ENERGY

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Pennsylvania benefits from having diverse, reliable and affordable energy resources, and utilizes those resources to rank second in the country in terms of electrical generation. Pennsylvania is the number one exporter of electricity in the United States. The majority of the electricity generated in Pennsylvania relies upon coal, nuclear and natural gas for fuel, although there is a clear trend over recent years that is changing the energy sector within the Commonwealth. The policy focus of increasing energy efficiency, reliability and development of renewable energy resources coupled with the recent expansion of natural gas resources from the Marcellus Shale regions have had significant impact on the energy infrastructure of the Commonwealth.

Pennsylvania has a solid foundation of energy, electrical generation and transmission infrastructure that is continuing to transform and react to market forces. The infrastructure appears to be reasonably well positioned to meet the current and 20-year planning horizon needs of the Commonwealth, although it is clear that energy and environmental policy will likely have a significant impact on the direction of the Energy Infrastructure in Pennsylvania.

BACKGROUND

In the development of this Report Card for Pennsylvania's Energy Infrastructure, the authors were cognizant of the massive network of infrastructure related to the Energy sector, and have attempted to focus this report and corresponding report card grades on the significance of the Commonwealth's primary energy resources (coal and natural gas), the electrical generation capacity, and the electrical transmission and distribution network.

The Commonwealth of Pennsylvania is rich in energy resources, with vast supplies of coal and natural gas, as well as geography and topography that allows for solar, wind, and hydroelectric generating potential. The electrical generation market within Pennsylvania is deregulated, and therefore completely driven by market forces, while the electrical transmission and distribution market is regulated by the Pennsylvania Public Utility Commission (PUC) which provides a guaranteed rate of return for their services.

PRIMARY ENERGY RESOURCES

Coal

Pennsylvania is the fourth leading coal producing state, mining 55.03 million short tons in 2012. The Northern Appalachia Coal Basin located in Western Pennsylvania accounts for over 12,000 million tons of recoverable coal reserves. With this amount of coal reserves, Pennsylvania can sustain the current production rate for over 200 years.

Pennsylvania's coal is mainly utilized as a source of electrical power, accounting for 49.5 % of the total amount of electricity produced.

Natural Gas

Marcellus shale underlies NY, PA, OH, and WV. Most Marcellus drilling and development in Pennsylvania takes place in the western, central and northern areas of the Commonwealth. Development began in 2005 followed by substantial activity since 2007 and now Marcellus production has reached 12 billion cubic feet a day. That's the energy equivalent of about 2 million barrels of oil a day, and more than six times the 2009 production rate. Putting this in perspective, if the Marcellus Shale region were a country, its natural gas production would rank third in the world, after Russia and the rest of the U.S. Current estimates show that the Marcellus contains 141 trillion cubic feet (TCF) of natural gas that is classified as unproved technically recoverable reserves.

By 2017 Pennsylvania is expected to produce 1.2 trillion cubic feet of natural gas, equating to almost eight times the volume produced in 2000. In the same period, national production is only expected to increase 27%. The impact of Marcellus Shale on pipeline infrastructure is apparent in pipeline capacity trends. Since 2000, pipeline flows in Pennsylvania have reversed from an inflow of 0.3 billion cubic feet per day (bcfd) to an outflow in 2011 estimated at 1.3 bcfd. Pennsylvania's pipeline infrastructure is expected to increase capacity significantly as natural gas production continues in Marcellus, Utica, and other unconventional shale formations. The development of new gathering pipelines is expected to accelerate to connect drilling sites with the larger network of interstate/intrastate pipelines. It is estimated that anywhere from 500 to 1,250 miles of gathering pipeline will be needed over the 20-year period from 2010 to 2030.

Renewables

Pennsylvania's primary sources of renewable energy are hydroelectric, wind, and solar power. Historically, the number of large dams on the Susquehanna River that were constructed in the early 1900's presented the bulk of the available capacity for hydroelectric power, which has been an important component of renewable energy in PA. Development of renewable power utilizing wind and solar has been spurred in recent years due to the Alternative Energy Portfolio Standards Act of 2004 (AEPS).

ELECTRICAL GENERATION CAPACITY

The map below depicts the locations of the generating facilities in the state that, together, have a combined generating installed capacity in excess of 45,000 Megawatts.

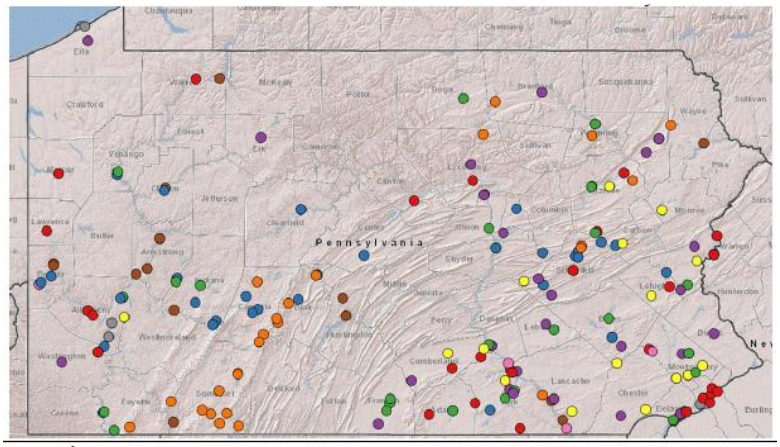


Figure 1: Electrical Generating Facilities in Pennsylvania

Coal has been the dominant fuel for electrical generation within Pennsylvania for many years, followed by Natural Gas and Nuclear as other primary fuels. The pie chart to the right depicts the amount of installed generating capacity for Pennsylvania separated by fuel type.

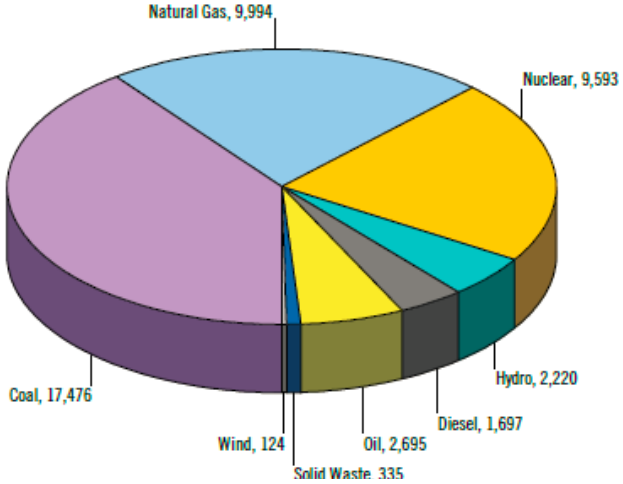
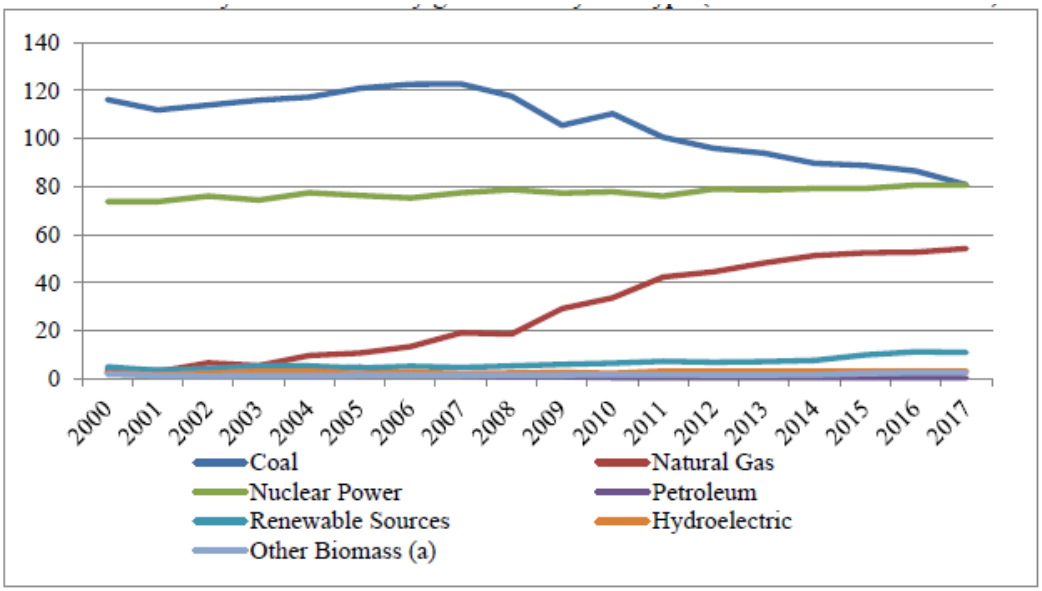


Figure 2: Generating Capacity in Megawatts by Fuel Type

As shown in the chart below, there is a trend that started in the late 2000's and is projected to continue into the near future. The steady decline in coal generating capacity and steady increase in natural gas generation is a function of environmental policy hurdles for the aging fleet of 78 coal-fired generating units. The average age of Pennsylvania's coal-fired plants in 2015 will be 46 years old. These older units tend to require routine maintenance and have a limited amount of emissions control. The cost of performing emission control upgrades on some older plants outweighs the benefit. As such, a large amount of coal-fired plants have begun to retire. By 2015, 31 of the 78 coal-fired generating units are scheduled to retire, a 29% decrease in the total amount of electricity produced by coal.

Natural gas fired facilities are the second largest in terms of generating capacity in the state, with the vast majority of the facilities being constructed within the past 15 years. These newer facilities typically achieve greater operational efficiencies than the older coal generators.

The generation from Pennsylvania's 5 nuclear plants (9 reactors) makes up the third largest portion of the electricity created in the state. The plants were mostly put into service in the 1970s and 1980s, and are all licensed for commercial operation until at least 2024. As the commercial licenses begin to expire, the operations and base-load generating capacity of the facilities will need to be evaluated.



Source: Pennsylvania Public Utility Commission, Energy Information Administration

Figure 3: Electrical Generating Capacity by Fuel Type

Overall, electricity generation in Pennsylvania averaged an annual growth rate of 1.3% from 2000 to 2010, but the growth rate is projected to slow in the near term due to continued efficiency gains and modest increases in demand for electricity in nearly all sectors of the state economy.

Electrical Transmission Network

Pennsylvania's electric generation, transmission and distribution infrastructure is part of the highly interconnected electric system that extends beyond state boundaries and is actively managed by regulatory agencies and commissions who enforce performance criteria, standards, and requirements to ensure reliability of the electric power system.

Pennsylvania is within the boundaries of the PJM RTO that covers 214,000 square miles (See Figure 4) and coordinates the operation of more than 59,750 miles of transmission lines and 185,600 MW of generating capacity.

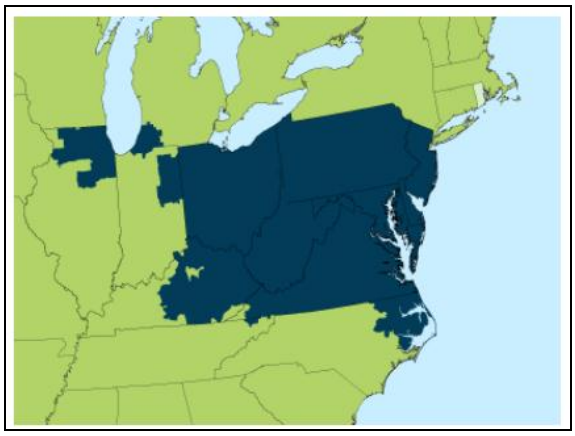


Figure 4: PJM Service Territory

Current Long-Term Reliability Assessments performed by NERC continue to project that PJM will have adequate Planning Reserve Margins[1] throughout the 2019 summer season.

Transmission expansion plans and the electric power outlook for Pennsylvania are based on regional forecast data from PJM, as the bulk electric system is planned on a regional basis rather than a state basis. Currently in Pennsylvania, 14,979 MW of proposed additional generating capacity is under active study by PJM. This proposed capacity is attributed to both new generating plants and increased capacity to existing plants. PJM continually evaluates transmission congestion and implements transmission construction and enhancements when congestion costs become too high. Congestion concerns within the PJM territory have most recently been addressed by the following 2 transmission infrastructure projects in Pennsylvania:

- TrAIL: The 500kV Trans Allegheny Interstate Line (TrAIL) was constructed in three segments, connecting substations in southwestern Pennsylvania, northern West Virginia and northern Virginia to alleviate congestion and improve reliability in Washington, D.C., Baltimore, and northern Virginia. The line was placed in service on May 23, 2011.
- Susquehanna-Roseland: A 500kV line approved by the PJM Board in order to resolve overloads on a critical 230kV circuit across eastern Pennsylvania and northern New Jersey. Expected in-service date is June 1, 2015.

CONDITIONS AND CAPACITY

Affordability

The United States Energy Information Administration publishes summary statistics in a State Electricity Profile to provide a comparative understanding of the US electricity

[1] Planning Reserve Margins = metrics used to measure the ability of a system's resources to meet customer demands based on current capacity plans and load forecasts (NERC)

market. The average retail price of 10.31 cents/kWh for electricity in Pennsylvania ranked 16th nationally.

Reliability

PJM has implemented numerous smart grid programs that may enhance future reliability.

While the high-voltage transmission system (nominally >100kV) is regulated by the Federal Energy Regulatory Commission (FERC), the electric distribution system in Pennsylvania is under the purview of the Pennsylvania Public Utility Commission (PUC or Commission). The PUC, as mandated by the Electricity Generation Customer Choice and Competition Act, is responsible for ensuring the reliability of the electric distribution system. In response to the mandate, the PUC has implemented reporting requirements designed to monitor safety, adequacy, and reliability of the system and thus, has established reliability standards to measure the performance of each electric distribution company (EDC). In Pennsylvania, 11 jurisdictional electric distribution companies (EDCs) serve the majority of the state's electricity needs for homes, businesses, and industries.

The PUC monitors the reliability of these 11 EDCs through the assessment of reliability performance metrics adopted from the Institute of Electrical and Electronic Engineers. These metrics, reported by the EDCs on a rolling 12-month average, are considered the minimum level of EDC reliability performance. In 2012, all 11 EDCs achieved compliance with two of the three reliability performance metrics and 10 EDCs achieved compliance with the third metric. All three reliability performance metrics experienced improvements in 2012 compliance compared to 2011 compliance. Note that reliability performance metrics include outages only during normal event periods; abnormal events, such as major storms are not captured in the calculations of reliability metrics.

While not included in the reliability metrics, major storms have brought to light the vulnerability of Pennsylvania's distribution infrastructure. Hurricane Sandy represented a major storm event that ranked as the worst storm for numerous Pennsylvania EDCs, causing more than 1.9 million electric outages in Pennsylvania, with many affected customers experiencing outages greater than 72 hours. These weather-related events are the leading cause of power outages in the US and have increased significantly since 1992. While transmission system outages do occur during these storm events, approximately 90 percent of outages occur along distribution systems. This highlights the need for EDCs to implement and/or have active plans in place to harden their infrastructure against storm events.

Diversity

The Commonwealth of Pennsylvania is fortunate to have multiple options for energy resources, and electrical generating capabilities. The infrastructure required for the resources and generating facilities is quite diverse, leaving the opportunity for the energy market to be responsive to market forces.

POLICY OPTIONS

Pennsylvania is a leader within the energy market in the United States, and has been on the forefront of proactive policy that shapes the direction of the energy sector in the Commonwealth. Recent legislation of note is as follows:

Act 129 - Signed into law in 2008, this legislation expanded responsibilities of the PA Public Utility Commission (PUC) to create an overall program to oversee and work with electricity distribution companies to implement electricity efficiency and peak load reduction measures in an incremental manner. Since the Act was signed into law, it is estimated that 3,383,465 MWh of electricity has been saved in Pennsylvania.

Act 13 - Signed into law in 2012, this legislation provided an update to the Oil and Gas Act (Act 223 of 1984), and established new rules and regulations for the Natural Gas Industry, including an unconventional gas well fee (also called an impact fee) for any bore holes being drilled in the production of natural gas from a geological shale formation.

Act 213 - Signed into law in 2004, this legislation requires electric generation and distribution companies to supply 18% of PA's electricity using alternative energy resources by 2021. The percentages required are escalating on an annual basis. The result of this has been a significant increase in solar power within the state. Solar is currently projected to increase within PA to meet the 2021 AEPS targets. It is important to note that the AEPS does not require generating projects to be located in PA and that targets can be met using alternate energy sources from anywhere within the PJM grid.

RECOMMENDATIONS

Electric Transmission and Distribution System

A recent electric grid resilience report released in August 2013 by the Executive Office of the President of the United States, identified hurricane-force winds as the primary cause of damage to electric infrastructure systems, recommending the upgrade of poles and structures with stronger material as a cost-effective storm hardening strategy. For distribution system upgrades, it was recommended that woods poles be replaced by concrete, steel, or composite material, and installing support wires / structural supports. Similarly, recommended transmission upgrades included replacing aluminum structures with galvanized steel lattice or concrete.

Distribution Systems should be designed to the same level of resiliency as Transmission System Structures, as well as comply with the ASCE minimum weather loading recommendations even if the structure does not exceed 60ft in height.

Although there is widespread agreement on the high strategic importance of transmission infrastructure, a comprehensive and consistent methodology for collecting transmission information does not exists. Data is typically non-comparable between regions, as each RTO/ISO has its own definition, methodologies, and formats for

calculating and publishing LMPs (locational marginal pricing) and congestion cost. By establishing universal definitions, methodologies, and data reporting requirements for transmission information, it would provide regulatory agencies with clearer information regarding the condition within and between regions.

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ASCE POLICY STATEMENTS

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- ASCE Policy Statement 489: Energy Policy (PS 489)
- ASCE Policy Statement 539: Hydraulic Fracturing (PS 539)
- ASCE Policy Statement 379: Hydropower (PS 379)
- ASCE Policy Statement 490: Nuclear Power (PS 490)