Environmental and Renewable Energy Regulations

Environmental requirements and renewable energy mandates have a significant impact on PJM markets. The Mercury and Air Toxics Standards Rule (MATS) requires significant investments for some fossil-fired power plants in the PJM footprint in order to reduce heavy metal emissions. The EPA has promulgated intrastate and interstate air quality standards and associated emissions limits for states. The most recent interstate emissions rule, the Cross-State Air Pollution Rule (CSAPR), would if implemented, also require investments for some fossil-fired power plants in the PJM footprint in order to reduce SO_2 and NO_X emissions. New Jersey's High Electric Demand Day (HEDD) Rule limits NO_X emissions on peak energy demand days and requires investments for noncompliant units. CO_2 costs resulting from RGGI affect some unit offers in the PJM energy market. The investments required for environmental compliance have resulted in higher offers in the capacity market, and when units do not clear, in the retirement of units.

Renewable energy mandates and associated incentives by state and federal governments have resulted in the construction of substantial amounts of renewable capacity in the PJM footprint, especially wind and solar powered resources. Renewable energy credit (REC) markets created by state programs and federal tax credits have potentially significant impacts on PJM wholesale markets.[1]

Overview

Federal Environmental Regulation

- **EPA Mercury and Air Toxics Standards Rule.**[2] On December 16, 2011, the U.S. Environmental Protection Agency (EPA) issued its Mercury and Air Toxics Standards rule (MATS), which applies the Clean Air Act (CAA) maximum achievable control technology (MACT) requirement to new or modified sources of emissions of mercury and arsenic, acid gas, nickel, selenium and cyanide.[3] The rule establishes a compliance deadline of April 16, 2015.

  In addition, in a related EPA rule issued on the same date regarding utility New Source Performance Standards (NSPS), the EPA requires new coal and oil fired electric utility generating units constructed after May 3, 2011, to comply with amended emission standards for SO_2, NO_X and filterable particulate matter. On March 28, 2013, EPA issued a rule that raised the new source limits for new coal- and oil-fired power plants based on new information and analysis.[4]

- **Air Quality Standards (NO_X and SO_2 Emissions).** The CAA requires each state to attain and maintain compliance with fine particulate matter and ozone national ambient air quality standards (NAAQS). The CAA requires each State to prohibit emissions that significantly interfere with the ability of another State to meet NAAQS.

  On August 21, 2012, the U.S. Court of Appeals for the District of Columbia Circuit vacated the most recently issued rule limiting interstate emissions, the Cross-State Air Pollution Rule (CSAPR), which previously had been subject to a stay.[5] The Supreme Court granted EPA's petition for certiorari on June 24, 2013, and its review of CSAPR is pending. Meanwhile, the Clean Air Interstate Rule (CAIR) remains in effect. The EPA continues to process a number of pending requests under CAIR, including State Implementation Plans (SIPs), originally submitted under CSAPR.

- **National Emission Standards for Reciprocating Internal Combustion Engines.** On January 14, 2013, EPA signed a final rule regulating emissions from a wide variety of stationary reciprocating internal combustion engines (RICE).[6] RICE includes certain types of electrical generation facilities like diesel engines typically used for backup, emergency or supplemental power. RICE includes facilities located behind the meter. The

1 For quantification of the economics of new entrant wind and solar installations, see the *2012 State of the Market Report for PJM*, Volume 2: Section 6, "Net Revenue."

2 MATS replaces the Clean Air Mercury Rule (CAMR). It has been widely known previously as the "HAP" or "Utility MACT" rule.

3 *National Emission Standards for Hazardous Air Pollutants From Coal and Oil-Fired Electric Utility Steam Generating Units and Standards of Performance for Fossil-Fuel-Fired Electric Utility, Industrial-Commercial-Institutional, and Small Industrial-Commercial-Institutional Steam Generating Units*, EPA Docket No. EPA-HQ-OAR-2009-0234, 77 Fed. Reg. 9304 (February 16, 2012).

4 *Reconsideration of Certain New Source Issues: National Emission Standards for Hazardous Air Pollutants From Coal- and Oil-Fired Electric Utility Steam Generating Units and Standards of Performance for Fossil-Fuel-Fired Electric Utility, Industrial-Commercial-Institutional, and Small Industrial-Commercial-Institutional Steam Generating Units*, EPA Docket No. EPA-HQ-OAR 2009-0234, 78 Fed. Reg. 24073 (April 24, 2013).

5 *See* EME Homer City Generations, L.P. v. EPA, NO. 11-1302.

6 *National Emission Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines; New Source Performance Standards for Stationary Internal Combustion Engines*, Final Rule, EPA Docket No. EPA-HQ-OAR-2008-0708, 78 Fed. Reg. 9403 (January 30, 2013).

rule exempts from its requirements one hundred hours of RICE operation in emergency demand response programs, provided that RICE uses ultra low sulfur diesel fuel (ULSD). Otherwise, a 15-hour exception applies. Emergency demand response programs include Demand Resources in RPM.

- **Greenhouse Gas Emissions Rule.** On September 20, 2013, EPA proposed standards placing national limits on the amount of CO_2 that new power plants would be allowed to emit.[7] The proposed rule includes two limits for fossil fuel fired utility boilers and IGCC units based on the compliance period selected: 1,100 lb CO_2/MWh gross over a 12 operating month period, or 1,000–1,050 lb CO_2/MWh gross over an 84 operating month (7-year) period. The proposed rule also includes two standards for natural gas fired stationary combustion units based on the size (MW): 1,000 lb CO_2/MWh gross for larger units (> 850 mmBtu/hr), or 1,100 lb CO_2/MWh gross for smaller units (≤ 850 mmBtu/hr). Contemporaneously, the EPA withdrew its proposed rule on the same matter, published April 13, 2012.[8]

State Environmental Regulation

- **NJ High Electric Demand Day (HEDD) Rule.** New Jersey addressed the issue of NO_X emissions on peak energy demand days with a rule that defines peak energy usage days, referred to as High Electric Demand Days or HEDD, and imposes operational restrictions and emissions control requirements on units responsible for significant NO_X emissions on such high energy demand days.[9] New Jersey's HEDD rule, which became effective May 19, 2009, applies to HEDD units, which include units that have a NO_X emissions rate on HEDD equal to or exceeding 0.15 lbs/MMBtu and lack identified emission control technologies.[10]
- **Regional Greenhouse Gas Initiative (RGGI).** The Regional Greenhouse Gas Initiative (RGGI) is a cooperative effort by Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont to cap CO_2 emissions from power generation facilities. Auction prices in 2013 for the 2012-2014 compliance period were an average of $2.89 per ton, above the price floor for 2013. The clearing price is equivalent to a price of $3.19 per metric tonne, the unit used in other carbon markets.

Emissions Controls in PJM Markets

Due to environmental regulations and agreements to limit emissions, many PJM units burning fossil fuels have installed emission control technology. Environmental regulations may affect decisions about emission control investments in existing units, investment in new units and decisions to retire units lacking emission controls. On June 30, 2013, 69.4 percent of coal steam MW had some type of FGD (flue-gas desulfurization) technology to reduce SO_2 emissions from coal steam units, while 97.6 percent of coal steam MW had some type of particulate control, and 91.3 percent of fossil fuel fired capacity in PJM had NOx emission control technology in place.

State Renewable Portfolio Standards

Many PJM jurisdictions have enacted legislation to require that a defined percentage of utilities' load be served by renewable resources, for which there are many standards and definitions. These are typically known as Renewable Portfolio Standards, or RPS. As of September 30, 2013, Delaware, Illinois, Indiana, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, and Washington D.C. had renewable portfolio standards. Virginia has enacted a voluntary renewable portfolio standard. Kentucky and Tennessee have enacted no renewable portfolio standards. West Virginia has enacted a renewable portfolio standard, but it will not be in effect until 2015.

Renewable energy credits provide out of market payments to qualifying resources, primarily wind and solar. The out of market payments in the form of RECs and federal production tax credits mean these units have an incentive to generate MWh until the LMP is equal to the marginal cost of producing minus the credit received for each MWh. As the net of LMP and credits can be negative, the credits can provide an incentive to make negative energy offers. These subsidies affect the offer behavior of these resources in PJM markets and thus the market prices and the mix of clearing resources.

7 *Standards of Performance for Greenhouse Gas Emissions from New Stationary Sources: Electric Utility Generating Units, Propose Rule*, EPA-HQ-OAR-2013-0495.

8 *Withdrawal of Proposed Standards of Performance for Greenhouse Gas Emissions for New Stationary Sources: Electric Utility Generating Units*, EPA-HQ-OAR-2011-0660 (September 20, 2013).

9 N.J.A.C. § 7:27–19.

10 CTs must have either water injection or Selective Catalytic Reduction (SCR) controls; steam units must have either an SCR or and Selective Non-Catalytic Reduction (SNCR).

Conclusion

Environmental requirements and renewable energy mandates at both the Federal and state levels have a significant impact on the cost of energy and capacity in PJM markets. Renewable energy credit markets are markets related to the production and purchase of wholesale power, but are not subject to FERC regulation or any other market regulation or oversight. RECs markets are, as an economic fact, integrated with PJM markets including energy and capacity markets, but are not formally recognized as part of PJM markets.

PJM markets provide a flexible mechanism for incorporating the costs of environmental controls and meeting environmental requirements in a cost effective manner. PJM markets also provide a flexible mechanism that incorporates renewable resources and renewable energy credit markets, and ensures that renewable resources have access to a broad market. PJM markets provide efficient price signals that permit valuation of resources with very different characteristics when they provide the same product.

Federal Environmental Regulation

The U.S. Environmental Protection Agency (EPA) administers the Clean Air Act (CAA), which, among other things, comprehensively regulates air emissions by establishing acceptable levels of and regulating emissions of hazardous air pollutants. EPA issues technology based standards for major sources and certain area sources of emissions.[11,12] EPA actions have and are expected to continue to affect the cost to build and operate generating units in PJM which in turn affects wholesale energy prices and capacity prices.

The EPA also regulates water pollution, and its regulation of cooling water intakes under section 316(b) of the Clean Water Act (CWA) affects generating plants that rely on water drawn from jurisdictional water bodies.[13]

11 42 U.S.C. § 7401 et seq. (2000).

12 EPA defines "major sources" as a stationary source or group of stationary sources that emit or have the potential to emit 10 tons per year or more of a hazardous air pollutant or 25 tons per year or more of a combination of hazardous air pollutants. An "area source" is any stationary source that is not a major source.

13 The CWA applies to "navigable waters," which are, in turn, defined to include the "waters of the United States, including territorial seas." 33 U.S.C. § 1362(7). An interpretation of this rule has created some uncertainty on the scope of the waters subject to EPA jurisdiction, (*see Rapanos v. U.S., et al.*, 547 U.S. 715 (2006)), which the EPA continues to attempt to resolve.

Control of Mercury and Other Hazardous Air Pollutants

Section 112 of the CAA requires the EPA to promulgate emissions control standards, known as the National Emission Standards for Hazardous Air Pollutants (NESHAP), from both new and existing area and major sources. There are at least three NESHAP rulemakings in progress that will impact operations at various classes of generating units.[14]

On December 21, 2011, the U.S. Environmental Protection Agency (EPA) issued its Mercury and Air Toxics Standards rule (MATS), which applies the Clean Air Act (CAA) maximum achievable control technology (MACT) requirement to new or modified sources of emissions of mercury and arsenic, acid gas, nickel, selenium and cyanide.[15] The rule establishes a compliance deadline of April 16, 2015.

In addition, in a related EPA rule issued on the same date regarding utility New Source Performance Standards (NSPS), the EPA requires new coal and oil fired electric utility generating units constructed after May 3, 2011, to comply with amended emission standards for SO_2, NO_X and filterable particulate matter. On March 28, 2013, EPA issued a rule that raised the new source limits for new coal- and oil-fired power plants based on new information and analysis.[16]

Air Quality Standards: Control of NO_x and SO_2 Emissions Allowances

The CAA requires each state to attain and maintain compliance with fine particulate matter and ozone national ambient air quality standards (NAAQS). The CAA requires each State to prohibit emissions that significantly interfere with the ability of another State to meet NAAQS.[17] The EPA has sought to promulgate default Federal rules to achieve this objective.[18]

14 For more details see the *2012 State of the Market Report for PJM*, Volume 2; Section 7, "Environmental and Renewables."

15 *National Emission Standards for Hazardous Air Pollutants From Coal and Oil-Fired Electric Utility Steam Generating Units and Standards of Performance for Fossil-Fuel-Fired Electric Utility, Industrial-Commercial-Institutional, and Small Industrial-Commercial-Institutional Steam Generating Units*, EPA Docket No. EPA-HQ-OAR-2009-0234, 77 Fed. Reg. 9304 (February 16, 2012).

16 *Reconsideration of Certain New Source Issues: National Emission Standards for Hazardous Air Pollutants From Coal- and Oil-Fired Electric Utility Steam Generating Units and Standards of Performance for Fossil-Fuel-Fired Electric Utility, Industrial-Commercial-Institutional, and Small Industrial-Commercial-Institutional Steam Generating Units*, EPA Docket No. EPA-HQ-OAR 2009-0234, 78 Fed. Reg. 24073 (April 24, 2013).

17 CAA § 110(a)(2)(D)(i)(I).

18 For more details see the *2012 State of the Market Report for PJM*, Volume 2: Section 7, "Environmental and Renewables."

On August 21, 2012, the U.S. Court of Appeals for the District of Columbia Circuit vacated CSAPR, which previously had been subject to a stay.[19] The Supreme Court granted EPA's petition for certiorari on June 24, 2013, and its review of CSAPR is pending. Meanwhile, the Clean Air Interstate Rule (CAIR) remains in effect. The EPA continues to process a number of pending requests under CAIR, including State Implementation Plans (SIPs), originally submitted under CSAPR.

Emission Standards for Reciprocating Internal Combustion Engines

On January 14, 2013, EPA signed a final rule regulating emissions from a wide variety of stationary reciprocating internal combustion engines (RICE).[20] RICE include certain types of electrical generation facilities like diesel engines typically used for backup, emergency or supplemental power. RICE include facilities located behind the meter. These rules include: National Emission Standard for Hazardous Air Pollutants (NESHAP) for Reciprocating Internal Combustion Engines (RICE); New Source Performance Standards (NSPS)–Standards of Performance for Stationary Spark Ignition Internal Combustion Engines; and Standards of Performance for Stationary Compression Ignition Internal Combustion Engines (collectively "RICE Rules").[21]

The RICE rules apply to emissions such as formaldehyde, acrolein, acetaldehyde, methanol, CO, NO_X, volatile organic compounds (VOCs), and PM. The regulatory regime for RICE is complicated, and the applicable requirements turn on the location of the engine (area source or major source), and the starter mechanism for the engine (compression ignition or spark ignition).

On May 22, 2012, the EPA proposed amendments to the RICE NESHAP Rule.[22] The proposed rule allowed owners and operators of emergency stationary internal combustion engines to operate them in emergency conditions, as defined in those regulations, as part of an emergency demand response program for 100 hours per year or the minimum hours required by an Independent System Operator's tariff, whichever is less. The Market Monitoring Unit objected to the proposed rule, as it had to similar provisions in a related proposed settlement released for comment, explaining that it was not required for participation by demand side resources in the PJM markets nor for reliability.[23] The final rule approves the proposed 100 hours per year exception, provided that RICE uses ultra low sulfur diesel fuel (ULSD).[24] Otherwise a 15-hour exception applies.[25] The exempted emergency demand response programs include Demand Resources in RPM.

Regulation of Greenhouse Gas Emissions

On April 2, 2007, the U.S. Supreme Court overruled the EPA's determination that it was not authorized to regulate greenhouse gas emissions under the CAA and remanded the matter to EPA to determine whether greenhouse gases endanger public health and welfare.[26] On December 7, 2009, the EPA determined that greenhouse gases, including carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride, endanger public health and welfare.[27] In a decision dated June 26, 2012, the U.S. Court of Appeals for the D.C. Circuit upheld the endangerment finding, rejecting challenges brought by industry groups and a number of states.[28,29]

On September 20, 2013, EPA proposed standards placing national limits on the amount of CO_2 that new power plants would be allowed to emit.[30] The standards would require advanced technologies like efficient natural gas units and efficient coal units implementing partial carbon capture and storage (CCS). The proposed rule includes two limits for fossil fuel fired utility boilers and IGCC units based on the compliance period selected: 1,100 lb CO_2/MWh gross

19 *See* EME Homer City Generations, L.P. v. EPA, NO. 11-1302.

20 *National Emission Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines; New Source Performance Standards for Stationary Internal Combustion Engines, Final Rule*, EPA Docket No. EPA-HQ-OAR-2008-0708, 78 Fed. Reg. 6674 (January 30, 2013) ("Final NESHAP RICE Rule").

21 EPA Docket No. EPA-H-OAR-2009-0234 & -2011-0044, codified at 40 CFR Part 63, Subpart ZZZZ; EPA Dockets Nos. EPA-HQ-OAR-2005-0030 & EPA-HQ-OAR-2005-0029, -2010-0295 , codified at 40 CFR Part 60 Subpart JJJJ.

22 *National Emission Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines; New Source Performance Standards for Stationary Internal Combustion Engines*, Proposed Rule, EPA Docket No. EPA-HQ-OAR-2008-0708.

23 *See* Comments of the Independent Market Monitor for PJM, Docket No. EPA-HQ-OAR-2008-0708 (August 9, 2012); *In the Matter of: EnerNOC, Inc., et al.*, Comments of the Independent Market Monitor for PJM, Docket No. EPA-HQ-OGC-2011-1030 (February 16, 2012).

24 Final NESHAP RICE Rule at 31-24.

25 *Id.* at 31.

26 Massachusetts v. EPA, 549 U.S. 497.

27 *See Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act*, 74 Fed. Reg. 66496, 66497 (December 15, 2009).

28 Coalition for Responsible Regulation, Inc., et al. v. EPA, No 09-1322.

29 For more details see the *2012 State of the Market Report for PJM*, Volume 2: Section 7, "Environmental and Renewables.

30 *Standards of Performance for Greenhouse Gas Emissions from New Stationary Sources: Electric Utility Generating Units, Propose Rule*, EPA-HQ-OAR-2013-0495; The President's Climate Action Plan, Executive Office of the President (June 2013); Presidential Memorandum–Power Sector Carbon Pollution Standards, Environmental Protection Agency ("June 25, 2013); Presidential Memorandum–Power Section Caron Pollution Standards (June 25, 2013) (June 25th Presidential Memorandum").

over a 12 operating month period, or 1,000–1,050 lb CO_2/MWh gross over an 84 operating month (seven year) period. The proposed also includes two standards for natural gas fired stationary combustion units based on the size (MW): 1,000 lb CO_2/MWh gross for larger units (> 850 mmBtu/hr), or 1,100 lb CO_2/MWh gross for smaller units (≤ 850 mmBtu/hr). Contemporaneously, the EPA withdrew its proposed rule on the same matter, published April 13, 2012.[31]

Federal Regulation of Environmental Impacts on Water

On March 28, 2011, the EPA issued a proposed rule intended to ensure that the location, design, construction, and capacity of cooling water intake structures reflects the best technology available (BTA) for minimizing adverse environmental impacts, as required under Section 316(b) of the CWA.[32] A settlement in a Federal Court, as modified, obligates the EPA to issue a final rule no later than November 4, 2013.[33,34]

State Environmental Regulation

New Jersey High Electric Demand Day (HEDD) Rules

The EPA's transport rules apply to total annual and seasonal emissions. Units that run only during peak demand periods have relatively low annual emissions, and have less incentive to make such investments under the EPA transport rules.

New Jersey addressed the issue of NO_X emissions on peak energy demand days with a rule that defines peak energy usage days, referred to as High Electric Demand Days or HEDD, and imposes operational restrictions and emissions control requirements on units responsible for significant NO_X emissions on such high energy demand days.[35] New Jersey's HEDD rule, which became effective May 19, 2009, applies to HEDD units, which include units that have a NO_X emissions rate on HEDD equal to or exceeding 0.15 lbs/MMBtu and lack identified emission control technologies.[36,37]

Table 8-1 shows the HEDD emissions limits applicable to each unit type. Emissions limits for coal units became effective December 15, 2012.[38] Emissions limits for other unit types will become effective May 1, 2015.[39]

Table 8-1 HEDD maximum NO_X emission rates[40]

Fuel and Unit Type	Emission Limit (lbs/MWh)
Coal Steam Unit	1.50
Heavier than No. 2 Fuel Oil Steam Unit	2.00
Simple cycle gas CT	1.00
Simple cycle oil CT	1.60
Combined cycle gas CT	0.75
Combined cycle oil CT	1.20
Regenerative cycle gas CT	0.75
Regenerative cycle oil CT	1.20

State Regulation of Greenhouse Gas Emissions

The Regional Greenhouse Gas Initiative (RGGI) is a cooperative effort by Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont to cap CO_2 emissions from power generation facilities.[41,42]

Table 8-2 shows the RGGI CO_2 auction clearing prices and quantities for the 14 2009-2011 compliance period auctions and additional auctions for the 2012-2014 compliance period held as of December 31, 2012. Prices for auctions held in the first nine months of 2013 for the 2012-2014 compliance period were from $2.80 to $3.21 per allowance (equal to one ton of CO_2), which is

31 *Withdrawal of Proposed Standards of Performance for Greenhouse Gas Emissions for New Stationary Sources: Electric Utility Generating Units*, EPA-HQ-OAR-2011-0660 (September 20, 2013).
32 *EPA, National Pollutant Discharge Elimination System—Cooling Water Intake Structures at Existing Facilities and Phase I Facilities, Proposed Rule*, Docket No. EPA-HQ-OW-2008-0667, 76 Fed. Reg. 22174 (April 20, 2011) (Cooling Water Proposed Rule).
33 Settlement Agreement among the United States Environmental Protection Agency, Plaintiffs in Cronin, et al. v. Reilly, 93 Civ. 314 (LTS) (SDNY), and Plaintiffs in Riverkeeper, et al. v. EPA, 06 CIV. 12987 (PKC) (SDNY), dated November 22, 2010, *modified*, Second Amendment to Settlement Agreement among the Environmental Protection Agency, Plaintiffs in Cronin, et al. v. Reilly, dated July 17, 2012; Third Amendment to Settlement Agreement among the Environmental Protection Agency, the Plaintiffs in Conin, et al. v. Reilly, 93 Civ. 314 (LTS) (SDNY), and the Plaintiffs in Riverkeeper, et al. v. EPA, 06 Civ. 12987 (PKC) (SDNY).
34 For more details see the *2012 State of the Market Report for PJM*, Volume 2: Section 7, "Environmental and Renewables."
35 N.J.A.C. § 7:27–19.
36 CTs must have either water injection or Selective Catalytic Reduction (SCR) controls; steam units must have either an SCR or and Selective Non-Catalytic Reduction (SNCR).
37 For more details see the *2012 State of the Market Report for PJM*, Volume 2: Section 7, "Environmental and Renewables."
38 N.J.A.C. § 7:27-19.4.
39 N.J.A.C. § 7:27-19.5.
40 Regenerative cycle CTs are combustion turbines that recover heat from its exhaust gases and uses that heat to preheat the inlet combustion air which is fed into the combustion turbine.
41 RGGI provides a link on its website to state statutes and regulations authorizing its activities, which can be accessed at: <http://www.rggi.org/design/regulations>.
42 For more details see the *2012 State of the Market Report for PJM*, Volume 2: Section 7, "Environmental and Renewables."

above the current price floor for RGGI auctions.[43] The RGGI clearing prices ranged from $1.86 to $1.93 per ton from June 2010 through December 2012. In 2013, the clearing price in June 2013 rose to to $3.21 per ton, the highest price since June 2009. The average spot price the first nine months of 2013 for a 2012-2014 compliance period allowance was $2.98 per ton, $0.96 higher than the average of the first nine months of 2012. Monthly average spot prices for the 2012-2014 compliance period ranged from $1.99 per ton in January to $3.42 per ton in April. Table 8-3 converts the RGGI CO_2 clearing prices and quantities to metric tonnes and corresponding prices per metric tonne for comparison to other CO_2 markets.

Table 8-2 RGGI CO_2 allowance auction prices and quantities in short tons: 2009-2011 and 2012-2014 Compliance Periods[44]

Auction Date	Clearing Price	Quantity Offered	Quantity Sold
September 25, 2008	$3.07	12,565,387	12,565,387
December 17, 2008	$3.38	31,505,898	31,505,898
March 18, 2009	$3.51	31,513,765	31,513,765
June 17, 2009	$3.23	30,887,620	30,887,620
September 9, 2009	$2.19	28,408,945	28,408,945
December 2, 2009	$2.05	28,591,698	28,591,698
March 10, 2010	$2.07	40,612,408	40,612,408
June 9, 2010	$1.88	40,685,585	40,685,585
September 10, 2010	$1.86	45,595,968	34,407,000
December 1, 2010	$1.86	43,173,648	24,755,000
March 9, 2011	$1.89	41,995,813	41,995,813
June 8, 2011	$1.89	42,034,184	12,537,000
September 7, 2011	$1.89	42,189,685	7,847,000
December 7, 2011	$1.89	42,983,482	27,293,000
March 14, 2012	$1.93	34,843,858	21,559,000
June 6, 2012	$1.93	36,426,008	20,941,000
September 5, 2012	$1.93	37,949,558	24,589,000
December 5, 2012	$1.93	37,563,083	19,774,000
March 13, 2013	$2.80	37,835,405	37,835,405
June 5, 2013	$3.21	38,782,076	38,782,076
September 4, 2013	$2.67	38,409,043	38,409,043

Table 8-3 RGGI CO_2 allowance auction prices and quantities in metric tonnes: 2009-2011 and 2012-2014 Compliance Periods[45]

Auction Date	Clearing Price	Quantity Offered	Quantity Sold
September 25, 2008	$3.38	11,399,131	11,399,131
December 17, 2008	$3.73	28,581,678	28,581,678
March 18, 2009	$3.87	28,588,815	28,588,815
June 17, 2009	$3.56	28,020,786	28,020,786
September 9, 2009	$2.41	25,772,169	25,772,169
December 2, 2009	$2.26	25,937,960	25,937,960
March 10, 2010	$2.28	36,842,967	36,842,967
June 9, 2010	$2.07	36,909,352	36,909,352
September 10, 2010	$2.05	41,363,978	31,213,514
December 1, 2010	$2.05	39,166,486	22,457,365
March 9, 2011	$2.08	38,097,972	38,097,972
June 8, 2011	$2.08	38,132,781	11,373,378
September 7, 2011	$2.08	38,273,849	7,118,681
December 7, 2011	$2.08	38,993,970	24,759,800
March 14, 2012	$2.13	31,609,825	19,558,001
June 6, 2012	$2.13	33,045,128	18,997,361
September 5, 2012	$2.13	34,427,270	22,306,772
December 5, 2012	$2.13	34,076,665	17,938,676
March 13, 2013	$3.09	34,323,712	34,323,712
June 5, 2013	$3.54	35,182,518	35,182,518
September 4, 2013	$2.94	34,844,108	34,844,108

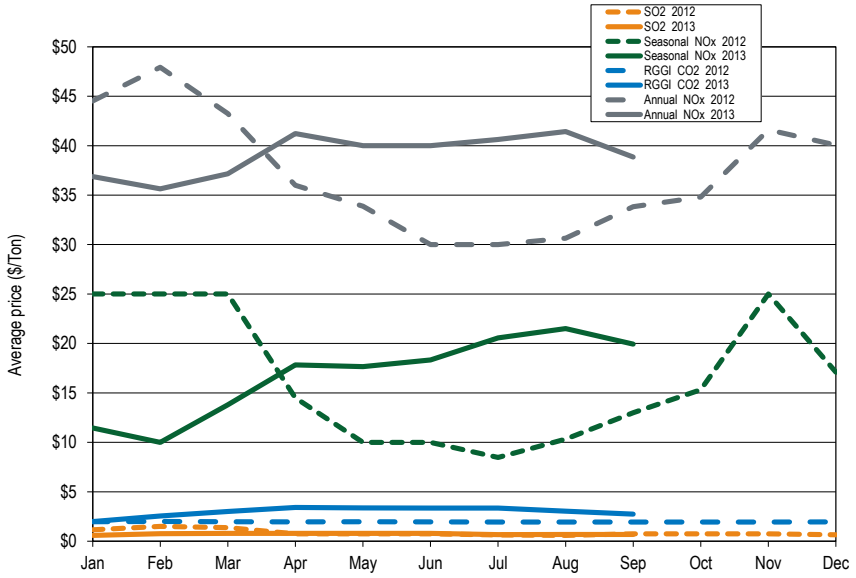
Figure 8-1 shows average, daily settled prices for NO_X and SO_2 emissions within PJM. In the first nine months of 2013, NO_X prices were 6.6 percent higher than in 2012. SO_2 prices were 20.3 percent lower in the first nine months of 2013 than in 2012. Figure 8-1 also shows the average, daily settled price for the Regional Greenhouse Gas Initiative (RGGI) CO_2 allowances. RGGI allowances are required by generation in participating RGGI states. This includes PJM generation located in Delaware and Maryland.

43 RGGI measures carbon in short tons (short ton equals 2,000 pounds) while world carbon markets measure carbon in metric tonnes (metric tonne equals 1,000 kilograms or 2,204.6 pounds).

44 See "Regional Greenhouse Gas Initiative: Auction Results," <http://www.rggi.org/market/co2_auctions/results> (Accessed July 15, 2013).

45 See "Regional Greenhouse Gas Initiative: Auction Results," <http://www.rggi.org/market/co2_auctions/results> (Accessed July 15, 2013).

Figure 8-1 Spot monthly average emission price comparison: 2012 and 2013



Renewable Portfolio Standards

Many PJM jurisdictions have enacted legislation to require that a defined percentage of utilities' load be served by renewable resources, for which there are many standards and definitions. These are typically known as Renewable Portfolio Standards, or RPS. As of June 30, 2013, Delaware, Illinois, Indiana, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, and Washington D.C. had renewable portfolio standards. Virginia has enacted a voluntary renewable portfolio standard. Kentucky and Tennessee have enacted no renewable portfolio standards. West Virginia has enacted a renewable portfolio standard, but it will not be in effect until 2015.

Under the proposed standards, a substantial amount of load in PJM is required to be served by renewable resources by 2023. As shown in Table 8-4, New Jersey will require 22.5 percent of load to be served by renewable resources in 2023, the most stringent standard of all PJM jurisdictions. Typically, renewable generation earns renewable energy credits (also known as alternative energy credits), or RECs, when they generate. These RECs are bought by utilities and load serving entities to fulfill the requirements for renewable generation. Standards for renewable portfolios differ from jurisdiction to jurisdiction. For example, Illinois only requires utilities to purchase renewable energy credits, while Pennsylvania requires all load serving entities to purchase renewable energy credits (known as alternative energy credits in Pennsylvania).

Renewable energy credit markets are markets related to the production and purchase of wholesale power, but are not subject to FERC regulation or any other market regulation or oversight. RECs markets are, as an economic fact, integrated with PJM markets including energy and capacity markets, but are not formally recognized as part of PJM markets. Revenues from RECs markets are out of market revenues for PJM resources and are in addition to revenues earned from the sale of the same MWh in PJM markets. Many jurisdictions allow various types of renewable resources to earn multiple RECs per MWh, though typically one REC is equal to one MWh. For example, West Virginia allows one credit per MWh from generation from "alternative energy resources" including waste coal and pumped-storage hydroelectric, and allows two credits per MWh of electricity generated by "renewable energy resources," which include wind, solar, and run of river hydroelectric. PJM Environmental Information Services (EIS), an unregulated subsidiary of PJM, operates the Generation Attribute Tracking System (GATS), which is used by many jurisdictions to track these renewable energy credits.

Many PJM jurisdictions have also added specific requirements for the purchase of solar resources. These solar requirements are included in the standards shown in Table 8-4 but must be met by solar RECs (SRECs) only. Delaware, Illinois, Maryland, New Jersey, North Carolina, Ohio, Pennsylvania, and Washington, D.C., all have requirements for the proportion of load served by solar units by 2023.[46] Indiana, Michigan, Virginia, and West Virginia have no specific solar standards. In 2013, the most stringent standard in PJM was New Jersey's, requiring that 0.75 percent of load be served by solar resources. As Table 8-5 shows, by 2023, the most stringent standard will be New Jersey's which requires that at least 3.65 percent of load be served by solar.

Table 8-4 Renewable standards of PJM jurisdictions to 2023[47,48]

Jurisdiction	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Delaware	10.00%	11.50%	13.00%	14.50%	16.00%	17.50%	19.00%	20.00%	21.00%	22.00%	23.00%
Illinois	7.00%	8.00%	9.00%	10.00%	11.50%	13.00%	14.50%	16.00%	17.50%	19.00%	20.50%
Indiana	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	7.00%	7.00%	7.00%	7.00%	7.00%
Kentucky	No Standard										
Maryland	10.70%	12.80%	13.00%	15.20%	15.60%	18.30%	17.70%	18.00%	18.70%	20.00%	20.00%
Michigan	<10.00%	<10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%
New Jersey	10.14%	11.10%	12.07%	13.08%	14.10%	16.16%	18.25%	20.37%	22.50%	22.50%	22.50%
North Carolina	3.00%	3.00%	6.00%	6.00%	6.00%	10.00%	10.00%	10.00%	12.50%	12.50%	12.50%
Ohio	2.00%	2.50%	3.50%	4.50%	5.50%	6.50%	7.50%	8.50%	9.50%	10.50%	11.50%
Pennsylvania	10.20%	10.70%	11.20%	13.70%	14.20%	14.70%	15.20%	15.70%	18.00%	18.00%	18.00%
Tennessee	No Standard										
Virginia	4.00%	4.00%	4.00%	7.00%	7.00%	7.00%	7.00%	7.00%	7.00%	12.00%	12.00%
Washington, D.C.	9.00%	10.50%	12.00%	13.50%	15.00%	16.50%	18.00%	20.00%	20.00%	20.00%	20.00%
West Virginia			10.00%	10.00%	10.00%	10.00%	10.00%	15.00%	15.00%	15.00%	15.00%

Table 8-5 Solar renewable standards of PJM jurisdictions to 2023

Jurisdiction	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Delaware	0.60%	0.80%	1.00%	1.25%	1.50%	1.75%	2.00%	2.25%	2.50%	2.75%	3.00%
Illinois	0.00%	0.12%	0.27%	0.60%	0.69%	0.78%	0.87%	0.96%	1.05%	1.14%	1.23%
Indiana	No Solar Standard										
Kentucky	No Standard										
Maryland	0.25%	0.35%	0.50%	0.70%	0.95%	1.40%	1.75%	2.00%	2.00%	2.00%	2.00%
Michigan	No Solar Standard										
New Jersey	0.75%	2.05%	2.45%	2.75%	3.00%	3.20%	3.29%	3.38%	3.47%	3.56%	3.65%
North Carolina	0.07%	0.07%	0.14%	0.14%	0.14%	0.20%	0.20%	0.20%	0.20%	0.20%	0.20%
Ohio	0.09%	0.12%	0.15%	0.18%	0.22%	0.26%	0.30%	0.34%	0.38%	0.42%	0.46%
Pennsylvania	0.05%	0.08%	0.14%	0.25%	0.29%	0.34%	0.39%	0.44%	0.50%	0.50%	0.50%
Tennessee	No Standard										
Virginia	No Solar Standard										
Washington, D.C.	0.50%	0.60%	0.70%	0.83%	0.98%	1.15%	1.35%	1.58%	1.85%	2.18%	2.50%
West Virginia	No Solar Standard										

46 Pennsylvania and Delaware allow only solar photovoltaic resources to fulfill the solar requirement.
47 This shows the total standard of renewable resources in all PJM jurisdictions, including Tier I and Tier II resources.
48 Michigan in 2012-2014 must make up the gap between 10 percent renewable energy and the renewable energy baseline in Michigan. In 2012, this means baseline plus 20 percent of the gap between baseline and 10 percent renewable resources, in 2013, baseline plus 33 percent and in 2014, baseline plus 50 percent.

Table 8-6 Additional renewable standards of PJM jurisdictions to 2023

Jurisdiction		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Illinois	Wind Requirement	5.25%	6.00%	6.75%	7.50%	8.63%	9.75%	10.88%	12.00%	13.13%	14.25%	15.38%
Maryland	Tier II Standard	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	0.00%	0.00%	0.00%	0.00%	0.00%
New Jersey	Class II Standard	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%
New Jersey	Solar Carve-Out (in GWh)	596	772	965	1,150	1,357	1,591	1,858	2,164	2,518	2,928	3,433
North Carolina	Swine Waste	0.07%	0.07%	0.14%	0.14%	0.14%	0.20%	0.20%	0.20%	0.20%	0.20%	0.20%
North Carolina	Poultry Waste (in GWh)	700	900	900	900	900	900	900	900	900	900	900
Pennsylvania	Tier II Standard	6.20%	6.20%	6.20%	8.20%	8.20%	8.20%	8.20%	8.20%	10.00%	10.00%	10.00%
Washington, D.C.	Tier 2 Standard	2.50%	2.50%	2.50%	2.00%	1.50%	1.00%	0.50%	0.00%	0.00%	0.00%	0.00%

Some PJM jurisdictions have also added other specific requirements to their renewable portfolio standards for other technologies. The standards shown in Table 8-6 are also included in the base standards. Illinois requires that a percentage of utility load be served by wind farms, with 5.25 percent of load served in 2013 escalating to 15.38 percent in 2023. Maryland, New Jersey, Pennsylvania, and Washington D.C. all have "Tier 2" or "Class 2" standards, which allow specific technology types, such as waste coal units in Pennsylvania, to qualify for renewable energy credits.[49] North Carolina also requires a certain amount of power generated using swine waste and poultry waste to fulfill their renewable portfolio standards (Table 8-6).

PJM jurisdictions include various methods for complying with required renewable portfolio standards. If an LSE is unable to comply with the renewable portfolio standards required by the LSE's jurisdiction, LSEs may make alternative compliance payments, with varying standards. These alternative compliance payments are a way to make up any shortfall between the RECs required by the state and those the LSE actually purchased. In New Jersey, solar alternative compliance payments are $641 per MWh.[50] Pennsylvania requires that the alternative compliance payment for solar credits be 200 percent of the average market value of solar RECs sold in the RTO. Compliance methods differ from jurisdiction to jurisdiction. For example, Illinois requires that 50 percent of the state's renewable portfolio standard be met through alternative compliance payments. Alternative resources include solar, wind energy, organic biomass, and hydro power not requiring new construction. Burning waste wood, garbage, or other forms of solid waste do not qualify as alternative resources. Table 8-7 shows the alternative compliance standards in PJM jurisdictions, where such standards exist. These alternative compliance methods can have a significant impact on the traded price of RECs.

Table 8-7 Renewable alternative compliance payments in PJM jurisdictions: 2013

Jurisdiction	Standard Alternative Compliance ($/MWh)	Tier II Alternative Compliance ($/MWh)	Solar Alternative Compliance ($/MWh)
Delaware	$25.00		$400.00
Illinois	$2.16		
Indiana	Voluntary standard		
Kentucky	No standard		
Maryland	$40.00	$15.00	$400.00
Michigan	No specific penalties		
New Jersey	$50.00		$641.00
North Carolina	No specific penalties		
Ohio	$45.00		$350.00
Pennsylvania	$45.00	$45.00	200% market value
Tennessee	No standard		
Virginia	Voluntary standard		
Washington, D.C.	$50.00	$10.00	$500.00
West Virginia	$50.00		

49 Pennsylvania Tier II credits includes energy derived from waste coal, distributed generation systems, demand-side management, large-scale hydropower, municipal solid waste, generation from wood pulping process, and integrated combined coal gasification technology.

50 See "New Jersey Renewables Portfolio Standard," <http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NJ05R&re=0&ee=0> (Accessed July 1, 2013).

Table 8-8 shows renewable generation by jurisdiction and resource type in the first nine months of 2013. This includes only units that would qualify for REC credits by primary fuel type, including waste coal, battery, and pumped-storage hydroelectric, which can qualify for Pennsylvania Tier II credits if they are located in the PJM footprint. Wind units account for 11,289.4 GWh of 19,322.1 Tier I GWh, or 58.4 percent, in the PJM footprint. As shown in Table 8-8, 39,358.2 GWh were generated by resources that were renewable, including both Tier II and Tier I renewable credits, of which, Tier I type resources accounted for 49.1 percent. Landfill gas, solid waste, and waste coal were 16,847.8 GWh of renewable generation or 42.8 percent of the total Tier I and Tier II.

Table 8-8 Renewable generation by jurisdiction and renewable resource type (GWh): January through September, 2013

Jurisdiction	Landfill Gas	Pumped-Storage Hydro	Run-of-River Hydro	Solar	Solid Waste	Waste Coal	Wind	Tier I Credit Only	Total Credit GWh
Delaware	81.6	0.0	0.0	0.0	0.0	0.0	0.0	81.6	163.2
Illinois	121.1	0.0	0.0	0.0	0.0	0.0	4,218.1	4,339.2	4,339.2
Indiana	0.0	0.0	34.2	0.0	0.0	0.0	2,333.3	2,367.5	2,367.5
Kentucky	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maryland	77.5	0.0	1,357.0	50.4	709.6	0.0	360.5	1,845.3	2,554.9
Michigan	16.5	0.0	48.0	0.0	0.0	0.0	0.0	64.5	64.5
New Jersey	249.8	409.2	16.6	180.3	1,058.6	0.0	6.5	453.1	1,920.9
North Carolina	0.0	0.0	520.8	0.0	0.0	0.0	0.0	520.8	520.8
Ohio	252.0	0.0	157.3	0.7	0.0	0.0	743.0	1,152.9	1,152.9
Pennsylvania	749.9	1,406.0	2,218.5	1.1	1,195.8	7,379.1	2,527.5	5,497.0	15,477.9
Tennessee	0.0	0.0	0.0	0.0	242.7	0.0	0.0	0.0	242.7
Virginia	316.3	3,244.2	603.5	0.0	1,037.1	2,578.5	0.0	919.8	7,779.5
Washington, D.C.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
West Virginia	6.4	0.0	973.4	0.0	0.0	775.5	1,100.6	2,080.3	2,855.8
Total	1,871.1	5,059.4	5,929.2	232.4	4,243.7	10,733.0	11,289.4	19,322.1	39,358.2

Table 8-9 shows the capacity of renewable resources in PJM by jurisdiction, as defined by primary or alternative fuel types.[51] This capacity includes various coal and natural gas units that have a renewable fuel as a secondary fuel, and thus are able to earn renewable energy credits. West Virginia has the largest amount of renewable capacity in PJM, 10,027.6 MW, or 26.7 percent of the total renewable capacity. West Virginia allows coal technology, coal bed methane, waste coal and fuel produced by a coal gasification facility to be counted as alternative energy resources. New Jersey has the largest amount of solar capacity in PJM, 186.8 MW, or 75.4 percent of the total solar capacity. Wind resources are located primarily in western PJM, in Illinois and Indiana, which include 3,707.6 MW, or 56.6 percent of the total wind capacity.

Table 8-9 PJM renewable capacity by jurisdiction (MW), on September 30, 2013

Jurisdiction	Coal	Landfill Gas	Natural Gas	Oil	Pumped-Storage Hydro	Run-of-River Hydro	Solar	Solid Waste	Waste Coal	Wind	Total
Delaware	0.0	8.1	1,835.3	13.8	0.0	0.0	0.0	0.0	0.0	0.0	1,857.2
Illinois	0.0	78.9	0.0	0.0	0.0	0.0	0.0	20.0	0.0	2,454.4	2,553.3
Indiana	0.0	0.0	0.0	0.0	0.0	8.2	0.0	0.0	0.0	1,253.2	1,261.4
Iowa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	185.0	185.0
Kentucky	510.0	0.0	0.0	0.0	0.0	70.0	0.0	0.0	0.0	0.0	580.0
Maryland	60.0	28.7	129.0	31.9	0.0	581.0	40.1	109.0	0.0	120.0	1,099.8
Michigan	0.0	4.8	0.0	0.0	0.0	11.8	0.0	0.0	0.0	0.0	16.6
New Jersey	0.0	85.5	0.0	0.0	400.0	5.0	186.8	189.1	0.0	7.5	873.9
North Carolina	0.0	0.0	0.0	0.0	0.0	315.0	0.0	94.0	0.0	0.0	409.0
Ohio	5,021.8	52.3	125.5	225.0	0.0	178.0	1.1	0.0	0.0	500.0	6,103.7
Pennsylvania	35.0	222.0	2,370.7	0.0	1,505.0	682.3	18.0	247.0	1,422.2	1,365.6	7,867.7
Tennessee	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	50.0
Virginia	63.0	124.8	80.0	7.0	3,588.0	457.1	2.7	215.0	0.0	0.0	4,537.6
West Virginia	8,539.0	2.0	450.0	0.0	0.0	243.1	0.0	0.0	130.0	663.5	10,027.6
PJM Total	14,228.8	607.1	4,990.5	277.7	5,493.0	2,551.5	248.8	924.1	1,552.2	6,549.2	37,422.8

51 PJM GATS.

Table 8-10 shows renewable capacity registered in the PJM Generation Attribute Tracking System (GATS), a system operated by PJM EIS. This includes solar capacity of 1,354.3 MW of which 895.8 MW is in New Jersey. These resources can also earn renewable energy credits, and can be used to fulfill the renewable portfolio standards in PJM jurisdictions. All capacity shown in Table 8-10 is registered in PJM GATS, and may sell renewable energy credits through PJM EIS. Some of this capacity is located in jurisdictions outside PJM, but that may qualify for specific renewable energy credits in some jurisdictions. This includes both behind-the-meter generation located inside PJM, and generation connected to other RTOs outside PJM.

Table 8-10 Renewable capacity by jurisdiction, non-PJM units registered in GATS[52,53] (MW), on September 30, 2013

Jurisdiction	Coal	Hydroelectric	Landfill Gas	Natural Gas	Other Gas	Other Source	Solar	Solid Waste	Wind	Total
Delaware	0.0	0.0	0.0	0.0	0.0	0.0	46.7	0.0	2.1	48.8
Georgia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.0	0.0	60.0
Illinois	0.0	6.6	91.8	0.0	0.0	0.0	34.5	0.0	302.5	435.4
Indiana	0.0	0.0	49.7	0.0	679.1	0.0	1.2	0.0	0.0	730.0
Kentucky	600.0	2.0	16.0	0.0	0.0	0.0	0.6	88.0	0.0	706.6
Maryland	0.0	0.0	7.0	0.0	0.0	0.0	95.2	1.2	0.3	103.7
Michigan	55.0	0.0	1.6	0.0	0.0	0.0	0.3	0.0	0.0	56.9
Minnesota	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Missouri	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	146.0	146.0
New Jersey	0.0	0.0	39.9	0.0	0.0	23.3	895.8	0.0	0.4	959.4
New York	0.0	146.7	0.0	0.0	0.0	0.0	0.4	0.0	0.0	147.1
North Carolina	0.0	0.0	0.0	0.0	0.0	0.0	8.0	0.0	0.0	8.0
Ohio	0.0	1.0	39.8	52.6	67.0	1.0	85.1	109.3	17.4	373.2
Pennsylvania	0.0	37.0	40.6	4.8	86.2	0.3	170.9	0.0	3.2	342.9
Virginia	0.0	12.5	14.8	0.0	0.0	0.0	5.9	318.1	0.0	351.4
West Virginia	0.0	9.0	0.0	0.0	0.0	0.0	0.4	44.6	0.0	54.0
Wisconsin	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	1.7
District of Columbia	0.0	0.0	0.0	0.0	0.0	0.0	7.7	0.0	0.0	7.7
Total	655.0	214.8	301.1	57.4	832.4	24.6	1,354.3	621.2	472.0	4,532.8

52 There is a 0.00216 MW solar facility registered in GATS from Minnesota that can sell solar RECs in the PJM jurisdictions of Pennsylvania and Illinois.
53 See "Renewable Generators Registered in GATS," <https://gats.pjm-eis.com/myModule/rpt/myrpt.asp?r=228> (Accessed July 15, 2013).

Emissions Controlled Capacity and Renewables in PJM Markets

Emission Controlled Capacity in the PJM Region

Environmental regulations may affect decisions about emission control investments in existing units, investment in new units and decisions to retire units lacking emission controls. Many PJM units burning fossil fuels have installed emission control technology.

Coal and heavy oil have the highest SO_2 emission rates, while natural gas and light oil have low to negligible SO_2 emission rates. Many coal steam units in PJM have installed FGD (flue-gas desulfurization) technology to reduce SO_2 emissions from coal steam units. Of the current 81,452.4 MW of coal steam capacity in PJM, 55,890.3 MW of capacity, 68.6 percent, has some form of FGD technology. Table 8-11 shows SO_2 emission controls by unit type, of fossil fuel units in PJM.[54]

Table 8-11 SO_2 emission controls (FGD) by unit type (MW), as of September 30, 2013

	SO_2 Controlled	No SO_2 Controls	Total	Percent Controlled
Coal Steam	55,890.3	25,562.1	81,452.4	68.6%
Combined Cycle	0.0	27,563.3	27,563.3	0.0%
Combustion Turbine	0.0	32,322.1	32,322.1	0.0%
Diesel	0.0	371.1	371.1	0.0%
Non-Coal Steam	0.0	8,735.4	8,735.4	0.0%
Total	55,890.3	94,554.0	150,444.3	37.2%

NO_x emission control technology is used by nearly all fossil fuel unit types. Coal steam, combined cycle, combustion turbine, and non-coal steam units in PJM have NO_x controls. Of current fossil fuel units in PJM, 137,192.6 MW, 91.2 percent, of 150,444.3 MW of capacity in PJM, have emission controls for NO_x. Table 8-12 shows NO_x emission controls by unit type in PJM. While most units in PJM have NO_x emission controls, many of these controls will likely need to be upgraded in order to meet each state's emission compliance standards. Future NO_x compliance standards will require SCRs or SCNRs for coal steam units, as well as SCRs or water injection technology for HEDD combustion turbine units.

Table 8-12 NO_x emission controls by unit type (MW), as of September 30, 2013

	NO_X Controlled	No NO_X Controls	Total	Percent Controlled
Coal Steam	78,694.8	2,757.6	81,452.4	96.6%
Combined Cycle	27,362.3	201.0	27,563.3	99.3%
Combustion Turbine	26,764.7	5,557.4	32,322.1	82.8%
Diesel	0.0	371.1	371.1	0.0%
Non-Coal Steam	4,370.8	4,364.6	8,735.4	50.0%
Total	137,192.6	13,251.7	150,444.3	91.2%

Most coal steam units in PJM have particulate controls. Typically, technologies such as electrostatic precipitators (ESP) or baghouses are used to reduce particulate matter in coal steam units. In PJM, 79,568.4 MW, 97.7 percent, of all coal steam unit MW, have some type of particulate emissions control technology. Table 8-13 shows particulate emission controls by unit type in PJM. Most coal steam units in PJM have particulate emission controls in the form of ESPs, but many of these controls will need to be upgraded in order to meet each state's emission compliance standards. Future particulate compliance standards will require baghouse technology or a combination of an FGD and SCR to meet EPA regulations, which many coal steam units have not installed.

Table 8-13 Particulate emission controls by unit type (MW), as of September 30, 2013

	Particulate Controlled	No Particulate Controls	Total	Percent Controlled
Coal Steam	79,568.4	1,884.0	81,452.4	97.7%
Combined Cycle	0.0	27,563.3	27,563.3	0.0%
Combustion Turbine	0.0	32,322.1	32,322.1	0.0%
Diesel	0.0	371.1	371.1	0.0%
Non-Coal Steam	3,047.0	5,688.4	8,735.4	34.9%
Total	82,615.4	67,828.9	150,444.3	54.9%

54 See "Air Market Programs Data," <http://ampd.epa.gov/ampd/> (Accessed July 15, 2013)

Fossil fuel fired units in PJM emit multiple pollutants, including CO_2, SO_2, and NO_x. Table 8-14 shows the estimated emissions from units in PJM in the first nine months of 2013. It is estimated that over 323 million tons of CO_2, 1.2 million tons of SO_2, and 599 thousand tons of NO_x were emitted in the first nine months of 2013 by PJM units.

Table 8-14 CO_2, SO_2, NO_x emissions by month (tons), by PJM units, January through September 2013

	Tons of CO_2	Tons of SO_2	Tons of NO_x
January	37,228,219.6	134,864.3	70,054.9
February	34,317,804.9	111,597.2	64,118.8
March	35,202,337.6	124,634.3	65,220.0
April	29,674,417.2	117,490.4	55,220.0
May	31,892,446.9	104,075.3	58,020.0
June	36,950,754.6	136,733.2	67,620.4
July	43,908,563.3	195,781.2	81,327.6
August	39,182,723.1	161,062.7	72,095.7
September	35,310,555.1	142,389.6	65,215.9
Total	323,667,822.2	1,228,628.1	598,893.2

Wind Units

Table 8-15 shows the capacity factor of wind units in PJM. In the first nine months of 2013, the capacity factor of wind units in PJM was 26.7 percent. Wind units that were capacity resources had a capacity factor of 26.7 percent and an installed capacity of 4,888 MW. Wind units that were classified as energy only had a capacity factor of 26.9 percent and an installed capacity of 1,476 MW. Wind capacity in RPM is derated to 13 percent of nameplate capacity for the Capacity Market, and energy only resources are not included in the Capacity Market.[55]

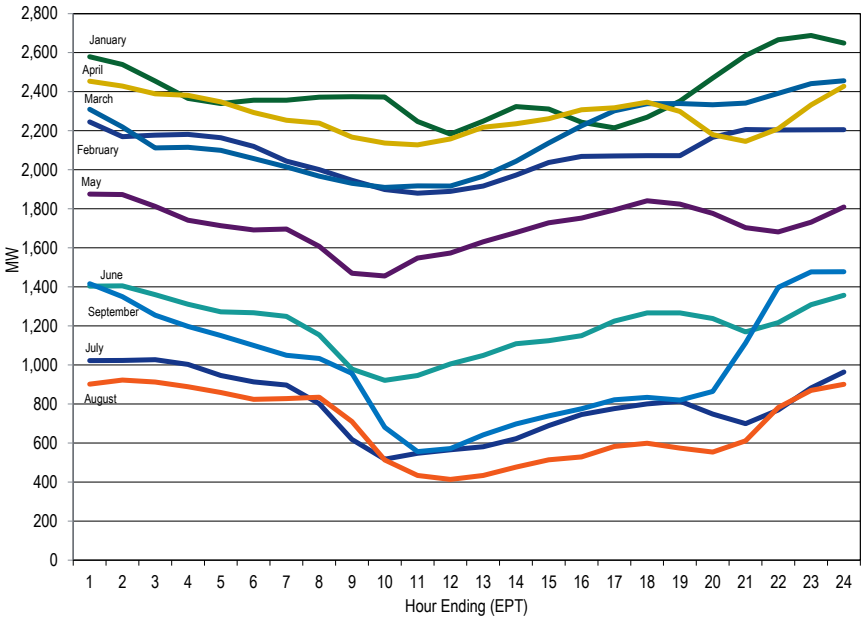
55 Wind resources are derated to 13 percent unless demonstrating higher availability during peak periods.

Table 8-15 Capacity factor of wind units in PJM: January through September 2013[56]

Type of Resource	Capacity Factor	Capacity Factor by cleared MW	Installed Capacity (MW)
Energy-Only Resource	26.9%	NA	1,476
Capacity Resource	26.7%	146.7%	4,888
All Units	26.7%	146.7%	6,364

Figure 8-2 shows the average hourly real time generation of wind units in PJM, by month. The highest average hour, 2,688.8 MW, occurred in January, and the lowest average hour, 413.6 MW, occurred in August. Wind output in PJM is generally higher in off-peak hours and lower in on-peak hours.

Figure 8-2 Average hourly real-time generation of wind units in PJM: January through September 2013



56 Capacity factor does not include external resources which only offer in the DA market. Capacity factor is calculated based on online date of the resource. Capacity factor by cleared MW is calculated during peak periods (peak hours during January, February, June, July and August) and includes only MW cleared in RPM.

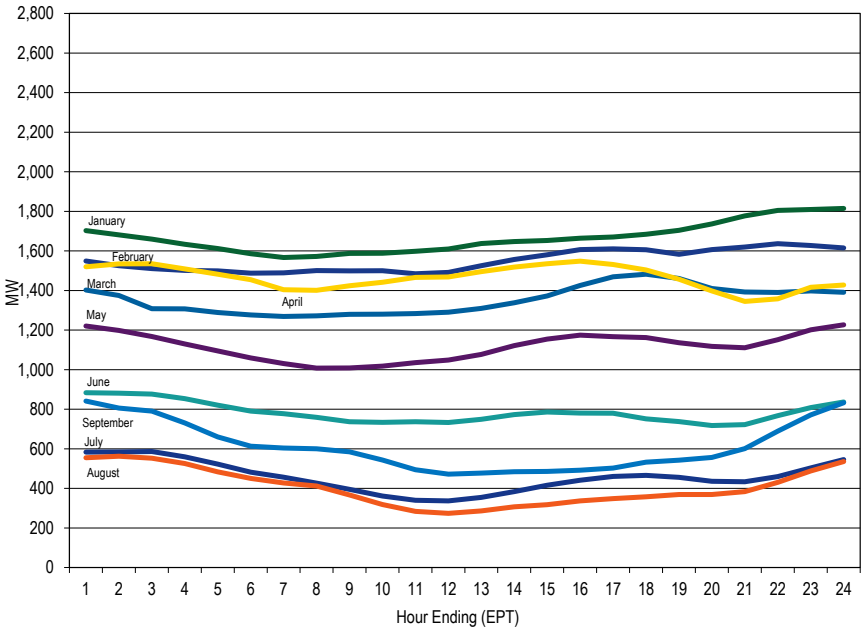
Table 8-16 shows the generation and capacity factor of wind units in each month of 2012 and the first nine months of 2013.

Table 8-16 Capacity factor of wind units in PJM by month, 2012 and January through September 2013

	2012		2013	
Month	Generation (MWh)	Capacity Factor	Generation (MWh)	Capacity Factor
January	1,608,349.8	41.9%	1,784,359.3	40.3%
February	1,167,011.9	32.4%	1,397,468.3	35.4%
March	1,416,278.0	35.6%	1,606,248.3	36.5%
April	1,345,643.3	34.7%	1,639,590.9	37.8%
May	885,583.1	21.6%	1,271,272.4	28.5%
June	882,597.0	22.2%	862,532.2	19.8%
July	546,676.9	13.3%	588,174.8	13.4%
August	415,544.2	10.1%	510,448.5	12.0%
September	677,039.5	16.9%	719,196.4	16.7%
October	1,213,664.0	27.7%		
November	1,022,628.8	22.9%		
December	1,452,588.7	31.1%		
Annual	12,633,605.2	25.7%	10,379,291.1	26.7%

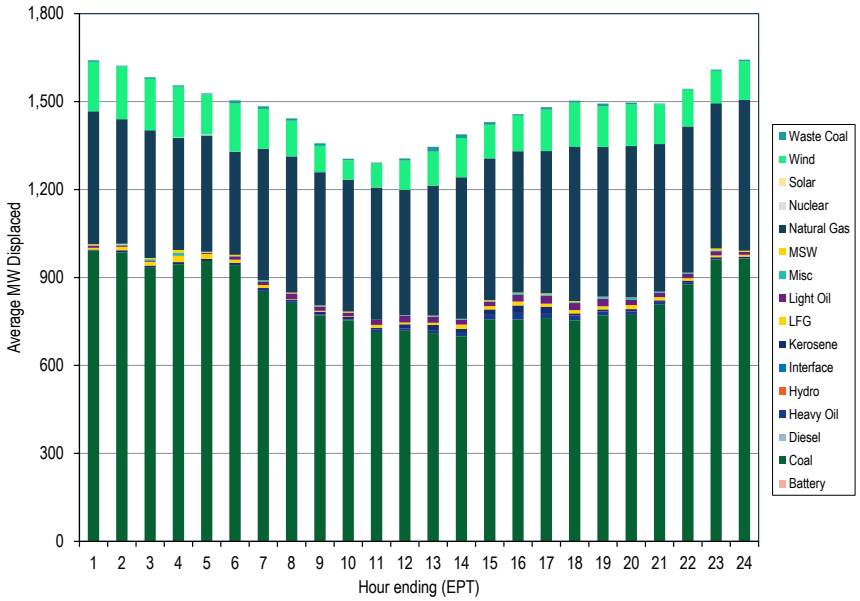
Wind units that are capacity resources are required, like all capacity resources, to offer the energy associated with their cleared capacity in the Day-Ahead Energy Market. In addition, the owners of wind resources have the flexibility to offer the non-capacity related wind energy at their discretion. Figure 8-3 shows the average hourly day-ahead generation offers of wind units in PJM, by month. The hourly day-ahead generation offers of wind units in PJM may vary.

Figure 8-3 Average hourly day-ahead generation of wind units in PJM: January through September 2013



Output from wind turbines displaces output from other generation types. This displacement affects the output of marginal units in PJM. The magnitude and type of effect on marginal unit output depends on the level of the wind turbine output, its location, time and duration. One measure of this displacement is based on the mix of marginal units when wind is producing output. Figure 8-4 shows the hourly average proportion of marginal units by fuel type mapped to the hourly average MW of real time wind generation through the first nine months of 2013. Figure 8-4 shows potentially displaced marginal unit MW by fuel type in January through September 2013. This is not an exact measure of displacement because it is not based on a redispatch of the system without wind resources. When wind appears as the displaced fuel at times when wind resources were on the margin this means that there was no displacement for those hours.

Figure 8-4 Marginal fuel at time of wind generation in PJM: January through September 2013



Solar Units

Solar output differs from month to month, based on seasonal variation and daylight hours during the month. Figure 8-5 shows the average hourly real time generation of solar units in PJM, by month. On average, solar generation was highest in September, the month with the highest average hour, 150.5 MW, compared to 248.8 MW of solar installed capacity in PJM. Solar generation in PJM is highest during the hours of 11:00 through 13:00 EPT.

Figure 8-5 Average hourly real-time generation of solar units in PJM: January through September 2013