PPRP – CEIR – 18
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MARYLAND DEPARTMENT OF NATURAL RESOURCES

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

December 2016

MARYLAND POWER PLANT RESEARCH PROGRAM

Lawrence J. Hogan, Jr., Governor ♦ Boyd K. Rutherford, 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.

Mark J. Belton, Secretary
Maryland Department of Natural Resources

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Introduction

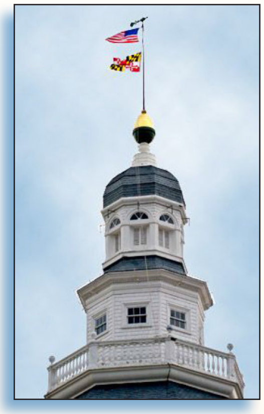
The Maryland Department of Natural Resources (DNR) Power Plant Research Program (PPRP) evaluates how the design, construction, and operation of power plants and transmission lines impact Maryland's environmental, socioeconomic, and cultural resources. PPRP's legislative mandate seeks to ensure that the 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 CEIR-18. The complete online report contains more detailed background on many topics and can be accessed from the PPRP website at pprp.info/ceir18/HTML/Chapter1.html.

Key Technical Issues Addressed by PPRP 1971 - 2016

1971



Power Plant Siting Act was passed by the Maryland legislature in 1971 to address potential effects on the Chesapeake Bay from the Calvert Cliffs Nuclear Power Plant as well as several major proposed coal-fired power plants. PPRP was created to ensure a comprehensive, objective evaluation, based on sound science, to resolve environmental and economic issues associated with building power generating facilities.

1975

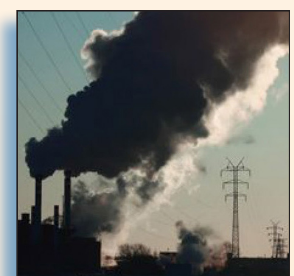
Aquatic impacts of power plants were identified due to entraining fish eggs, larvae, and/or prey organisms into their cooling systems, impinging adult and juvenile fish and crabs on intake screens, and discharging heat and chemicals into receiving waters. PPRP began testing intake designs that discourage fish congregation and determined in 1988 that impingement and entrainment could be reduced to acceptable levels, not adversely affecting aquatic biota in Maryland's surface water bodies. PPRP later evaluated methods such as barrier nets and wedge-wire screens that have become widely used for reducing impingement and entrainment levels at power plants.

1975

PPRP established the radioecology program and initiated radiological assessment of the Calvert Cliffs Nuclear Power Plant. In the aftermath of the Three Mile Island accident in 1979, the U.S. Nuclear Regulatory Commission requested PPRP's assistance in evaluating impacts to human health and the environment from radioactivity released during the event and its cleanup. The ongoing monitoring program expanded to cover the Peach Bottom Atomic Power Station in Pennsylvania, just upstream from Conowingo Dam on the Susquehanna River, in 1981. Over the past 40 years, the radioecology program has developed a valuable long-term database of radionuclide fate and transport throughout the Bay ecosystem.

1978

Clean Air Act Amendments of 1977 included provisions for the Prevention of Significant Deterioration (PSD) and non-attainment areas stringent regulations that affected every U.S. major power plant project. PPRP recommended forming a policy board, establishing an offset bank exchange, and creating a multi-state planning council to share information and resolve disputes between states. On an ongoing basis, continuing with the Clean Air Act Amendments of 1990 and Maryland's Healthy Air Act of 2006, PPRP has analyzed compliance alternatives for the state's power plants and helped provide State agencies and lawmakers with technical background to support policy decisions.



1970s

1982

Coal-fired power plant operations create large quantities of solid combustion products, primarily fly ash, which need to be managed. While reuse is desired, some quantity of waste must be landfilled. PPRP conducted the first survey of CCB management methods across the state, a landmark first step in developing a thorough technical basis for evaluating, minimizing, and mitigating potential adverse impacts.

1984

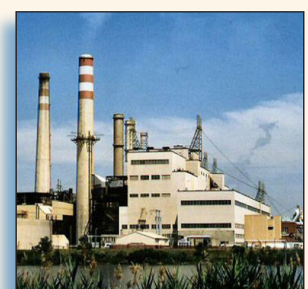
Sulfur and nitrogen emissions generated by power plants were identified as a large contributor to the formation of acid rain in the Northeast and Maryland. PPRP funded significant research to determine the extent of the problem and to identify remedial actions.

1985

Aquatic impacts such as denied access of anadromous fish to upstream spawning areas were observed at main stem Susquehanna hydroelectric dams. As the State lead, PPRP worked with Pennsylvania agencies, federal agencies, and private intervenors to address both fish passage and water quality in the federal relicensing of Conowingo and other dams on the Susquehanna. The first fish passage facility on the Susquehanna began operating in 1985. An additional stretch of more than 400 miles of the river is now open to migratory fish as a result of these settlement agreements reached with power companies seeking to renew their federal licenses.

1992

As an outcome of PPRP's evaluation of aquatic impacts from large-volume water withdrawals at all of Maryland's power plants, BGE and PEPCO were required to conduct additional studies on long-term impacts at the Calvert Cliffs, Chalk Point, Dickerson, and Wagner power plants. In addition, PEPCO established a fish hatchery operation on the Patuxent River estuary. From 1992 to 1997, the hatchery produced 3.5 million juvenile striped bass and 750,000 shad to mitigate losses caused by the power plant's intake of cooling water. PEPCO also provided the State with $100,000 per year for five years to fund environmental education and support projects to remove passage obstructions for anadromous fish.



1993

The effects of electromagnetic fields (EMFs) associated with generating, transmitting, distributing, and using electric power were evaluated and studies revealed conflicting results. PPRP reviewed all EMF studies and provided annual summary reports to the PSC on significant findings. Utilities constructing transmission lines have agreed to protocols for EMF measurements as well as utilization of conductor configurations resulting in the lowest EMF field strengths.

1980s and 1990s

1995

PPRP and MDE Bureau of Mines initiated an extensive program to address the problems of acid mine drainage as well as disposal of coal combustion byproducts. The Winding Ridge project demonstrated the feasibility of using 100 percent waste products — fly ash plus by-product from sulfur dioxide removal —to seal an abandoned underground mine and minimize acidic discharges to surface water ecosystems.

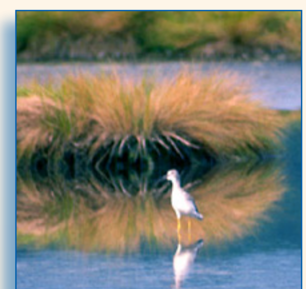
1996

PPRP joined the Maryland Geological Survey and the U.S. Geological Survey in operating ground water monitoring programs to track water levels in affected aquifers over time, in response to increasing public awareness of ground water withdrawal by Maryland power plants from several coastal aquifers.

1997

As part of the CPCN licensing process, Panda Energy agreed to use treated effluent from the Mattawoman Wastewater Treatment Facility as a source of 1.5 million gallons per day of cooling water at its combined cycle plant in Brandywine, following PPRP's technical evaluations to demonstrate safety and feasibility. This approach, the first use of treated effluent for power plant cooling water in the state, conserves ground water resources in Southern Maryland, and has helped generate operational data for other Maryland power plant proposals. Reclaimed wastewater is now also used as scrubber makeup water at the Brandon Shores power plant.

1990s



Beginning in the 1990s with state-of-the-art modeling and monitoring studies, PPRP has a long and successful track record of sponsoring critical research on the impacts to the Chesapeake Bay watershed from atmospheric deposition of nitrogen and mercury (Hg). Fossil fuel-fired power plants are significant contributors of nitrogen oxides (NO_x) and Hg emissions. PPRP has developed innovative dispersion modeling techniques, and shared these approaches with other states. In addition to modeling efforts, the State conducts a range of air and water monitoring programs to evaluate nitrogen and mercury impacts across the Bay watershed.

2000

The Maryland legislature introduced electricity competition. PPRP studied the potential environmental and economic impacts of restructuring and, over the next few years, observed that low utility rate freezes were limiting the development of a competitive retail market in Maryland.

1995-2000

2003

Initial federal regulations came into force, under Section 316(b) of the Clean Water Act, intended to minimize aquatic impacts from large-volume surface water withdrawals at power plants. New requirements for power plant cooling water withdrawals were phased in over several years, and legal challenges have also affected the timing of implementation. PPRP followed these regulatory developments closely and evaluated how the new rules would impact Maryland power plants.

2006

Maryland passed the Healthy Air Act, a comprehensive regulatory program to reduce emissions and improve air quality in the state and the region. During 2006-07, PPRP completed expedited licensing reviews of substantial air pollution control projects at Maryland's coal-fired plants. PPRP has done subsequent modeling to assess the air quality benefits of implementing the Healthy Air Act.

2008

Increasing concerns about the long-term reliability of the electricity supply in the state and surrounding region resulted in numerous proposals for transmission line projects. These included two major interstate transmission lines — PATH and MAPP — that would have traversed parts of Maryland, as well as many new or upgraded transmission lines located within the state. PPRP was actively involved in evaluating potential environmental and socioeconomic impacts of these proposed linear facilities. While the PATH and MAPP interstate projects were later canceled due to changing economic conditions (and a slowdown in electricity demand growth), significant evaluations were conducted regarding the potential undersea cable crossing of the Chesapeake Bay and other project elements.

2009

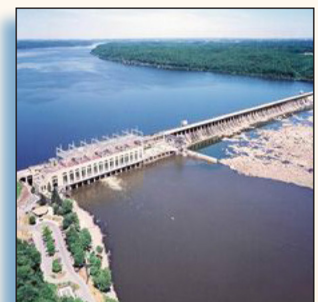
Maryland's Public Service Commission granted a CPCN to UniStar for the construction of Calvert Cliffs Unit 3, a 1600 MW nuclear power plant proposed for the existing Calvert Cliffs site. PPRP coordinated the State's review of all relevant environmental and socioeconomic issues associated with the Calvert Cliffs expansion, and assisted the U.S. Nuclear Regulatory Commission (NRC) in its evaluation as well. The proposed expansion did not ultimately receive NRC approval. Over the past four decades, PPRP has carried out several important technical projects related to Calvert Cliffs, including review of the NRC operating license renewal for existing Units 1 and 2; assessment of risks posed to Calvert Cliffs by expanded operations at the nearby Cove Point LNG terminal; and participation in license renewal evaluation for the existing on-site storage facility for spent nuclear fuel.

2000s

2010

Then-Governor Martin O'Malley directed PPRP to prepare a comprehensive report evaluating approaches to meet Maryland's long-term electricity needs. PPRP conducted a thorough assessment under an array of alternative future economic, legislative, and market conditions, considering such variables as natural gas prices and climate change impacts (among many others). PPRP is currently preparing an updated LTER with energy projections through 2035, scheduled for publication in December 2016, as required under the initial mandate.

2012



Exelon filed its application to renew its federal license for Conowingo Hydroelectric facility operations on the Susquehanna River. PPRP is participating in the scoping of necessary studies and analysis of the findings, as well as providing technical support regarding fish passage and downstream flows. These efforts build upon the long-term collaborative work PPRP has done to support enhanced fish passage at Conowingo and other Susquehanna hydroelectric facilities (see timeline entry for 1985). The current license renewal evaluation is also addressing new impact issues, most notably the buildup of sediment behind the Conowingo Dam and the implications for natural resources and dam operations.

2010

The Clean Air Act established the concept of National Ambient Air Quality Standards (NAAQS) — concentration limits of pollutants in the air established by EPA to be protective of health and welfare. In 2010, EPA established more stringent ambient standards for sulfur dioxide (SO_2) and nitrogen dioxide (NO_2), two by-products of combustion emitted by fossil fuel-fired power plants. PPRP developed innovative approaches to evaluate the impacts of power plants emissions on the NO_2 and SO_2 NAAQS as part of the CPCN review process, allowing the State and EPA to ensure that regional quality is maintained as developers build new or modify existing power plants in Maryland.

2013

Maryland PSC received new or modified applications for five proposed gas-fired power plants, reflecting the predominant shift across the power industry toward natural gas as a primary fuel for generation. Dominion also applied for PSC approval to construct 130 MW of onsite generating capacity as part of its plans to begin exporting LNG from its Cove Point terminal. PPRP utilized its technical expertise and coordinated effectively with other State agencies to provide thorough and rigorous technical review of all these applications.

2013

Source: National Renewable Energy Laboratory. Artist: Josh Bauer

With the passage of the Maryland Offshore Wind Energy Act by the General Assembly, the State took a major step toward harnessing ocean winds as a renewable energy resource. The law's implementation has led to the leasing of an offshore wind area in federal waters off the coast of Maryland with the federal Bureau of Ocean Energy Management serving as lead permitting agency. State agencies have been undertaking geotechnical, environmental, archaeological, and socioeconomic assessments of the site and associated onshore infrastructure needs. PPRP is providing assistance in natural resource impact assessment.

2014

Southern Maryland Electric Cooperative (SMECO) completed the Southern Maryland Reliability Project, a 30-mile, 230 kV transmission system upgrade. One of the most significant components of the project was the crossing under the Patuxent River — 4,800 feet of horizontal directional drill installation under the river from the Naval Recreation Center in Calvert County to Town Creek in St. Mary's County. To ensure protection of the river's resources, PPRP, in coordination with other State agencies, utilized its technical expertise to review all aspects of the drilling project.

2014

The U.S. EPA released new regulations addressing the management of coal combustion by-products (CCBs). The rule establishes minimum federal requirements for both existing and new CCB landfills and surface impoundments, including expansions of any existing unit. PPRP and MDE are examining the new rules, which took effect in October 2015, to determine whether they will impact the landfilling and beneficial use of CCBs in Maryland.

2014

Final federal 316(b) rules came into effect for aquatic resource protection — addressing technical issues that PPRP has been working on since 1975. These new requirements for power plant cooling water withdrawals were issued after several years of legal challenges. PPRP participated in these regulatory developments and is working with MDE and Maryland power plants to implement the new regulations.

2016

Maryland's first wind turbines came online in 2010 — the Criterion and Roth Rock projects. As of 2016, two additional wind turbine projects have come online — the Fair Wind Power and Fourmile Ridge projects. All four projects are located along the western Maryland ridgeline known as Backbone Mountain. PPRP took an active role in reviewing plans for all four of these facilities, especially the potential for adverse impacts to bird and bat populations in the vicinity of these sites.

2016

In 2011, PPRP coordinated the State's review of Maryland Solar's proposed 20 MW project in Hagerstown. The PSC granted a CPCN for this project, the first utility-scale solar electrical generating facility in the state. Maryland's goal of supplying 2 percent of the state's electricity from solar resources by 2022 has spurred significant interest in solar power development. As of November 2016, Maryland has more than 65 MW of utility-scale solar generating capacity in operation; additional projects totaling 82.5 MW of capacity have received CPCNs and are under development, while roughly 78.4 MW are under review.

2010 and Beyond

See Chapter 2 of CEIR-18

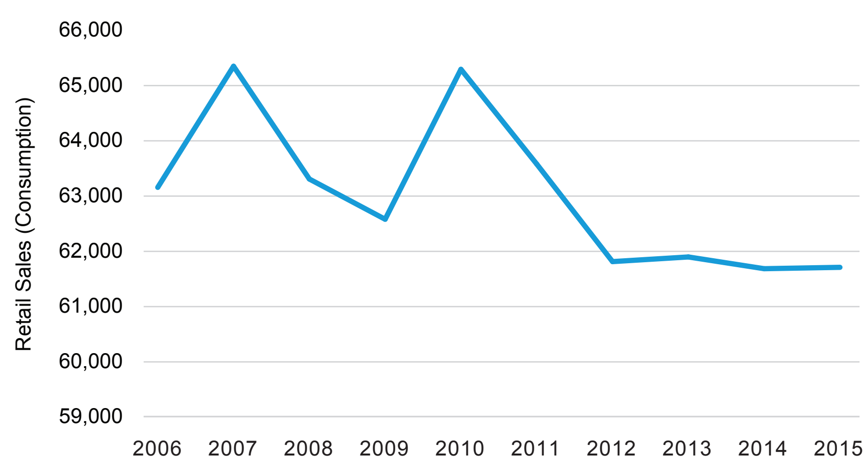
Power Generation, Transmission, and Use

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. Currently in Maryland, 55 power plants with generation capacities greater than 2 megawatts (MW) are interconnected to the regional transmission grid. For more information on electricity in Maryland and full content of the Electricity in Maryland Fact Book for 2014, go to http://pprp.info/factbook/factbook.htm.

Electricity Demand

Maryland end-use customers consumed about 62 million megawatt-hours (MWh) of electricity during 2015. Between 2006 and 2015, electricity consumption in Maryland declined by 2.3 percent (see Figure 1). Over that period, the annual average growth rate in electricity consumption in Maryland was lower than in the U.S. as a whole—negative 0.97 percent in Maryland versus 0.23 percent in the U.S.

Figure 1 Maryland Electricity Consumption 2006-2015

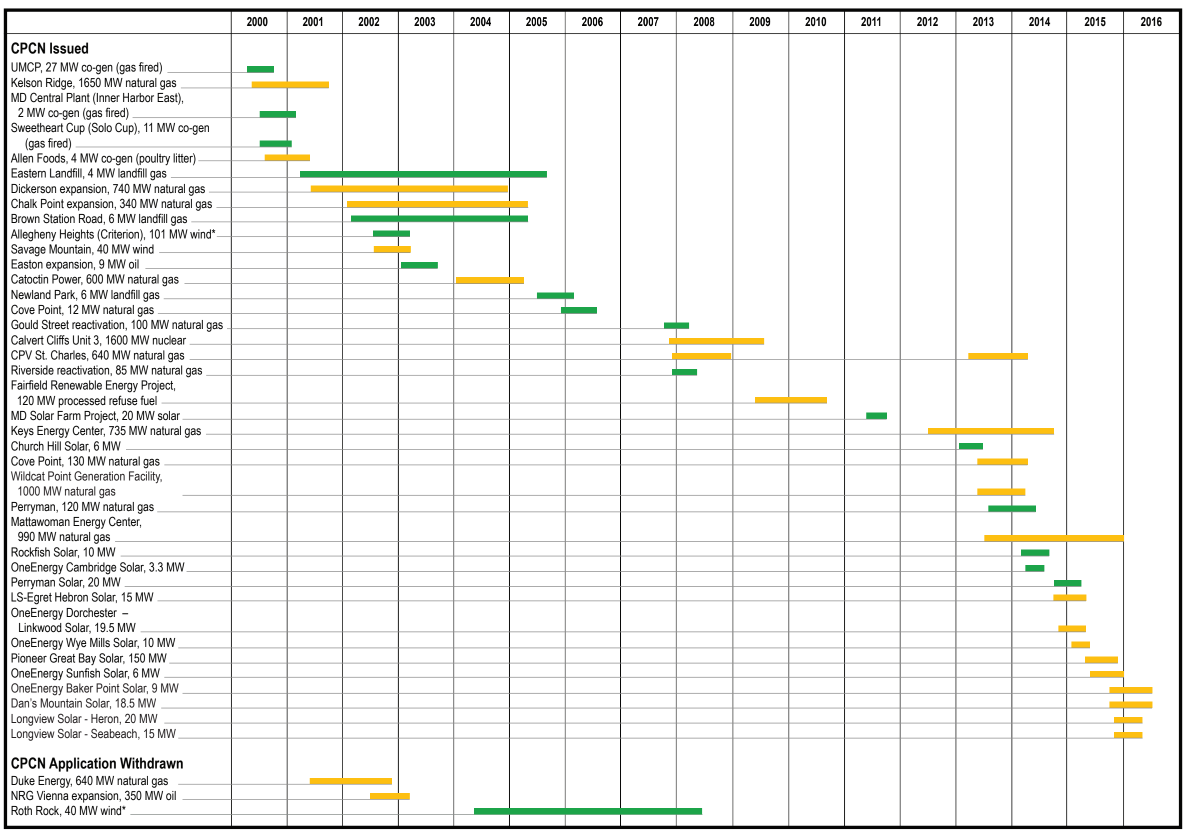


The economic recession that began in 2008 resulted in a downward trend for electricity consumption in Maryland. While Maryland was not as seriously affected by the recession as many other states, it was not immune to the higher unemployment levels and lower levels of economic activity generally. As the economy began to recover in 2010, electricity consumption also increased. Since 2010, electricity consumption has fallen more, largely due to the impact of the EmPOWER Maryland legislation. This law targeted a 15 percent reduction in per capita electricity consumption by 2015 from 2007 levels. Recent reductions in electricity consumption (2013-2015) in Maryland have been outpacing those in the United States across all non-residential sectors. Electricity consumption is discussed further in Section 2.5 of the CEIR-18 web-based report. For more information about EmPOWER Maryland, refer to Section 5.1.2.

Power Plant Licensing Activity

Since the start of 2015, the Maryland Public Service Commission (PSC) has received 17 Certificate of Public Convenience and Necessity (CPCN) applications from developers of proposed new generating facilities - an unprecedented level of licensing activity. Over the past 16 years, the PSC has received 52 CPCN applications for new generation, representing several thousand megawatts of potential generating capacity at existing facilities and at greenfield sites, with several application reviews ongoing (see Figure 2).

Figure 2 CPCN Requests, 2000 through 2016



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 (green)
= Project is not operational (yellow)

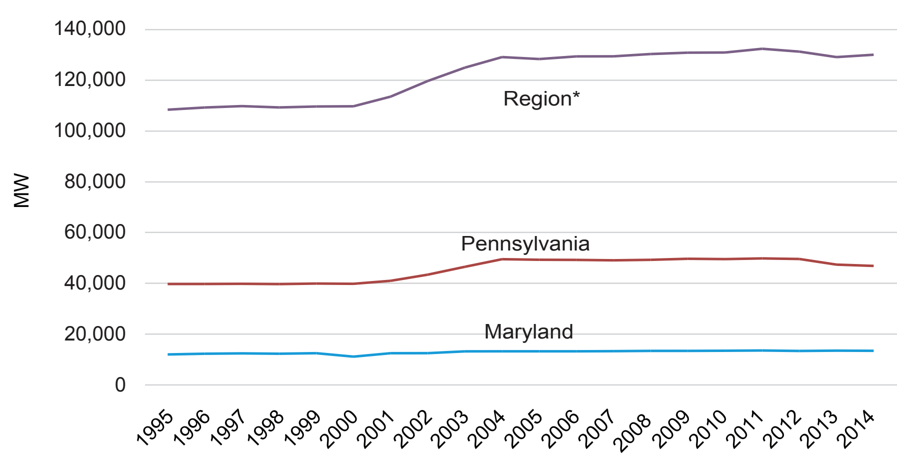
* Project was subsequently reconfigured, granted a CPCN exemption, and is now operational. See Section 2.1.5 for more information.

Chart does not reflect CPCN cases ongoing as of September 2016: OneEnergy Blue Star Solar, OneEnergy Ibis Solar, Pinesburg Solar, Big Spring Solar, Massey Solar, Perennial Solar, Gateway Solar, Mills Branch Solar, Todd Solar, and Dan's Mountain Wind Force.

While the majority of these proposed plants did obtain a CPCN, only 18 are now in operation, with the remainder under construction or being delayed or canceled because of various financial or commercial reasons, compounded by the reduction in electricity demand resulting from the economic recession and state energy efficiency initiatives in PJM Interconnection, LLC (PJM). Maryland has seen a sharp increase in utility-scale solar projects in recent years. Developers are proposing these solar projects to capitalize on Maryland state tax incentives and support the Maryland Renewable Energy Portfolio Standard (see Solar discussion in Section 2.1.5).

The process by which new power plants are proposed and developed in Maryland has changed as a result of the move to retail competition and electric utility restructuring. Maryland's regulated utilities are no longer responsible for building new generation. Resource planning resides with the competitive electricity market, driven by economics and price signals. High prices that result from tight supply markets are expected to attract investors, developers, and demand response providers; low prices that result from over-supplied markets are projected to discourage new generation development and demand response providers. However, substantial and sustained price differentials are required to elicit such market behaviors. The up-and-down movement of wholesale prices in PJM has resulted in a "boom-bust" cycle in the development of new generating plants in PJM. This trend produces a situation where many power plants are proposed and built in a short time frame followed by a period where few plants are built. Figure 2 demonstrates the recent increase in the number of CPCN requests in Maryland after a multi-year period with relatively few open applications. Figure 3 shows the amount of capacity on-line for Maryland, Pennsylvania, and the region.

Figure 3 Maryland and Regional Capacity



* Region includes Delaware, Maryland, New Jersey, Pennsylvania, Virginia, Washington, D.C., and West Virginia.

Renewable Energy

Presently, there are four main types of renewable energy resources in use in Maryland: wind, waste-to-energy, solar, and hydropower. Approximately 1,458 MW of generation capacity in Maryland comes from these resources, with hydroelectric accounting for the largest share (see Figure 4).

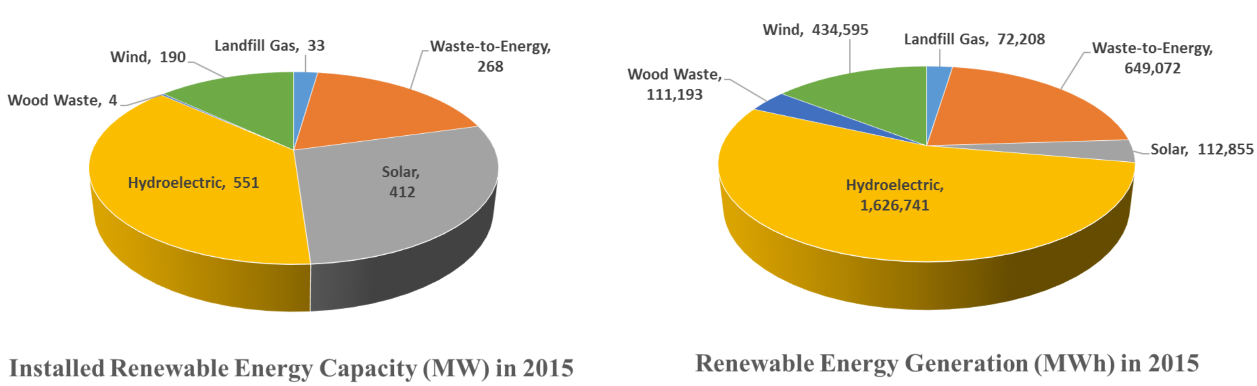
The Maryland Renewable Energy Portfolio Standard (RPS) was enacted in May 2004. The RPS requires retail electrical suppliers to provide a specified percentage of their electricity deliveries from Maryland-certified Tier 1 and Tier 2 renewable resources. Every megawatt-hour generated by qualified renewable resources is eligible to be registered as one Maryland-certified Renewable Energy Credit (REC). Eligible RECs may come from a certified renewable energy facility that is either located within PJM or delivers electricity into PJM.

The 2004 RPS law was modified by legislation six times from 2007 through 2013 to effectuate change in qualifying resources, the percentage requirements, and other aspects of the statute. The current RPS law contains the following provisions:

- *Tier 1 renewable resources include fuel cells that produce electricity from other Tier 1 renewable fuel resources, geothermal, hydroelectric facilities under 30 MW, methane, ocean, poultry litter-to-energy, qualifying biomass, solar, wind, waste-to-energy, and refuse-derived fuel. The Tier 1 requirement began at 2 percent and increases annually; in 2013 it was 7.95 percent, and will reach its 20 percent maximum in 2022.*

- *The solar energy set-aside requires that a specified percentage of energy supply must come from solar facilities located in Maryland. This requirement increases annually to reach 2 percent in 2020. The 2 percent solar requirement is part of the Tier 1 overall 20 percent requirement.*

Figure 4 Renewable Energy in Maryland, as of 2015

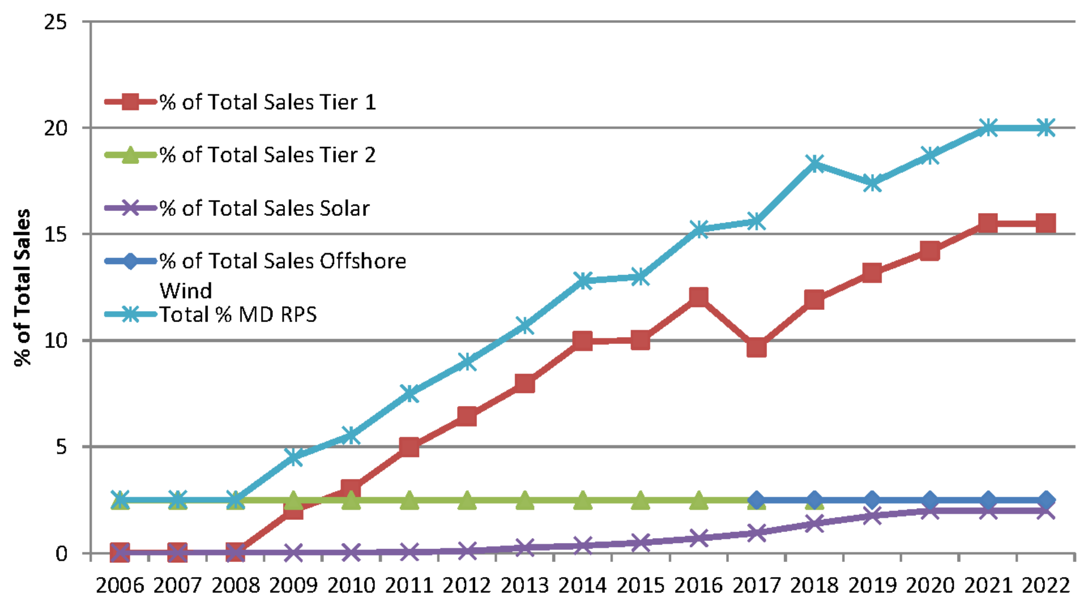


Note: Solar capacity includes both utility-scale and rooftop solar. Solar generation does not include rooftop solar.

- *Existing hydroelectric facilities over 30 MW qualify to meet the Tier 2 standard. Tier 1 resources may also be used to meet the 2.5 percent Tier 2 standard. Tier 2 will sunset in 2018.*
- *The Maryland Offshore Wind Energy Act, which was passed in 2013, created a new set-aside for offshore wind facilities. Each year, the PSC will set the percentage of offshore energy to be mandated in the RPS based on the projected annual output from qualified and approved offshore wind projects. This percentage may not exceed 2.5 percent of total retail sales.*

Figure 5 illustrates the renewable sources that are required for the RPS, shown as a percentage of total energy sales over time.

Figure 5 Maryland RPS Summary, 2006-2022

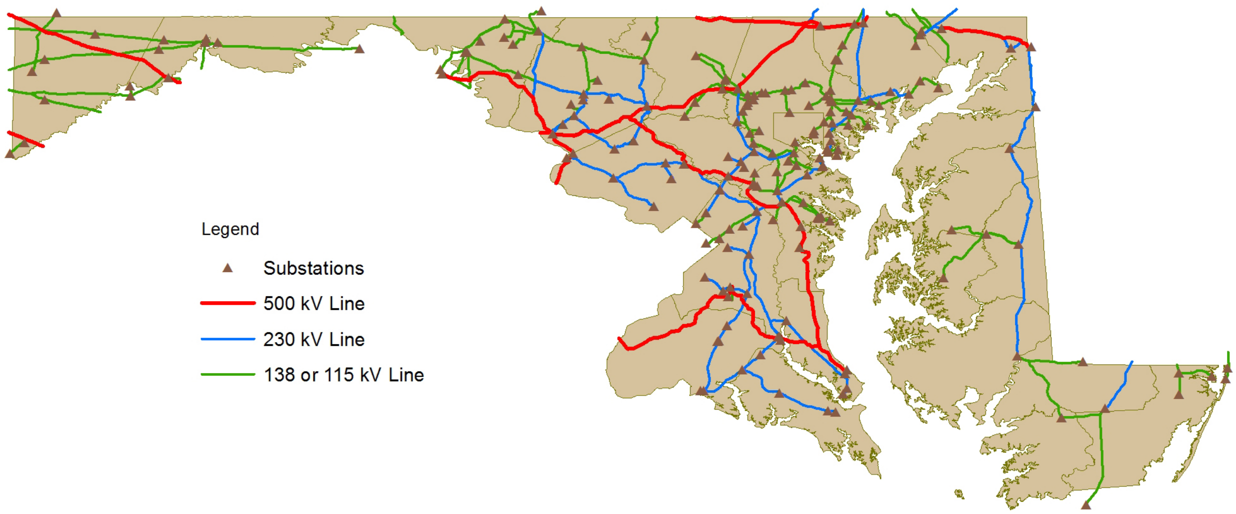


Electricity Transmission

The network of high-voltage lines, transformers, and other equipment that connect power generating facilities to distribution systems are part of an expansive electric transmission system. In Maryland, there are more than 2,000 miles of transmission lines operating at voltages between 115 kV and 500 kV. Figure 6 shows a map of this high-voltage transmission grid in Maryland.

While the economic and environmental effects of generation are substantial, transmission also has major environmental and socioeconomic implications in Maryland, particularly since Maryland is a net importer of electricity. Building new transmission facilities is costly with significant environmental impacts and ratepayer costs. Upgrading existing heavily used facilities must be done quickly, often in short

Figure 6 Transmission Lines in Maryland (>115 kV)



windows of time, while minimizing environmental impacts. Shortages of transmission capacity or congestion can lead to higher priced out-of-merit generation dispatch and extremely high energy and capacity prices over peak time periods.

PJM has operational control over and planning responsibility for most of 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 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, there is an expectation that the transmission owner will file for a CPCN seeking permission to construct the proposed transmission line.

The PSC has received two CPCN applications for new and modified transmission line projects since early 2014. Delmarva Power proposed both of these new projects.

- ***Church to Steele*** *is a rebuild of an existing 138 kV transmission line from the Church Substation in Queen Anne's County to the Steele Substation in Caroline County. The Church to Steele project received CPCN approval from the PSC in 2015.*

- ***Piney Grove to State Line*** *is a new 138 kV line of about 25 miles in Maryland. It begins at the Piney Grove Substation in Wicomico County and terminates at the Maryland/Delaware state line. The entire project extends to the Wattsville Substation in Virginia. PPRP has completed its review of the portion in Maryland; the PSC issued a Final Order in November 2016, giving Delmarva Power its CPCN for the project.*

Transmission planning and regulatory drivers, as well as oversight, are described in Section 3.3.

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 the FERC. The Energy Policy Act of 2005 requires electricity market participants to comply with NERC reliability standards, or be 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 that serves the PJM RTO.

One of the NERC reliability standards applicable to PJM is the Resource Planning Reserve Requirement. This standard requires that each load serving entity (LSE) participating in PJM have sufficient resources such that there is no loss of load more than one day in ten years. In order to maintain compliance under this reliability standard, PJM conducts annual resource planning exercises to ensure all LSEs have sufficient generation resources (either owned or contracted) to supply their peak electricity load, plus a specified annual reserve margin of approximately 15 percent.

Being able to detect outages during storms or during normal operations has been a challenge for utilities. Historically, utilities have relied on customers to report local outages. With the advent of new technologies, being able to "see" conditions on the distribution grid in real-time is becoming a reality. Maryland utilities with PSC-approved advanced metering infrastructure (AMI) plans have either finished installing or are in the process of installing AMI in their respective service territories. While AMI allows for electronic reading of customer meter information, the communication network created by the advanced meters also serves to provide much needed information on the current status of the distribution grid. (For more information on AMI and smart grid capability, see Section 5.5.3.)

In December 2015, the PSC adopted regulations that established numerical reliability standards in terms of allowable number of outage minutes for calendar years 2016 through 2019.

Markets and Pricing

See Chapter 3 and Appendix B of CEIR-18

Energy prices in PJM are based upon the bids designating a price and quantity at which a generator is willing to sell electricity. PJM stacks these bids from lowest price to highest price until it is able to 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 LMP.

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.

Historically, coal plants were the least-cost generators due to the long-term availability of low-cost coal as a fuel, as well as the economies of scale arising from the construction of large, baseload coal plants. However, over the last several years natural gas has increasingly been used in place of coal for baseload generation. Shale gas discoveries in the United States have increased natural gas supplies, which in turn have led to sharp decreases in wholesale natural gas prices. The decrease in wholesale prices has trickled down into reductions in wholesale electricity price and, subsequently, retail electricity prices. These conditions are expected to continue since natural gas supplies are plentiful and wholesale natural gas prices are expected to remain low for the next decade.

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 fire natural gas. PJM's Market Monitor reports that approximately 23,700 MW of coal, oil, and older natural gas plants have retired within the PJM footprint between the beginning of 2011 and the end of 2015, with another approximately 3,300 MW expected to retire by the end of 2020. PJM does not expect these retirements to result in degraded reliability since there is currently excess generating capacity in PJM.

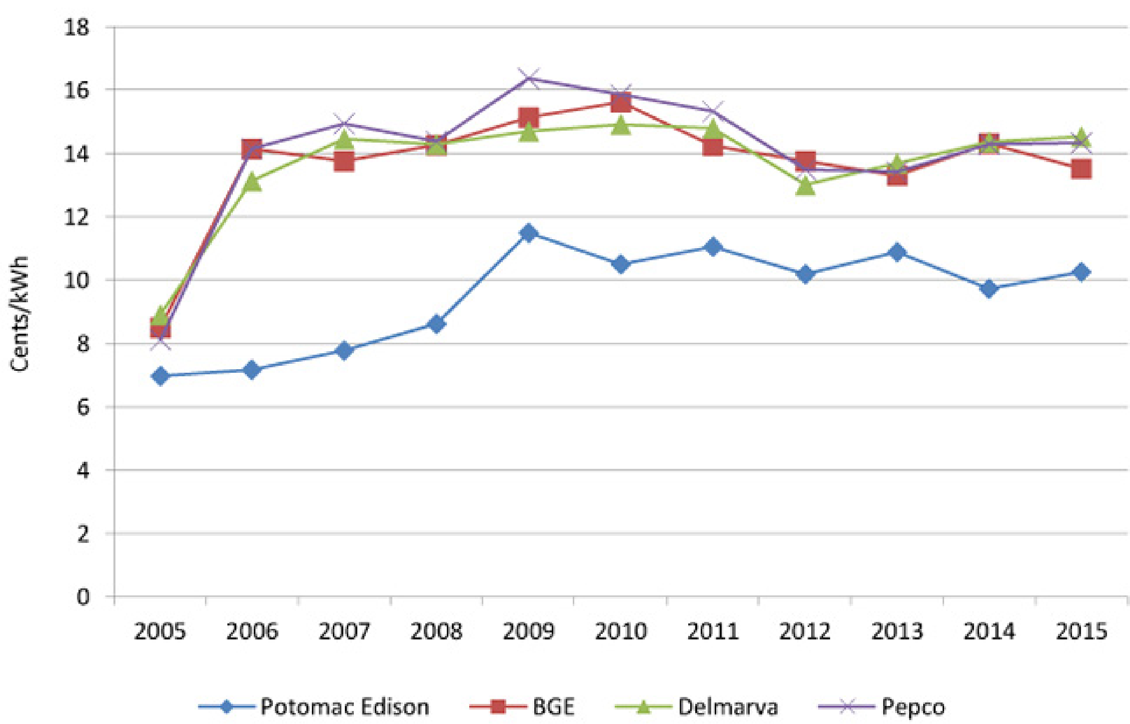
The distribution of electricity continues to be a regulated monopoly function of the local utility, and hence continues to be subject to price regulation by the Maryland PSC. The fundamental objective of the 1999 Maryland Electric Customer Choice and Competition Act (the Act) was to foster retail electric competition as a means of achieving favorable retail electricity prices for customers, stimulating an array of alternative supply products (for example, green power products and innovative rate design options), and giving customers a choice in their electric power supplier. Maryland's competitive market did not develop as rapidly as envisioned when the legislation was adopted. At the beginning of 2009, ten years after the Act's enactment, only 2.8 percent of residential customers were being served by competitive suppliers. By January 2016, however, 22.3 percent of residential customers had signed with competitive suppliers. The majority of medium to large commercial and industrial customers are currently purchasing electricity from competitive suppliers (see Table 1).

Table 1 Percentage of Maryland Customers Served by Competitive Suppliers

Residential	Small Commercial & Industrial	Mid-size Commercial & Industrial	Large Commercial & Industrial
22.3%	33.1%	59.9%	92.2%

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. Forward market prices have remained relatively stable since 2012. Figure 7 shows the average annual residential rates in effect in the summer of 2005 and for each subsequent summer.

Figure 7 Average Annual Retail Electricity Rates for Maryland Residential Customers, 2005-2015 (cents/kWh)



Air Quality

See Section 4.1 of CEIR-18

Emissions

Power plants in the U.S. are a major source of air emissions. According to the report Benchmarking Air Emissions of the 100 Largest Electric Power Producers in the United States, power plants in the U.S. contribute about 13 percent of all nitrogen oxide (NO_x), 63 percent of sulfur dioxide (SO_2), 38 percent of mercury, and about 61 percent of carbon dioxide (CO_2) emissions emitted by the industrial sector, including transportation (based on 2013, the most recently published emissions data). Air emissions are often discussed in terms of three classes of pollutants: criteria pollutants, hazardous air pollutants (HAPs), and greenhouse gases (GHGs).

The Clean Air Act authorized the Environmental Protection Agency (EPA) to develop ambient air quality standards for six common air pollutants, referred to as "criteria pollutants:" NO_x, SO_2, particulate matter (PM), carbon monoxide (CO), lead, and ozone (O_3). Of the criteria pollutants, SO_2 and NO_x are among the most stringently regulated by EPA because they are the principal pollutants that react with water vapor and other chemicals in the atmosphere to create ozone smog, cause acid precipitation, and impair visibility. Recently, there has also been an increased focus on particulate matter (PM) emissions, both particulate matter less than 10 microns (PM10) and particulate matter less than 2.5 microns (PM2.5), as EPA has recognized that particulates are associated with adverse health effects, including premature mortality, cardiovascular illness, and respiratory illness. EPA continually attempts to better understand which attributes of particles may cause these health effects, who may be most susceptible to their effects, how people are exposed to PM air pollution, how particles form in the atmosphere, and what sources in different regions of the country contribute to PM. This research has allowed EPA to hone its focus over time from regulating emissions of total suspended particulates to PM10 and PM2.5.

Power plants, specifically coal-fired units, are significant contributors of SO_2, NO_x, PM10, PM2.5, and GHG emissions nationwide and in Maryland (GHG emissions are discussed in the Climate Change section; see page 22 of this summary report). Figures 8 and 9 show trends in SO_2 and NO_x emissions, respectively, from power plants with coal-fired units in Maryland during the years 2009 to 2014. Figures 10 and 11 show trends in PM10 and PM2.5 during the same period.

Reducing Emissions from Coal-Fired Generation

Emissions of SO_2, PM10, and PM2.5 are dependent on the types and amounts of coal combusted at specific generating units and the type, age, and configuration of any air pollution control equipment. Most coal-fired power plants in Maryland installed state-of-the-art pollution control systems to meet requirements of the Maryland Healthy Air Act (HAA) in the late 2000s. Use of add-on control technologies, with efficient combustion and limits on sulfur content of fuels, are resulting in a decline in PM and SO_2 emissions since 2009. Note that some of the fluctuations in emissions seen from year to year are attributable in part to changes in fuel consumption rates caused by variations in power demand.

Annual emissions of NO_x also depend on the types and amounts of coal burned and pollution control systems in place. However, unlike SO_2 and PM emissions, NO_x emissions have been regulated more stringently and for a longer period of time, and so there was a less remarkable decrease with implementation of the HAA. NO_x emissions from power plants have been declining in previous years due to installation of control equipment and process changes. Like SO_x and PM emissions, some fluctuation in emissions is seen throughout the year as a result of changes in fuel consumption. Various other factors affect facility emissions throughput the years, including the control type and usage.

Figure 8 Annual SO_2 Emissions from Coal-fired Power Plants in Maryland

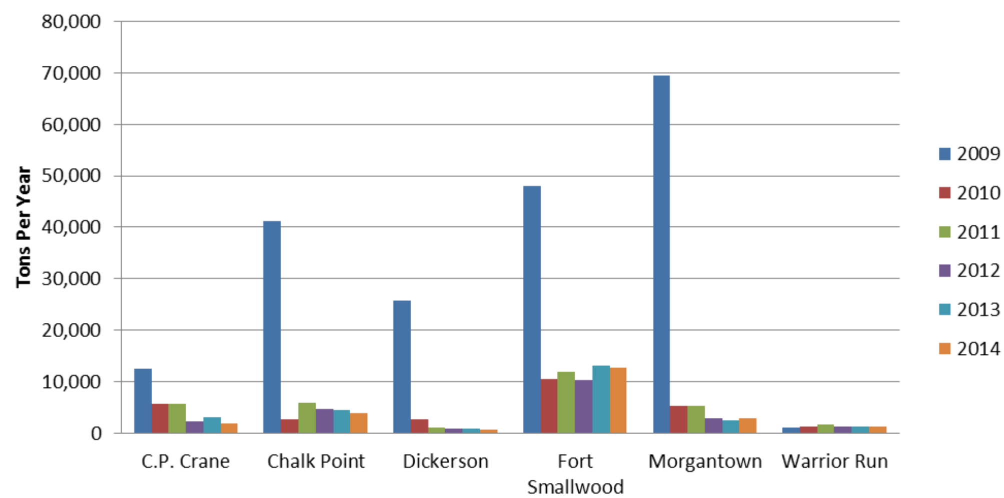
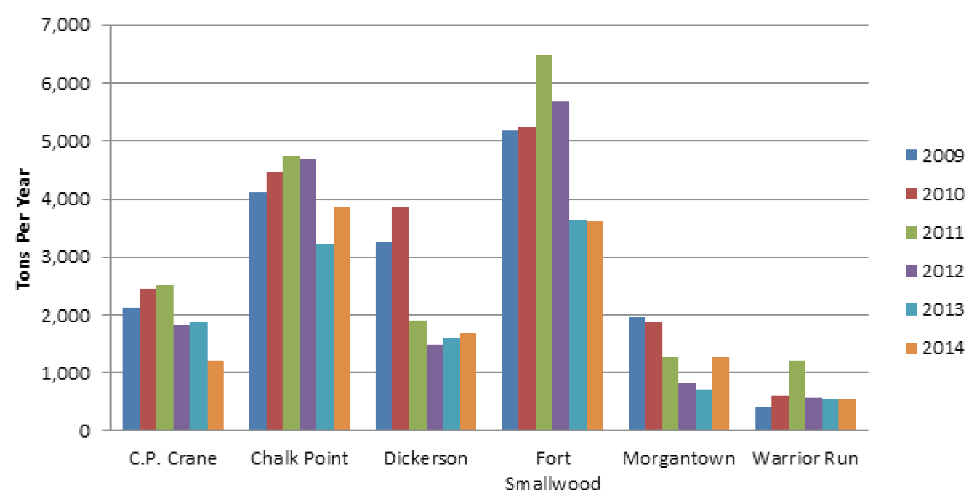


Figure 9 Annual NO_x Emissions from Coal-fired Power Plants in Maryland



Note: Fort Smallwood consists of Brandon Shores and Wagner power plants.

Figure 10 Annual PM10 Emissions from Coal-fired Power Plants in Maryland

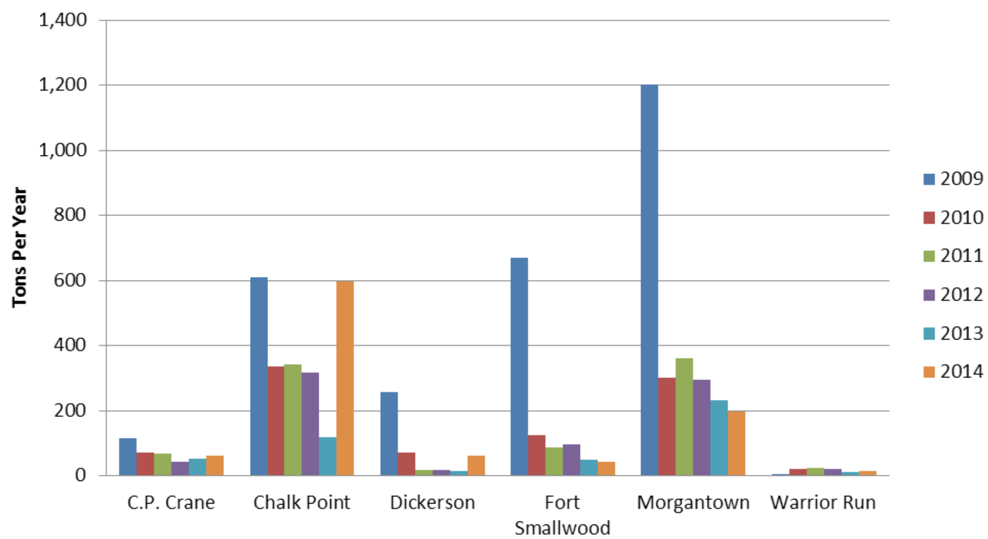
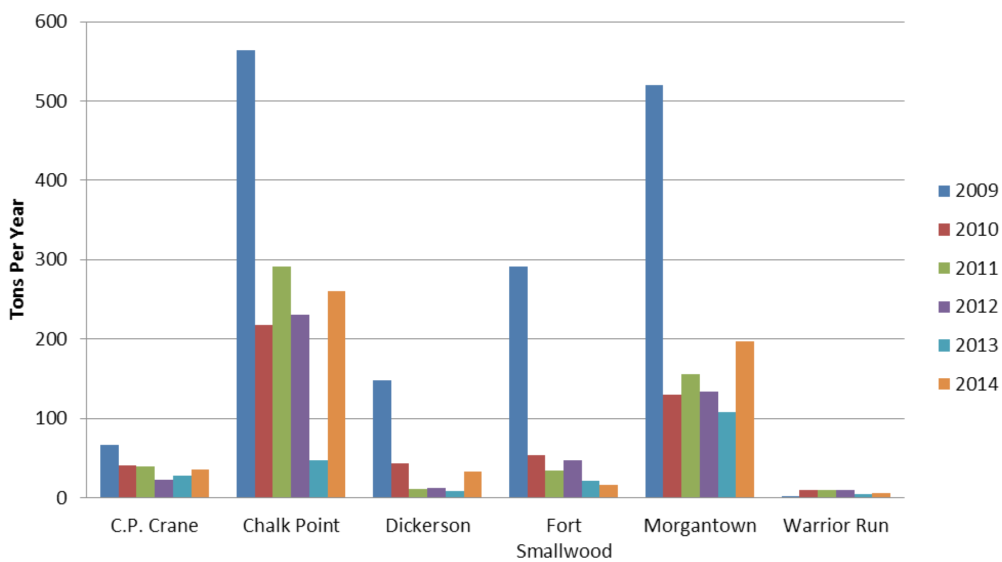


Figure 11 Annual PM2.5 Emissions from Coal-fired Power Plants in Maryland



Note: Fort Smallwood consists of Brandon Shores and Wagner power plants.

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.

- ***Acid rain*** *- Occurs when precursor pollutants, NO_x and SO_2, react with water and oxidants in the atmosphere to form acidic compounds. These acidic compounds are deposited with precipitation ("acid rain") or as dry particles ("dry deposition"), acidifying lakes and streams, harming forest and coastal ecosystems, and damaging man-made structures.*

- ***Ozone*** *- An invisible and reactive gas that is the major component of photochemical smog. It is not emitted directly into the atmosphere in significant amounts but 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 VOCs from industrial, chemical, and petroleum facilities and from natural sources — react in the presence of sunlight and elevated temperatures.*

- ***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. PM2.5 is the principal air pollutant associated with visibility impairment.*

- ***Nitrogen Deposition*** *- Excess nitrogen is one of the major sources of eutrophication — caused by the increase of chemical nutrients, typically containing nitrogen or phosphorus — 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 Chesapeake Bay Program estimates that approximately 30 percent of the nitrogen load to the 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. Increased efforts have been devoted recently to the role of ammonia in deposition processes.*

- ***Mercury*** *- A pollutant of particular concern because of its significant adverse health effects. Due to the significance of power plant mercury emissions (including emissions from out-of-state sources), PPRP plays a significant 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.*

Recent regulatory developments have focused on controlling emissions of hazardous air pollutants such as mercury and other compounds from power plants. More information on these rulemakings can be found in Section 4.1.4.

Climate Change

See Section 5.2 of CEIR-18

A greenhouse gas (GHG) is broadly defined as any gas that absorbs infrared radiation in the atmosphere. The pollutant "GHG," as defined in federal air regulations (40 CFR Part 51.21), is the aggregate of six greenhouse gas compounds: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). EPA issued a Greenhouse Gas Reporting Rule and other regulations that address GHGs. The principal GHGs that enter the atmosphere due to human activities are:

- *Carbon dioxide: This gas enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees and wood products, and also as a result of other chemical reactions (e.g., manufacture of cement).*
- *Methane: Emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and agricultural processes and from the decay of organic waste in municipal solid waste landfills.*
- *Nitrous oxide: Emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.*
- *Fluorinated gases: HFCs, PFCs, and SF_6 are synthetic, powerful GHGs that are emitted from a variety of industrial processes. Fluorinated gases are sometimes used as substitutes for ozone-depleting substances (i.e., chlorofluorocarbons (CFCs), hydrochlorofluorocarbon (HCFCs), and halons). These gases are typically emitted in smaller quantities, but because they are potent GHGs, they are sometimes referred to as High Global Warming Potential gases.*

Maryland has been working to reduce the State's impact on the climate. The Maryland Climate Change Commission (MCCC) was formed in 2007 to develop a state-wide Climate Action Plan, which was published in 2008. This plan contained 61 policy options, programs, and measures to reduce GHG emissions in Maryland 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), a key recommendation of the Climate Action Plan. This law sets a state-wide GHG emissions reduction goal of 25 percent from a 2006 baseline by 2020. The GGRA also requires 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.

Emissions of GHGs are reported on a "carbon dioxide equivalent" (CO_2e) basis under EPA's GHG Reporting Rule. This "CO_2 equivalency" allows other greenhouse gases to be expressed in terms of CO_2 based on their global warning potentials (GWP). For example, CO_2 has a GWP of 1; methane has a GWP of about 25, which means that every ton of methane emitted has the same greenhouse effect as 25 tons of CO_2. Figure 12 presents GHG emissions from coal-fired power plants in Maryland, as

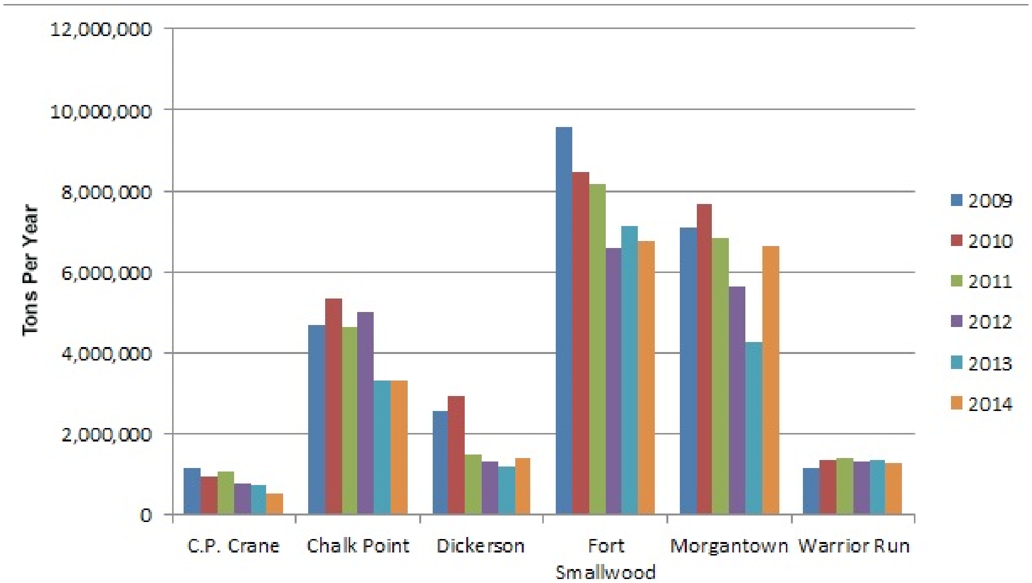
Clean Power Plan

EPA recently launched the Clean Power Plan (CPP), a comprehensive program mandating reductions in GHG emissions from large existing sources, including power plants, and potential new sources of GHGs. The CPP establishes state-specific interim and final goals for each state, based on baseline average emission rates for the region and the state's mix of power plants. Maryland's goal is 14.3 million tons by 2030, a 37 percent reduction from the 20.1 million tons emitted in CPP's baseline year of 2012. On February 9, 2016, the Supreme Court, in a 5-4 vote, stayed implementation of the CPP pending judicial review. Even with the stay in place, many states, including Maryland, are continuing to move ahead with the development of state implementation plans or with stakeholder engagement and development. These states are viewing the stay as an opportunity to have additional time to work with neighboring states and power generators on developing coordinated plans.

reported to the Maryland Department of Environment (MDE), for the years 2009 through 2014. GHG emissions are not controlled at the stack like other pollutants and none of the coal-fired power plants in Maryland switched to lower GHG fuels, which means that fluctuations in emissions seen year-to-year generally reflect changes in fuel consumption caused by power demand.

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 17 power plants in Maryland that are covered by RGGI. Maryland's 2016 RGGI budget allowance is 14.4 million tons of CO_2, or 22 percent of the 2016 budget for the region of 64.6 million tons. Contrary to what was expected when the CO_2 state apportionments were negotiated, emissions in the power sector have

Figure 12 Annual GHG Emissions from Coal-fired Power Plants in Maryland



Note: Fort Smallwood consists of Brandon Shores and Wagner power plants.

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. By 2015, the RGGI power sector recognized a 40 percent decline in emissions since 2005. Since 2005, annual emissions from Maryland's power sector have declined 52 percent, or by 19 million tons of CO_2.

The RGGI program allows covered entities to use qualifying offset projects to reduce the total number of allowances they are required to secure. Offset projects or emission credit retirements will be awarded one CO_2 offset allowance for every ton of CO_2 reduced or sequestered. A source may cover up to 3.3 percent of its CO_2 emissions with offset project allowances. Currently, no offset projects have been awarded to offset allowances under RGGI.

In Maryland, two additional offset project categories are being pursued, specifically terrestrial sequestration through urban forestry and the restoration of salt marshes. Maryland is promoting the development of programs within urban communities to plant and grow trees, which reduces GHG emissions in two ways. First, CO_2 is removed from the atmosphere during the growing of the trees due to an increase in biomass. Second, GHG emissions are avoided through energy conservation, as the trees can provide shade with a natural cooling effect for residences and other buildings in the community. Several State agencies and community groups are interested in pursuing urban forestry projects as an alternative or supplement to other more traditional afforestation projects.

Salt marshes are prevalent in Maryland and are of critical importance for estuarine ecosystems, such as those associated with the Chesapeake Bay, by serving as habitats for wildlife and buffers to large storms. In addition, salt marsh soils have the capacity to sequester large amounts of CO_2 through organic and mineral accretion. Marsh decline, however, is becoming more prevalent throughout the region due to the increase in water levels. Raising the elevation of the marsh beds via supplementation of natural sediment (e.g., depositing clean dredged material) can restore the tidal fluctuations required to support the marsh systems and promote carbon storage. Over the last several years, PPRP has assisted with an effort by Restore America's Estuaries to develop a formal offset protocol for salt marsh systems.

See Section 4.2 of CEIR-18

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 ground water 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 typically met by on-site wells or municipal water systems. (Hydroelectric facilities also have significant surface water impacts; see discussion on page 30 of this summary report.)

Four steam power plants in Maryland – AES Warrior Run, Brandon Shores, Brandywine, and Vienna – use closed-cycle cooling (cooling towers) exclusively instead of once-through cooling. Chalk Point has multiple steam boilers: two that use once-through cooling and two that use closed-cycle cooling. Closed-cycle systems recycle cooling water and withdraw less than one-tenth of the water required for once-through cooling; however, depending on plant design and operating parameters, 50 to 80 percent of the water evaporates from the cooling tower and does not return to the source, thus representing a consumptive use. Closed-cycle cooling systems consume 1.5 to 2 times more water per MWh than once-through systems.

Nuclear power plants also fall within the steam generating category; however, they use nuclear reactions instead of fossil fuel combustion to create 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. Nuclear stations generally operate at a lower steam temperature and pressure compared to fossil fuel-fired generating plants, which causes a 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.

Maryland has one nuclear power plant operating on the western shore of the Chesapeake Bay, Calvert Cliffs, which withdraws an average of 3.2 billion gallons per day from the Bay. This is the largest single appropriation of water in Maryland, and 13 times larger than the municipal supply for the Baltimore City metropolitan area of 250 million gallons per day (mgd). While the majority of this water is returned to the Bay, an estimated 17 mgd of Bay water is lost to evaporation as a result of the heated discharge (see Table 2).

Table 2 Surface Water Appropriations and Use at Maryland Power Plants with Steam Cycles

Power Plant	Surface Water Appropriation (average, mgd)	2013 Actual Surface Withdrawal (average, mgd)	2014 Actual Surface Withdrawal (average, mgd)	Estimated Consumption (mgd)	Water Source
Once-Through Cooling					
Calvert Cliffs	3500	3,286	3,019	17.2	Chesapeake Bay
Chalk Point[a]	720	560	265	1.7	Patuxent River
C.P. Crane	475	196	87	1.0	Seneca Creek
Dickerson	401	142	150	0.6	Potomac River (non-tidal)
H.A. Wagner	940	342	306	1.9	Patapsco River
Morgantown	1503	942	1,195	2.3	Potomac River
Riverside	40	3.51	3.48	0.0	Patapsco River
Wheelabrator	50	37.4	14.4	0.1	Gwynns Falls
SUBTOTAL	7,629	5,508	5,040	24.7	
Closed-Cycle Cooling					
AES Warrior Run[b]	0.021	1.6	1.5	1.0	City of Cumberland
Brandon Shores	35	11.8	8.1	6.7	Patapsco River (Wagner discharge)
Montgomery Co. Resource Recovery Facility	1.342	0.73	0.34	0.41	Potomac River (Dickerson Station's discharge canal)
Brandywine	none	0.74	0.86	0.54	Mattawoman WWTP
Vienna	2	0.002	0.001	0.00	Nanticoke River
SUBTOTAL	**38**	**14.8**	**10.8**	**8.6**	
TOTAL	**7,667**	**5,523**	**5,051**	**33.3**	

Source: MDE WMA

mgd = million gallons per day

(a) Chalk Point has two units on once-through cooling and two on closed-cycle cooling. The appropriation of 720 mgd covers all four steam units; data on each cooling system individually are not available.

(b) AES Warrior Run purchases its water from the City of Cumberland. The surface water appropriation of 0.021 mgd is for backup surface water withdrawals only.

In addition to cooling systems, air pollution control systems at power plants can also require substantial amounts of water. As a result of the Healthy Air Act, Maryland's four largest coal-fired power plants – Brandon Shores, Chalk Point, Dickerson, and Morgantown – have begun operating wet flue gas desulfurization (FGD) systems to control SO_2 emissions. Typically, about 85 percent of the water used in these systems is consumptively lost through evaporation out of the stack. Operation of the FGD systems at Maryland's coal-fired power plants results in an additional evaporative loss of approximately 8 mgd combined. This additional loss is not significant in the tidal estuarine environments at Brandon Shores, Chalk Point, and Morgantown. NRG, the operator of the Dickerson plant, is required to provide on-site water storage to minimize the potential impacts of its FGD system's water use on other users of the Potomac River.

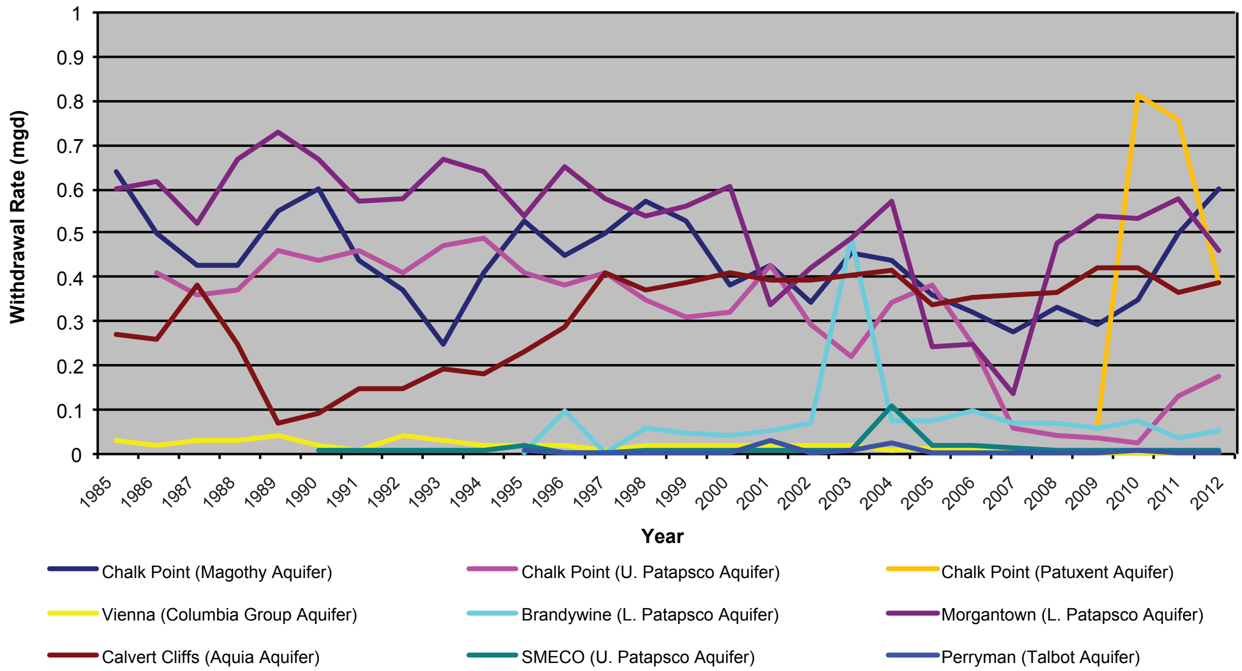
Groundwater Withdrawals

The use of ground water for process cooling is severely restricted in Maryland, but some of Maryland's power plants are significant users of ground water for other purposes. Ground water is used for boiler feedwater in coal-fired power plants, inlet air cooling, emissions control in gas- and oil-fired combustion turbines, and potable water throughout the power plants. High-volume ground water withdrawals have the potential to lower the water table of an area, thus reducing the amount of water available for other users. Excessive withdrawals from Coastal Plain aquifers can also cause intrusion of salt water into the aquifer. Although large volumes of ground water are available in the Coastal Plain aquifers, withdrawals must be managed over the long term to ensure adequate ground water supplies for the future.

The impact of these withdrawals has been a key issue in southern Maryland, where there is a significant reliance on ground water for public water supply. Currently, five power plants withdraw ground water from southern Maryland coastal plain aquifers for plant operations: Exelon's Calvert Cliffs Nuclear Power Plant, NRG's Chalk Point and Morgantown power plants, Southern Maryland Electric Cooperative's (SMECO's) combustion turbine facility located at the Chalk Point plant, and the Brandywine combined cycle power plant (formerly owned by Panda and now owned by KMC Thermo, LLC). These five plants have historically withdrawn ground water from three aquifers in Southern Maryland: the Aquia, the Magothy, and the Patapsco. The Chalk Point power plant began withdrawing ground water from the deeper Patuxent Aquifer in 2010. Two additional power plants utilize ground water: Perryman, located in Harford County northeast of Baltimore, and Vienna, located in Dorchester County on the Eastern Shore. Figure 13 shows the ground water withdrawal rates expressed as daily averages from 1985 to 2014 for each of these power plants. Power plants typically withdraw ground water at rates well below their appropriation permit limits. The average withdrawal for all seven power plants in 2014 was 2.4 mgd compared to a combined daily appropriations limit of 3.8 mgd.

The amount of ground water withdrawn by power plants has fluctuated between about 0.9 and 2.4 mgd over the past 40 years. Ground water

Figure 13 Average Daily Ground Water Withdrawal Rates at Maryland Power Plants



withdrawals reached a low point during 2006-2007, when electricity demand was also at a low point, but withdrawals have increased somewhat since then as the State's economy has improved.

Three government agencies – the Maryland Geological Survey (MGS), the USGS, and PPRP – jointly operate a ground water monitoring program to measure the water levels in the Coastal Plain aquifers of Southern Maryland to ensure the long-term availability of ground water. MDE Water Management Administration (WMA), the permitting authority for all ground water appropriations, uses the data from this joint monitoring program to assess the significance of impacts to aquifers when reviewing additional appropriation requests.

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 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 historic 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.*

Section 316(b) of the federal Clean Water Act requires power plants to use cooling water intake structures that reflect the best technology available for minimizing adverse environmental impacts. Maryland has eleven existing steam electric power plants that are subject to Section 316(b). After several decades, the U.S. EPA has now implemented final rules for existing power plants that withdraw at least 2 million gallons per day (mgd), which Maryland power plants will need to address in the coming years:

- *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.*
- *One year of impingement studies and 2 years of entrainment studies (for facilities withdrawing greater than 125 mgd) must be conducted within the last 10 years. Some facilities already conducted some or all of these studies while others need to conduct additional studies.*
- *All applicable facilities will need to conduct economic and engineering studies to comply with the new rule as their discharge permits are renewed.*

Wastewater Discharges

Wastewater discharged from coal ash ponds, air pollution control equipment, and other equipment at power plants can contaminate drinking water sources, impact fish and other wildlife, and create other detrimental environmental effects. Although air pollution controls have made great strides in reducing emissions from power plants, some of the equipment used to clean air emissions does so by "scrubbing" the boiler exhaust with water ("wet" flue gas desulfurization (FGD) systems), which then can pollute rivers and other receiving water bodies. Treatment technologies are available to remove these pollutants before they are discharged to waterways, but these systems have been installed at only a fraction of the power plants. Types of treatment systems for FGD systems include settling ponds, chemical precipitation, biological treatment, constructed wetlands, and zero-liquid discharge.

In 2009, EPA completed a multi-year study of power plant wastewater discharges and concluded that current regulations, which were issued in

1982, have not kept pace with changes that have occurred in the electric power industry over the last three decades. As part of this multi-year study, EPA measured the pollutants present in the wastewater and reviewed treatment technologies, focusing mostly on coal-fired power plants. Many of the toxic pollutants discharged from these power plants come from coal ash ponds and the FGD systems used to scrub SO_2 from air emissions.

EPA issued a proposed rule to amend guidelines and standards for the steam electric power generating industry in 2013, and took final action in November 2015. Now that the new rule for electric power plants has been finalized, EPA and states are incorporating the new standards into wastewater discharge permits as they come up for renewal. In Maryland, MDE is also imposing lower limits on total nitrogen, total phosphorus, and sediment, applicable to all NPDES discharges, including power plant wastewater. This is part of the implementation strategy to meet Total Maximum Daily Load (TMDL) limits in the Chesapeake Bay watershed.

In addition to the contaminants covered under EPA's effluent guidelines, and as a result of the implementation of the Chesapeake Bay TMDL, all dischargers with NPDES permits, including industrial dischargers such as power plants, will have reduced limits on total nitrogen, total phosphorus, and sediment.

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. Five additional small-scale facilities also generate electricity within the state (see map and table in Section 2.1.5). Hydroelectric facilities may present special environmental concerns that are not encountered at steam electric power plants. Development and operation of hydroelectric facilities causes three main types of impacts:

Changes in water quality – Impoundments created for hydroelectric dams significantly alter river flow from free-flowing streams to deepwater flow. This alteration causes changes in natural water clarity, thermal stratification, and lower dissolved oxygen concentrations.

Changes to flow regime – Operating hydroelectric facilities in a peaking mode (in response to peak electrical demand) produces unnatural and frequently extreme water level fluctuations in impoundments as well as downstream from the dams. In addition, large hydroelectric dams allow suspended sediments to accumulate in the impoundment resulting in reduced storage, reduction in navigational waters, and changes in the timing and distribution of sediment and associated nutrients downstream of the dam.

Direct adverse effects on fish populations – Dams prevent the natural upstream and downstream movement of both resident and migratory fish species. Entrainment of fish attempting to move downstream past the dam may cause mortality due to the turbines.

Conowingo Hydroelectric Project Relicensing

The federal license to operate the Conowingo Project (owned by Exelon) expired in August 2014. FERC has the authority to issue the license for Conowingo, although with significant regulatory input from Maryland (with PPRP as the lead for the state) and other federal agencies. Studies and discussions have been taking place since 2009 between Exelon and various natural resource agencies and other interested parties. Relicensing participants include FERC, Exelon, Maryland (DNR and MDE), Pennsylvania (Fish and Boat Commission and Department of Environmental Protection), U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service, National Park Service, Susquehanna River Basin Commission, The Nature Conservancy, and the Lower Susquehanna Riverkeeper.

Exelon submitted to FERC a Final License Application in 2012 for continued operation of the Conowingo project. PPRP coordinated all Maryland agency reviews and provided input on various studies and the license application for FERC to consider as part of its review. Principal issues that were the subject of multi-year studies based on recommendations from PPRP include sediment and nutrient management, upstream and downstream fish passage (for migratory species such as American shad, river herring and American eel), flow and water level management, dissolved oxygen (DO) levels, debris management, land conservation and recreation. PPRP's goal is to develop appropriate protection, mitigation, and enhancement (PM&E) measures in consultation with MDE and other resource agencies, and ultimately to reach agreement on license conditions prior to issuance of a final license by FERC. Such a license will contain state-mandated license terms contained in the state's Water Quality Certification (WQC) for the project; a 3-year sediment/nutrient study funded by Exelon is underway to provide information for the WQC. FERC issued a notice in 2013 declaring that the project is Ready for Environmental Analysis and subsequently prepared an Environmental Impact Statement in preparation for issuing a new license, pending issuance of the State's WQC and the USFWS fishway prescription. In the meantime, Conowingo will continue operating under existing requirements with annual licenses until a new one can be issued.

After extended negotiations with Exelon, USFWS issued its fishway prescription in May 2016. In that prescription, Exelon agreed to implement improvements to the existing fish passage facilities within three years of the renewal of its federal license. The initial items to be addressed include:

- *Modifying the East Fish Lift to increase capacity and improve performance.*
- *Modifying the West Fish Lift to facilitate trap and transport.*
- *Evaluating potential trapping locations for American eel on the east side of Conowingo Dam including Octoraro Creek.*

In addition to these initial construction items, Exelon will trap and transport American shad and river herring from Conowingo to above the York Haven Hydroelectric Project beginning with the first fish passage season after license issuance. Exelon also has committed to trap and transport American eels at the west side of Conowingo Dam.

Exelon will conduct periodic efficiency tests of migratory fish passage through its improved facilities. If the project doesn't achieve specified passage goals, additional mitigation measures from a tiered list of items will be implemented to make further improvements in passage efficiency throughout the term of its license.

Terrestrial Impacts

See Section 4.4 of CEIR-18

Maryland's physiographic diversity, geology, and climate have produced a variety of ecoregions that foster numerous, and sometimes unique, habitats. While human activities such as agriculture and urban/suburban development have altered all of these areas to some extent, the majority of the landscape continues to possess a 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.

The construction and operation of power generation facilities can have significant effects on terrestrial environments, including wetlands. Power plant infrastructure includes production units; pipelines to transport water, oil, and natural gas; electrical transmission lines; and roadways and railways. These facilities can occupy extensive areas on the landscape. Notably, these facilities can:

- *Physically alter or eliminate existing natural habitats;*
- *Disturb or result in the loss of wildlife species;*
- *Affect landscape ecology through atmospheric emission and deposition of PM and other air pollutants; and*
- *Degrade habitats by the permitted discharge of pollutants or from accidental spills.*

Impacts on Maryland's landscape from future power plant development depend largely on the mode of power production. Power plants that use traditional resources such as coal and natural gas are generally confined to an intensively developed installation and associated linear facilities, whereas renewable energy projects using wind turbines or solar panel arrays may occupy hundreds of acres. There are approximately 15 proposed solar generation facilities throughout the state that have recently undergone review by PPRP. Great Bay Solar is a recently approved project that involved coordination with the Critical Area Commission. It will be constructed on approximately 1,000 acres near Princess Anne in Somerset County and will have the capability to generate up to 150 MW of power. PPRP evaluates the ecological impacts of these facilities as part of the PSC licensing process. Through the development of recommended CPCN conditions, PPRP has helped to ensure that the current wave of solar projects incorporate wetland protection, tree planting, vegetation management, and establishment of pollinator habitat.

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, 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.

Transmission line corridors may affect specific environmental features, alter the landscape over long distances, or change the way people use nearby residential, commercial, or agricultural land. For each right-of-way modification or construction proposal, PPRP reviews the potential impacts of the proposed project on streams, floodplains, wetlands, forests, rare species, historical and archeological sites, and surrounding land use. Quantitative comparisons of alternate routes are derived from digital maps, aerial photographs, and other data sets, and supplemented by field inspections. The purpose of these comparisons is to identify the types of impacts that may occur along each possible corridor and to find the route with the lowest overall impact. Where undesirable impacts cannot be avoided, PPRP recommends mitigation measures as part of the licensing process.

PPRP's role in the CPCN process is to facilitate compliance with Maryland's environmental regulations and natural resource management objectives. Environmental laws affecting Waterways Construction, Water Quality and Water Pollution Control, and Erosion and Sediment Control require 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. Additional, specific measures to avoid, minimize, or mitigate impacts on natural resources may also be included in CPCN conditions, if warranted. Under these circumstances, conditions placed on a CPCN to mitigate impacts to wetlands, forests, and sensitive species habitats may be more stringent than requirements under the individual statutes.

Socioeconomics and Land Use

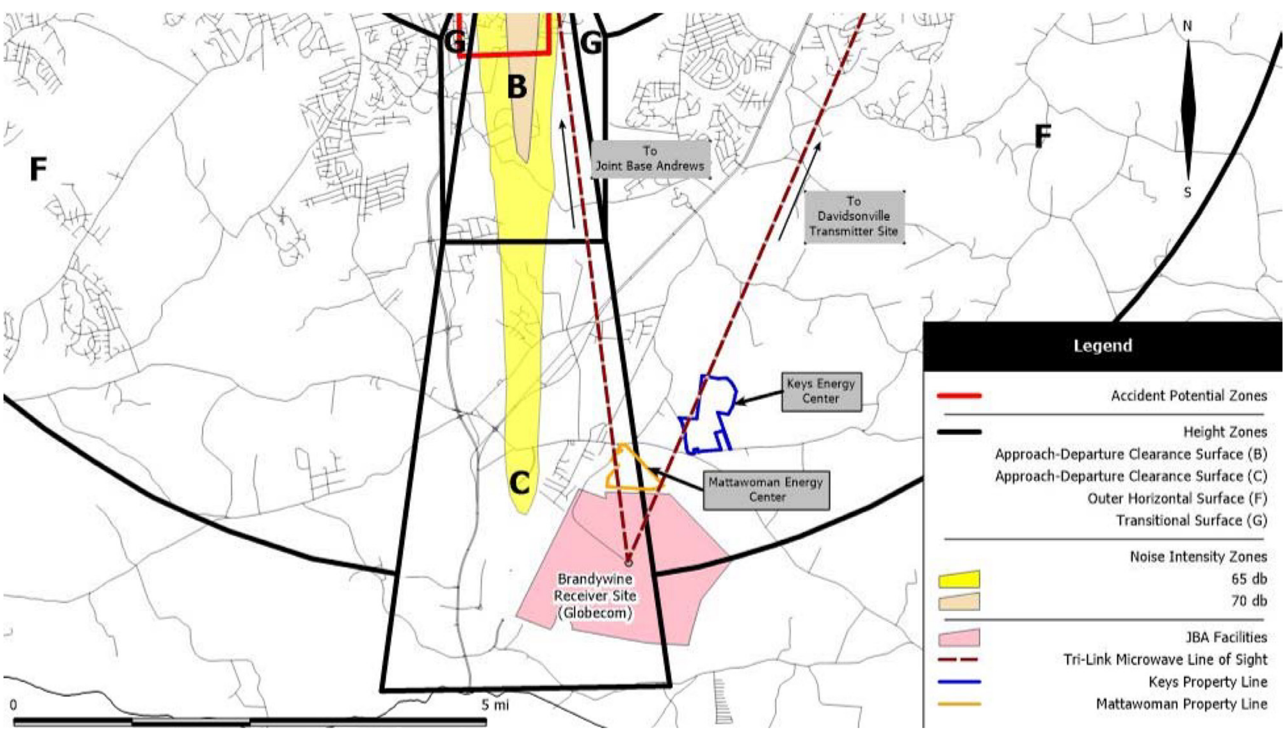
See Section 4.4 of CEIR-18

Since the publication of CEIR-17 in late 2014, three natural gas generation facilities have been permitted in Maryland. In addition, Maryland's Renewable Portfolio Standard has stimulated a large number of proposals for solar photovoltaic facilities, particularly on the Eastern Shore and in central Maryland. While producing both environmental and economic benefits, the licensing of these facilities has required PPRP to consider socioeconomic impacts in its environmental reviews unique either to the generation technology or its location.

Natural Gas

Two projects that have recently received CPCNs to construct and operate natural gas-fired generation plants in Prince George's County illustrate the uniqueness of land use issues that arose from their location. Located near Brandywine in southern Prince George's County, both the Keys Energy Center and Mattawoman Energy Center were sited in an area of concern to Joint Base Andrews (JBA) (formerly Andrews Air Force Base). The projects are also directly north of the Globecom Receiver Site, one part of the Andrews Tri-Link, a secure communications facility linking JBA and the Davidsonville Transmitter Site (see Figure 14).

Figure 14 Interaction of Keys Energy Center and Mattawoman Energy Center with Joint Base Andrews



Among other issues, the USAF was concerned with microwave and high frequency communications interference, radio frequency interference with the Andrews Tri-Link, and potentially other conflicts that could impact missions affecting national security. Aircrews from JBA also use four landing zones at the Globecom Receiver Site to practice unimproved landing area operations and helicopter flight patterns overfly the Mattawoman site. In response to Keys' filing of a Notice of Proposed Construction or Alteration, the Federal Aviation Administration (FAA) issued a Notice of Presumed Hazard. In particular, the FAA found that at the proposed height (175 feet) and location, the stacks would exceed obstruction standards or have an adverse physical or electromagnetic interference effect upon navigable airspace by blocking the JBA terminal Doppler weather radar low elevation scans. The FAA also indicated that if the stacks were reduced to a height no more than 141 feet above ground level, they would not exceed obstruction standards, and a favorable determination could be issued. Keys modified its facility plans by reducing stack heights to 140 feet. In response to the proposed change in stack heights, PPRP conducted additional air quality modeling to ensure that lower stacks would not adversely affect air quality in the region.

Keys subsequently entered into a stipulated agreement with JBA to address remaining concerns regarding the proposed generating facility. A similar agreement, which included a clause retaining JBA's rights to continue helicopter operations over the generating station, was later executed between Mattawoman and JBA. PPRP's consultation with JBA in both licensing cases was an important catalyst for resolving the issues and ensuring the actions would not result in adverse air quality impacts.

Solar Photovoltaic

Solar photovoltaic (PV) generation facilities are land intensive. As a rule of thumb, a solar PV facility consumes 5-10 acres per MW capacity, depending upon the strength of the solar resource and other factors. With ever-increasing efficiencies in solar panel technology, the density is approximately 5 acres per MW currently. Since most existing and proposed solar facilities are sited on agricultural land, decommissioning has been an ongoing concern in PPRP's environmental reviews of these projects.

There are no nationwide or statewide standards for decommissioning at present. However, restoration of a site to its "original state" would appear to be a reasonable goal of a decommissioning plan. A model bylaw developed by the Massachusetts Executive Office of Environmental Affairs defines restoration as the physical removal of all large-scale ground-mounted solar photovoltaic installations, structures, equipment, security barriers and transmission lines from the site; disposal of all solid and hazardous waste in accordance with local, state, and federal waste disposal regulations; and stabilization or re-vegetation of the site. Physical removal of ground-mounted structures includes the removal of all or some of below-ground foundations and supports, although the landowner or operator may leave designated below-grade foundations in order to minimize erosion and disruption to vegetation.

Particularly for agricultural land, the abandonment of below ground structures is a concern. A review of decommissioning plans of proposed or existing solar facilities in North America revealed no consensus with respect to below-ground structures, with decommissioning ranging from complete removal without exception to removal to a depth of between two and four feet below grade.

PPRP interprets restoration of a site previously used for agriculture to an "original state" to mean being returned to an agriculturally productive state which allows for safe agricultural practices. With soil compaction being a recurring problem in agriculture, and the potential for deep tillage applications on decommissioned solar farms to restore the land to agricultural use, PPRP recommends removal of below ground structures and cabling to a depth of at least three feet in project decommissioning plans.

Another concern is whether land converted from agriculture to solar generating facilities will actually be returned to agriculture after the facility reaches the end of its useful life. Clearly, a viable option for solar generators is to refit the facilities with new solar panels, given the existing infrastructure in place to support solar generation (cabling, supports, inverters, etc.) and both increased efficiencies and declining prices for PV panels. If solar PV generation is not overtaken by another technology but instead continues to contribute to Maryland's generation capacity, it could be a very long time before the land is returned to agriculture or converted to another use.

See Section 4.5 and Section 4.6 of CEIR-18

Power Plant Wastes

Radiological

Production of nuclear power in the United States is licensed, monitored, and regulated by the U.S. Nuclear Regulatory Commission (NRC). Calvert Cliffs Nuclear Power Plant, in Calvert County, is the only nuclear power plant in Maryland. The next closest plant, Peach Bottom Atomic Power Station, is on the Susquehanna River just north of the Pennsylvania/Maryland border. Both of these facilities release very low levels of radionuclides into Maryland's environment. Based on data from regular sampling events in the vicinity of Calvert Cliffs and Peach Bottom during 2012 to 2014 (the most recent period for which data have been compiled), environmental, biological, and human health effects from releases of radioactivity were not significant.

In addition to the production of atmospheric and liquid effluent releases as a by-product of normal power generation operations, both Calvert Cliffs and Peach Bottom generate radioactive waste products which require disposal. Used (spent) nuclear fuel from both Calvert Cliffs and Peach Bottom are presently stored at each site within spent fuel pools for the recently discharged fuel or, in the case of older fuel generated in earlier years of plant operation, at dry storage independent facilities located within the protected plant area. These Independent Spent Fuel Storage Installations (ISFSIs) were originally licensed by the NRC for 20 years, although recent regulatory changes now allow a plant operator to apply for a 40-year license period. ISFSI design and construction must conform to strict NRC specifications (10 CFR 72) that protect against unauthorized entry, earthquakes, and other natural phenomena such as floods and hurricanes. On-site storage facilities, such as the ISFSI, are currently the only long-term storage facilities for irradiated fuel available.

Exelon's dry cask storage facility at Peach Bottom is estimated to have used over 70 percent of its currently available storage pad space. Peach Bottom's ISFSI license will expire in 2040. It is also estimated that Calvert Cliffs has filled over 70 percent of its currently licensed storage capacity. In October 2014, the NRC granted the 40-year license renewal for Calvert Cliffs' ISFSI; that license will expire in 2052.

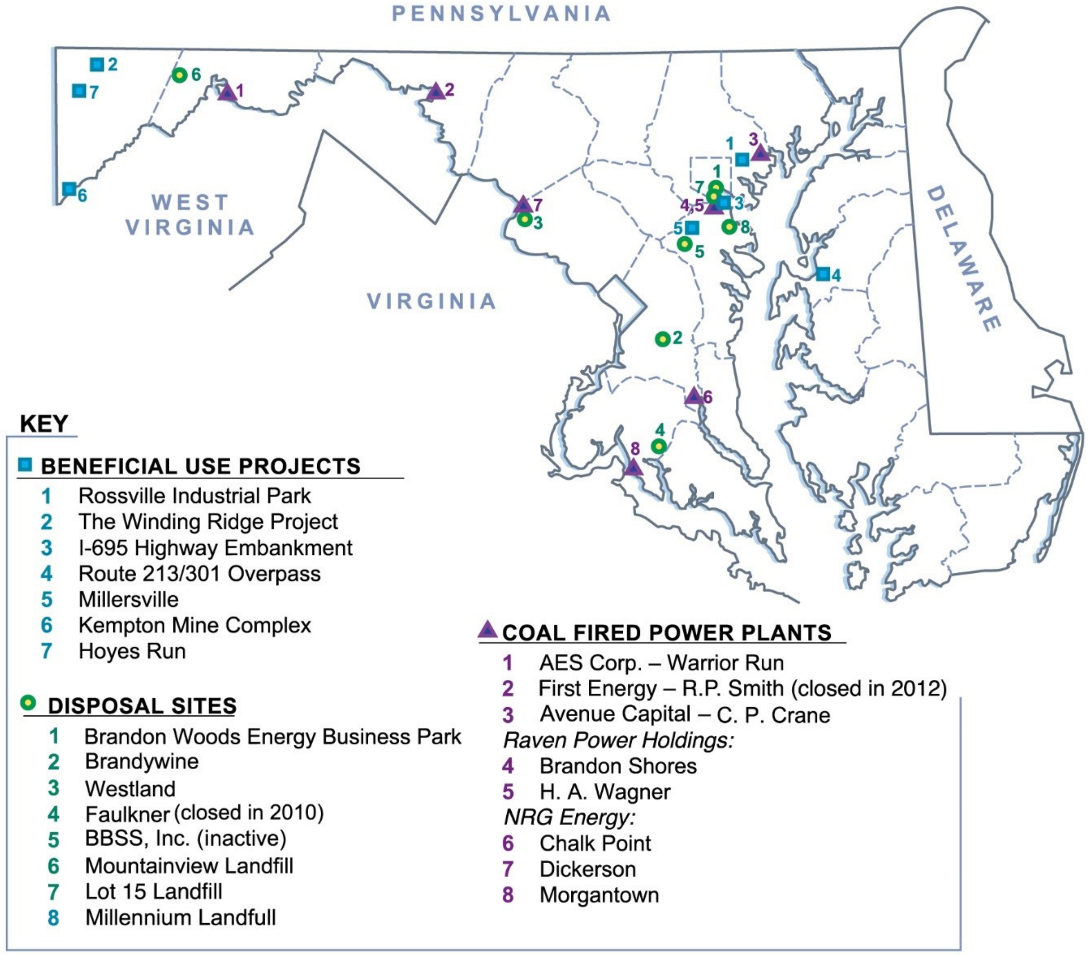
Coal Combustion By-products

In 2014, coal-fired power plants in Maryland generated an estimated 1.5 million tons of coal combustion by-products (CCBs), as reported to MDE. The term CCBs includes several solid materials with different physical and chemical characteristics. The exact chemical nature of CCBs depends upon the nature of the coal burned, the combustion process used, and any emission control processes used.

Most power plants in Maryland burn bituminous coal from the eastern United States and produce predominantly Class F fly ash and bottom ash. Fly ash and bottom ash are distinguished by their physical characteristics. Fly ash is composed of very fine, and 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, and porous glassy particles that are heavier and thus fall to the bottom of the furnace, where they are collected. Boiler slag is a specialized type of bottom ash that collects in a molten form and is entirely glassy. There is little difference in the chemical makeup of fly ash and bottom ash. Class F ash is primarily composed of silicon, aluminum, and iron oxides, making it an excellent pozzolan material (meaning that it contributes to cementitious reactions when combined with water and free lime). It may also contain trace metals such as titanium, nickel, manganese, cobalt, arsenic, and mercury. For this reason, electric utilities are required to include all applicable constituents of their CCBs when reporting chemical releases to EPA's Toxics Release Inventory (TRI) program, which maintains a database listing the quantities of toxic chemicals released to the environment annually by various industries.

When properly engineered and correctly applied, CCBs can be utilized in manufacturing, civil engineering, mine restoration, and agricultural applications. Beneficial use of CCBs in Maryland has historically included predominantly large-scale fill applications as in highway embankments and mine reclamation. However, over time the use of CCBs in encapsulated forms, such as cement, concrete, wallboard, and roofing tile has become more prevalent. Such changes are driven by industry practice, technology, costs of natural materials, regulations and guidelines, public perception, and demands for sustainability in the commercial marketplace. Of the approximately 1.5 million tons of CCBs produced by Maryland power plants in 2014, just over 200,000 tons were placed in disposal sites. More than 350,000 tons of CCBs were used in concrete and cement and another 500,000 tons were used in wallboard manufacture. Coal mine reclamation is the third largest use of CCBs in Maryland, with about 360,000 tons of alkaline CCBs being used to reclaim surface coal mines in Western Maryland. Other, smaller scale uses included agricultural amendments, and the manufacture of roofing tiles, blasting grit, and grouts. Figure 15 shows the locations of Maryland's coal-fired power plants and the sites where CCBs are beneficially used or disposed around the state.

Figure 15 Locations of CCB Generation, Use, and Disposal in Maryland



With 86 percent of the state's CCBs being beneficially used, Maryland is well above the national utilization rate of 45 percent. PPRP has supported research and demonstration projects for more than 20 years regarding beneficial use of CCBs, particularly those applications that could use massive quantities of CCBs. A wide variety of bench-scale research projects and field-scale demonstration projects have been completed with significant focus being placed on uses of CCBs in underground mine reclamation, restoration of disturbed lands, and manufacturing.

For More Information…

The Power Plant Research Program (PPRP) was established in 1971 to ensure that Maryland could meet its demands for electric power in a timely manner and at a reasonable cost, while protecting the State's valuable natural resources.

PPRP coordinates the State's comprehensive review of new power plants and associated facilities as part of the state and federal licensing process. The Program also conducts a range of research and monitoring projects to better understand the impacts of power generation and transmission. PPRP publishes the Electricity in Maryland Fact Book, which provides information on power generation and use in Maryland. A bibliography listing the general and site-specific reports that PPRP has produced since the early 1970s is also available.

If you want more information, or to request a copy of the Fact Book, bibliography, or other reports, contact PPRP at (410) 260-8660 (toll-free number in Maryland, 1-877-620-8DNR, x8660). You can also visit our website at: www.pprp.info where most of our reports are available for download. References are available upon request for all technical topics discussed in this report.

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