

# 2012-2014 CO<sub>2</sub>, SO<sub>2</sub> and NO<sub>x</sub> Emission Rates

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## Introduction

In recent years, federal and state environmental regulations have applied or will apply more stringent restrictions on electric generators. In order to support the efforts of regulators, stakeholders and other interested parties, PJM Interconnection provides this report with data on marginal and average emissions rates in the PJM footprint.

## Marginal Units

To balance electricity supply and demand, strategically located electric generating units are scheduled to operate to ensure the efficient and reliable delivery of power. A marginal unit is the generation resource that sets the real-time energy price (Locational Marginal Price or LMP) in each five-minute interval. The price at which the final resource committed to maintain system reliability and match energy supply and demand is the marginal price of electricity. The marginal price, compared to the average price, most accurately represents the cost of producing the last megawatt of energy used or saved. Any changes in dispatch patterns may change the set of marginal units for that dispatch interval. Therefore, a significant change in dispatch could change the emission rate accordingly.

## Methodology

Average emissions rates for generators in the PJM footprint were developed by PJM Environmental Information Services, Inc. (PJM EIS) for use in the Generation Attribute Tracking System (GATS). The GATS is an all-generation tracking system administered by PJM EIS to enable compliance with PJM state mandates for 1) fuel mix and emission disclosure and 2) renewable energy. Emissions data tracked in GATS include carbon dioxide, nitrogen oxides and sulfur dioxide. Emission factors for all PJM generators are calculated by PJM EIS on an annual basis using PJM generation data and emission data from a number of publicly available sources:

- U.S. Environmental Protection Agency unit-level annual emissions from Continuous Emission Monitoring Systems (CEMS) for generators in the Acid Rain Program,
- EPA Emissions & Generation Resource Integrated Database (eGRID) emission rate, and
- Fuel Type Default factors.

For 2014, 97 percent of all PJM generation either was a non-emitting resource or was assigned a unit-specific emission rate calculated using EPA CEMS data. Another 2.4 percent of generation was assigned an emission factor based on EPA eGRID data. Only a very small percentage of PJM generation was assigned a fuel-type default emission factor. As a general matter, PJM only has visibility into generation resources that participate in the wholesale electricity market. Such generation sources, including small diesel and behind-the-meter generation, are not accounted for in this emissions report.

In a given five-minute interval, there will be one marginal unit on the system plus an additional marginal unit for each transmission constraint that is being experienced. The emissions rates for all marginal units in each interval are averaged to form a marginal emissions rate for the five-minute interval. These five-minute rates are averaged to form the rates presented in this report.

The PJM system average emissions rate is calculated monthly and is publicly available on the PJM EIS website ([www.pjm-eis.com](http://www.pjm-eis.com)). Generation (in megawatt-hours) for each PJM generator is received monthly from the PJM Market Settlement System. The energy output of each generator is multiplied by an emission factor, and a weighted average emission rate is calculated for all PJM generation for the month.

Peak periods are all non-holiday weekdays from 7 a.m. until 11 p.m., and off-peak periods are all other hours.

**Figure 1. Marginal Units by Fuel**

Fuel Type	2012	2013	2014
Coal	58.84%	56.94%	52.90%
Gas	30.35%	34.72%	35.80%
Oil	6.00%	3.27%	7.45%
Wind	4.19%	4.76%	3.29%
Other	0.47%	0.20%	0.43%
Municipal Waste	0.13%	0.07%	0.05%
Demand Response	0.00%	0.02%	0.04%
Uranium	0.02%	0.02%	0.04%

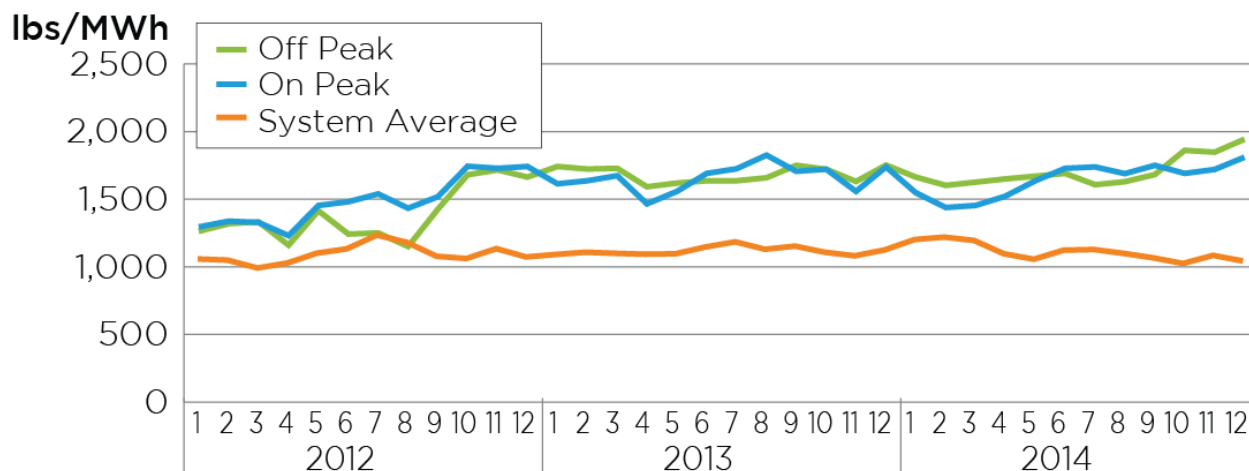
## Carbon Dioxide

The EPA is developing the Clean Power Plan under the Clean Air Act to regulate carbon dioxide emissions in the electricity sector. This rule is expected to be finalized in the summer of 2015 and will aim to reduce carbon dioxide emissions from the electricity sector by 30 percent (below 2005 levels) by 2030. The table and chart below show the CO<sub>2</sub> emission rates, measured in pounds per megawatt-hour, from marginal units in the PJM footprint.

Figure 2. CO<sub>2</sub> Emission Rates

CO <sub>2</sub> (lbs/MWh)		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2012	Marginal On-Peak	1,338	1,341	1,460	1,286	1,531	1,479	1,581	1,449	1,520	1,698	1,745	1,769	1,516
	Marginal Off-Peak	1,281	1,303	1,315	1,208	1,453	1,262	1,353	1,217	1,391	1,614	1,695	1,678	1,400
	PJM System Average	1,051	1,042	983	1,020	1,094	1,125	1,227	1,175	1,070	1,054	1,127	1,066	1,092
2013	Marginal On-Peak	1,619	1,648	1,696	1,455	1,520	1,666	1,708	1,817	1,686	1,716	1,539	1,798	1,656
	Marginal Off-Peak	1,752	1,722	1,704	1,606	1,658	1,655	1,652	1,670	1,766	1,723	1,703	1,777	1,699
	PJM System Average	1,083	1,100	1,092	1,085	1,089	1,139	1,177	1,123	1,145	1,101	1,073	1,117	1,112
2014	Marginal On-Peak	1,548	1,439	1,453	1,522	1,636	1,729	1,740	1,690	1,750	1,692	1,721	1,810	1,646
	Marginal Off-Peak	1,664	1,602	1,627	1,650	1,671	1,691	1,608	1,630	1,682	1,861	1,848	1,944	1,707
	PJM System Average	1,194	1,212	1,187	1,088	1,049	1,116	1,121	1,092	1,059	1,017	1,077	1,036	1,108

Figure 3. Marginal CO<sub>2</sub> Emission Rates



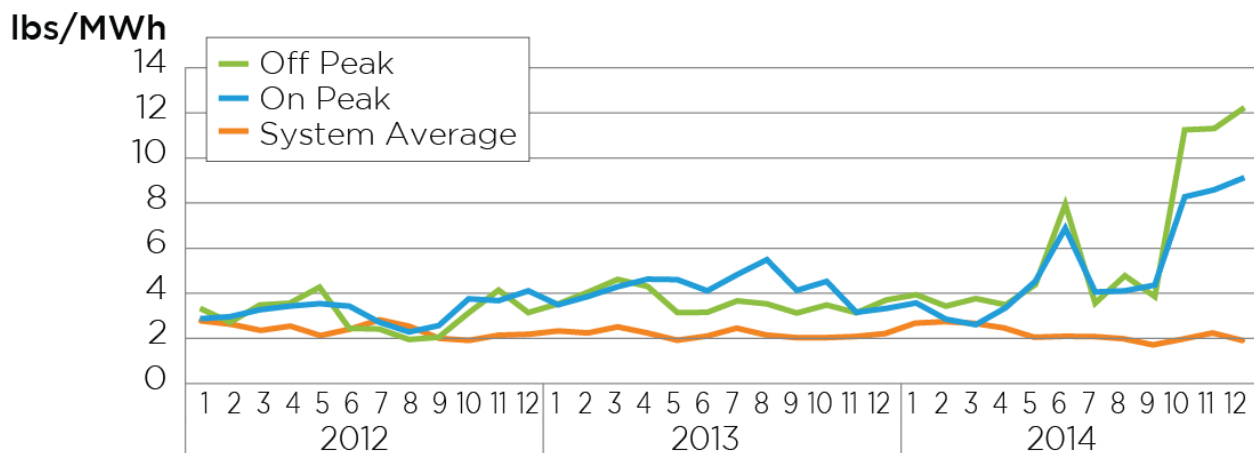
## Sulfur Dioxide

The electricity sector is impacted by two sets of regulations for sulfur dioxide and nitrogen oxides issued by the EPA under the Clean Air Act. National Ambient Air Quality Standards (NAAQS) were set for six critical pollutants, including sulfur dioxide and nitrogen dioxide, and are monitored for attainment on a county-by-county basis. The NAAQS for SO<sub>2</sub> and NO<sub>x</sub> were made more stringent in 2012, and the state requirements for monitoring currently are being revised. The Cross-State Air Pollution Rule (CSAPR), finalized in 2014, is a “good neighbor” provision that requires states to reduce SO<sub>2</sub> and NO<sub>x</sub> emissions if they are interfering with their neighbor’s ability to comply with NAAQS. All PJM states, except Delaware and the District of Columbia, are impacted by this rule. The first CSAPR compliance date was in January 2015; the second compliance date is January 2017. For NAAQS and CSAPR, states are required to follow state-developed implementation plans that have been approved by the EPA. The table and chart below show the SO<sub>2</sub> emission rates, measured in pounds per megawatt-hour, from marginal units in the PJM footprint.

Figure 4. SO<sub>2</sub> Emission Rates

SO <sub>2</sub> (lbs./MWh)		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2012	Marginal On-Peak	2.88	2.96	3.27	3.43	3.54	3.44	2.72	2.57	2.57	3.76	3.67	4.12	3.24
	Marginal Off-Peak	3.33	2.71	3.48	3.57	4.28	2.45	2.42	1.96	2.05	3.14	4.14	3.15	3.06
	PJM System Average	2.78	2.63	2.36	2.55	2.13	2.42	2.83	2.54	2.01	1.92	2.15	2.19	2.38
2013	Marginal On-Peak	3.49	3.86	4.29	4.63	4.61	4.12	4.83	5.49	4.14	4.53	3.16	3.33	4.21
	Marginal Off-Peak	3.54	4.06	4.62	4.30	3.15	3.16	3.67	3.54	3.13	3.48	3.14	3.71	3.63
	PJM System Average	2.34	2.25	2.52	2.25	1.93	2.11	2.46	2.16	2.04	2.04	2.09	2.22	2.20
2014	Marginal On-Peak	3.57	2.85	2.61	3.36	4.54	6.89	4.07	4.11	4.37	8.27	8.59	9.13	5.20
	Marginal Off-Peak	3.94	3.44	3.77	3.49	4.38	7.95	3.56	4.78	3.86	11.25	11.31	12.23	6.16
	PJM System Average	2.68	2.75	2.67	2.47	2.06	2.10	2.09	1.99	1.72	1.98	2.25	1.92	2.22

Figure 5. Marginal SO<sub>2</sub> Emission Rates



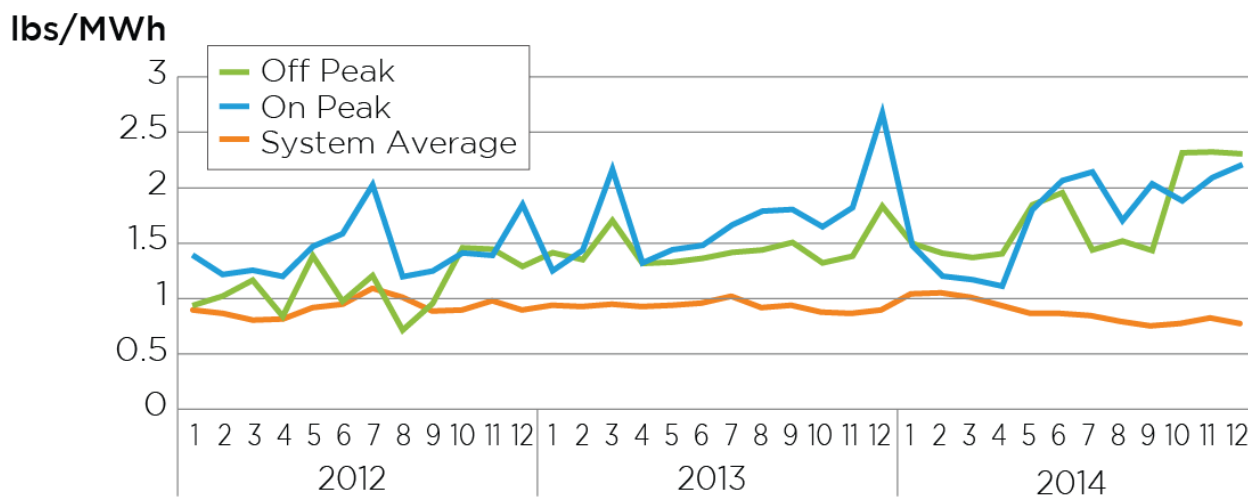
## Nitrogen Oxides

Nitrogen oxides also are regulated through the NAAQS and the CSAPR. The table and chart below show the NO<sub>x</sub> emission rates, measured in pounds per megawatt-hour, from marginal units in the PJM footprint.

Figure 6. NO<sub>x</sub> Emission Rates

NO <sub>x</sub> (lbs./MWh)		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2012	Marginal On-Peak	1.40	1.22	1.26	1.20	1.47	1.58	2.03	1.20	1.25	1.41	1.39	1.85	1.44
	Marginal Off-Peak	0.94	1.02	1.17	0.84	1.38	0.98	1.21	0.71	0.96	1.46	1.45	1.29	1.12
	PJM System Average	0.92	0.89	0.83	0.84	0.94	0.97	1.11	1.03	0.91	0.92	1.00	0.92	0.94
2013	Marginal On-Peak	1.25	1.43	2.17	1.32	1.44	1.48	1.67	1.79	1.80	1.65	1.82	2.67	1.71
	Marginal Off-Peak	1.41	1.35	1.70	1.32	1.33	1.36	1.42	1.44	1.51	1.32	1.38	1.83	1.45
	PJM System Average	0.96	0.95	0.97	0.95	0.96	0.98	1.04	0.94	0.96	0.90	0.89	0.92	0.95
2014	Marginal On-Peak	1.48	1.20	1.17	1.11	1.80	2.07	2.14	1.70	2.03	1.88	2.09	2.21	1.74
	Marginal Off-Peak	1.50	1.41	1.37	1.40	1.84	1.95	1.44	1.52	1.43	2.32	2.32	2.31	1.73
	PJM System Average	1.06	1.07	1.03	0.96	0.89	0.89	0.87	0.82	0.78	0.80	0.85	0.80	0.90

Figure 7. Marginal NO<sub>x</sub> Emission Rates



## Appendix – Statistical Information

The following tables list standard deviations for the emissions rates provided to help inform interested parties of the level of variance in the averages presented above.

**Figure 8. CO<sub>2</sub> Emission Rates Standard Deviation**

CO <sub>2</sub> STD (lbs/MWh)		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2012	Marginal On-Peak	421	473	389	355	326	390	416	388	358	239	302	365	369
	Marginal Off-Peak	384	379	408	352	428	434	451	426	377	331	334	335	387
2013	Marginal On-Peak	325	340	341	332	326	288	247	295	248	274	407	300	310
	Marginal Off-Peak	321	340	326	370	310	336	337	460	289	289	369	278	335
2014	Marginal On-Peak	288	272	280	266	194	274	207	242	233	177	209	245	241
	Marginal Off-Peak	268	296	307	330	254	305	408	304	301	231	176	310	291

**Figure 9. SO<sub>2</sub> Emission Rates Standard Deviation**

SO <sub>2</sub> STD (lbs/MWh)		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2012	Marginal On-Peak	3.6	2.4	2.8	2.5	2.8	3.6	2.1	2.2	2.0	2.4	3.0	3.3	2.7
	Marginal Off-Peak	3.6	2.4	3.2	3.2	4.2	2.7	2.1	2.2	1.6	2.1	3.2	2.5	2.8
2013	Marginal On-Peak	3.0	2.6	3.6	4.1	4.0	3.2	3.8	4.4	2.9	2.9	2.7	2.2	3.3
	Marginal Off-Peak	2.9	3.2	3.8	4.2	2.7	2.9	3.3	3.2	2.2	2.5	2.4	2.6	3.0
2014	Marginal On-Peak	3.2	2.2	2.1	2.8	2.8	4.7	2.7	3.9	3.5	3.5	4.3	4.1	3.3
	Marginal Off-Peak	2.4	3.0	2.9	3.0	3.2	5.5	3.3	5.0	3.9	3.7	3.4	3.8	3.6

**Figure 10. NO<sub>x</sub> Emission Rates Standard Deviation**

NO <sub>x</sub> STD (lbs/MWh)		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2012	Marginal On-Peak	1.8	1.1	1.0	1.1	0.9	1.5	2.0	0.9	0.9	0.5	0.5	1.4	1.1
	Marginal Off-Peak	0.8	0.7	0.9	0.6	1.0	1.1	1.3	0.5	0.6	1.0	0.6	0.6	0.8
2013	Marginal On-Peak	0.6	1.0	2.4	0.7	0.7	0.6	0.6	1.0	1.1	0.9	2.5	3.2	1.3
	Marginal Off-Peak	0.6	0.7	1.4	0.9	0.6	0.6	0.6	0.7	0.7	0.5	1.3	1.7	0.9
2014	Marginal On-Peak	0.8	0.6	0.7	0.5	0.6	0.7	1.1	1.1	2.0	0.5	0.8	1.1	0.9
	Marginal Off-Peak	0.6	0.8	0.6	0.6	0.6	0.7	0.8	1.0	1.2	0.6	0.5	0.5	0.7