MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

PPRP – CEIR-21
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PPRP

Maryland Power Plants and the Environment

A review of the impacts of power plants and transmission lines on Maryland's natural resources

Summary Document

February 2022

MARYLAND POWER PLANT RESEARCH PROGRAM

Wes Moore, Governor ◊ **Aruna Miller, Lt. Governor**

The Maryland Department of Natural Resources (DNR) seeks to preserve, protect and enhance the living resources of the state. Working in partnership with the citizens of Maryland, this worthwhile goal will become a reality. This publication provides information that will increase your understanding of how DNR strives to reach that goal through its many diverse programs.

Joshua E. Kurtz, Secretary
Maryland Department of Natural Resources

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Introduction

The Maryland Department of Natural Resources (DNR) Power Plant Research Program (PPRP) evaluates how the design, construction, and operation of power plants and transmission lines impact Maryland's environmental, socioeconomic, and cultural resources. PPRP's legislative mandate seeks to ensure that the citizens of Maryland can continue to enjoy reliable electricity supplies at a reasonable cost while minimizing impacts to Maryland's resources. The program plays a key role in the licensing process for power plants and transmission lines by coordinating the State agencies' review of new or modified facilities and developing recommendations for license conditions.

PPRP is directed by the Maryland Power Plant Siting Act (§3-304 of the Natural Resources Article of the Annotated Code of Maryland) to prepare a biennial Cumulative Environmental Impact Report (CEIR). The intent of the CEIR is to assemble and summarize information regarding the impacts of electric power generation and transmission on Maryland's natural resources, cultural foundation, and economic situation.

This document serves as a summary of the 21st edition of CEIR. The full report contains more detailed background on many topics, compiled as of November 2021, and can be accessed from the PPRP website: https://dnr.maryland.gov/pprp.

Evolving Energy Topics in Maryland

Systems for generating electricity and providing it to customers have changed significantly over the past 20 years, and they continue to evolve. With the rise of digital technology, distributed generation, and demands for decarbonization, the traditional electric utility framework, and regulatory structures are being transformed. This section provides an overview of key energy topics and how they are affecting the state's electricity infrastructure.

Electrification

Electrification is the replacement of technologies that combust fossil fuel sources with technologies that rely on electricity as an energy source. An emerging consensus among climate and energy experts is to transition the electric grid to zero-carbon sources while simultaneously transitioning industry sectors that rely on fossil fuel sources to electricity.

Maryland will rely upon electrification as a tool for meeting targets set by the Greenhouse Gas Reduction Act (GGRA). The GGRA calls for a 40 percent reduction in greenhouse gas (GHG) emissions from 2006 levels by 2030. In February 2021, the Maryland Department of the Environment (MDE) published the "2030 GGRA plan" calling for 49 percent reductions in GHG emissions by 2031 and net-zero, economy-wide GHG emissions by 2045. MDE's plan calls on 46 percent of new light-duty vehicles and 35 percent of new medium- and heavy-duty vehicles sold in 2030 to be zero-emission vehicles, and 50 percent of heating system sales to consist of heat pumps, also by 2030. Maryland has a goal of having 300,000 zero-emission vehicles on the road by 2025.

In November 2021, the Maryland Commission on Climate Change approved a plan for electrifying buildings. Among the recommendations include new buildings being all-electric by 2024; heat pumps to account for 95% of HVAC and water heater sales by 2030; and net-zero direct emissions from large buildings by 2040.

PJM Generation Interconnection Queue

New generation projects seeking to connect to the PJM Interconnection LLC (PJM) grid must submit a generator interconnection request. PJM performs the requisite studies for generator interconnection in clusters grouped together based on a six-month queue cycle. The aggregate list of dated interconnection requests is referred to as the generation interconnection queue.

PJM experienced a sharp increase in interconnection requests from generators in recent years, driven mostly by renewable energy projects. PJM reports that the number of interconnection requests in 2020 more than doubled what was requested in 2018, and in 2021 the number of requests accelerated further to nearly triple the number of requests made in 2018. Renewable energy projects make up 75% of the capacity in the interconnection queue that is active, suspended or under construction as of the end of 2021. Most of the capacity in the PJM queue, whether from renewable or non-renewable projects, will not come on-line. PJM's historical record shows that about 16% of capacity becomes operational.

PJM stated the large number of interconnection requests has resulted in delays in PJM processing these applications in a timely manner, with about 1% of the Facility

Studies—the last study before an interconnection agreement is executed between PJM and the applicant—completed in the time period required under the Federal Energy Regulatory Commission (FERC) Order 845. The lack of transparency regarding available transmission capacity that could accommodate new generation leads generators to file multiple interconnection requests for the same project in an attempt to file an interconnection location with the least adverse impacts and therefore least cost. PJM also cites relatively low minimum and largely refundable study deposits, which do not encourage generation projects to withdraw. Additionally, for every generation project that withdraws, PJM must restudy projects further down in the queue to ensure accurate identification of any required system upgrades, resulting in study delays. The withdrawal of generation projects can contribute to substantial cost uncertainty for lower-queued projects that may prompt those projects to withdraw, creating a chain reaction of withdrawals.

PJM held several workshops in 2020 to review its generation interconnection process and receive feedback and recommendations from stakeholders. That led to the creation of the Interconnection Process Reform Task Force in March 2021. The task force is considering changing the interconnection studies from a project-by-project basis to grouping projects in clusters, and moving from a first-come, first-serve approach to first-ready approach as a means of weeding out generation projects that are unlikely to come on-line.

Renewable Portfolio Standard

The Maryland Renewable Energy Portfolio Standard (Maryland RPS) was enacted in May 2004. The Maryland RPS requires retail electrical suppliers to provide a specified percentage of their electricity sales from Maryland-certified Tier 1 and Tier 2 renewable resources.

In 2019, the Maryland General Assembly enacted the Clean Energy Jobs Act, or CEJA. CEJA increased Tier 1 of the Maryland RPS from 25% by 2020 to 50% by 2030.[*] CEJA also changed the levels of the Tier 1 carve-outs. Specifically, it increased the solar carve-out from 2.5% by 2020 to 14% by 2030 and added an additional 1,200 megawatts (MW) of required offshore wind to the 368 MW previously approved by the Public Service Commission (PSC) in 2017. In December 2021, the PSC awarded offshore renewable energy credits to 1,654 MW of additional offshore wind proposed by U.S. Wind and Skipjack. Both projects are expected to be in operation by 2026.

[*] Tier 1 includes solar energy (solar photovoltaics and solar water heating), wind, various types of biomass, methane from a landfill or wastewater treatment plant, geothermal, ocean energy, hydro less than 30 MW, fuel cells powered from a Tier 1 source, poultry litter, waste-to-energy, refuse-derived fuel, and thermal energy from biomass.

CEJA eliminated the 2.5% Tier 2 requirement for hydro facilities larger than 30 MW at the end of 2020, but it was re-established and made permanent in 2021. Therefore, the total Maryland RPS is 52.5% (50% Tier 1, 2.5% Tier 2). Also in 2021, the Maryland General Assembly enacted a new carve-out for geothermal, starting at 0.05% in 2023 and peaking at 1% in 2028.

Decommissioning

Decommissioning refers to the process of permanently removing a facility from operation. In the power industry, plant decommissioning can include removing some or all of the physical components; however, some power plant structures may remain in place, especially if they may have value for future reuse or redevelopment. As the number of renewable energy projects in Maryland grows, there has been an increased focus on plans for decommissioning these facilities in the event a facility becomes non-operational.

Anticipated impacts from decommissioning renewable energy facilities in Maryland are dependent upon a number of factors relating to past and future use of underlying lands, their location, and the extent to which the surrounding economic landscape changes over their operational life.

At the end of a utility-scale solar or wind power plant lifespan, components are expected to be decommissioned or the facility could be replaced or repowered. Decommissioning includes removing the power generating equipment and all infrastructure, recontouring the site and access roads, replacing or supplementing soil, and revegetating to suit the desired post-decommissioning land use.

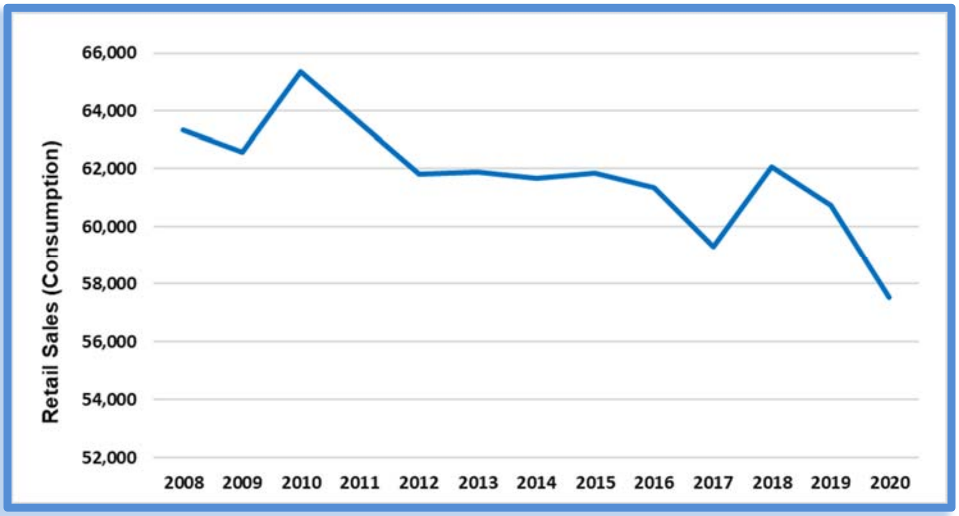
Power Generation, Transmission, and Use

In Maryland, electrical power is provided to its residents through a variety of fossil fuel sources, which account for the largest portion of the state's generating capacity, in addition to nuclear and renewable sources such as solar photovoltaics, wind turbines, hydroelectric dams and biomass. As of November 2021, 41 power plants in Maryland with generation capacities of 10 MW or greater are interconnected to the regional transmission grid.

Electricity Demand

Maryland end-use customers consumed about 57.5 thousand gigawatt hours (GWh) of electricity during 2020. Between 2009 and 2018, the annual average growth rate in electricity consumption in Maryland was lower than in the U.S. as a whole (negative 0.76 percent in Maryland versus a positive 0.17 percent in the U.S.).

Figure 1 Maryland Electricity Consumption 2008-2020



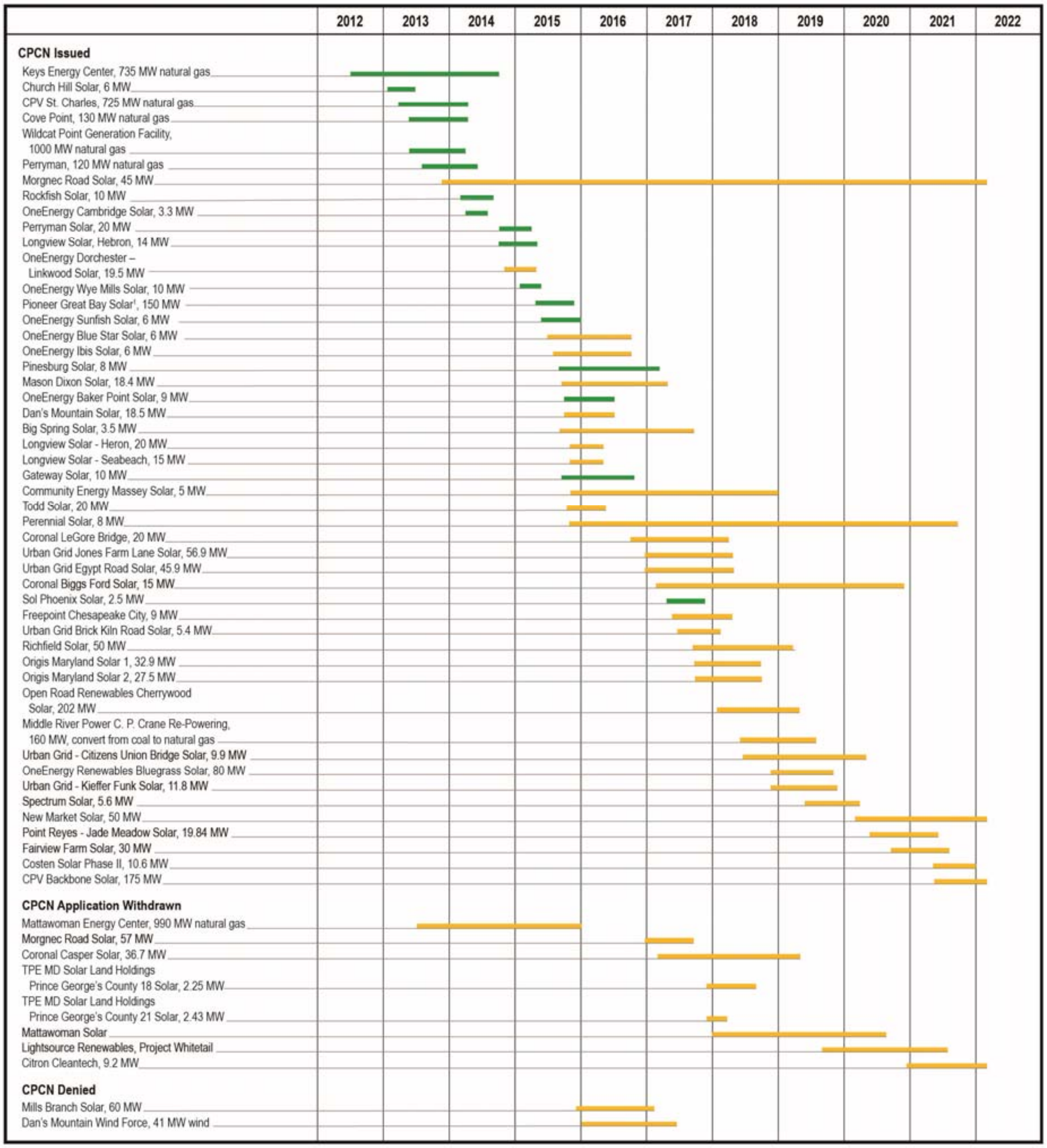
The economic recession that began in 2008 resulted in a downward trend for electricity consumption in Maryland (see Figure 1). Electricity consumption fell nearly every year from 2011-2017 before increasing in 2018, though the 2018 value (62.0 thousand GWh) is still below the 2009 value (62.6 thousand GWh). This decline is largely due to the impact of the EmPOWER Maryland legislation.

EmPOWER Maryland targeted a 15 percent reduction in per capita electricity consumption by 2015 from 2007 levels. Since 2018, electricity consumption in Maryland has continued its downward trend, decreasing annually by an average of 3.7 percent. The growth rate in electricity consumption in Maryland averages an increase of 0.14 percent per year over the 10-year forecast period.

Power Plant Licensing Activity

From 2001 to February 2022, the PSC has received 76 Certificate of Public Convenience and Necessity (CPCN) applications for new generation, representing several thousand megawatts of potential generating capacity at existing facilities and at greenfield sites, with numerous application reviews ongoing. While the majority of the proposed plants obtained a CPCN, only 26 are in operation as of February 2022. The remainder are under construction or have been delayed or abandoned for various financial or commercial reasons. Figure 2 details the 59 CPCN applications received from 2012 to February 2022.

Figure 2 CPCN Requests, 2012 through February 2022



Bar length indicates the duration of the CPCN process from the time the application was filed to the time it was withdrawn or a PSC order was filed. Bar coloring indicates whether the project is now in operation:

= Project is operational = Project is not operational

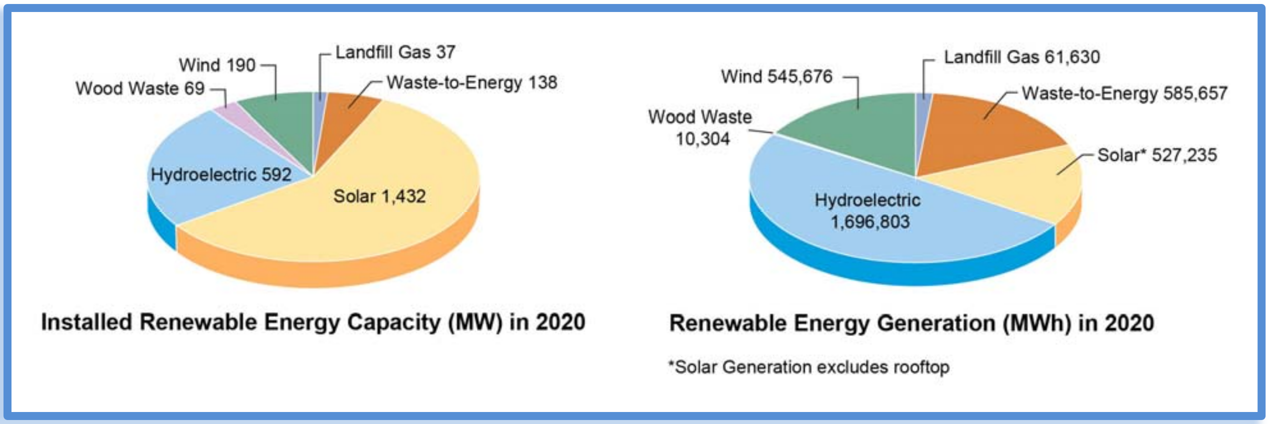
[1] The CPCN is for 150 MW solar array; only 75 MW of the project are in operation as of October 2019.

Chart does not reflect the following CPCN cases ongoing as of February 2022: Waypost Solar.

Renewable Energy

Presently, there are four main types of renewable energy resources in use in Maryland: wind, biomass (including wood waste, landfill gas and municipal waste-to-energy), solar and hydropower. Approximately 2,459 MW of generation capacity in Maryland comes from these resources (see Figure 3).

Figure 3 Renewable Energy in Maryland as of 2020



Wind

The conversion of wind power to electricity is typically accomplished by constructing an array of wind turbines in a suitable location. Wind turbines range in size from 20-watt microturbines (used for small-scale residential or institutional applications) to new 10 MW prototypes, with manufacturers now researching the possibility of 20 MW turbines for offshore facilities. Land-based, utility-scale wind turbines typically have a rated capacity between 1.5 and 3 MW, although some are as large as 5 MW.

In Maryland, the greatest wind resources are located in the westernmost counties and off the Atlantic coast on the Outer Continental Shelf. Maryland is estimated to have a potential land-based wind resource capacity of approximately 1.5 gigawatts (GW) when the hub height is at 80 meters. Currently, there are four operating utility-scale wind facilities in Maryland, all located in Garrett County. Their combined power capacity of 190 MW is estimated to represent about 12 percent of Maryland's land-based wind resource potential at a hub height of 80 meters. One other project, representing about 70 MW, is currently in the planning and development stage.

Maryland has an offshore wind power capacity in excess of 130 GW, with a potential generation of 603 terawatt hours (TWh). Using existing offshore wind turbine technology and limiting development to shallow waters reduces the offshore wind potential to 23.8 GW and 80 TWh, respectively. Still, if fully developed, offshore wind would far exceed the state's electric demand.

The PSC received applications for Offshore Renewable Energy Credits (ORECs) under the Maryland Offshore Wind Energy Act from US Wind, Inc. and Skipjack Offshore Wind Energy in November 2016. After review, the PSC approved both applications, with conditions, in May 2017 (PSC Order No. 88192). Before construction starts, PPRP may conduct studies to identify potential environmental impacts from any submarine transmission cables that cross Maryland's offshore waters. U.S. Bureau of Ocean Energy Management (BOEM) approved Site Assessment Plans in 2018 and the applicants are currently conducting site assessments for these projects.

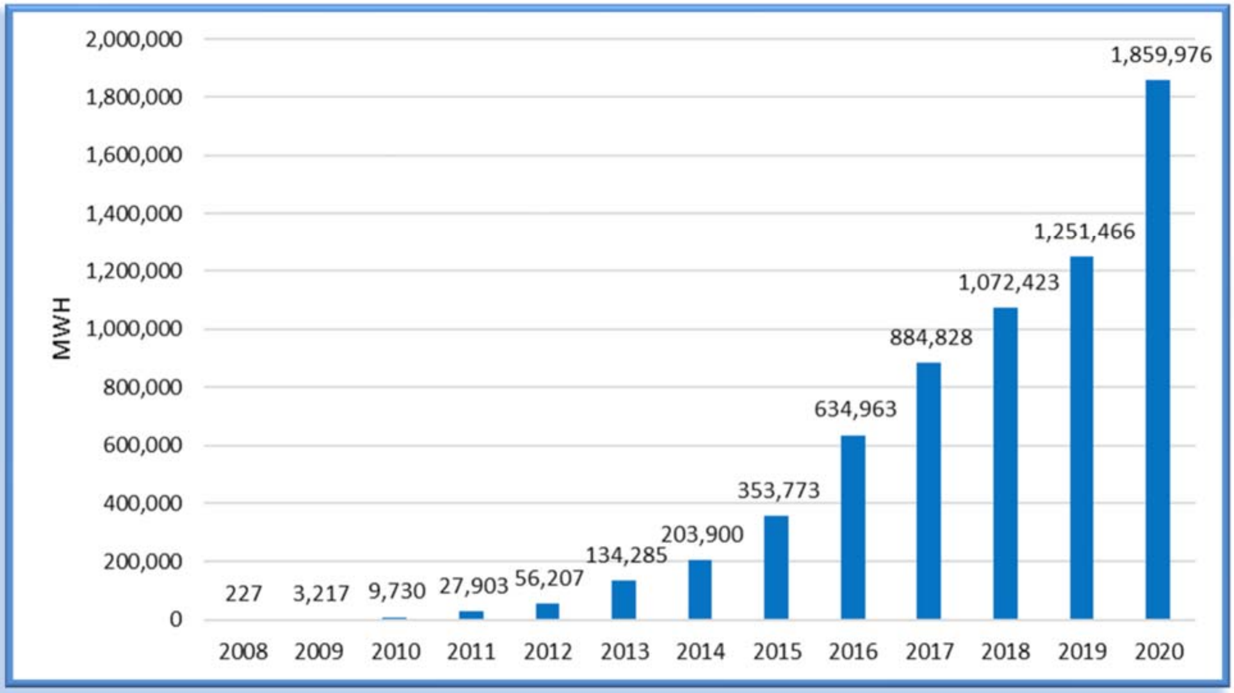
In Maryland's 2019 Legislative Session, additional offshore wind project ORECs were authorized through the Clean Energy Jobs Act. These ORECs are to support the development of at least an additional 1,200 MW of wind energy by 2030 from applications for "Round 2" of offshore wind development (which started as of July 1, 2017). In December 2021, the PSC accepted bids for two additional offshore wind projects from US Wind and Skipjack, representing an additional 1,654 MW. The two projects are slated to come online by 2026. This amount of offshore wind energy will more than quintuple the offshore wind contribution to the state's renewable energy portfolio.

Solar

At the end of 2020, there were 74,529 solar facilities in Maryland representing 1,425 MW of generating capacity, according to the PJM Generation Attribute Tracking System (GATS). GATS tracks solar renewable energy credits (SRECs) that are eligible for use in complying with the Maryland RPS. While most of the facilities are smaller than 10 kilowatts (kW), 164 systems larger than 1 MW have come online representing 600 MW of solar generating capacity. In 2020, Great Bay Solar Phase I in Somerset County became the largest operational solar facility in Maryland. From 2016 to September 2021, the PSC issued CPCNs to 32 solar facilities with a combined capacity of 941 MW, and as of September 2021 there were six cases pending before the Commission with a combined capacity of 296 MW. The largest solar CPCN approved is for Cherrywood Solar, a 202 MW facility located in Caroline County.

Solar energy generation capacity in Maryland went from 0.1 MW in 2007 to 1,425 MW in 2020 due in large part to Maryland's implementation of a solar carve-out under the Maryland RPS. The General Assembly passed a bill in 2019 that further increased the percentage of the solar carve-out in the Maryland RPS from 2.5 percent by 2020 to 14.5 percent by 2030. Overall, solar generation in Maryland increased 1,285 percent, or approximately 1,725,691 MWh, between 2013 and 2020 (see Figure 4).

Figure 4 Solar Generation in Maryland, 2008-2020



Hydroelectric

Hydropower is one of the oldest sources of power, used thousands of years ago to grind grain. The first U.S. hydroelectric power plant began operations in the 1880s. A hydroelectric dam is the most well-known form of hydropower production, often built on a very large scale by closing off an entire river and forming a large lake-like reservoir.

Maryland has two large-scale (greater than 10 MW capacity) hydroelectric dam projects and four additional small-scale facilities that are currently in operation. One of the two large-scale hydroelectric dam projects recently received a license renewal for continued operation. In October 2019, Exelon, the then owner and operator of Conowingo Dam, proposed a settlement with MDE to FERC, in which Exelon will spend in excess of $200 million over 50 years on several protection, mitigation and enhancement measures, including fish passage attraction flows, eel passage, invasive species management, a revised downstream operating flow regime, trash and debris removal, dissolved oxygen monitoring, shoreline management, turtle management, a waterfowl nest plan, sturgeon monitoring, mussel restoration, water quality project funding and other measures. In March 2021, FERC approved relicensing, granting Exelon a new 50-year license to operate the dam. Exelon transferred the Conowingo project to Constellation Energy Corporation in early 2022 as part of a corporate restructuring.

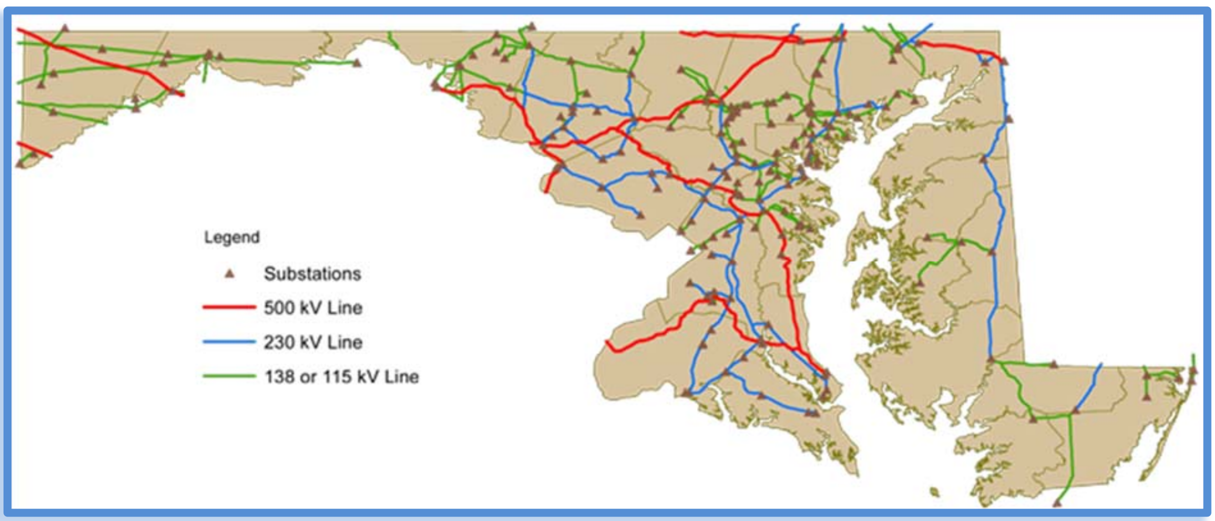
Biomass

In the energy production sector, biomass refers to biological material that can be used as fuel for transportation, steam heat and electricity generation. Biomass fuels are most commonly created from wood and agricultural wastes, alcohol fuels, animal waste and municipal solid waste. Biomass can be combusted to produce heat and electricity; transformed into a liquid fuel such as biodiesel, ethanol or methanol; or transformed into a gaseous fuel such as methane.

Electricity Transmission

The network of high-voltage lines, transformers and other equipment that connects power-generating facilities to distribution systems is part of an expansive electric transmission system. In Maryland, there are more than 2,000 miles of transmission lines operating at voltages between 115-500 kV. Figure 5 shows a map of this high-voltage transmission grid in Maryland.

Figure 5 Transmission Lines in Maryland (> 115 kV)



PJM has operational control over and planning responsibility for the high-voltage transmission facilities in Maryland. As part of its transmission planning responsibilities, PJM routinely examines projections of generation, transmission and loads to determine if additional transmission facilities are needed to comply with applicable transmission planning standards and associated reliability criteria. PJM also periodically examines whether certain new transmission lines will produce economic benefits, usually in the form of market efficiency projects that may relieve congestion and provide the lowest electric costs for consumers in the region, even if they are not needed for reliability reasons. To the extent PJM determines a need for a transmission project and includes it in the Regional Transmission Expansion Plan (RTEP), there is an expectation that the transmission owner will file for a CPCN seeking permission to construct the proposed transmission line.

Reliability

Historically, transmission infrastructure enabled utilities to locate power plants near inexpensive sources of fuel and transmit electricity over long distances to consumers. By interconnecting different utilities' transmission systems, utilities were able to access additional sources of generation and back up each other's generating capacity, thus improving overall reliability and also reducing overall operating costs.

The North American Electric Reliability Corporation (NERC) is charged with developing and implementing reliability standards and periodically assessing the reliability of the bulk power system. NERC, which is governed by a 12-member independent board of trustees, develops mandatory reliability standards that are reviewed and ultimately approved by FERC. The Energy Policy Act of 2005 requires electricity market participants to comply with NERC reliability standards. If participants are found in violation of the Energy Policy Act, they are subject to fines of up to $1 million per day per violation. NERC delegates enforcement authority to eight regional reliability councils, including the ReliabilityFirst Corporation (RF), which serves the PJM regional transmission organization (RTO).

On December 2, 2015, the PSC adopted proposed regulations regarding reliability and service quality standards. The proposed regulations established numerical reliability standards in terms of an allowable number of outage minutes for calendar years 2016 through 2019. The PSC has since updated the allowable number of outage minutes by utility through 2023.

Markets and Pricing

Energy prices in PJM are based upon the offers that designate a price and quantity at which a generator is willing to sell electricity. PJM stacks these offers from lowest price to highest price until it can satisfy the quantity required to meet energy requirements in its footprint. It is the price of the last resource called upon—the marginal price—that becomes the PJM-wide energy component of the hourly, day-ahead locational marginal price (LMP).

Since energy prices may vary considerably by location due primarily to transmission congestion, PJM must also account for congestion costs. Congestion occurs between two delivery points on the transmission system when the transmission grid cannot accommodate the power flows between these specific locations. When congestion occurs, higher-priced local resources are used instead of lower-cost electricity that would otherwise be used to meet load by being transported into the area via transmission lines. During periods of congestion, PJM must dispatch generation resources that are located at or near the load zone even if those resources are not the most economic resources that would otherwise be available to meet load. The cost of congestion refers to the incremental cost of dispatching these more expensive, location-specific resources.

As a result of lower wholesale electricity prices coupled with other factors, such as stricter environmental regulations for fossil-fuel plants and the aging of the coal fleet, some companies have opted to either retire older, less efficient coal plants or convert them to natural gas. PJM's Market Monitor reports that it anticipates 44,684 MW of generation to retire between 2011 and 2022, approximately 70 percent of which is from coal-fired steam units. In 2020, 3,255 MW of generation resources and 457 MW of pseudo-tied resources were retired, and 2,557 MW of new generation resources were added. PJM does not expect these retirements to result in degraded reliability since as of December 31, 2020, there were 173,581 MW of capacity in the generation queue, indicating that there is still sufficient capacity in the queue to compensate for retirement of generation units. In addition, PJM has a reserve margin of over 23.9 percent, or about 39,500 MW for the 2020/2021 delivery year. PJM's required reserve margin is 24.2 percent of expected demand, when accounting for fixed resource requirement.

Wholesale market prices in Maryland rose significantly between 2005 and 2009, and as a result, residential customers saw substantial increases in their electric bills. Between 2009 and 2012, however, retail rates declined as wholesale energy prices decreased. Market prices remained relatively stable from 2012 through 2018, but have experienced some volatility in recent years, depending upon the utility. Figure 4-2 in the CEIR-21 full report shows the average annual residential rates in effect in summer 2011 and for each subsequent summer.

Air Quality

Emissions

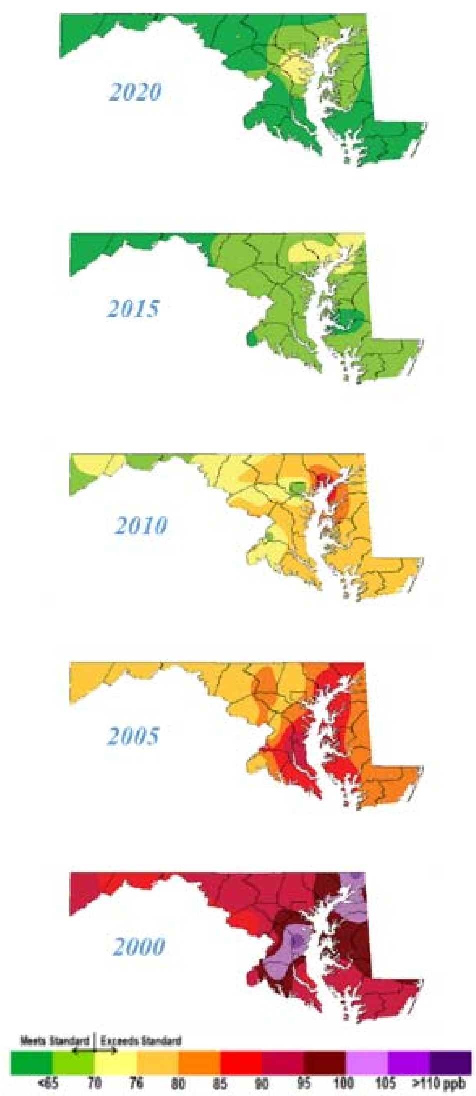
Power plants in the U.S. are a major source of air emissions. However, according to the report "*Benchmarking Air Emissions of the 100 Largest Electric Power Producers in the United States*" (based on the July 2021 update), emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon dioxide (CO_2) and mercury have all decreased significantly in recent years. Power plant emissions of SO_2 and NO_x were 95 percent and 88 percent lower, respectively, than in 1990 when the Clean Air Act amendments were passed, mercury emissions were 92 percent lower than they were in 2000, and CO_2 emissions decreased by 40 percent from their peak in 2007. Overall trends in electric generation show a displacement of coal by natural gas and renewable energy sources, contributing to the observed decrease in emissions over time.

Power plant emissions in Maryland mostly come from natural gas, petroleum, biomass and coal-fired plants. With the slated retirement of the Morgantown coal-fired power plant by June 2022, Maryland will be left with three coal-fired power plants in operation. Two of those three plants are scheduled to retire in October 2025, and the third plant by 2035.

Impacts

Air emissions from power plants affect the environment in a number of ways; some of the most significant are listed below. PPRP has worked over the past several decades to study these air quality issues, and continues to support research to improve our understanding of these impacts in Maryland.

Figure 6 Maryland's Ozone Trend – 2000-2020



- **Ozone** - An invisible and reactive gas that is the major component of photochemical smog. Sources do not emit ozone directly into the atmosphere in significant amounts, but ozone instead forms through chemical reactions in the atmosphere. Ground-level ozone is formed when the precursor compounds—NO_x from both mobile and stationary combustion sources (such as automobiles and power plants, respectively) and volatile organic compounds (VOCs) from industrial, chemical, and petroleum facilities and natural sources—react in the presence of sunlight and elevated temperatures. Ozone levels are consequently highest during the summer months when temperatures are higher, the hours of daylight are longer and the sun's rays are more direct. Figure 6 shows the positive trend in ozone concentrations in Maryland over the last 20 years.

- **Visibility and Regional Haze** - In general, visibility refers to the conditions that can facilitate the appreciation of natural landscapes. The national visibility goal, established as a part of the CAA Amendments of 1977, requires improving the visibility in federally managed "Class I areas." These areas include more than 150 parks and wilderness areas across the United States that are considered pristine air quality areas. Four of these areas are located in states surrounding Maryland.

Since 1988, the Environmental Protection Agency (EPA) and other agencies have been monitoring visibility in these areas.

- **Nitrogen Deposition** - Reducing nitrogen input from controllable sources is a high priority because excess nitrogen is one of the major sources of eutrophication in the Chesapeake Bay. Eutrophication is a process whereby water bodies, such as lakes or estuaries, receive excess nutrients that stimulate excessive plant and algal growth, and ultimately reduce the dissolved oxygen content in the water, thus limiting the oxygen available for use by aquatic organisms. The 1987 Chesapeake Bay Agreement established a goal of reducing controllable nitrogen by 40 percent compared to 1985 levels, and program participants reaffirmed that goal in their 2000 agreement. The Chesapeake Bay Program estimates that approximately 30 percent of the nitrogen load to the Chesapeake Bay comes from atmospheric deposition and subsequent transport of nitrogen through the watershed. Much of this loading comes from NO_x emissions from power plants, industrial sources and mobile sources. MDE recently devoted increased efforts toward studying the role of ammonia in the deposition processes.

- **Mercury Impacts** - Due to the significance of power plant mercury emissions (including emissions from out-of-state sources), PPRP plays an important role in supporting scientific research on this topic. PPRP has been actively involved in the study of regional sources of mercury emissions and their impacts on Maryland and the Chesapeake Bay. In cooperation with the University of Maryland, PPRP has sponsored several deposition monitoring programs and continues to evaluate the impacts of toxic emissions from power plants in Maryland. PPRP has also supported a project to measure ambient air mercury concentrations at the Piney Run monitoring site in Garrett County using a continuous mercury monitoring instrument.

Climate Change

Evidence of a rising average global temperature has driven global efforts to reduce human impact on the earth's climate. Human activities, such as fossil fuel combustion for electricity generation and transportation, industrial processes, and changes in land use, including deforestation, contribute significant amounts of CO_2 and other greenhouse gases (GHGs) to the atmosphere. At the turn of the twenty-first century, record-high levels of atmospheric concentrations of GHGs sparked national debate about the responsibility to reduce human contribution to global climate change.

Some of the potential impacts associated with increased GHG levels in the atmosphere are global temperature increases, sea-level rise that may gradually inundate coastal areas and increase shoreline erosion, flooding from coastal storms, changes in precipitation patterns, increased risk of severe weather events and droughts, threats to biodiversity, and challenges for public health and wellness.

The electricity sector is particularly vulnerable to the effects of sea level rise and extreme weather events. If global temperatures continue to trend upward, sea levels will continue to rise and extreme weather events are likely to occur more frequently. Thermal generating units often require large quantities of cooling water, which has resulted in the siting of these facilities adjacent to large water bodies, often in tidal waters. Therefore, investments in renewable energy stations sited in areas not affected by sea level rise and investments that modernize our transmission grids are necessary to make our electric systems more resilient and reliable.

Maryland has been working to reduce the its impact on the climate. The Maryland Commission on Climate Change (MCCC) was formed in 2007 to develop a statewide Climate Action Plan, which was published in 2008. This plan contained 61 policy options, programs and measures to reduce GHG emissions in the state and to help the state respond and adapt to the impacts of climate change.

Maryland also implemented the Greenhouse Gas Emissions Reduction Act of 2009 (GGRA). This law set a statewide GHG emissions reduction goal of 25 percent from a 2006 baseline by 2020. The GGRA also required that Maryland prepare a plan to meet a longer-term goal of reducing its GHG emissions up to 90 percent by 2050 while promoting new "green" jobs, protecting existing jobs and positively influencing the state's economy. A GGRA 2012 Plan was designed to achieve the goals identified in the 2009 GGRA. The Plan describes 65 control measures for reducing GHG emissions, including reinforcement of Maryland's participation in the Regional Greenhouse Gas Initiative (RGGI) and programs to support terrestrial and geological carbon storage. In addition to achieving GHG reductions, the Plan was designed to create jobs and improve Maryland's economy, and to assist in advancing other environmental priorities of the state, including restoration of the Chesapeake Bay, improving air quality and other critical energy and national security issues. MDE released a GGRA Plan Update in October 2015 that provided additional environmental benefits by helping the state further Chesapeake Bay restoration efforts, continuing improving air quality and working to preserve agricultural and forest lands.

In May 2015, the Maryland Climate Change Commission Act was signed into law to expand the MCCC. MDE worked with the MCCC on the 2015 GGRA Plan Update and will continue to work with MCCC to address climate change in Maryland. The MCCC has various workgroups to address climate change issues including mitigation; adaptation; science and technology; and education, communication and outreach.

Maryland participates in the Regional Greenhouse Gas Initiative (RGGI) with the objective of reducing CO_2 emissions specifically from the electricity generation sector.

There are 18 power plants in Maryland that are covered by RGGI. Maryland's 2020 RGGI budget allowance was 12.5 million tons of CO_2 or 17 percent of the 2020 regional CO_2 budget of 74.4 million tons. Contrary to what was expected when the CO_2 state apportionments were negotiated, emissions in the power sector have fallen over the last several years due to plant closures, the economic downturn, mild weather patterns, shifts to natural gas-fired generation, increased generation from renewable energy sources, and increases in conservation and demand response. At the conclusion of the third control period, the RGGI power sector recognized a 65 percent decline in emissions since 2005. Since 2005, emissions from Maryland's power sector have declined 66 percent, or by 24.58 million tons of CO_2.

Water Resources

Power plants are significant users of water in Maryland, and their operation can affect aquatic ecosystems as well as the availability of water for other users. This section describes the surface and groundwater withdrawals, consumption and discharges in Maryland from power plant operations. It also describes potential resource impacts and methods for minimizing any adverse impacts.

Cooling Water Supply

Most electricity produced in Maryland is generated by one of four types of generating technologies: steam-driven turbines, combustion turbines, combined cycle facilities (a combination of steam and combustion turbine units) and hydroelectric facilities. Power plants utilizing steam have significant water withdrawals because of the need to cool and condense the recirculating steam. Typically, a power plant will obtain cooling water from a surface water body. The other, much smaller water needs of the power plant, such as boiler makeup water, are usually met by onsite wells or municipal water systems.

Nuclear power plants fall within the steam generating category; however, they use nuclear reactions instead of fossil fuel combustion to create the needed thermal energy. The typical nuclear power plant operating today requires 10 to 30 percent more cooling water, on a per-MWh basis, compared to a fossil fuel plant since nuclear stations generally operate at a lower steam temperature and pressure compared to fossil fuel-fired generating plants. This results in somewhat lower efficiency in the conversion of thermal energy to mechanical and, ultimately, electrical energy. Consequently, more waste heat is created per MWh generated than would occur in a fossil fuel plant, and more cooling water is needed to absorb that waste heat.

Calvert Cliffs Nuclear Power Plant withdraws an average of 3.3 billion gallons per day directly from the Chesapeake Bay. This is the largest single appropriation of water in

Maryland and is roughly 13 times larger than the municipal supply for the Baltimore City metropolitan area of 250 million gallons per day (mgd). While the majority of the water withdrawn by Calvert Cliffs is returned to the Chesapeake Bay, an estimated 18 mgd is lost to evaporation as a result of the heated discharge.

Ground Water Withdrawals

The impact of groundwater withdrawals has been a key issue in Southern Maryland, where there is a significant reliance on groundwater for public water supply. Currently, five power plants withdraw groundwater from Southern Maryland Coastal Plain aquifers for plant operations: Constellation Energy Corporation's Calvert Cliffs Nuclear Power Plant, NRG's Chalk Point and Morgantown power plants, NRG's combustion turbine facility (located at the Chalk Point plant and formerly owned by Southern Maryland Electric Cooperative (SMECO)) and KMC Thermo's combined cycle power plant. These five plants have historically withdrawn groundwater from three aquifers in Southern Maryland: the Aquia, the Magothy and the Patapsco. Chalk Point began withdrawing groundwater from the deeper Patuxent Aquifer in 2009. Four additional power plants utilize groundwater, but these facilities withdraw groundwater from sources other than the Coastal Plain aquifers: Dickerson, located in Montgomery County (New Oxford Formation); Perryman, located in Harford County northeast of Baltimore (Talbot Aquifer); Rock Springs, located in Cecil County (Baltimore Gabbro Complex); and Vienna, located in Dorchester County on the Eastern Shore (Columbia Group Aquifer).

Long-term monitoring indicates a steady decline in water levels in the Aquia, Magothy, Patapsco and Patuxent aquifers. However, these declines are not solely due to withdrawal by power plants and are considered acceptable by MDE Water Management Administration (WMA) when compared to the amount of water available in the aquifers. The amount of water available is expressed as the aquifer's "available drawdown," which is defined in MDE regulations as 80 percent of the distance from the historical pre-pumping water level to the top of the pumped aquifer.

Surface Water Withdrawal Impacts

Cooling water withdrawals can cause adverse ecological impacts in three ways:

- **Entrainment** – drawing in of plankton and larval and/or juvenile fish through plant cooling systems;
- **Impingement** – trapping larger organisms on barriers such as intake screens or nets; and
- **Entrapment** – accumulation of fish and crabs (brought in with cooling water) in the intake region.

EPA's implementation of CWA Section 316(b) in 2014 has resulted in updated assessments of the impacts of cooling water withdrawals. Maryland has seven existing steam electric power plants with a National Pollutant Discharge Elimination System (NPDES) permit and a cooling water intake and discharge. Of these, two plants are below the 2 mgd design threshold for affected facilities (Warrior Run and Vienna); the remaining five (Calvert Cliffs, Chalk Point, Morgantown, Wagner-Brandon Shores and Wheelabrator/Baltimore Refuse Energy System Company [RESCO]) were required to conduct further evaluations based on the 2014 regulations. Two of these (Chalk Point and Morgantown) are being decommissioned in 2022 and no further evaluations are likely to be required.

The 2014 rule includes the following requirements, which facilities in Maryland that withdraw at least 2 mgd are addressing in the coming years; some facilities have started or completed studies to address these issues:

- Facilities are required to choose one of seven options to reduce fish impingement.
- Facilities that withdraw at least 125 mgd must conduct studies to help their permitting authority determine whether and what site-specific controls, if any, would be required to reduce entrainment of aquatic organisms.
- New units added to an existing facility are required to reduce both impingement and entrainment that achieves one of two alternatives under national entrainment standards.
- Power plant owners must conduct one year of impingement studies and two years of entrainment studies (for facilities withdrawing greater than 125 mgd) within the last 10 years. Some facilities already conducted some or all of these studies while others need to conduct additional studies.
- All facilities subject to the 2014 rule are required to conduct economic and engineering studies to comply with the new rule as their NPDES permits are renewed.

Hydroelectric Facility Impacts

Maryland has only two large-scale hydroelectric projects (with capacities greater than 10 MW): Conowingo Dam on the Susquehanna River and Deep Creek Lake in Western Maryland. Four additional small-scale facilities also generate electricity within the state and an additional one (Jennings Randolph Hydroelectric Project) has received a license from FERC but is not yet constructed.

Terrestrial Impacts

Maryland's physiographic diversity, geology and climate have produced a variety of ecoregions that foster numerous, and sometimes unique, habitats ranging from ocean barrier islands in the east through salt marshes, fields and forests on the coastal plain, into rolling piedmont hills, and on to forested mountains with remnant alpine glades to the west. While human activities (agriculture, urban/suburban development, etc.) have altered all these areas to some extent, the majority of the landscape still consists of a wide variety of habitats that support diverse communities of flora and fauna. Many of these communities help define their regions and may contain rare, threatened or endangered species.

PPRP has reviewed more than 40 proposed solar generation facilities. These projects are located throughout the state and raise several environmental issues, many related to their size. For example, projects located near the Chesapeake Bay may include development in the Critical Area, and projects in agriculturally zoned areas may remove designated prime farmland out of production.

In addition to generating facilities, terrestrial impacts are also associated with the more than two thousand miles of electric power transmission line and natural gas pipeline rights-of-way located throughout Maryland. Constructing and maintaining these rights-of-way creates long, and mostly linear, corridors that are often quite different from the surrounding environment. These corridors can affect terrestrial habitats and wetlands in a variety of ways, either temporarily during construction or over the long term.

Environmental laws affecting waterways construction, water quality and water pollution control, and erosion and sediment control require the use of best management practices (BMPs) to eliminate or minimize disturbance in and discharges to Maryland waters. These BMPs are uniformly included as conditions to a CPCN. However, a CPCN can also recommend conditions to avoid, minimize or mitigate specific impacts on natural resources. Under these circumstances, conditions placed on a CPCN to mitigate impacts to wetlands, forests and sensitive species and their associated habitats may often be more stringent than requirements under the individual statutes.

Socioeconomics and Land Use

Siting utility-scale solar energy generating systems (SEGS) on agricultural land does not come without costs, and PPRP's role has been to weigh these costs against the benefits of renewable energy generation in its environmental reviews. Some of the issues PPRP has addressed are discussed below.

Cultural and Heritage Resources

Historic preservation laws require state and federal government agencies to consider the direct or indirect effects of their projects on historic and archeological resources. The Maryland Historical Trust (MHT) is the primary state agency charged with preserving and interpreting Maryland's cultural resources. Other agencies involved include the Maryland Department of Transportation (MDOT) State Highway Administration (SHA) through its Scenic Byways Program, DNR (Scenic Rivers, Rural Legacy), county historical and preservation organizations, private land trusts and citizen groups. As Maryland's State Historic Preservation Office (SHPO), MHT may also coordinate its reviews with the U.S. Army Corps of Engineers, National Park Service, Federal Communications Commission, Federal Energy Regulatory Commission, state-recognized Native American tribes and others.

Setbacks and Buffering

By far, the most common form of mitigation for SEGS in Maryland is setbacks and buffering. In agricultural areas, mitigation can be quite robust where projects abut residential properties, scenic resources or cultural landscapes. For SEGS, a setback is the minimum distance from a property line, right-of-way or other feature to a solar component such as a panel or inverter within a project's limit of disturbance.

Most buffering conditions require landscaping to be installed before the project becomes operational and to be effective in blocking views of and glare from the project after three to five years.

Coal Combustion By-products

In 2020, coal-fired power plants in Maryland generated approximately 460,000 tons of coal combustion by-products (CCBs), as reported to the MDE. The term CCBs includes several solid materials with different physical and chemical characteristics. The chemical characteristics of CCBs depend upon the nature of the coal burned, the method of combustion and the use of any emission control processes. Most power plants in Maryland burn bituminous coal from the eastern United States and produce Class F fly ash and bottom ash. Fly ash is composed of very fine, generally spherical, glassy particles that are fine enough to be transported from the furnace along with emission gases and are captured in electrostatic precipitators or baghouses. Bottom ash is composed of coarser, angular porous particles that are heavier and thus fall to the bottom of the furnace, where they are collected.

Manufacturing, civil engineering, mine restoration and agricultural applications can utilize CCBs when properly engineered and correctly applied. The beneficial use of

CCBs as raw materials in applications that are environmentally sound, technically safe and commercially competitive leads to a reduction in the disposal. Beneficial use of CCBs in Maryland historically included large-scale fill applications as in highway embankments and mine reclamation. Over time, the use of CCBs in encapsulated forms, such as cement, concrete and wallboard, has become more prevalent. In 2020, all beneficial use of Class F fly ash was for cement and concrete production. The vast majority of flue gas desulfurization (FGD) material was used for wallboard, though a very small amount was used for agriculture. Industry practice, technology, costs of natural materials, regulations and guidelines, public perception and demands for sustainability in the commercial marketplace drive these changes. The other beneficial use that was active in 2020 was coal mine reclamation. About 250,000 tons of alkaline CCBs material were used to reclaim surface coal mines in Western Maryland.

With over 90 percent of the state's annual production of CCBs currently being beneficially used, Maryland is well above the national utilization rate of 52 percent, as reported by the American Coal Ash Association for 2019. PPRP has supported research and demonstration projects for more than 35 years regarding the beneficial use of CCBs, particularly those applications that could use massive quantities of CCBs in encapsulated form.

For More Information…

If you want more information contact PPRP at (410) 260-8660 (toll-free number in Maryland, 1-877-620- 8DNR, x8660), or visit our website: dnr.maryland.gov/pprp. References are available upon request for all technical topics discussed in this report.

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