2% overall<br>0.25% DG | 2021 | 2014 (2015) |
| South Dakotaº | 10% overall | 2015 | 2008 (2009, 2011) |
| Texas | 5,880 MW overall* | 2015 | 1999 (2005) |
| Utahº | 20% overall*†<br>2.4 multiplier for solar electric | 2025 | 2008 (2010) |
| Vermont | 75% overall<br>1% DG + 3/5th of 1%/year until 10% | 2032<br>2017 to 2032 | 2006 (2008, 2010, 2016) |
| Virginiaº | 15% overall† | 2025 | 2007 (2010, 2013, 2014) |
| Washington | 15% overall*<br>2 MW DG (with multipliers) | 2020 | 2006 |
| Wisconsin | 10% overall | 2015 | 2001 (2006, 2010, 2011, 2014) |
| District of Columbia | 50% overall<br>5% solar electric†† | 2032 | 2005 (2008, 2011, 2012, 2015, 2016) |

DG = distributed generation; IOUs = investor-owned utilities; PV = photovoltaic

º Denotes states with voluntary renewable portfolio goals.

* Extra credit for solar or customer-sited renewables.

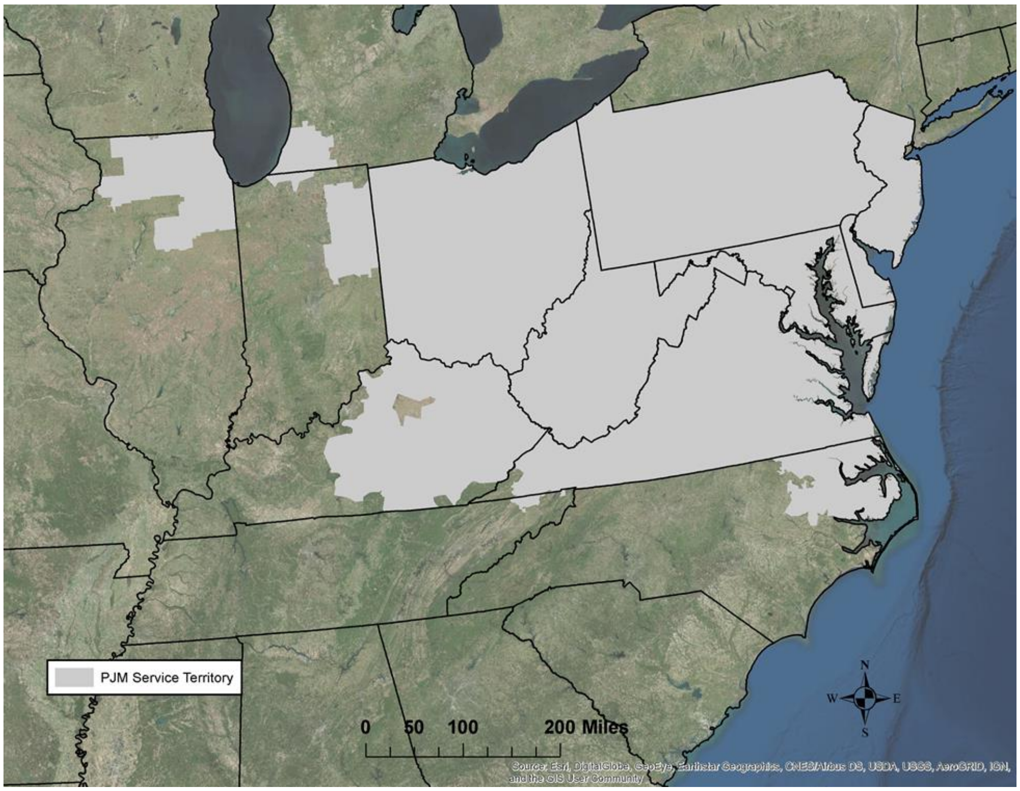
† Includes non-renewable alternative resources.

†† Solar water heating counts toward solar/DG provision.

## 2. Renewable Portfolio Standards in PJM

PJM is the RTO that serves all or portions of Maryland, Delaware, Illinois, Indiana, Kentucky, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, and the District of Columbia. Figure A-1 illustrates the PJM service region.

**Figure A-1. PJM Service Region**




Eight PJM states (Delaware, Illinois, Maryland, Michigan, New Jersey, North Carolina, Ohio, and Pennsylvania) and the District of Columbia have RPS requirements. In contrast, Indiana and Virginia have voluntary renewable energy goals. Described below are the specific RPS requirements for each PJM state and the District of Columbia. Following the descriptions, Table A-2 presents summaries of each state's RPS requirements.

### *Delaware*

Delaware's RPS requires retail electricity suppliers to purchase 25 percent of the electricity sold in the state from renewable sources by compliance year 2025-2026. Besides investor-owned utilities (IOUs), the Delaware RPS is also applicable to retail electric suppliers, municipal utilities, and rural electric cooperatives. Municipal utilities and rural electric cooperatives may opt out if they established a comparable program to the Delaware RPS requirements beginning in 2013.

Industrial customers with a peak demand of 1,500 kW or greater are exempt from the Delaware RPS. Technologies that are eligible for meeting the Delaware RPS include solar electric, wind, ocean tidal, ocean thermal, fuel cells powered by renewable fuels, hydroelectric facilities with a maximum capacity of 30 MW, sustainable biomass, anaerobic digestion, and landfill gas. Credit multipliers are also available. Among them is a 10 percent credit for solar or wind projects installed in Delaware where at least half of the equipment or components are manufactured in Delaware. Another 10 percent credit is available for solar and wind projects located in Delaware, and the projects are installed by a workforce where at least 75 percent of the workers live in Delaware.[56]

### *District of Columbia*

The District of Columbia's RPS applies to all retail electricity sales in the District. In 2011, the RPS was amended to increase the solar carve-out from 0.4 percent to 2.5 percent by 2023. In 2016, the RPS Expansion Act of 2016 made significant modifications to the D.C. RPS by expanding the Tier 1 RPS requirement to 50 percent by 2032 and the solar requirement to 5 percent by 2032. The D.C. RPS also has a Tier 2, consisting entirely of hydropower, that began at 2.5 percent in 2007, declined to 2 percent in 2016, and declines by 0.5 percent each year thereafter until it expires in 2020.

Based on the D.C. Public Service Commission's final rule, the solar requirement is incorporated as part of the Tier 1 requirement. This means that an SREC used to comply with the solar requirement may also be used to meet the Tier 1 requirement. Energy from Tier 1 resources is eligible to meet the RPS requirement regardless of when the generating system or facility was activated. Energy from Tier 1 projects may be applied to the percentage requirements for either Tier 1 or Tier 2 renewable resources.[57]

### *Illinois*

Illinois requires that 25 percent of the state's electricity sales come from renewable energy sources by 2026. The Illinois RPS also includes a provision that solar PV must make up 1.5 percent and wind must make up 18.75 percent of the 2026 requirement. It also requires utilities serving over 100,000 customers comply with its renewable energy requirements. The

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[56] Delaware, Database of State Incentives for Renewables & Efficiency®, North Carolina Clean Energy Technology Center, last updated February 11, 2015, http://programs.dsireusa.org/system/program/detail/1231.
[57] Ibid., District of Columbia, last updated October 19, 2016, http://programs.dsireusa.org/system/program/detail/303.

two utilities that meet this threshold are Commonwealth Edison and Ameren Corporation. Municipal and cooperative utilities are currently exempt from the Illinois RPS.[58]

### *Michigan*

Michigan's RPS, passed in 2008, requires that IOUs, electric cooperatives, municipal utilities, and competitive retail suppliers generate 10 percent of their retail electricity from renewable energy sources. That requirement was required to be met by 2015.[59] The 2008 RPS also called for specific thresholds for the state's two largest IOUs, DTE Electric and Consumers Energy: 300 MW by 2013 and 600 MW by 2015, and 200 MW by 2013 and 500 MW by 2015, respectively. SB 438, signed in December 2016, increased the RPS requirement to 15 percent by 2021.[60] No additional renewable energy capacity standards were included in the recent update.

### *New Jersey*

New Jersey standards require that 24.39 percent of the state's electricity sales come from qualifying renewable energy sources by energy year (EY) 2028 (June 2027 – May 2028). The New Jersey RPS includes two separate provisions for renewable energy. The first provision, which was part of the initial RPS requirement, required each supplier/provider serving retail customers in the state to procure 20.38 percent of the electricity it sells in New Jersey from qualifying renewables by EY 2021. The addition of a solar-specific provision in 2010 requires suppliers and providers to procure an additional 4.1 percent of sales from qualifying solar electric generation facilities by EY 2028.[61]

### *North Carolina*

North Carolina's Renewable Energy and Energy Efficiency Portfolio Standard (REPS) requires that by 2021, IOUs supply 12.5 percent of the state's 2020 retail electricity sales from eligible energy resources. The overall target for renewable energy includes technology-specific targets of 0.2 percent solar by 2018 (which includes solar electric, solar water-heating, solar absorption cooling, solar dehumidification, solar thermally driven refrigeration, and solar industrial process heat) and 0.2 percent energy recovery from swine waste by 2020.[62]

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[58] Ibid., Illinois, last updated December 9, 2016, http://programs.dsireusa.org/system/program/detail/584.
[59] Ibid., Michigan, last updated May 16, 2017, http://programs.dsireusa.org/system/program/detail/3094.
[60] Ibid.
[61] Ibid., New Jersey, last updated May 20, 2015, http://programs.dsireusa.org/system/program/detail/564.
[62] Ibid., North Carolina, last updated September 23, 2016, http://programs.dsireusa.org/system/program/detail/2660.

### *Ohio*

Ohio's Alternative Energy Portfolio Standard (AEPS), passed in 2008, requires that all retail electricity providers except municipal utilities and electric cooperatives generate 12.5 percent of their retail electricity from renewable energy sources, of which 0.5 percent must be from solar PV, by 2027.[63] In 2014, SB 310 established a two-year freeze for the AEPS while the cost and benefits of the standard were studied, during which time the AEPS was voluntary. In 2016, the Ohio legislature passed HB 554, which established a target of 7.5 percent by 2021 and made the AEPS voluntary; however, Governor Kasich vetoed the bill, allowing the original AEPS standards to be reinstated beginning January 1, 2017.[64]

### *Pennsylvania*

Pennsylvania's AEPS requires each electric distribution company and electric generation supplier to supply a total of 18 percent of its electricity using alternative energy resources by compliance year 2021, with the requirement broken down by tiers; by compliance year 2021, Tier 1 has an 8 percent requirement, and Tier 2 has a 10 percent requirement. The Tier 1 category includes wind, low-impact hydropower, geothermal, biologically derived methane gas, fuel cells, biomass, coal mine methane, and a solar carve-out; the solar carve-out mandates that solar PV generate a percentage of electricity ranging from 0.0013 percent in compliance year 2007 to 0.5 percent in compliance year 2021. Tier 2 includes demand-side management, waste coal, large-scale hydro, municipal solid waste, thermal energy from the generation of electricity, wood and manufacturing byproducts from out-of-state energy projects, distributed generation projects under 5 MW, and coal gasification as eligible technologies.[65]

### *Indiana*

Indiana established a voluntary renewables goal in 2011. The state's Clean Energy Portfolio Standard (CEPS) sets a target of 10 percent alternative energy production by 2025. Up to 30 percent of the goal may be met with clean coal technology, nuclear energy, combined heat and power systems, natural gas that displaces electricity from coal, and net-metered

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[63] "Ohio's renewable energy portfolio standard," Public Utilities Commission of Ohio, last updated July 24, 2014, https://www.puco.ohio.gov/industry-information/industry-topics/ohioe28099s-renewable-and-advanced-energy-portfolio-standard/.

[64] "Gov. Kasich Vetoes Continued Freeze on Ohio Clean Energy Mandates," Greentech Media, December 27, 2016, https://www.greentechmedia.com/articles/read/gov-kasich-vetoes-renewables-efficiency-freeze-in-ohio#gs.tX5vx8g.

[65] Pennsylvania, Database of State Incentives for Renewables & Efficiency®, North Carolina Clean Energy Technology Center, last updated August 24, 2016, http://programs.dsireusa.org/system/program/detail/262.

distributed generation facilities. No less than 50 percent of qualifying energy obtained by Indiana utilities participating in the CEPS must come from within the state. Utilities that comply with the CEPS can increase their return on equity up to 50 basis points over their otherwise authorized rate of return or implement a periodic rate adjustment mechanism, upon review and approval from the Indiana Utility Regulatory Commission.[66]

### *Virginia*

Similar to Indiana, Virginia's renewable energy portfolio goal sets voluntary targets that the state's electric IOUs may meet. There are four voluntary RPS goals for the IOUs to procure a percentage of renewable energy based upon 2007 electric sales: (1) 4 percent in 2010; (2) an average of 4 percent annually from 2011 through 2015 and 7 percent in 2016; (3) 7 percent annually from 2017 through 2021 and 12 percent in 2022; and (4) an average of 12 percent in 2023 and 2024 and 15 percent in 2025. Qualified energy resources under the Virginia RPS include solar, wind, geothermal, hydropower, wave, tidal, and biomass; however, certain energy sources are worth more credit than others. In particular, onshore wind and solar power receive double credit towards the RPS; offshore wind receives triple credit. Electricity must be generated in Virginia or within an RTO of which the participating utility is a member.[67] In 2012, the state legislature passed a bill allowing the IOUs to meet 20 percent of the voluntary targets by conducting certificated research and development activity regarding renewable and alternative energy sources, as approved by the Virginia State Corporation Commission (SCC). To incentivize utilities to achieve the voluntary RPS, the SCC offered utilities to the opportunity to earn an increased rate of return for each goal that is attained from renewable energy facilities approved prior to January 1, 2013 or from offshore wind and nuclear power facilities after July 1, 2013.[68]

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[66] Ibid., Indiana, last updated November 20, 2015, http://programs.dsireusa.org/system/program/detail/4832.
[67] Virginia Electric and Power Company d/b/a Dominion Virginia Power, *Annual Report to the State Corporation Commission on Renewable Energy, in accordance with § 56-585.2.H of the code of Virginia*, November 1, 2012, https://www.scc.virginia.gov/pur/renew/dvp_renew_12.pdf.
[68] Virginia, Database of State Incentives for Renewables & Efficiency®, North Carolina Clean Energy Technology Center, last updated February 8, 2015, http://programs.dsireusa.org/system/program/detail/2528.

**Table A-2. Overview of RPS Requirements of States and Territories in PJM**

| State | Qualifying Facilities | Requirements | Geographic Footprint | ACPs |
|---|---|---|---|---|
| **Maryland** | Tier 1 – Solar, wind, qualifying biomass* (excluding sawdust), methane from the anaerobic decomposition of organic materials in a landfill or a wastewater treatment plant, geothermal, ocean (including energy from waves, tides, currents, and thermal differences), fuel cells powered by methane or biomass, small hydroelectric plants (systems less than 30 MW in capacity), waste-to-energy facilities, qualified geothermal heating and cooling systems, and poultry litter incineration facilities in Maryland.<br>Tier 2 – Hydroelectric power other than pump-storage generation, thermal decomposition incineration of poultry litter, and waste-to-energy facilities. For first and third sources, the facility must have been in existence and operational as of January 1, 2004.[a] | 25% by 2020.<br>Solar – 2.5% by 2020.<br>Offshore wind – 2.5% maximum beginning in 2017.[b] | The source must be: (1) located in the PJM region; or (2) outside the area described in item (1) but in a control area that is adjacent to the PJM service territory, if the electricity is delivered into the PJM service territory.[c]<br><br>Solar must come from within the State. | Tier 1 (non-carve-out) – $37.50/MWh in 2017 and thereafter.<br><br>Tier 1 Solar – $195/MWh in 2017 and 2018; $150 in 2019; $125 in 2020; $100 in 2021, $75 in 2022; $60 in 2023; and $50 in 2024 and after.<br><br>Tier 2 – $15/MWh until the sunset of the standard in 2018. No fee for industrial load process.<br><br>Industrial process load Tier 1: $2.00/MWh in 2017 and thereafter. |

| State | Qualifying Facilities | Requirements | Geographic Footprint | ACPs |
|---|---|---|---|---|
| **Delaware** | Geothermal electric, solar thermal electric, solar PV, wind, biomass, small hydroelectric plants (systems less than 30 MW in capacity), fuel cells using non-renewable fuels, LFG, tidal, wave, ocean thermal, anaerobic digestion, and fuel cells using renewable fuels.[e] | 25% overall by CY 2025-2026; solar PV – 3.5% by CY 2025-2026.[f] | A generation unit must be: (1) in the PJM region or located outside the PJM region with the ability to import into the PJM region; and (2) tracked through the PJM Market Settlement Reporting System.[g] | For the ACPs, $25/MWh shortfall for non-carve-out. The payment increases in subsequent years for suppliers who elect to pay it. After the first year that suppliers pay the ACP, the payment increases to $50/MWh. After the second year, it increases to a maximum $80/MWh. For solar power, the shortfall begins at $400/MWh and increases $50/MWh for every year the ACP is elected up to a maximum of $500/MWh.[h] |
| **District of Columbia** | Tier 1 – Solar energy, wind, biomass, methane, geothermal, ocean, fuel cells, waste heat from combined and sanitary sewage systems, and effluence from wastewater treatment.[i]<br>Tier 2 – Hydroelectric (other than pumped storage) and municipal solid waste. | 50% overall by 2032; 5% solar by 2032.[j] | A generation unit must be located: (1) in the PJM region; (2) in a state that is adjacent to the PJM region; or (3) outside the PJM region in a control area that is adjacent to the PJM region if the electricity from either is delivered into the PJM region.[k] | Tier 1 – $50/MWh[l]<br>Tier 2 – $10/MWh<br>Solar – $500/MWh in 2016 and eventually drops to $50/MWh in 2033. |

| State | Qualifying Facilities | Requirements | Geographic Footprint | ACPs |
|---|---|---|---|---|
| **Illinois** | Solar thermal (heat or electricity), solar PV, LFG, wind, biomass, hydroelectric, biodiesel, waste heat, anaerobic digestion, tree waste.[m] | 25% by CY2025-2026.<br>Wind: 18.75% by CY 2025-2026 (75% of annual requirement for IOUs; 60% of annual requirement for alternative retail electric suppliers.)<br>PV: 6% of annual requirement beginning in CY 2015-2016; 1.5% by CY 2025-2026.[n]<br>DG: 1% of annual requirement beginning in CY 2015-2016; 0.25% by CY 2025-2026. | Eligible resources must be located in the state. If there are insufficient cost-effective in-state resources, then Illinois can procure resources from adjoining states, and if these are also not cost-effective, it can procure resources from other regions of the country.[o] | For CY June 2017 – May 2018, the estimated ACP for LSEs in the Ameren territory is $1.8054/MWh; $1.8917/MWh in the ComEd territory; and $1.2415/MWh for MidAmerican. Illinois has not yet established an ACP beyond 2018.[p] |
| **Indiana** | Solar water heat, solar space heat, geothermal electric, solar thermal electric, solar PV, wind (all), biomass, hydroelectric, hydrogen, geothermal heat pumps, municipal solid waste, combined heat and power, fuel, nuclear, coal bed methane, clean coal, geothermal direct-use.[q] | 10% by 2025; 30% of the goal may be met with clean coal technology, nuclear energy, combined heat and power systems, natural gas that displaces electricity from coal, and other alternative fuels.[r] | Indiana utilities participating in the voluntary Clean Energy Portfolio Standard must obtain 50% of qualifying energy from within the state.[s] | There is no ACP. The program is voluntary.[t] |
| **Kentucky** | No RPS. | | | |

| State | Qualifying Facilities | Requirements | Geographic Footprint | ACPs |
|---|---|---|---|---|
| **Michigan** | Solar thermal electric or PV, LFG, wind, biomass, hydroelectric, geothermal electric, municipal solid waste, combined heat and power/cogeneration, coal-fired with carbon capture and sequestration, gasification, anaerobic digestion, tidal energy, and wave energy.[u] | 15% by 2021. | Electricity must be generated in Michigan or outside the state in the retail electric customer service territory of any provider that is not an alternative electric supplier.[v] | There are no specific penalties; however, there are various regulatory actions based on electric provider type.[w] Rate-regulated providers: The electric provider must purchase sufficient RECs to meet the standard; the costs of such RECs are not recoverable from ratepayers if the Michigan Public Service Commission finds the provider does not make a good-faith effort to meet the standard.<br><br>Municipalities and member-regulated cooperatives: The attorney general (or cooperative member) may commence a civil action for injunctive relief. Alternative electric suppliers: The state may revoke licenses, issue orders to cease and desist, and charge fines between $5,000 and $50,000. |

| State | Qualifying Facilities | Requirements | Geographic Footprint | ACPs |
|---|---|---|---|---|
| **New Jersey** | Class I – Solar technologies, PV technologies, wind energy, fuel cells using renewable fuels, wave or tidal action, geothermal technologies, methane gas from landfills or a biomass facility, provided that the biomass is cultivated and harvested in a sustainable manner.<br><br>Class II – Hydropower facilities no greater than 30 MW and resource-recovery facilities located in NJ and approved by the NJ Department of Environmental Protection.[x] | 24.48% by 2020.<br>20.38% Class I or Class II (resource recovery or hydropower) renewables by 2020-2021.<br>4.1% solar electric by 2027-2028.<br>Class II Standard 2.5% since 2005.<br><br>Offshore wind 1,100 MW.[y] | Electricity must be generated within or delivered into the PJM region. For both Class I and II facilities, renewable energy delivered into the PJM region must be generated at a facility that was constructed on or after January 1, 2003.[z] | Non-carve-out ACP is $50/MWh.<br><br>Solar ACPs are as follows:[aa]<br>Energy Year (EY) 2017: $315/MWh.<br><br>EY 2018: $308/MWh<br>EY 2019: $300/MWh<br>EY 2020: $293/MWh<br>EY 2021: $286/MWh<br>EY 2022: $279/MWh<br>EY 2023: $272/MWh<br>EY 2024: $266/MWh<br>EY 2025: $260/MWh<br>EY 2026: $253/MWh<br>EY 2027: $250/MWh<br>EY 2028: $239/MWh |
| **North Carolina** | Solar electric or thermal, wind, hydropower up to 10 MW, ocean current or wave energy, biomass (agricultural waste, animal waste, wood waste, spent pulping liquors, combustible residues, combustible liquids, combustible gases, energy crops, landfill methane, waste heat derived from a renewable energy resource) that uses Best Available Control Technology for air emissions, LFG, combined heat and power using waste heat from renewables, hydrogen derived from renewables, demand-side management.[bb] | 12.5% by 2021 (IOUs).[cc]<br><br>Municipal utilities and electric cooperatives only have to meet an overall goal of 10% by 2018.<br><br>Solar: 0.2% by 2018.<br><br>Swine waste: 0.2% by 2021.<br><br>Poultry waste: 900,000 MWh by 2015.<br><br>The state offers credit multipliers for biomass facilities located in cleanfields renewable energy demonstration parks. | Utilities may use unbundled RECs from out-of-state renewable energy facilities to meet up to 25% of the portfolio standard.[dd] | The state has no ACP; however, the North Carolina Utilities Commission may assess penalties if utilities fail to comply.[ee] |

| State | Qualifying Facilities | Requirements | Geographic Footprint | ACPs |
|---|---|---|---|---|
| **Ohio** | Solar thermal electric or PV, LFG, wind, biomass, hydroelectric, geothermal electric, fuel cells, municipal solid waste, combined heat and power, waste heat, energy storage, clean coal, advanced nuclear, anaerobic digestion, and microturbines.[ff] | 25% alternative energy by 2026.[gg]<br>12.5% renewable energy resources.<br>12.5% advanced energy resources (advanced energy resources include co-generation, advanced nuclear power, and clean coal).<br><br>Solar: 0.5% by 2026. | Out-of-state facilities may be used to fulfill RPS requirements.[hh] | The ACP is $50.24/MWh for non-carve-out. The Public Utilities Commission of Ohio will adjust this number annually, but it can never be below $45/MWh.[ii]<br><br>The solar ACP is $250 in 2017 and 2018; $200 in 2019 and 2020; decreasing similarly biannually to a minimum of $50/MWh in 2026. |
| **Pennsylvania** | Tier 1 – PV energy, solar-thermal energy, wind, low-impact hydro, geothermal, biomass, wood pulping and manufacturing byproducts from energy facilities within the state, biologically derived methane gas, coal-mine methane, and fuel cells.<br><br>Tier 2 – Waste coal, distributed generation systems less than 5 MW in capacity, demand-side management, large-scale hydro, municipal solid waste, wood pulping and manufacturing byproducts from energy facilities outside the state, and integrated gasification combined cycle coal technology.[jj] | 18% by 2021.[kk]<br><br>Tier 1 – 8% by 2021.<br><br>Tier 2 –10% by 2021.<br><br>PV – 0.5% by 2021. | Sources located inside the geographical boundaries of the Commonwealth or within the service territory of any RTO that manages the transmission system in any part of the Commonwealth.[ll] | The ACP is $45/MWh for non-carve-out.[mm]<br><br>For solar PV, the ACP is valued at 200% of the average market value of solar RECs sold during the reporting period. |
| **Tennessee** | No RPS. | | | |

| State | Qualifying Facilities | Requirements | Geographic Footprint | ACPs |
|---|---|---|---|---|
| **Virginia** | Solar thermal electric or PV, LFG, wind, biomass, hydroelectric, geothermal electric, energy from waste, anaerobic digestion, tidal energy, and wave energy.[nn] | 15% by 2025 (IOUs).[oo] | Electricity must be generated or purchased in Virginia or in the PJM region.[pp] | There are only voluntary goals, no ACP.[qq] |
| **West Virginia** | No RPS. | SB 1/HB 2001, effective January 27, 2015, repealed most provisions of the Alternative and Renewable Energy Portfolio Act, with the exception of Chapter 24 Article 2F-8, Net Metering of Customer-Generators.[rr] | | |

CY = compliance year; LFG = landfill gas; PV = photovoltaic; IOU = investor-owned utility.

[a] "PJM Program Information – Maryland," PJM Environmental Information Services, https://www.pjm-eis.com/program-information/maryland.aspx.

[b] Jocelyn Durkay, "State Renewable Portfolio Standards and Goals – Maryland," National Conference of State Legislatures, December 28, 2016, http://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx#md.

[c] "PJM Program Information – Maryland," PJM Environmental Information Services, https://www.pjm-eis.com/program-information/maryland.aspx.

[d] "Renewable Energy Portfolio Standard," Database of State Incentives for Renewables & Efficiency®, North Carolina Clean Energy Technology Center, last updated June 30, 2016, http://programs.dsireusa.org/system/program/detail/1085.

[e] "Renewables Portfolio Standard – Delaware," Database of State Incentives for Renewables & Efficiency®, North Carolina Clean Energy Technology Center, last updated February 11, 2015, http://programs.dsireusa.org/system/program/detail/1231.

[f] Jocelyn Durkay, "State Renewable Portfolio Standards and Goals – Delaware," National Conference of State Legislatures, December 28, 2016, http://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx#de.

[g] "PJM Program Information – Delaware," PJM Environmental Information Services, https://www.pjm-eis.com/program-information/delaware.aspx.

[h] "Renewables Portfolio Standard – Delaware," Database of State Incentives for Renewables & Efficiency®, North Carolina Clean Energy Technology Center, last updated February 11, 2015, http://programs.dsireusa.org/system/program/detail/1231.

[i] B21-0650 - Renewable Portfolio Standard Expansion Amendment Act of 2016, Council of the District of Columbia, effective October 8, 2016, http://lims.dccouncil.us/Legislation/B21-0650?FromSearchResults=true.

[j] Ibid.

[k] "PJM Program Information – District of Columbia," PJM Environmental Information Services, https://www.pjm-eis.com/program-information/district-of-columbia.aspx.

[l] "Renewable Portfolio Standard –District of Columbia," Database of State Incentives for Renewables & Efficiency®, North Carolina Clean Energy Technology Center, last updated October 19, 2016, http://programs.dsireusa.org/system/program/detail/303.

| State | Qualifying Facilities | Requirements | Geographic Footprint | ACPs |
|---|---|---|---|---|

[m] "Renewables Portfolio Standard – Illinois," Database of State Incentives for Renewables & Efficiency®, North Carolina Clean Energy Technology Center, last updated December 9, 2016, http://programs.dsireusa.org/system/program/detail/584.

[n] Jocelyn Durkay, State Renewable Portfolio Standards and Goals – Illinois, National Conference of State Legislatures, December 28, 2016, http://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx#il.

[o] "PJM Program Information – Illinois," PJM Environmental Information Services, https://www.pjm-eis.com/program-information/illinois.aspx.

[p] "RPS Alternative Compliance Payment Notices," Illinois Commerce Commission, https://www.icc.illinois.gov/electricity/rpscompliancepaymentnotices.aspx.

[q] "Clean Energy Portfolio Standard – Indiana," Database of State Incentives for Renewables & Efficiency®, North Carolina Clean Energy Technology Center, last updated November 20, 2015, http://programs.dsireusa.org/system/program/detail/4832.

[r] Jocelyn Durkay, State Renewable Portfolio Standards and Goals – Indiana," National Conference of State Legislatures, December 28, 2016, http://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx#in.

[s] Clean Energy Portfolio Standard – Indiana, Database of State Incentives for Renewables & Efficiency®, North Carolina Clean Energy Technology Center, last updated November 20, 2015, http://programs.dsireusa.org/system/program/detail/4832.

[t] Ibid.

[u] "Renewable Energy Standard – Michigan" Database of State Incentives for Renewables & Efficiency®, North Carolina Clean Energy Technology Center, last updated November 19, 2015, http://programs.dsireusa.org/system/program/detail/3094.

[v] Clean, Renewable, and Efficient Energy Act 295 of 2008, Section 460.1029, Renewable energy system location; requirements, Michigan Legislature, effective October 6, 2008, http://legislature.mi.gov/doc.aspx?mcl-460-1029.

[w] Clean, Renewable, and Efficient Energy Act 295 of 2008, Section 460.1053: Failure to meet renewable energy credit standard by deadline; civil action; contested case; final order, Michigan Legislature, effective October 6, 2008, http://legislature.mi.gov/doc.aspx?mcl-460-1053.

[x] "Renewables Portfolio Standard – New Jersey," Database of State Incentives for Renewables & Efficiency®, North Carolina Clean Energy Technology Center, last updated May 20, 2015, http://programs.dsireusa.org/system/program/detail/564.

[y] Jocelyn Durkay, "State Renewable Portfolio Standards and Goals – New Jersey," National Conference of State Legislatures, December 28, 2016, http://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx#nj.

[z] "PJM Program Information – New Jersey," PJM Environmental Information Services, https://www.pjm-eis.com/program-information/new-jersey.aspx.

[aa] "Renewables Portfolio Standard – New Jersey," Database of State Incentives for Renewables & Efficiency®, North Carolina Clean Energy Technology Center, last updated May 20, 2015, http://programs.dsireusa.org/system/program/detail/564.

[bb] "Renewable Energy and Energy Efficiency Portfolio Standard – North Carolina," Database of State Incentives for Renewables & Efficiency®, North Carolina Clean Energy Technology Center, last updated September 23, 2016, http://programs.dsireusa.org/system/program/detail/2660.

[cc] Jocelyn Durkay, "State Renewable Portfolio Standards and Goals – North Carolina," National Conference of State Legislatures, December 28. 2016, http://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx#nc.

[dd] North Carolina General Assembly, Chapter 62 of the North Carolina General Statutes, § 62-133.8 – Renewable Energy and Energy Efficiency Portfolio Standard, Public Utilities Act, 1963, http://www.ncleg.net/enactedlegislation/statutes/html/bychapter/chapter_62.html.

[ee] "Renewable Energy and Energy Efficiency Portfolio Standard – North Carolina," Database of State Incentives for Renewables & Efficiency®, North Carolina Clean Energy Technology Center, last updated September 23, 2016, http://programs.dsireusa.org/system/program/detail/2660.

[ff] "Alternative Energy Portfolio Standard – Ohio," Database of State Incentives for Renewables & Efficiency®, North Carolina Clean Energy Technology Center, last updated July 24, 2014, http://programs.dsireusa.org/system/program/detail/2934.

[gg] Jocelyn Durkay, "State Renewable Portfolio Standards and Goals – Ohio," National Conference of State Legislatures, December 28, 2016, http://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx#oh.

[hh] "Alternative Energy Portfolio Standard – Ohio," Database of State Incentives for Renewables & Efficiency®, North Carolina Clean Energy Technology Center, last updated July 24, 2014, http://programs.dsireusa.org/system/program/detail/2934.

[ii] Ohio Revised Code Title 49, Chapter 4928.64, "Electric distribution utility to provide electricity from alternative energy resources," effective July 31, 2008, http://codes.ohio.gov/orc/4928.64.

[jj] "Alternative Energy Portfolio Standard – Pennsylvania," Database of State Incentives for Renewables & Efficiency®, North Carolina Clean Energy Technology Center, last updated August 24, 2016, http://programs.dsireusa.org/system/program/detail/262.



[kk] Jocelyn Durkay, "State Renewable Portfolio Standards and Goals – Pennsylvania," National Conference of State Legislatures, December 28, 2016, http://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx#pa.

[ll] "PJM Program Information – Pennsylvania," PJM Environmental Information Services, https://www.pjm-eis.com/program-information/pennsylvania.aspx.

[mm] "Alternative Energy Portfolio Standard – Pennsylvania," Database of State Incentives for Renewables & Efficiency®, North Carolina Clean Energy Technology Center, last updated August 24,

# Appendix B.  Methodology

The 2017 Inventory Database that was utilized for the analysis in this report was compiled using the data sources and study methodologies that are described below.

## 1.  Data Collection and Sources

The primary source of data for this report is the PJM GATS database, made available by PJM Environmental Information Services.[69] GATS is a tracking system that tracks generation, environmental attributes, and emissions, and was developed in response to the needs of state regulatory commissions, other state agencies, and market participants for a single, regional, integrated system to implement state fuel mix and emissions disclosure requirements and RPS policies.[70] The structure of GATS is: (1) a master database of all of the generators located within or registered to sell electricity into the PJM region; and (2) a subset database of renewable generators located within or registered to sell electricity into the PJM region.  GATS is updated frequently—the data compiled for this project was accessed on December 31, 2017. Table B-1 lists information obtained from the GATS system for each generator.

**Table B-1.  Data Gathered from PJM GATS Database**

| Data Field | Description |
|---|---|
| Plant Name | Facility name |
| Unit Name | Name of generator unit |
| ORISPL (Plant Code) | EIA plant code (if available) |
| GATS Unit ID | GATS System ID code |
| State | State location |
| County | County location |
| Location | PJM Control Area |
| Nameplate | Nameplate capacity (MW) |
| Date Online | Date unit began production |
| Primary through Eighth Fuel Type | Fuel/energy source |
| RPS Eligible | Energy certificate numbers by state and fuel type |

[69] http://www.pjm-eis.com.
[70] "About GATS," PJM Environmental Information Services, https://www.pjm-eis.com/getting-started/about-GATS.aspx.

Data provided in the plant and generator-level databases from EIA Form 860M helped augment the information obtained from the GATS database.[71] The EIA-860M is a generator-level data file that includes information about electric power plants owned and operated by electric utilities and non-utilities (including independent power producers, combined heat and power producers, and other non-utility companies). The EIA-860M contains generator-specific information such as initial date of commercial operation, prime movers, generating capacity, energy sources, status of existing and proposed generators, proposed changes to existing generators, county and state location.[72] At the time the 2017 Renewable Inventory was prepared, the data available in EIA-860M were through October 2017. Finally, to complete the updated inventory data set, information detailing net electric generation from facilities with an EIA code was obtained from the EIA-923 databases, which include monthly and annual data on generation and fuel consumption at power plants. The EIA-923 forms provided data through July 2016.

Table B-2 details the information used to supplement the GATS data.

Finally, to complete the updated inventory data set, information detailing net electric generation from facilities with an EIA code was obtained from the EIA-923 databases, which include monthly and annual data on generation and fuel consumption at power plants. The EIA-923 forms provided data through July 2016.

[71] Of the eligible GATS systems, facilities that matched with EIA data were compared. If the nameplate capacity difference was greater than the absolute value of 10 MW, EIA data were used.

[72] "Form EIA-860 detailed data with previous form data (EIA-860A/860B)," U.S. Energy Information Administration, https://www.eia.gov/electricity/data/eia860m/.

**Table B-2. Data Obtained in Addition to PJM GATS**

| Source | Data Field | Description |
|---|---|---|
| EIA-860 | EIA plant code | Unique identification number |
| | Plant name | Name of plant |
| | Nameplate capacity (MW) | Potential electricity generation for the plant |
| | Energy source | Fuel used to generate electricity |
| | Latitudinal coordinates | x-coordinate of plant location |
| | Longitudinal coordinates | y-coordinate of plant location |
| EIA-923 | Plant ID | Unique identification number |
| | Plant name | Name of plant |
| | Reported fuel type code | Fuel used to generate electricity |
| | Net Generation (MWh) | Actual electricity generation for the plant using the specified fuel |
| U.S. Census Bureau (County Totals Dataset: Population, Population Change and Estimated Components of Population Change: April 1, 2010 to July 1, 2015) | Population estimate 2015 | Census projections |

## 2. Data Collection and Compilation

The fuel type provided in GATS helped identify renewable energy facilities in PJM. The first-listed qualified fuel type served as the classification for multi-fuel plants. The information provided in Table B-1 and Table B-2 was then integrated into the overall 2017 Inventory Database. These data were cross-checked against the EIA-860 and EIA-923 data, using the EIA plant code if provided by the GATS database.

## 3. Data Challenges and Resolution

As of December 31, 2017, the GATS contains information about 167,907 electric generating units. Of these entries, 165,841 are in the PJM control area and 2,066 units were found to be located outside PJM.[73] There were 387 facilities in the PJM control area removed from consideration due to the following reasons: not qualifying as Maryland-eligible, considered as

[73] There are two facilities outside of the PJM control area that are certified for the Maryland Tier 1 non-carve-out category; both are wind facilities (Tatanka Wind Farm in North Dakota and Farmer City Wind Farm in Missouri) with a combined capacity of 326 MW.

secondary facilities, or considered as duplicate facilities.[74] The remaining entries were aggregated by EIA facilities code (if this unique identifier was available) for a total of 165,452 unique generating facilities. Of these facilities in PJM, 165,159 are Tier 1 solar-qualifying, 282 are Tier 1-qualifying (exclusive of solar), and 11 are eligible for Tier 2 compliance based upon Maryland RPS requirements. For those facilities with more than one fuel source, the capacity associated with renewable energy was prorated based on historical generation by fuel source and the contribution of renewable resources.[75] Some facilities utilize more than one renewable energy technology, and the database lists them under the qualifying technology with the highest proportion of the facility's generation. The database does not identify any qualifying wastewater-treatment biogas, operational offshore wind, or poultry litter-to-energy electric plants.

For facilities larger than one MW that do not have an EIA facility code, manual searches through the EIA databases were conducted based on common data in both the EIA and GATS databases, such as county and state. Facility names in the GATS and EIA databases differ for some of the facilities, which presented a challenge in determining whether a facility has an EIA facility code. Comparing data such as location and start-up dates helped to minimize this issue.

The "Fuel Type" field in GATS provides the basis for determining the number of plants and total capacity available to satisfy the RPS requirements within the PJM region. Maryland's RPS requirement differs slightly from other state RPS policies. The renewable energy projects in GATS that are eligible to meet Maryland's requirements are categorized as described below:

1. Plants must be in the "PJM Control Area."
2. Solar thermal heating units must be commissioned on or after June 1, 2011.
3. Waste-to-energy facilities sited in Maryland are assumed to be connected to the distribution grid and are therefore eligible for Tier 1 compliance.
4. Plants listed as "Other biomass gas fuels" were listed with LFG plants.

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[74] It is assumed that the costs to transmit eligible generation from outside of PJM are too high to warrant using that generation for compliance with the Maryland RPS. Historically, minimal generation from sources outside PJM has been used for compliance.

[75] Generation data are typically not available for smaller, methane-based plants (e.g., those utilizing internal combustion generators). It is expected that the renewable share of methane capacity may be overstated owing to the extensive cofiring or fuel-switching between natural gas and diesel fuels.

5. Plants listed as "Other biomass liquid and solids" were listed as qualifying biomass in addition to wood/waste solids.

6. Natural gas and residual fuel oil (includes No. 5 and No. 6 fuel oils and bunker C fuel oil) plants were excluded.

7. Fuel cells utilizing renewable resources were categorized as LFG.

8. To match the Maryland requirement that qualifying hydropower be associated with a dam constructed prior to 2004, hydropower dam age was approximated by the age of the hydropower plant itself.

9. Energy efficiency improvements were excluded since energy efficiency does not qualify as an eligible resource for the Maryland RPS.

10. Similarly, plants listed as "Other gas" (butane, coal processes, coke-oven refinery, and other processes) were excluded as they do not qualify as an eligible resource for the Maryland RPS.

11. Waste coal plants were excluded as they do not qualify as an eligible resource for the Maryland RPS.

12. Pumped hydropower storage generators were excluded as they do not qualify as an eligible resource for the Maryland RPS. Some large hydropower plants include both conventional and pump turbines; for these facilities, the capacity of the pumped storage units was subtracted from total plant capacity.

There are 54 plants that utilize multiple fuels for either fuel switching or co-firing with other fuels. Out of these 54 plants, 17 did not produce electricity from resources that would qualify for the Maryland RPS. These plants were excluded from the 2017 Inventory Database. There were 25 additional plants that were derated—that is, the capacity that qualifies for the Maryland RPS was reduced based on the share of proportional generation from RPS-qualifying resources. The affected plants were typically large generating stations primarily burning coal and natural gas mixed with a limited amount of fuels that are eligible resources for the Maryland RPS, such as blast furnace gas, black liquor, or landfill methane.

## 4. Maryland Data Resolution

Owing to deratings and discrepancies in the reporting of capacity in GATS, the capacity of some Maryland facilities will be different than reported in other publications:

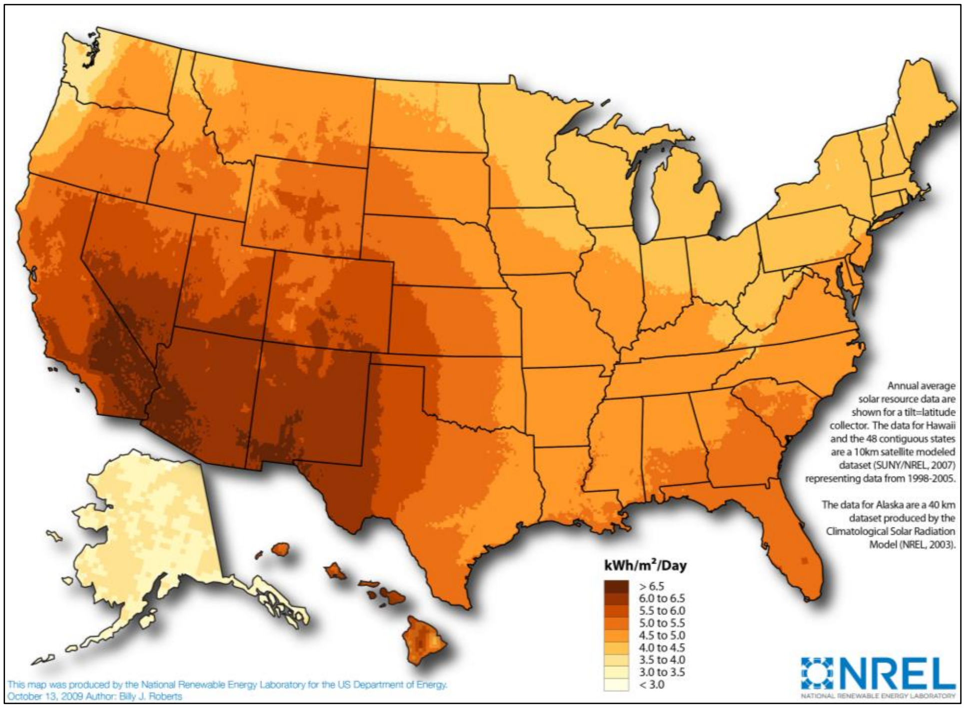
- The Conowingo Hydropower Station is reported in GATS to be 474 MW. EIA rates Conowingo as having 531 MW nameplate, and 572 MW of summer capability.
- The Newland Park Landfill (Wicomico County) was derated from 6 MW in GATS to 5.4 MW of renewable capacity based on actual LFG being used for energy production.
- The Easton generating facility, owned by Easton Utilities, was not included because the eligible renewable fuels did not produce any generation based on historical data. However, the internal combustion and gas turbine generators at the site are capable of using renewable fuels such as LFG.

## 5. Capacity Factors for Renewable Projects in PJM

***Solar*** – Solar energy is variable by nature due to the rotation and tilt of the planet, cloud cover, weather (season), and geographic location. The NREL OpenEI Transparent Cost Database uses a nationwide capacity factor range of 16 percent to 30 percent for solar PV generators with a median value of 20 percent.[76] PJM receives substantially less solar radiation than the national average, as shown in Figure B-1 and Figure B-2.

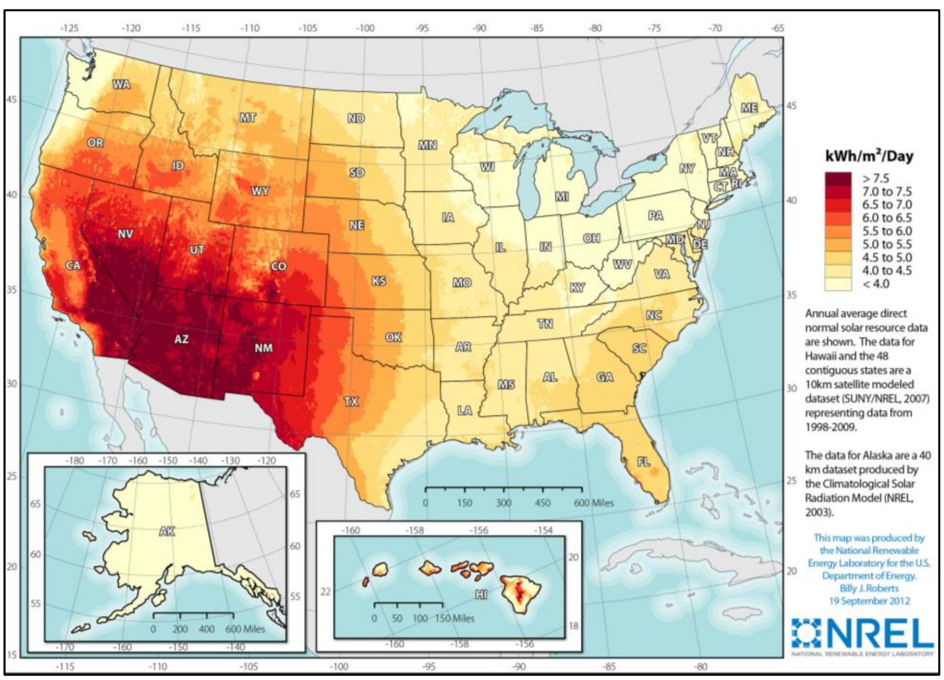
[76] "Transparent Cost Database: Capacity Factor," Open Energy Information, National Renewable Energy Laboratory, http://en.openei.org/apps/TCDB/#blank.

**Figure B-1. NREL Photovoltaic Solar Resource of the United States**




*Source:* Billy J. Roberts, National Renewable Energy Laboratory, September 19, 2012, http://www.nrel.gov/gis/images/eere_pv/national_photovoltaic_2012-01.jpg.

**Figure B-2. NREL Concentrating Solar Resource of the United States**




*Source:* Billy J. Roberts, National Renewable Energy Laboratory, September 19, 2012, http://www.nrel.gov/gis/images/eere_csp/national_concentrating_solar_2012-01.jpg.

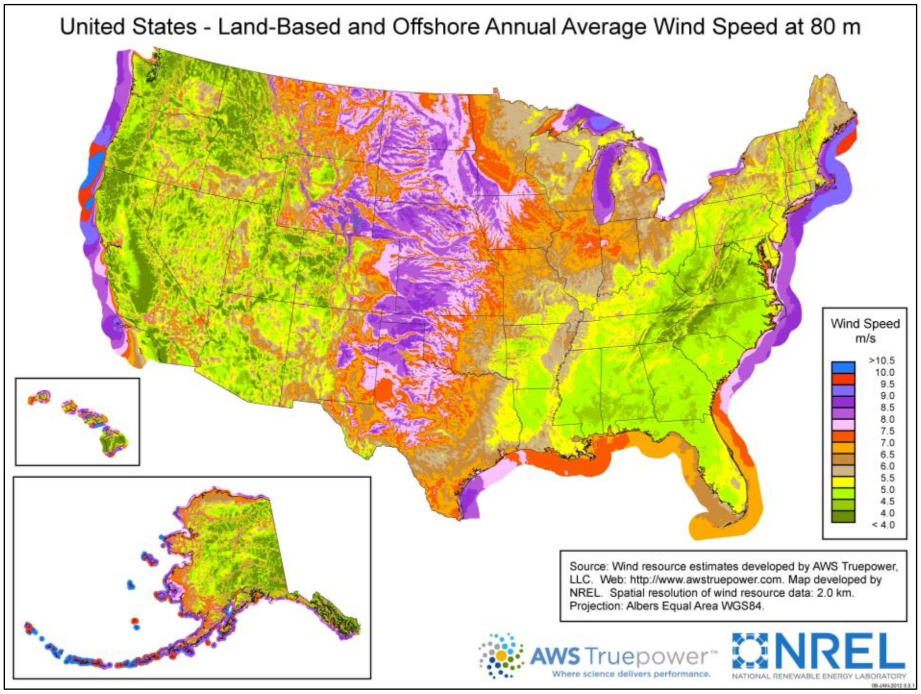
This analysis conservatively assumed NREL lower bounds of 16 percent for solar PV capacity factor and 25 percent for solar thermal capacity factor.

The distribution of solar unit sizes also affects the capacity factor of solar plants. A rooftop installation less than 10 kW typically does not track the sun (i.e., it is not at the optimal angle for power, other than at noon on one day per year, and frequently it is placed on a roof with a slope that is not at the optimal latitude angle), whereas a large-scale system has more economies of scale to allow it to be sited properly with tracking mechanisms.

***Wind*** – Wind speeds are naturally variable. Wind-generating units have performance curves bound by upper and lower wind-speed operating limits. Wind units have a zero capacity factor below the lower limit (i.e., there is not enough wind velocity to bring the turbine up to a productive level) and above the upper mechanical stress limit (i.e., the windmill is locked down to protect the blades and structure). Once above the lower wind speed limit, the turbine begins to produce electric power. As wind speed increases, energy production increases until the turbine reaches full capacity. Above this limit, the blades adjust to maintain maximum capacity. Additional wind speed does not produce more power. The NREL OpenEI Transparent Cost Database uses a nationwide capacity factor range of 26 percent to 52 percent for onshore wind generators with a median value of 38 percent, and a nationwide capacity factor range of 31 percent to 45 percent for offshore wind generators with a median value of 39 percent.[77] Onshore wind speeds are lower in PJM than the national average and, conversely, offshore wind speeds are higher in PJM than the national average, as shown in Figure B-3.

[77] Ibid.

**Figure B-3. United States – Land-Based and Offshore Annual Average Wind Speed at 80m**




*Source:* National Renewable Energy Laboratory, January 2012,https://www.nrel.gov/gis/images/80m_wind/awstwspd80onoffbigC3-3dpi600.jpg.

This study assumes a 26 percent capacity factor for land-based wind generators consistent with NREL lower bound estimates, and a 39 percent capacity factor for offshore wind generators consistent with the NREL median value.

***Hydroelectric*** – A hydroelectric unit's production is variable because of seasonal factors and environmental and/or recreational requirements to maintain water levels upstream and downstream. The NREL OpenEI Transparent Cost Database uses a nationwide capacity factor range of 12 percent to 61 percent for hydroelectric generators with a median value of 45 percent.[78] The 2017 Inventory Report includes data that allow the calculation of a capacity factor for a sampling of hydroelectric units under 30 MW. This sampling of units, on average, has a capacity factor of approximately 42 percent. This analysis assumed a 45 percent capacity factor for all hydroelectric generators, consistent with the NREL median value.

***Methane*** – Generation data from 47 units in PJM were available from EIA. Annual plant utilization ranged from less than one percent to over 96 percent. These compute to an average

[78] Ibid.

capacity factor of approximately 55 percent, which was assumed to apply to LFG facilities in PJM.

***Biomass*** – The NREL OpenEI Transparent Cost Database uses a nationwide capacity factor range of 70 percent to 90 percent for biomass generators with a median value of 84 percent.[79] This analysis assumed an 84 percent capacity for biomass generators consistent with the NREL median value.

***Black Liquor*** – As with biomass, an 84 percent capacity factor was used. Economic paper mill production is fully dependent on the ability to recover chemicals and energy from black liquor.

***Waste-to-Energy*** – Municipal solid waste-to-energy generating units are subject to variation in the quantity and quality of their waste supply (i.e., their fuel). These variations are seasonal, peak with holidays, and are weather-related (for example, rain soaks wastes resulting in lower efficiency in generation). Data for 11 units in the PJM control area were available. Annual plant utilization ranged from less than one percent to over 54 percent. These compute to an average capacity factor of approximately 27 percent, which was assumed to apply to waste-to-energy facilities in the PJM control area.

[79] Ibid.

# Appendix C.  Solar Project Capacity Analysis

Solar installations can be segregated into a variety of markets based on unit size (e.g., nameplate capacity) and/or type of installation.  This report examines the following size/type of markets:

- **Small-scale (≤10 kW)** typically represents single residential and small commercial rooftop installations.  This scale, referred to as Level 1, does not require a revenue-quality meter for determining the associated solar RECs.
- **Mid-scale (>10 kW and ≤100 kW)** represents community solar, larger commercial, and utility installations.[80]
- **Large-scale (>100 kW)** represents large commercial and utility installations; utility-scale installations are generally larger and can be many MW in size.

Table C-1 shows the distribution of generating units and power supply by unit scale.  About 71 percent of solar generation within PJM comes from 2 percent of the solar units (the 3,361 units with capacity of greater than 100 kW).  Likewise, in Maryland, 50 percent of the power comes from the one percent of the units classified as large-scale.

[80] Typically, utility solar projects are larger than 100 kW.

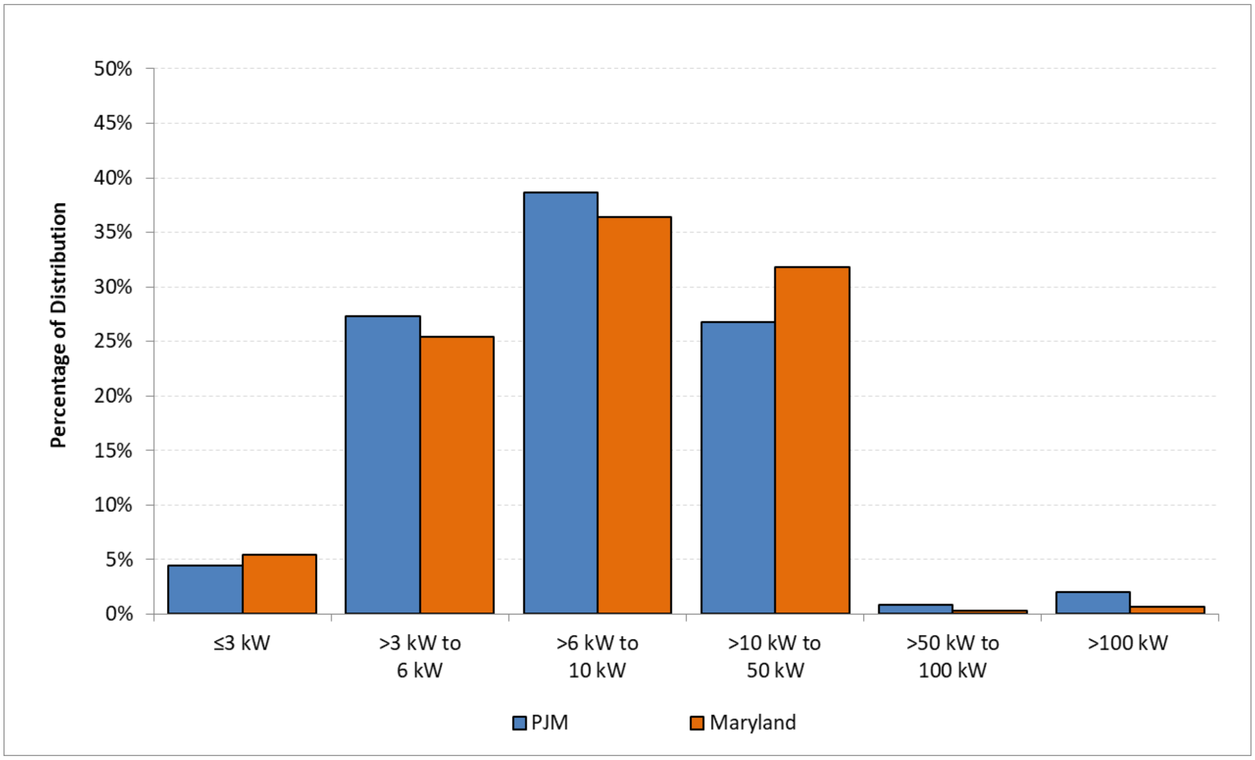
**Table C-1. Solar Unit Distribution by Number of Units, Total Power Capacity, and Average Unit Capacity in the Unit Size Category (as of December 31, 2017)**

| | Small-scale | Mid-scale | | | Large-scale | |
|---|---|---|---|---|---|---|
| | ≤3 kW | >3 kW to 6 kW | >6 kW to 10 kW | >10 kW to 50 kW | >50 kW to 100 kW | >100 kW |
| **PJM** | | | | | | |
| Number of Units | 7,334 | 45,114 | 63,833 | 44,163 | 1,354 | 3,361 |
| Percent of Units[a] | 4.44% | 27.32% | 38.65% | 26.74% | 0.82% | 2.04% |
| Power (total MW) | 17.5 | 213.0 | 506.4 | 648.7 | 96.5 | 3,641.8 |
| Average Unit (kW) | 2.4 | 4.7 | 7.9 | 14.7 | 71.3 | 1,083.6 |
| Percent of Power[a] | 0.34% | 4.16% | 9.88% | 12.66% | 1.88% | 71.08% |
| **Maryland** | | | | | | |
| Number of Units | 2,970 | 13,988 | 19,997 | 17,500 | 149 | 369 |
| Percent of Units[a] | 5.40% | 25.45% | 36.38% | 31.83% | 0.27% | 0.67% |
| Power (total MW) | 7.0 | 65.6 | 158.7 | 247.4 | 10.8 | 485.8 |
| Average Unit (kW) | 2.4 | 4.7 | 7.9 | 14.1 | 72.4 | 1,316.5 |
| Percent of Power[a] | 0.72% | 6.73% | 16.27% | 25.37% | 1.11% | 49.82% |

[a] Percent totals may not equal 100 percent due to independent rounding.

Figure C-1 shows the size distribution of the solar units in both PJM and those sited in Maryland by electric nameplate capacity.

**Figure C-1. PJM and Maryland Generating Unit Distribution for Tier 1 Solar (as of December 31, 2017)**




The volume of units leans heavily toward the smaller scale—presumably rooftop residential and commercial solar PV. However, most of the installed solar capacity, on a percentage basis, is from larger units, as depicted in Figure C-2.

**Figure C-2. Maryland and PJM Solar Capacity Distribution (as of December 31, 2017)**

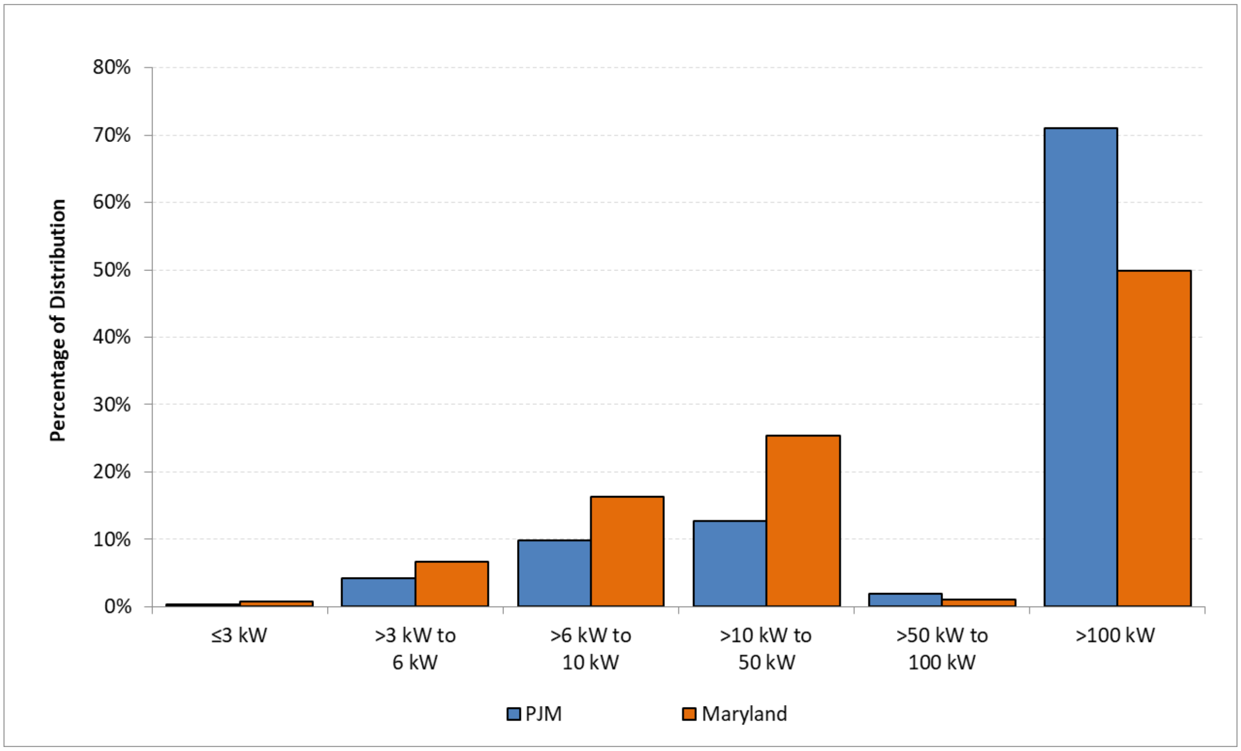



Table C-2 shows the number of units that will need to be installed in Maryland to meet the projected 2020 requirement, assuming that the average unit size in each distribution remains the same.

**Table C-2. Installed and Projected 2020 Solar Unit Requirements in Maryland**

| | Small-scale | | | Mid-scale | | Large-scale |
|---|---|---|---|---|---|---|
| | ≤3 kW | >3 kW to 6 kW | >6 kW to 10 kW | >10 kW to 50 kW | >50 kW to 100 kW | >100 kW |
| Average Capacity (kW) | 2.4 | 4.7 | 7.9 | 14.1 | 72.4 | 1,316.5 |
| 2017 Units (installed) | 2,970 | 13,988 | 19,997 | 17,500 | 149 | 369 |
| 2020 Units (projected) | 3,298 | 15,531 | 22,203 | 19,430 | 165 | 410 |

Note: The number of units is calculated based on the current distribution of solar units and average unit nameplate capacity for each size category.

For context, Maryland has an estimated 2,177,492 households.[81] To reach the 2020 compliance goal, based on the solar unit-scale distribution in 2017, approximately 4,000 Maryland single-family households will need to install rooftop solar units (assuming single-family homes make

[81] Estimate of Maryland's households is from U.S. Census data: "Maryland QuickFacts," U.S. Department of Commerce, U.S. Census Bureau, http://www.census.gov/quickfacts/table/PST045215/24.

up the majority of these small units). Table C-3 provides the historical context as to whether a 4,000-unit goal would be achievable; based on past data, the goal appears to be reasonable.

**Table C-3. Maryland Solar Installations by Year (2005-2017)**

| Year | No. of Systems | Capacity Installed (MW) | Average Size (MW) | Median Size (MW) | Largest Size (MW) |
|---|---|---|---|---|---|
| 2005 | 18 | 0.06 | 0.003 | 0.0027 | 0.02 |
| 2006 | 16 | 0.05 | 0.003 | 0.0032 | 0.01 |
| 2007 | 44 | 0.23 | 0.005 | 0.0031 | 0.04 |
| 2008 | 97 | 2.03 | 0.021 | 0.0036 | 0.58 |
| 2009 | 494 | 5.34 | 0.011 | 0.0046 | 0.30 |
| 2010 | 698 | 10.63 | 0.015 | 0.0055 | 1.84 |
| 2011 | 1,131 | 29.17 | 0.026 | 0.0058 | 2.22 |
| 2012 | 2,002 | 92.95 | 0.046 | 0.0065 | 29.06 |
| 2013 | 2,267 | 45.93 | 0.020 | 0.0065 | 3.66 |
| 2014 | 4,902 | 66.85 | 0.014 | 0.0081 | 2.20 |
| 2015 | 12,014 | 194.34 | 0.016 | 0.0081 | 13.09 |
| 2016 | 20,777 | 290.58 | 0.014 | 0.0081 | 18.60 |
| 2017 | 10,513 | 237.00 | 0.023 | 0.0087 | 99.91 |
| **TOTAL:** | **54,973** | **975.16** | **0.017**[a] | **0.0080**[b] | **99.91**[c] |

[a] Weighted average project size.
[b] Weighted average of the median project size.
[c] Largest project size.

# Appendix D. Legislative History of the Maryland RPS Requirements

In 2004, the Maryland General Assembly passed SB 869, the Renewable Energy Portfolio Standard and Credit Trading Act (Maryland RPS Act). At that time, the law required that 3.5 percent of retail energy sales come from renewable sources in 2006, increasing to 9.5 percent by 2018, and then decreasing to 7.5 percent in 2019 and subsequent years. The law distinguished between energy derived from Tier 1 and Tier 2 facilities. Energy derived from Tier 1 resources was to comprise one percent of electricity sales in 2006 and increase to 7.5 percent by 2019. Tier 2 resources were to make up 2.5 percent of electricity sales each year and then sunset by 2019 (i.e., there would be no Tier 2 requirement in 2019 and thereafter).

In April 2007, the Maryland State Legislature passed SB 595, Electricity – Net Energy Metering – Renewable Energy Portfolio Standard – Solar Energy. This bill mandated that 2 percent of retail electricity sales come from eligible solar facilities by 2022, in addition to the 7.5 percent sales from Tier 1 facilities.[82] In April 2008, the legislature passed HB 375, Renewable Portfolio Standard Percentage Requirements – Acceleration, which increased the total Tier 1 requirement to 20 percent in 2022, with 2 percent as a solar carve-out and 18 percent as Tier 1. At that time, out-of-state solar could qualify as a solar carve-out resource. The Tier 2 requirements did not change.[83] The legislature also passed SB 277 in May 2010, which increased the solar carve-out requirements between 2011 and 2016.

HB 375 also changed the geographic eligibility of facilities that qualify under Maryland's RPS. As provided in the original 2004 legislation (in effect through December 31, 2010), renewable energy generation could be located (1) in the PJM region; (2) in a state that is adjacent to the PJM region; or (3) in a control area (service territory) that is adjacent to the PJM region if the electricity is delivered into the PJM region. Changes to the definition of eligibility that the 2008 HB 375 enacted came into effect on January 1, 2011. These changes require that renewable energy generation be located: (1) in the PJM region; or (2) in a control area that is adjacent to the PJM region if the electricity accompanying the RECs is delivered into the PJM region. While Tier 1 and Tier 2 facilities in control areas adjacent to PJM regions could still be eligible under the modified RPS, the additional transmission and wheeling charges required to deliver this

[82] Senate Bill 595, State of Maryland, 2007, "Electricity – Net Energy Metering – Renewable Energy Portfolio Standard – Solar Energy Act," http://mlis.state.md.us/2007RS/chapters_noln/Ch_119_sb0595E.pdf.
[83] House Bill 375, State of Maryland, 2008, "Renewable Portfolio Standard Percentage Requirements – Acceleration," http://mlis.state.md.us/2008rs/chapters_noln/Ch_126_hb0375E.pdf.

energy into PJM provides a slight competitive disadvantage for facilities located outside of PJM regions.[84] Furthermore, smaller facilities operating behind the meter or serving onsite loads are unable to deliver bundled energy and RECs into PJM regions from an adjacent control area.

SB 690, passed in May 2011, allows Tier 1 eligibility for waste-to-energy and refuse-derived fuel facilities located in Maryland. Waste incineration facilities must also meet certain requirements regarding the recycling rate of the jurisdictions where the municipal solid waste is collected. Prior to SB 690, waste-to-energy generation was only eligible for Tier 2. Also passed in May 2011, SB 717 allows RECs from solar water-heating systems not solely used to heat a pool or hot tub to qualify for the Tier 1 solar carve-out. To qualify, these systems must use Solar Rating and Certification Corporation operating guidelines to certify solar collectors' equipment, and have been commissioned on or after June 1, 2011. Previously, only electric generation from solar power was eligible under the solar carve-out.

In 2012, the Maryland General Assembly passed SB 791 and HB 1187. Together, these bills accelerated the Maryland RPS solar carve-out compliance requirements beginning in 2013, moved the 2 percent solar carve-out requirement from 2022 to 2020, and allowed measurements of solar water-heating energy production for qualified in-home water heaters.[85] Also in 2012, the enactment of SB 652 and HB 1186 qualified eligible geothermal heating and cooling systems commissioned on or after January 1, 2013 as Tier 1 resources.

Additionally, in May 2012, SB 1004 and HB 1339 qualified thermal energy associated with biomass systems that primarily use animal waste as Tier 1 resources, effective January 1, 2013.

In 2013, Maryland enacted HB 226, which created a carve-out for offshore wind in Tier 1 of the Maryland RPS. Beginning in 2017, this bill allows qualified offshore wind generation to count toward the RPS up to a maximum of 2.5 percent of retail electricity sales. As a carve-out, this generation counts towards the overall Tier 1 requirement.[86] HB 226 defines qualified offshore wind projects as those located on the outer continental shelf, in an area of the ocean designated for leasing by the DOI, and between 10 and 30 miles off the Maryland coast. The

[84] Onshore wind power from outside of PJM, specifically Iowa, has been used to fulfill Maryland non-carve-out Tier 1 requirements.
[85] See Maryland PUA § 7-701(q).
[86] The Maryland PSC sets the actual amount, which may not exceed 2.5 percent.

projects must also interconnect to the PJM grid at the Delmarva Peninsula and be approved by the Maryland PSC.[87,88]

In February 2017, the Maryland General Assembly passed HB 1106, which increased the solar carve-out to 2.5 percent and overall Tier 1 requirement to 25 percent by 2020.[89]

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[87] General Assembly of Maryland, HB 0226 "*Maryland Offshore Wind Energy Act of 2013*," March 23, 2013, http://mgaleg.maryland.gov/2013RS/bills/hb/hb0226e.pdf.

[88] The Maryland PSC issued an order on May 11, 2017, approving ORECs for two projects: one to be completed by 2020, and the other by 2023.

[89] HB 1106 became law as the passage was an override of a gubernatorial veto. See http://mgaleg.maryland.gov/2016RS/bills/hb/hb1106e.pdf.