The Regional Greenhouse Gas Initiative
an initiative of the New England and Mid-Atlantic States of the U.S.

CO_2 Emissions from Electricity Generation and Imports in the Regional Greenhouse Gas Initiative: 2017 Monitoring Report

November 8, 2019

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The Regional Greenhouse Gas Initiative (RGGI) is a cooperative effort of the New England and Mid-Atlantic states to reduce emissions of carbon dioxide (CO_2), a greenhouse gas that causes global warming.

RGGI, Inc. is a non-profit corporation created to provide technical and administrative services to the states participating in the Regional Greenhouse Gas Initiative.

Executive Summary

This report, the ninth report in a series of annual monitoring reports, summarizes data for the period from 2005 through 2017, for electricity generation, net electricity imports, and related carbon dioxide (CO_2) emissions for the nine states[1] participating in the Regional Greenhouse Gas Initiative (RGGI) third control period. These monitoring reports were called for in the 2005 RGGI Memorandum of Understanding (MOU) in response to expressed concerns about the potential for the RGGI CO_2 Budget Trading Program to cause CO_2 emissions from generation serving load in the RGGI region to shift towards sources that are not subject to RGGI.[2] This potential shift has been referred to as “emissions leakage."

In the New England and Mid-Atlantic states, CO_2 emissions from the regional electric power sector are a function of highly dynamic wholesale electricity markets. The cost of compliance with the RGGI CO_2 Budget Trading Program is only one of multiple factors that influence the dispatch of electric generation, and resulting CO_2 emissions, through the operation of these markets. As a result, this report presents data without assigning causality to any one of the factors influencing observed trends.

A key metric presented in this report that may provide a preliminary or potential indication of emissions leakage, or a lack thereof, is electric generation and related CO_2 emissions from all non-RGGI electric generation serving electricity load in the nine-state RGGI region. Because this report does not establish the causes of observed trends, it should be emphasized that this report does not provide indicators of CO_2 emissions leakage.

This report tracks electricity generation, net electricity imports, and related CO_2 emissions during the three-year current period of 2015 to 2017 relative to 2006 to 2008, a three-year base period prior to the implementation of the RGGI program. The observed trends in electricity demand, electricity generation, and net electricity imports show there has been a small decrease in CO_2 emissions from total non-RGGI electric generation serving load in the nine-state RGGI region during the period of 2015 to 2017 and during the 2017 calendar year when compared to the base period.

Summary of Results

Change in Annual Average Electric Load (Demand for Electricity) and Annual Average Generation

- The annual average **electric load** in the nine-state RGGI region from 2015 to 2017 decreased by 25.9 million MWh, or 6.7 percent, compared to the average for 2006 to 2008.

[1] The “nine-state RGGI region” consists of Delaware, Connecticut, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont.
[2] The Memorandum of Understanding called for monitoring electricity imports into the RGGI participating states commencing from the start of the RGGI CO_2 Budget Trading Program and reporting the results of such monitoring on an annual basis beginning in 2010.

- The annual average **electric generation** from all sources in the nine-state RGGI region from 2015 to 2017 decreased by 41.2 million MWh, or 12.5 percent, compared to the average for 2006 to 2008.
    - Annual average net imports into the nine-state RGGI region from 2015 to 2017 increased by 22.2 million MWh, or 39.6 percent, compared to the average for 2006 to 2008 (see page 18).

- For the 2017 calendar year, **electric load** and **electric generation** in the nine-state region show a similar reduction compared to the annual average during the base period from 2006 to 2008.

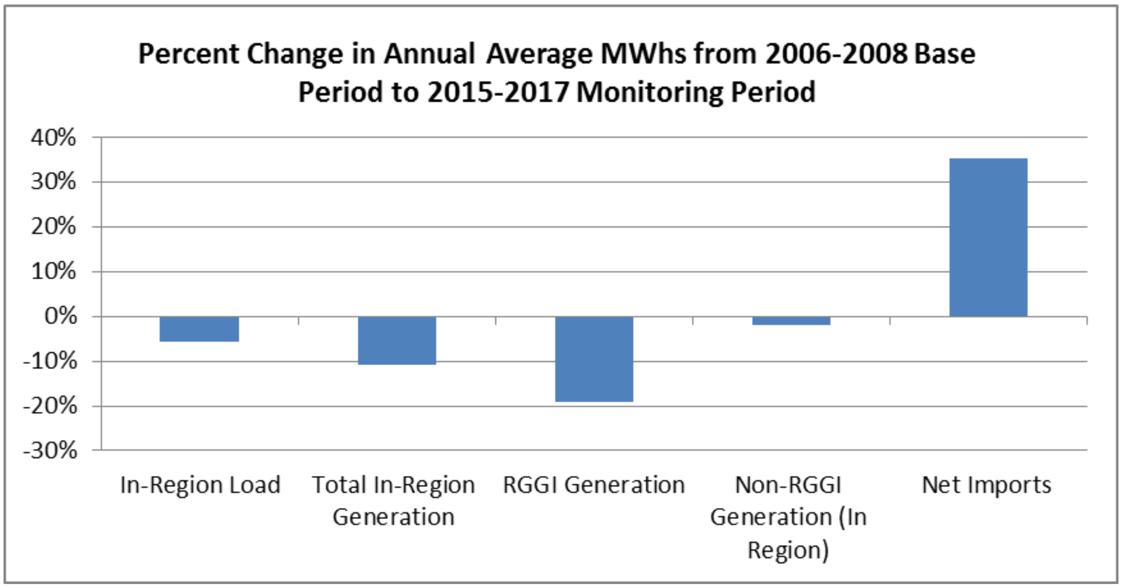

Figure 1. Percentage change in annual average electricity load and generation serving the nine-state RGGI region for 2015 to 2017, relative to the base period of 2006 to 2008.

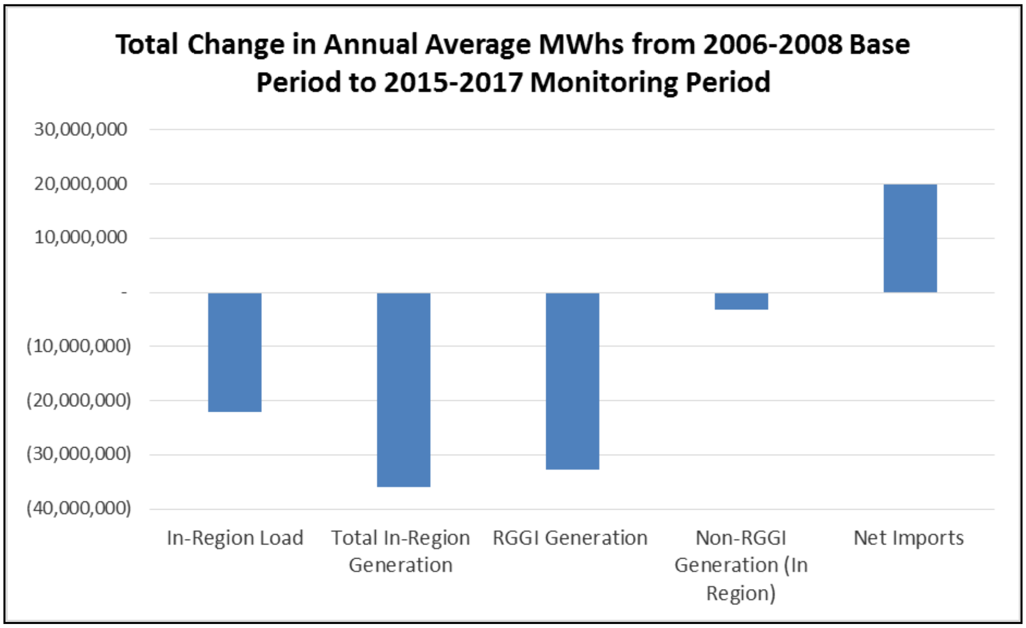

Figure 2. Change in MWhs of annual average electricity load and generation serving the nine-state RGGI Region for 2015 to 2017, relative to the base period of 2006 to 2008.

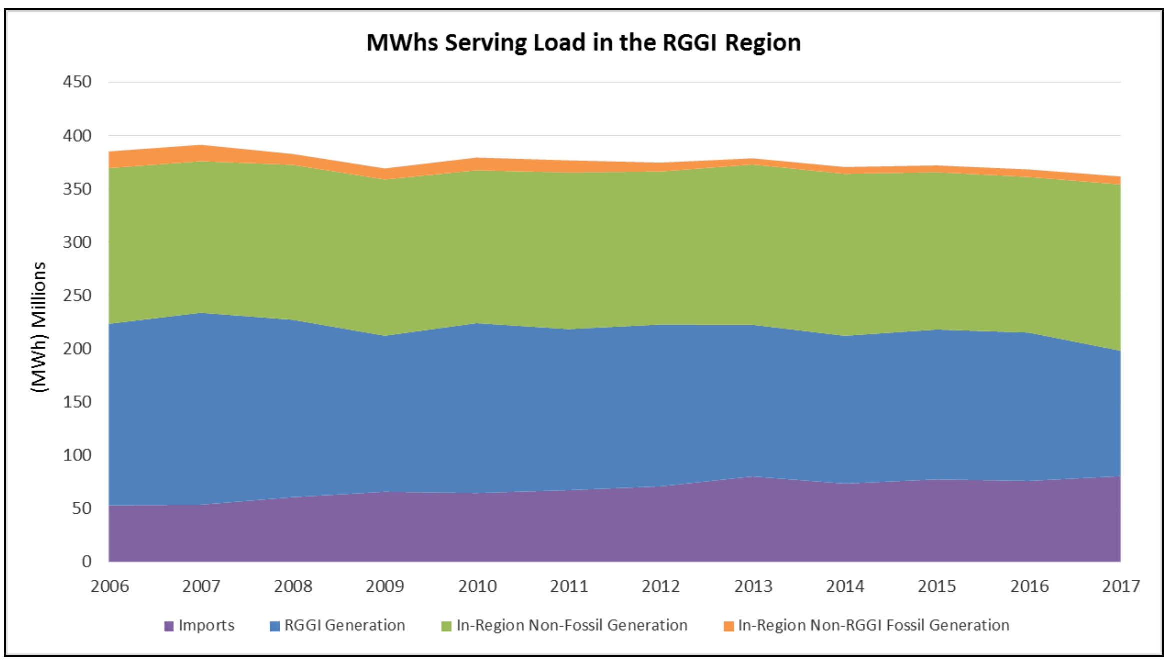

Figure 3. MWhs of generation serving load in the RGGI region from 2006-2017.

Change In Annual Average Non-RGGI Emissions, Non-RGGI Emissions Rate, and Non-RGGI Generation

- The monitoring results indicate there was a small decrease of 2.1 million short tons of CO_2, or 4.6 percent, in **CO_2 emissions** from non-RGGI electric generation serving load in the nine-state RGGI region for 2015 to 2017 relative to the base period of 2006 to 2008. The CO_2 emissions from this category for the 2017 calendar year show there has been a similar decrease of 4.7 percent when compared to the base period.[3]

- The annual average **CO_2 emissions rate** from all non-RGGI electric generation sources serving load in the RGGI region for 2015 to 2017 decreased by 54.9 lb CO_2/MWh, or 13.0 percent, compared to the base period of 2006 to 2008.

- The annual average **electric generation** from all non-RGGI electric generation sources serving load in the RGGI region for 2015 to 2017 increased by 20.7 million MWh, or 9.7 percent, compared to the base period of 2006 to 2008.

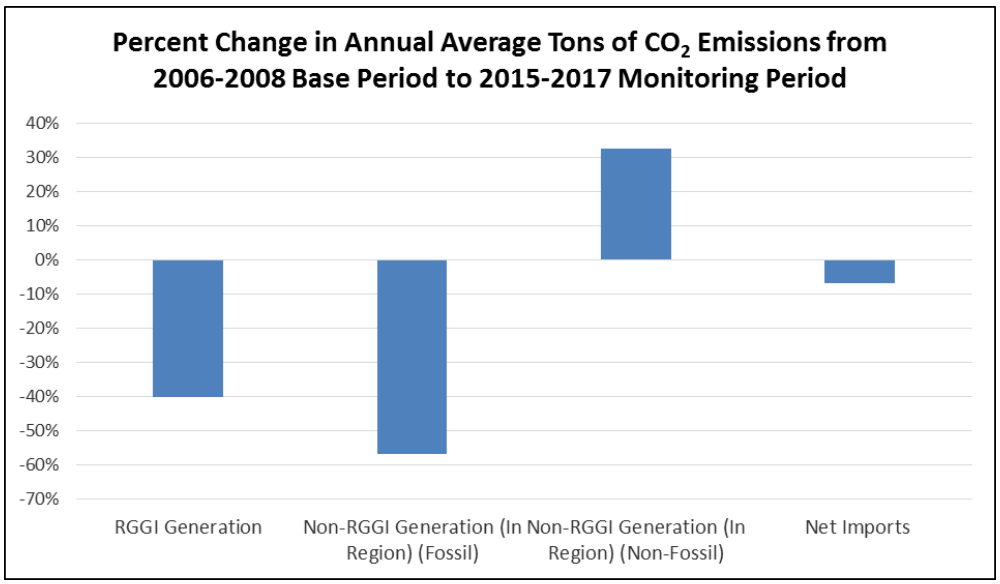

Figure 4. Percent change in annual average CO_2 emissions from generation serving load in the nine-state RGGI region for 2015 to 2017, relative to the base period of 2006 to 2008.

[3] In the calendar year 2017, non-RGGI electric generation was comprised of 63.9% in-region non-fossil fuel-fired generation, 33.0% net imports, and 3.1% in-region non-RGGI fossil fuel-fired generation. Further details on non-RGGI electric generation sources, including emissions intensity, can be found in Table 1 on pp. 16-17.

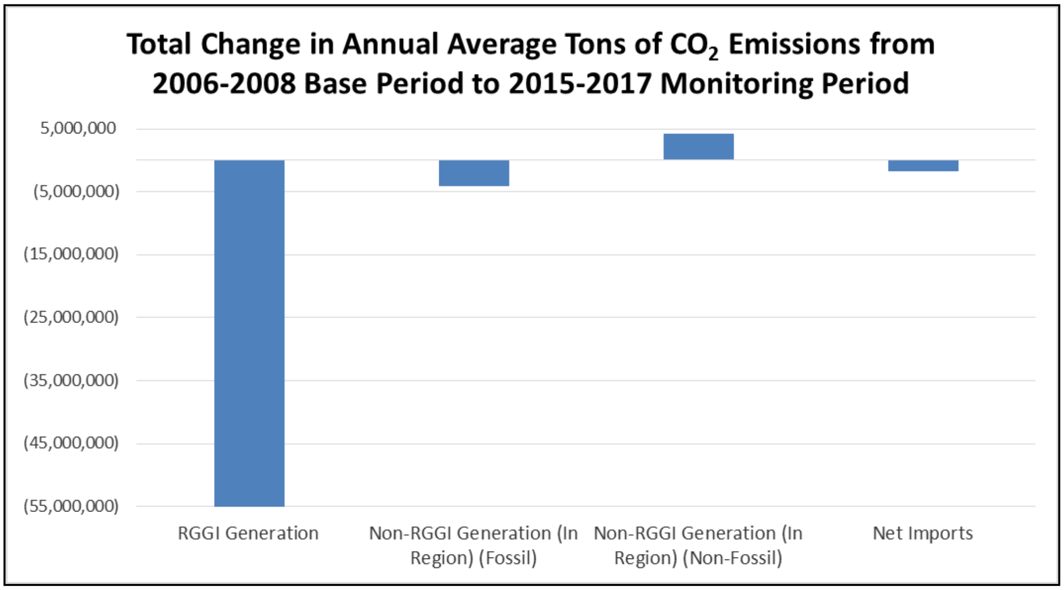

Figure 5. Change in annual average CO_2 emissions from generation serving load in the nine-state RGGI region for 2015 to 2017, relative to the base period of 2006 to 2008.

Change in Annual Average RGGI Emissions, RGGI Emissions Rate, and RGGI Generation

- The annual average **CO_2 emissions** from RGGI electric generation sources from 2015 to 2017 decreased by 62.9 million short tons of CO_2, or 45.3 percent, compared to the base period of 2006 to 2008.

- The annual average **CO_2 emissions rate** from RGGI electric generation sources from 2015 to 2017 decreased by 468.0 lb CO_2/MWh, or 29.0 percent, compared to the base period of 2006 to 2008.

- The annual average **electric generation** from RGGI electric generation sources from 2015 to 2017 decreased by 39.8 million MWh, or 23.1 percent, compared to the base period of 2006 to 2008.

- Both **electric generation** and **CO_2 emissions** from RGGI electric generation sources in the 2017 calendar year show a similar reduction compared to the annual average for the baseline period from 2006 to 2008.

Conclusions

As mentioned, it should be emphasized that this report does not provide indicators of CO_2 emissions leakage, but merely tracks electricity generation and imports, and related CO_2 emissions, in the RGGI region. A key metric presented in this report that may provide a preliminary or potential indication of emissions leakage, or a lack thereof, is electric generation and related CO_2 emissions from all non-RGGI electric generation serving electric load in the nine-state RGGI region. Monitoring results show that there has been an increase in the amount of non-RGGI electric generation serving load in the RGGI region, with a decrease in the CO_2 emissions rate of this generation, which largely offsets the increase in generation. Overall, the monitoring results show that there has been a 4.6 percent decrease in average annual CO_2 emissions from non-RGGI electric generation serving load in the RGGI region during the period of 2015 to 2017 when compared to the base period, and a similar decrease for the calendar year 2017 when compared to the base period.

I. Background

This annual report summarizes monitoring data and tracks trends for electricity demand, net electricity imports, electricity generation from multiple categories of generation sources (including net electricity imports), and the CO_2 emissions related to these categories of electric generation in the nine-state RGGI region, for the period from 2005 through 2017. This monitoring was called for in the 2005 RGGI MOU in response to expressed concerns about the potential for the nine RGGI CO_2 Budget Trading Programs[4] to result in "emissions leakage".[5] The monitoring approach that was used to compile the data summarized in this report was specified in a March 2007 report from the RGGI Staff Working Group, *Potential Emissions Leakage and the Regional Greenhouse Gas Initiative (RGGI): Evaluating Market Dynamics, Monitoring Options, and Possible Mitigation Mechanisms*.[6,7]

The report should not be used to draw definitive conclusions about whether CO_2 emissions leakage has occurred, as it does not address the causes of observed trends among different categories of electric generation serving load in the nine-state RGGI region. This report is an analysis of CO_2 emissions only and does not speak to other greenhouse gases.

II. Monitoring Approach

The data summarized in this report track electricity generation and electricity use in each of the three independent system operator (ISO) regions fully or partially subject to the RGGI CO_2 Budget Trading Program (ISO-New England – "ISO-NE", New York ISO – "NYISO", and PJM). The data track total MWh of electricity used to serve electric load in each ISO (or portion of an ISO subject to RGGI, in the case of PJM), the actual or estimated CO_2 emissions (in short tons of CO_2) related to the generation of this electricity, and the associated lb CO_2/MWh emission rate.

Throughout this report, references to "electric generation" and "electric load" include only that portion of electric generation or electric load dispatched or served through the regional transmission system administered by ISOs and tracked by individual ISOs. This excludes most electric generation output and electric load typically known as "behind-the-meter", which refers to electric generation that is not dispatched by ISOs, and electric load met through on-site electric generation facilities (e.g., industrial cogeneration and other smaller distributed generation resources, such as

[4] RGGI is comprised of state CO_2 Budget Trading Programs. Under each of these state programs, a regulated power plant must hold CO_2 allowances equal to its emissions to demonstrate compliance at the end of a three-year control period. Beginning in 2015, a regulated power plant must hold CO_2 allowances equal to 50% of its emissions to demonstrate compliance during each of the first two years of a three-year control period CO_2 allowances are issued by participating states in a finite amount, or "budget", resulting in a regional cap on CO_2 emissions from the electric generation sector in the RGGI region. Regulated power plants are fossil fuel-fired electric generating units with an electric generation capacity of 25 megawatts (MWe) or greater.

[5] Specifically, the Memorandum of Understanding called for monitoring electricity imports into the RGGI participating states commencing from the start of the RGGI CO_2 Budget Trading Program and reporting the results of such monitoring on an annual basis beginning in 2010.

[6] The report also specified requested changes that were made to generator attribute tracking systems for ISO-NE and PJM to facilitate RGGI monitoring. The report is available at il_report_final_3_14_07.pdf.

[7] This report for 2017 is the sixth of the annual monitoring reports to review the data as a nine-state program after New Jersey's withdrawal from the program at the end of 2011. On June 17, 2019, New Jersey enacted rules to resume its participation in RGGI beginning on January 1, 2020.

combined heat and power and solar photovoltaics). The electric generation MWh output that is used on-site is not included in the monitoring results.[8]

For each year 2005 through 2017, the following categories of data are presented for the nine-state RGGI region as well as for each ISO:

- RGGI Generation: Electric generation (MWh), CO_2 emissions (short tons), and emission rate (lb CO_2/MWh) for electric generating units subject to a CO_2 allowance compliance obligation under state CO_2 Budget Trading Program regulations.[9]

- Non-RGGI Generation: Electricity generation (MWh), CO_2 emissions, and emission rate (lb CO_2/MWh) for all non-RGGI electric generation serving electric load in the nine-state RGGI region (includes both in-region electric generation and net electricity imports). In addition to total non-RGGI generation, data for the following subcategories of non-RGGI generation are also presented:

  - Non-RGGI In-Region Generation: Electric generation from electric generation units located in the nine-state RGGI region that are not subject to a CO_2 allowance compliance obligation (e.g., generators under 25 megawatts electrical (MWe) capacity and non-fossil fuel-fired electric generators).

  - Net Imports: Electric generation from net electricity imports (MWh) from adjacent control areas (or portion of a control area) outside the nine-state RGGI region (can be fossil or non-fossil generation).[10]

III. Evaluation of Monitoring Data

This section addresses issues considered in evaluation of the monitoring data, including the selection of base periods for comparison of data and general monitoring limitations.

Base Period

This report compares monitoring data for the period from 2015 to 2017 to the base period from 2006 to 2008. The period of 2006 to 2008 represents the three years

[8] However, note that behind-the-meter electric generators eligible for credit under state renewable portfolio standards typically voluntarily report electric generation to the ISO-NE Generation Information System (GIS), NY Generation Attribute Tracking System (NYGATS), and PJM Generation Attribute Tracking System (GATS), which are discussed in Section IV. Methodology. These behind-the-meter electric generators that report to ISO-NE GIS, NYGATS, and PJM GATS are included in the monitoring results. CO_2 emissions data for behind-the-meter electric generation that is RGGI-affected are also included in this report. In addition, only electricity output from cogeneration facilities is reported by ISOs, meaning that the average lb CO_2/MWh emission rate for all reporting years in this report is for electricity generation dispatched to the ISO grid only and does not account for behind-the-meter MWh output or useful steam output from cogeneration facilities.

[9] For the purposes of this report, this category does not include electric generators that may be subject to a state CO_2 Budget Trading Program regulation, or portion of such regulation, but that are not subject to a CO_2 allowance compliance obligation that requires the generator to submit CO_2 allowances equivalent to its CO_2 emissions. For example, under Maryland's CO_2 Budget Trading Program regulations, certain industrial cogenerators may be subject to alternative CO_2 compliance obligations under certain conditions in lieu of submission of CO_2 allowances.

[10] For individual ISOs, net imports represent actual annual net electricity flows between ISOs, as reported by the ISOs. For PJM, net electricity imports represent inferred transfers of electricity from the non-RGGI geographic portion of PJM into the RGGI geographic portion of PJM.

immediately prior to the start of the program. It was selected for the base period to provide a point of comparison to the three-year control periods of the RGGI program.

In monitoring reports from 2009, 2010, and 2011, data comparisons were made to the base period for the ten-state region; please see the CO_2 Emissions from Electricity Generation and Imports in the 10-State Regional Greenhouse Gas Initiative: 2009, 2010, and 2011 Monitoring Reports.[11] For 2012, 2013, 2014, 2015, 2016, and 2017, data comparisons were made to the base period for the nine-state region, reflecting the states participating in RGGI during that time period.[12] ISO-NE data for years 2005-2015 was adjusted and corrected by the ISO-NE states to account for misclassifications of certain generators in the 2016 Monitoring Report, and New York Control Area (NYCA) data from years 2005-2011 was adjusted and corrected by New York State Department of Public Service (NYSDPS) to account for misclassifications of certain generators in the 2011 Monitoring Report.

Key Metrics

A key metric presented in this report that may provide a preliminary or potential indication of emissions leakage, or a lack thereof, is electric generation and related CO_2 emissions from all non-RGGI electric generation serving electric load in the nine-state RGGI region. This includes electric generation in the nine-state RGGI region from electric generating units that are not subject to a CO_2 allowance compliance obligation under a state CO_2 Budget Trading Program (e.g., small fossil units not subject to RGGI or non-fossil units not subject to RGGI), as well as net imports of electricity into the nine-state RGGI region. If CO_2 emissions leakage were to occur, it would manifest as an increase in CO_2 emissions from this category of non-RGGI electric generation, assuming all other factors that impact electricity system dispatch and CO_2 emissions (such as electricity demand, relative fossil fuel prices, and wholesale electricity prices) did not change. As a result, an increase in CO_2 emissions from this category of electric generation in a year subsequent to implementation of RGGI, relative to a baseline prior to the implementation of RGGI, could be an indicator of *potential* CO_2 emissions leakage.

General Limitations

It should be emphasized that this report does not provide indicators of CO_2 emissions leakage, but merely tracks electricity generation and net electricity imports and related CO_2 emissions in the RGGI region for 2015 to 2017, relative to baseline years prior to implementation of the RGGI program. Determining whether CO_2 emissions leakage has occurred requires the evaluation of a hypothetical counterfactual – the amount of CO_2 emissions from non-RGGI electric generation that would occur, assuming there is no shift in electric generation to CO_2-emitting non-RGGI electric generators as a result of the implementation of the RGGI CO_2 Budget Trading Program. In theory, an increase in CO_2 emissions or CO_2 emission rate from non-RGGI electric generation as compared to a historical baseline year could occur in a scenario in which CO_2 emissions leakage does not occur. Conversely, leakage could theoretically occur in a scenario in which CO_2 emissions and CO_2 emission rate for non-RGGI electric generation *decreased* as compared to a historical baseline year, if such emissions would have

[11] Reports available at https://www.rggi.org/allowance-tracking/emissions
[12] Reports available at https://www.rggi.org/allowance-tracking/emissions

decreased further under a hypothetical counterfactual where no CO_2 emissions leakage occurs.

Changes in these data over time may point to *potential* CO_2 emissions leakage as a result of the RGGI CO_2 Budget Trading Program, or a lack thereof, but may also be the result of wholesale electricity market and fuel market dynamics unrelated to the RGGI program, or a combination of these factors.

The analysis of lifecycle CO_2 emissions or reductions from fuels used in non-RGGI non-fossil-fuel units is also not within the scope of this report. For example, the direct emissions of CO_2 and the lb CO_2/MWh emission rates from non-RGGI non-fossil fuel units in this report do not reflect the biomass lifecycle carbon reduction of atmospheric CO_2 levels resulting from uptake of CO_2 from the atmosphere as a result of forest and biomass growth. Likewise for municipal solid waste combustors, direct emissions of CO_2 are presented with no analysis of the lifecycle of the components of the waste.

IV. Methodology

Data Sources

For ISO-NE and PJM, the data presented are primarily from the NEPOOL Generation Information System (GIS) and PJM Generation Attribute Tracking System (GATS),[13] supplemented by ISO electricity import/export data, and CO_2 emissions data for RGGI electric generation from the RGGI CO_2 Allowance Tracking System (RGGI COATS) and emissions statement data reported to state environmental agencies in the RGGI participating states. For non-RGGI electric generation, CO_2 emissions are based on CO_2 emissions for individual electric generation facilities in the GIS and PJM GATS tracking systems.

A summary of data sources for ISO-NE and PJM is provided in Appendix A.

For NYISO, MWh data for 2005-2015 were compiled by the NYS PSC from NYISO data (MWh generation data) and beginning in 2016 MWh data were compiled by the NYS PSC from NYISO data (MWh generation data) fed into the New York Generation Attribute Tracking System (NYGATS) which began operation for the 2016 calendar year. NYGATS also captures PJM, NEPOOL, and Hydro Quebec and Ontario data (MWh electricity net import data). This MWh data was supplemented by CO_2 emissions data compiled by the New York State Department of Environmental Conservation (NYSDEC), the EPA, and validated self-reporting in NYGATS. CO_2 emissions data for RGGI electric generation units were compiled from RGGI COATS and from NYSDEC emissions statement program data. CO_2 emissions data for fossil fuel-fired electric generation units that are non-RGGI were taken or extrapolated from

[13] These ISO tracking systems track every MWh of electric generation for each electric generator that participates in the ISO wholesale market. Modifications were made to both systems at the request of the RGGI Staff Working Group to facilitate the tracking presented in this report. (See Staff Working Group, *Potential Emissions Leakage and the Regional Greenhouse Gas Initiative (RGGI): Evaluating Market Dynamics, Monitoring Options, and Possible Mitigation Mechanisms,* pp. 18-26; available at il_report_final_3_14_07.pdf.) These systems do not fully capture the portion of electric generation that is "behind the meter" and used to serve on-site electric load (e.g., MWh supplied from industrial cogeneration to meet on-site industrial electricity load).

reports compiled by NYSDEC, the EPA, and validated self-reporting in NYGATS. A summary of data sources for NYISO is provided in Appendix A.

For each ISO, CO_2 emissions related to net electricity imports from each adjacent control area[14] are the product of a lb CO_2/MWh emission rate and the reported MWh of net imports. The CO_2 emission rate for electricity imports is based on the system average CO_2 emission rate for the respective exporting adjacent control area.[15] For ISO-NE and NYISO, net electricity imports are based on actual flow data for electricity transfers between adjacent control areas.[16] For PJM, net electricity imports are inferred and represent "transfers" of electricity from the non-RGGI geographic portion of PJM into the RGGI geographic portion of PJM (Delaware and Maryland). This data is compiled from PJM GATS, which reports data for both the non-RGGI and RGGI geographic portions of PJM. Inferred net imports are based on total MWh load in the RGGI geographic portion of PJM minus total electric generation in the RGGI geographic portion of PJM. Any shortfall in generation relative to load is assumed to be met through an inferred "import" of electricity from the non-RGGI geographic portion of PJM into the RGGI geographic portion of PJM.[17]

When aggregating individual ISO net import data, the reported regional net imports of electricity and related CO_2 emissions from net imports presented in this report represent net imports from adjacent regions not subject to the RGGI CO_2 Budget Trading Program. Some of the individual ISO net import subtotals represent net imports from another ISO (or portion of an ISO) that is also subject to the RGGI CO_2 Budget Trading Program (for example, from ISO-NE into NYISO and vice versa). In order to avoid inappropriate double counting of MWh and related CO_2 emissions, the net import subtotals from adjacent ISOs (or portion of ISO) subject to the RGGI CO_2 Budget Trading Program were not included when rolling up the individual ISO data into regional summary totals, as the electricity and CO_2 emissions represented by these net imports are included in the electric generation subtotals for each ISO. In rolling up total regional net imports, NYISO net imports from PJM represent a prorated portion of total net imports from PJM that are assumed to originate from the non-RGGI geographic portion of PJM. For each year, this proration is based on the percentage of total PJM MWh generation that occurred in the non-RGGI geographic portion of PJM. (See next subsection for further discussion).

Monitoring Limitations

The monitoring approach used in this report is subject to certain inherent limitations. These limitations primarily involve tracking for the PJM ISO, as well as how net exports from PJM to NYISO are addressed when rolling up ISO-specific data into regional totals for the nine-state RGGI region.

[14] For PJM, this represents inferred imports from the non-RGGI geographic portion of PJM.
[15] This assumes that power transferred originates in the adjacent control area and is delivered for use in the receiving control area. This assumption does not account for the wheeling of power through control areas.
[16] The exception is net import data from Hydro Quebec into NYISO, which represents net scheduled electricity imports. Scheduled flows are those flows that are scheduled at an ISO interface for a defined period, while actual flows are the metered flows at an ISO interface for a defined period. Differences between the two can arise from transactions scheduled on contract paths that do not fully correspond to the physical paths on which the electricity related to the transaction actually flows.
[17] For PJM, this category of data does not technically represent an import of electricity, as PJM is dispatched as a single control area.

For ISO-NE and NYISO, net electricity import data is based on the tracking of actual electricity flows between adjacent control areas.[18] This type of tracking is not possible for the RGGI portion of PJM, as PJM is dispatched as a single control area, and electricity flows between geographic subsets of PJM on a state-by-state basis are not available. As a result, "electricity imports" into the two-state RGGI portion of PJM (Delaware and Maryland) from the rest of PJM must be inferred.

This also means that net electricity exports from the non-RGGI portion of PJM into NYISO cannot be determined based on actual electricity flows, as the actual monitored flows of electricity between PJM and NYISO do not allow for a differentiation between these two geographic subsets of PJM. As a result, certain assumptions must be made in order to prorate the portion of net exports from the non-RGGI portion of PJM into NYISO. For this report, this proration is based on the annual percentage of electric generation in the non-RGGI portion of PJM for a respective reporting year, as a percentage of total PJM generation for that year. The actual monitored net electricity flows from PJM into NYISO are multiplied by this percentage to derive an estimate of net electricity exports from non-RGGI PJM into NYISO. These assumed flows may not be fully representative of the actual electric generation source of net exports from non-RGGI PJM into NYISO.

A more modest monitoring limitation involves the electric generation data tracked by the three ISOs. ISO tracking does not include electric generation that is not dispatched into the ISO.[19] This typically involves the portion of industrial cogeneration of electricity used on-site at industrial facilities as well as smaller distributed combined heat and power and renewable energy generation (sometimes referred to as "behind-the-meter" generation).

[18] The exception is net import data from Hydro Quebec into NYISO, which represents net scheduled electricity imports.
[19] This includes most electric generation and electric load typically referred to as "behind the meter" (see footnote 8).

V. Monitoring Results

Monitoring results are provided below for the full nine-state RGGI region. These results provide a compilation of data from each ISO fully or partially subject to the RGGI CO_2 Budget Trading Program: ISO-NE, NYISO, and PJM. For ISO-NE, the region is fully subject to RGGI. For PJM, monitoring data is compiled for the two-state portion of PJM subject to RGGI (Delaware and Maryland). Monitoring data for each ISO is presented in Appendix B.

Monitoring results for the nine-state RGGI region for 2005 through 2017 are summarized below in Table 1.[20]

[20] Note that reported regional net electricity imports represent net imports from adjacent control areas (or portion of a control area) not subject to the RGGI CO_2 Budget Trading Program. As a result, the net electricity imports and related CO_2 emissions as reported in tabular summaries for each ISO provided in Appendix B may not add up to the reported total regional net imports and related CO_2 emissions. This is because some of the individual ISO net import subtotals represent net imports from another ISO that is also subject to the RGGI CO_2 Budget Trading Program. In order to avoid inappropriate double counting of MWh and related CO_2 emissions, these net import subtotals were not included when rolling up the individual ISO data into regional summary totals, as the electricity and CO_2 emissions represented by these net imports are included in the electric generation subtotals for each ISO.

Table 1. 2005 – 2017 Monitoring Summary for Nine-State RGGI Region

MWh	Electricity Serving In-Region Demand (MWh)							In-Region Electricity Generation (MWh)					*Summary Data*
	Total in RGGI	**Net Imports - from Ontario to NYISO**	**Net Imports - from Quebec to NY & NE**	**Net Imports - from New Brunswick to NE**	**Net Imports - from non-RGGI PJM to NY**	**Net Imports - from non-RGGI PJM to RGGI PJM**	**Total Net Imports - from All Adjoining ISOs**	**RGGI-Affected Units**	**Non-RGGI Fossil Fuel-Fired Units**	**Non-Fossil Fuel-Fired Units**	**All Non-RGGI Units**	**All Units**	**Non-RGGI Generation (Non-RGGI Generation within RGGI + Net Imports)**
2005	393,135,125	1,898,020	7,375,317	1,620,000	6,967,235	31,878,151	49,738,723	182,340,181	15,355,763	145,831,734	161,187,497	343,396,401	210,926,220
2006	384,993,562	3,672,282	8,982,749	1,047,000	8,837,899	30,716,157	53,256,087	170,330,583	15,585,075	146,057,863	161,642,938	331,737,475	214,899,025
2007	391,243,211	2,637,442	11,912,292	896,000	9,452,157	28,944,540	53,842,431	180,079,639	15,377,543	142,160,325	157,537,868	337,400,780	211,380,299
2008	383,034,165	6,162,902	15,141,014	1,285,000	9,917,356	28,386,914	60,893,186	166,479,188	10,185,713	145,327,318	155,513,031	322,140,979	216,406,217
2009	368,848,273	6,463,657	17,065,805	1,569,000	7,760,904	33,089,871	65,949,237	146,453,756	10,341,603	146,563,495	156,905,098	302,899,036	222,854,335
2010	378,723,230	3,872,635	13,549,209	737,000	11,489,286	35,142,720	64,790,850	159,407,982	11,890,764	143,423,050	155,313,814	313,931,380	220,104,664
2011	375,309,279	3,318,681	18,681,204	846,000	10,452,544	34,250,993	67,549,422	151,036,118	11,356,368	146,908,941	158,265,309	307,759,857	225,814,731
2012	372,082,306	5,749,461	22,312,689	643,000	7,926,652	34,442,085	71,073,887	151,793,798	8,241,438	143,617,952	151,859,390	301,007,419	222,933,277
2013	374,872,244	7,593,954	24,566,017	3,711,000	8,700,473	35,843,247	80,414,691	142,194,444	5,682,543	150,478,150	156,160,693	294,458,553	236,575,384
2014	364,133,729	7,180,281	22,052,178	3,527,050	8,239,526	32,656,507	73,655,542	138,677,245	6,423,947	151,930,514	158,354,461	292,306,718	232,010,003
2015	365,508,854	8,302,624	22,375,396	4,108,000	7,144,877	35,680,933	77,611,830	140,574,471	6,427,097	147,569,738	153,996,835	289,855,382	231,608,665
2016	363,036,567	7,668,000	21,843,000	4,842,000	7,936,937	33,910,113	76,200,050	139,176,565	6,965,600	146,001,202	152,966,802	286,897,517	229,166,852
2017	352,974,095	7,720,948	25,290,091	4,305,000	7,551,092	35,770,266	80,637,398	117,676,806	7,497,659	156,000,097	163,497,757	273,959,695	244,135,154

CO_2	Tons of CO_2 from Electricity Serving In-Region Demand							Tons of CO_2 from in-Region Electricity Generation					*Summary Data*
	Total in RGGI	**Net Imports - from Ontario to NYISO**	**Net Imports - from Quebec to NY & NE**	**Net Imports - from New Brunswick to NE**	**Net Imports - from non-RGGI PJM to NY**	**Net Imports - from non-RGGI PJM to RGGI PJM**	**Total Net Imports - from All Adjoining ISOs**	**RGGI-Affected Units**	**Non-RGGI Fossil Fuel-Fired Units**	**Non-Fossil Fuel-Fired Units**	**All Non-RGGI Units**	**All Units**	**Non-RGGI Generation Serving Load in ISO (Non-RGGI Generation within ISO + Net Imports)**
2005	203,397,003	460,286	30,081	714,298	4,460,362	20,408,108	26,073,134	159,287,880	10,025,160	8,010,829	18,035,989	177,323,869	44,109,123
2006	187,356,738	769,120	39,607	547,053	5,484,024	19,059,750	25,899,553	139,924,128	8,820,383	12,712,674	21,533,057	161,457,185	47,432,610
2007	191,288,853	604,715	39,262	455,316	5,801,823	17,766,431	24,667,547	145,789,425	8,615,550	12,216,331	20,831,882	166,621,306	45,499,428
2008	172,528,388	1,154,884	41,725	736,564	5,999,390	17,172,335	25,104,898	129,374,761	4,650,564	13,398,165	18,048,729	147,423,490	43,153,628
2009	147,927,352	712,496	67,723	968,535	4,381,845	18,682,706	24,813,304	105,958,243	4,812,778	12,343,028	17,155,806	123,114,048	41,969,110
2010	163,080,863	554,950	37,339	406,202	6,656,944	20,361,849	28,017,283	116,053,938	5,405,123	13,604,519	19,009,642	135,063,580	47,026,925
2011	147,249,900	336,556	47,363	410,324	5,952,203	19,504,235	26,250,682	101,597,445	5,148,933	14,382,554	19,531,487	121,128,933	45,782,170
2012	135,245,657	602,081	66,408	297,690	4,287,069	18,627,737	23,880,985	92,734,116	4,037,376	14,593,226	18,630,601	111,364,717	42,511,586
2013	132,502,742	795,236	54,159	1,186,296	4,822,624	19,867,713	26,726,027	86,618,562	2,191,307	16,967,034	19,158,342	105,776,903	45,884,369
2014	130,934,052	603,144	34,032	1,088,614	4,534,250	17,971,031	24,231,071	86,530,517	2,613,572	17,560,032	20,173,603	106,703,922	44,404,674

2015	126,801,452	697,420	27,131	1,313,206	3,602,223	17,989,208	23,629,188	82,987,695	3,415,102	16,555,084	19,970,186	102,957,881	43,599,373
2016	122,211,267	337,392	28,893	1,761,339	3,908,557	16,699,087	22,735,269	79,054,009	3,511,705	16,736,138	20,247,842	99,301,852	42,983,111
2017	107,727,436	298,260	33,453	1,471,090	3,599,881	17,052,989	22,455,673	64,491,131	3,601,719	17,178,913	20,780,632	85,271,763	43,236,305
lbs CO_2/ MWh	**Emissions Rate for Electricity Serving In-Region Demand**							**Emissions Rate for In-Region Electricity Generation**					***Summary Data***
	Total in RGGI	**Net Imports - from Ontario to NYISO**	**Net Imports - from Quebec to NY & NE**	**Net Imports - from New Brunswick to NE**	**Net Imports - from non-RGGI PJM to NY**	**Net Imports - from non-RGGI PJM to RGGI PJM**	**Total Net Imports - from All Adjoining ISOs**	**RGGI-Affected Units**	**Non-RGGI Fossil Fuel-Fired Units**	**Non-Fossil Fuel-Fired Units**	**All Non-RGGI Units**	**All Units**	**Non-RGGI Generation Serving Load in ISO (Non-RGGI Generation within ISO + Net Imports)**
2005	1,035	485	8	882	1,280	1,280	1,048	1,747	1,306	110	224	1,033	418
2006	973	419	9	1,045	1,241	1,241	973	1,643	1,132	174	266	973	441
2007	978	459	7	1,016	1,228	1,228	916	1,619	1,121	172	264	988	430
2008	901	375	6	1,146	1,210	1,210	825	1,554	913	184	232	915	399
2009	802	220	8	1,235	1,129	1,129	752	1,447	931	168	219	813	377
2010	861	287	6	1,102	1,159	1,159	865	1,456	909	190	245	860	427
2011	785	203	5	970	1,139	1,139	777	1,345	907	196	247	787	405
2012	727	209	6	926	1,082	1,082	672	1,222	980	203	245	740	381
2013	707	209	4	639	1,109	1,109	665	1,218	771	226	245	718	381
2014	719	168	3	617	1,101	1,101	658	1,248	814	231	255	730	383
2015	694	168	2	639	1,008	1,008	609	1,181	1,063	224	259	710	376
2016	673	88	3	728	985	985	597	1,136	1,008	229	265	692	375
2017	610	77	3	683	953	953	557	1,096	961	220	254	623	354

The monitoring results indicate that the 2015 to 2017 annual average electricity load in the nine-state RGGI region decreased by 26.0 million MWh, or 6.7 percent, compared to the 2006 to 2008 base period. Annual average electric generation from all sources in the nine-state RGGI region decreased by 41.2 million MWh, or 12.5 percent, compared to the base period.

Annual average electric generation from RGGI generation decreased by 39.8 million MWh during this period, or 23.1 percent, and annual average CO_2 emissions from RGGI generation decreased by 62.7 million short tons, or 45.3 percent. The annual average CO_2 emission rate of RGGI generation decreased by 468.0 lb CO_2/MWh, a decrease of 29.1 percent. Annual average electric generation from non-RGGI generation sources located in the nine-state RGGI region decreased by 1.4 million MWh, or 0.9 percent, during this period, and annual average CO_2 emissions from this category of electric generation increased by 195.0 thousand short tons. The annual average CO_2 emission rate of non-RGGI electric generation located in the nine-state RGGI region increased by 5.1 lb CO_2/MWh, or 2.0 percent.

Compared to the annual average during the 2006 to 2008 base period, 2017 electricity load in the nine-state RGGI region decreased by 33.5 million MWh, or 8.7 percent, and 2017 electric generation from all sources in the nine-state RGGI region decreased by 49.4 million MWh, or 14.9 percent.

For 2015 to 2017, annual average electric generation from all non-RGGI electric generation serving load in the nine-state RGGI region increased by 20.7 million MWh, an increase of 9.7 percent, compared to the annual average generation for the baseline period of 2006 to 2008. In a comparison of the 2015 to 2017 annual average to the 2006 to 2008 base period, the CO_2 emissions from this category of electric generation decreased by 2.1 million short tons of CO_2, a decrease of 4.6 percent, and the CO_2 emission rate decreased by 54.9 lb CO_2/MWh, a reduction of 13.0 percent. (See Figures 6, 7, and 8.) The CO_2 emissions from this category of electric generation decreased by 4.7 percent for the calendar year 2017 when compared to the base period

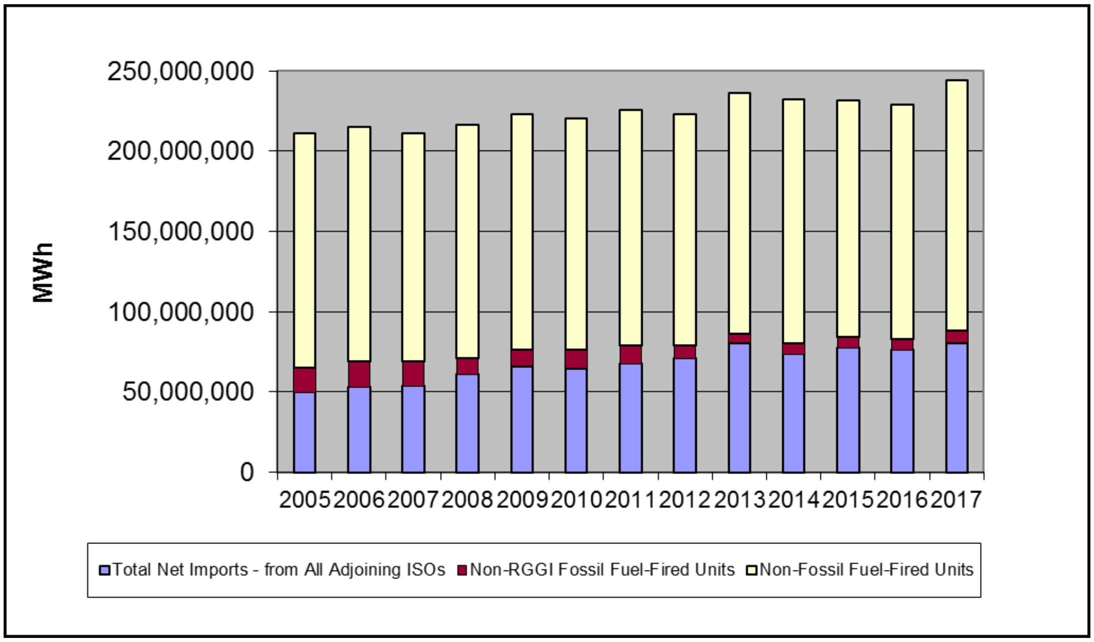

Figure 6. Non-RGGI Generation Serving Load in RGGI Region (MWh)

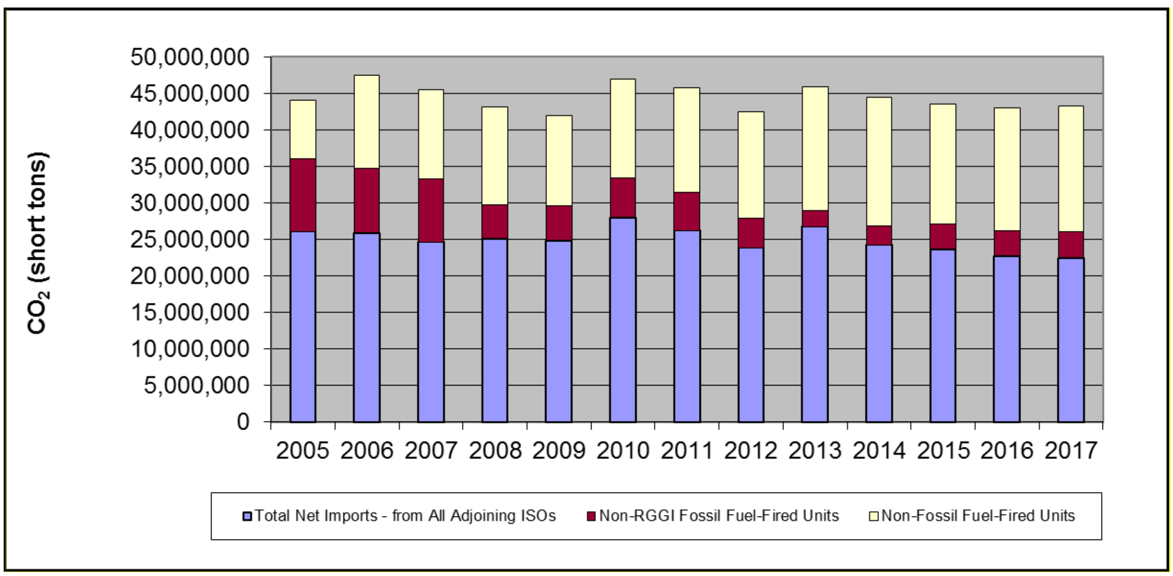

Figure 7. CO_2 Emissions from Non-RGGI Generation Serving Load in RGGI Region (short tons CO_2)

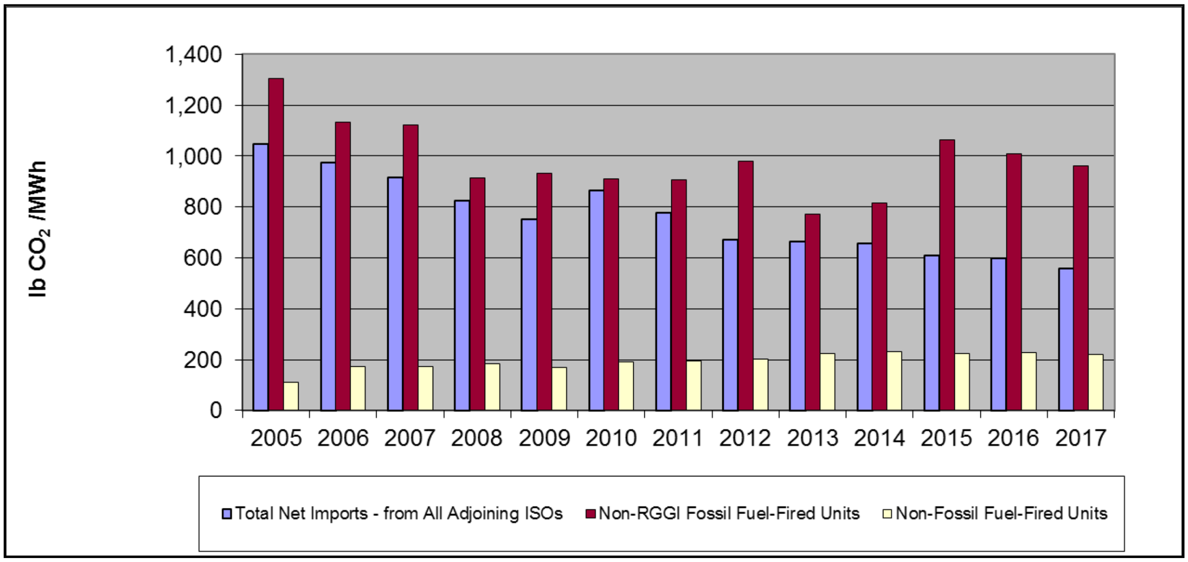

Figure 8. CO_2 Emission Rate for Non-RGGI Generation Serving Load in RGGI Region (lb CO_2/MWh)

Annual average net electricity imports into the nine-state RGGI region increased by 22.2 million MWh, or 39.6 percent, during the 2015 to 2017 annual average compared to the 2006 to 2008 base period. CO_2 emissions related to these net electricity imports decreased by 2.3 million short tons, or 9.1 percent, during this period, indicating a reduction in the average CO_2 emission rate of the electric generation supplying these imports of 317.0 lb CO_2/MWh, a reduction of 35.0 percent. (See Figures 9 and 10).

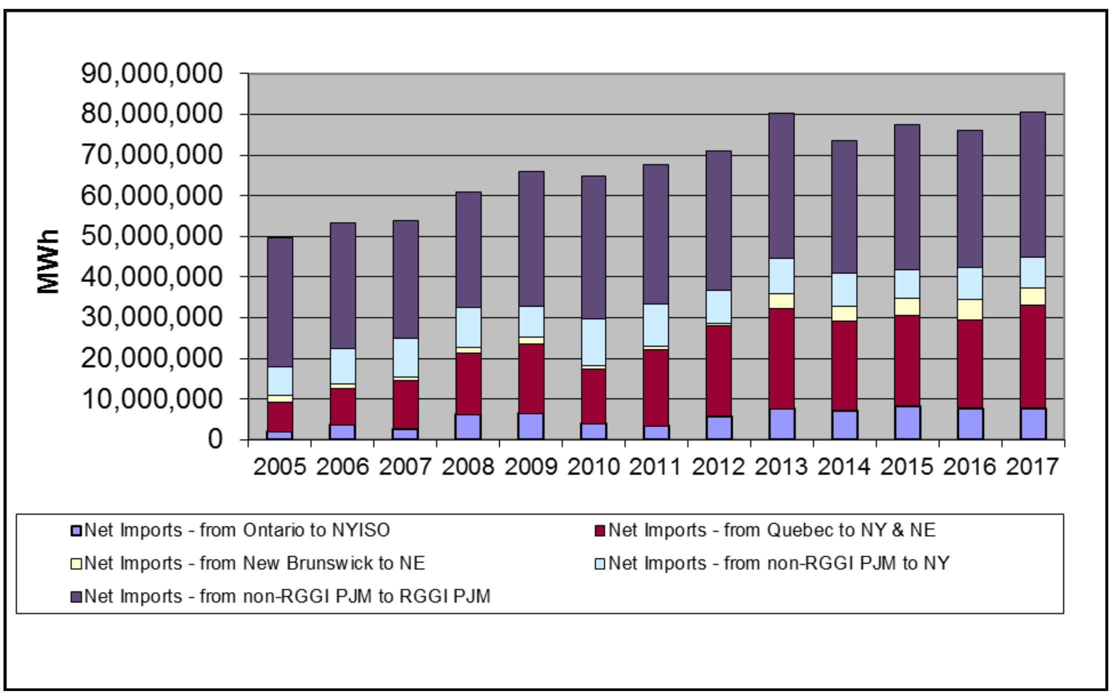

Figure 9. Net Electricity Imports to Nine-State RGGI Region (MWh)

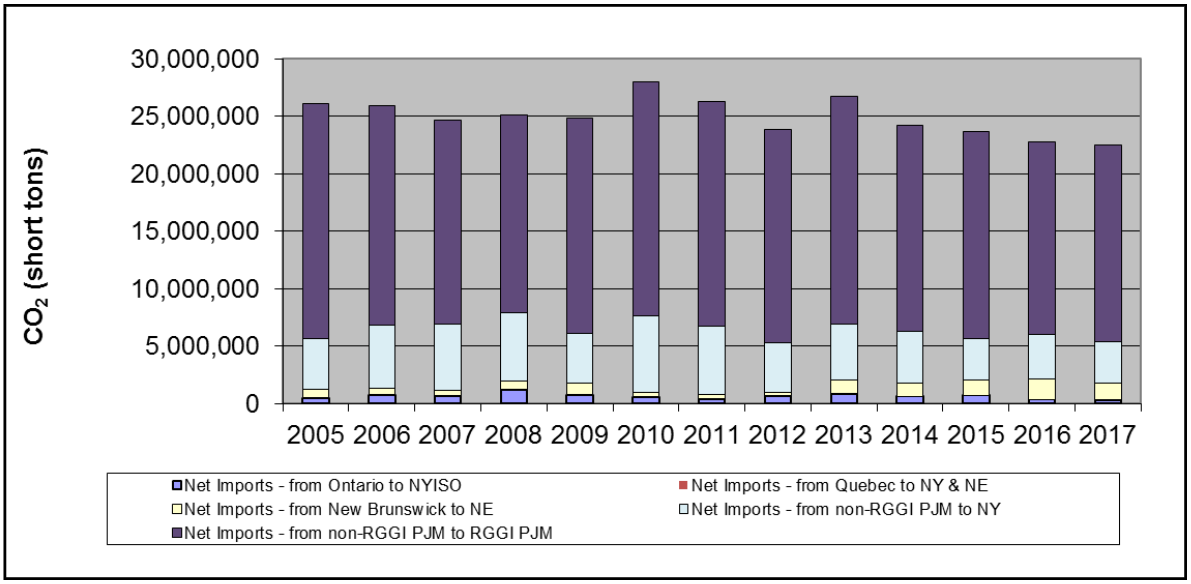

Figure 10. CO_2 Emissions Related to Net Electricity Imports to Nine-State RGGI Region (short tons CO_2)

Compared to the annual average during the 2006 to 2008 base period, 2017 electric generation from RGGI generation decreased by 54.6 million MWh, or 31.7 percent, and CO_2 emissions from RGGI generation decreased by 73.9 million short tons of CO_2, or 53.4 percent. The CO_2 emission rate of RGGI electric generation decreased by 509.4 lb CO_2/MWh, a reduction of 31.7 percent. Compared to the 2006 to 2008 annual average, 2017 electric generation from non-RGGI generation sources located in the nine-state RGGI region increased by 5.3 million MWh, or 3.3 percent, and CO_2 emissions from this category of electric generation increased by 642.7 thousand short tons, an increase of 3.2 percent. The CO_2 emission rate of non-RGGI electric generation located in the nine-state RGGI region showed virtually no change.

Compared to the annual average during the 2006 to 2008 base period, 2017 net electricity imports into the nine-state RGGI region increased by 24.6 million MWh, or 44.0 percent. CO_2 emissions related to these net electricity imports decreased by 2.8 million short tons of CO_2, or 11.0 percent, during this period. The average CO_2 emission rate of the electric generation supplying these imports decreased 347.5 lb CO_2/MWh, a reduction of 38.4 percent.

VI. Discussion

As mentioned earlier in this report, multiple market factors interact to influence the dispatch of electric generation. CO_2 allowance costs have been relatively modest compared to other factors that impact wholesale electricity prices.

The wholesale electricity price is paid by market participants such as utilities, who then supply power to end-use retail consumers at retail rates. Retail rates are influenced by the wholesale price, but also include other costs such as delivery charges, administrative costs, and premiums for shielding retail rates from wholesale price volatility. Retail rates vary by state and are approved by state public utility commissions.

Finally, consumer energy bills depend not just on the retail rate, but on the amount of power used by the end-use consumer. Improved energy efficiency can cause consumer bills to decline even as wholesale and/or retail rates increase. Without taking any of RGGI's benefits into account, CO_2 allowance costs accounted for 2.5 percent of the average all-in wholesale electricity price for ISO-NE, 5.4 percent of the average all-in wholesale electricity price for NYISO, and 0.3 percent of the average all-in locational marginal price on a per MWh basis for PJM in 2017.[21] However, the wholesale price is only one of many factors which determine the amount that consumers actually pay.

When RGGI's benefits are taken into account, independent reports indicate that RGGI is generating net bill savings for consumers. Independent reports from the Analysis Group studied RGGI's first, second, and third three-year control periods, finding that RGGI is reducing consumer energy bills and generating net economic benefits on the order of $4 billion.[22] In particular, the reports found that energy efficiency programs funded by RGGI investments reduce demand for electricity, resulting not only in direct savings for those consumers making the efficiency investments, but also in downward pressure on wholesale prices that reduce costs for all electricity ratepayers. These Analysis Group reports also do not include additional potential economic gains from co-benefits such as public health improvements and avoided climate change impacts.

Wholesale prices fell from 2008 to 2010. In 2010, higher fuel prices, increased economic activity, and hot weather led to an increase in wholesale prices in 2010 relative to 2009. Average electricity prices decreased in 2011 relative to 2010, primarily due to a decrease in natural gas prices and mild winter temperatures in late 2011.[23] This decline in electricity prices continued through 2012 as the price of natural gas continued to fall and temperatures remained mild through the winter. Higher natural gas prices, especially during winter months, resulted in higher electricity prices in 2013.[24] The first quarter of 2014 saw cold weather, with milder weather experienced in the following three quarters, and the net effect was an overall increase in prices in 2014[25]. Since 2014, we have seen a decline in wholesale prices in 2015 and 2016, with a slight increase in 2017 across the three ISOs.

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[21] For 2017, the average all-in wholesale electricity price was $45.46/MWh for ISO-NE and $36.56/MWh for NYISO, and the load-weighted average locational marginal price was $30.99/MWh for PJM (energy only) (see *ISO-NE Monthly Wholesale Load Cost Report; NYISO Power Trends 2019; 2017 State of the Market Report for PJM)*. The CO_2 allowance component is based on a 2017 average CO_2 allowance spot price of $3.42 per CO_2 allowance (See Potomac Economics, *Annual Report on the Market for RGGI CO_2 Allowances: 2017*). For PJM, the CO_2 allowance component of the Locational Marginal Price (LMP) for 2017 was $0.09 per MWh (See *2017 State of the Market Report for PJM*). ISO-NE and NYISO do not report the CO_2 allowance component of wholesale electricity prices. Both the New England and New York analyses used a 2017 average CO_2 allowance spot price of $3.42 as a starting point for deriving a CO_2 allowance wholesale price component. For both ISO-NE and NYISO, the CO_2 emission rate of the assumed marginal unit was used to translate the annual average spot price for CO_2 allowances into a dollar per MWh value. For ISO-NE, this resulted in an average CO_2 allowance wholesale price component of approximately $1.12 per MWh. For NYISO, this resulted in an average CO_2 allowance wholesale price component of $1.98 per MWh.

[22] "The Economic Impacts of the Regional Greenhouse Gas Initiative on Nine Northeastern and Mid-Atlantic States." Analysis Group. April 2018.
"The Economic Impacts of the Regional Greenhouse Gas Initiative on Nine Northeastern and Mid-Atlantic States." Analysis Group. July 2015.
"The Economic Impact of the Regional Greenhouse Gas Initiative on Ten Northeast and Mid-Atlantic States." Analysis Group. November 2011.

[23] See, for example, Monitoring Analytics, *2011 State of the Market Report for PJM*, Section 1, Introduction; Potomac Economics, *2011State of the Market Report New York ISO*, pp. ii-iv; ISO New England Internal Market Monitor, *2011Annual Markets Report*, May 2011, pp. 1-2.

[24] See, for example, *NYISO 2013 Annual Report*, p. 13.

[25] See, for example *NYISO 2014 Annual Report, p. ii.*

A number of market drivers have changed dramatically during the 2005 through 2017 monitoring timeframe. These changes are due to a number of factors, including additional investments in energy efficiency and renewable energy (funded in part by RGGI auction proceeds); complementary state clean energy programs and policies; lower natural gas prices (changes in relative fuel prices); changes in the generation mix, including additional renewable generation; and weather trends. An analysis of these changes, and their estimated impact on CO_2 emissions in the 10-state RGGI region from 2005 to 2009, was completed by the New York State Energy Research and Development Authority (NYSERDA).[26] A 2015 peer-reviewed study in the journal *Energy Economics* examined a similar set of factors and found that RGGI played a significant role in the observed emissions decline in the region.[27] A 2017 research report by the Congressional Research Service cited both studies towards a conclusion that the RGGI cap, the market signal sent by the allowance price, and the reinvestment of proceeds have worked together to help support a shift towards cleaner generation and regional emissions reductions.[28]

A key factor impacting the potential for emissions leakage is the relative cost of electric generation inside and outside the RGGI region (both with and without the incorporation of CO_2 allowance costs), and the relationship of this cost differential with physical transmission capability, the all-in market costs of inter-region power transmission, and the market impacts of transferring significant incremental amounts of power into the RGGI region. The dynamic and highly specific nature of market factors and physical constraints that may cause or mitigate emissions leakage make both a retrospective analysis and future projections of emissions leakage difficult. The factors that may result in emissions leakage are likely to be both temporally and geographically specific.

The dynamics of a competitive wholesale electricity market could drive emissions leakage if there is a sufficient net financial incentive to shift electric generation to units not subject to CO_2 regulation. The extent of this impact is likely to depend, at least in part, on the market value of CO_2 allowances (and the related \$/MWh CO_2 costs incorporated into bids by generators subject to the RGGI CO_2 Budget Trading Program) in relation to other economic factors associated with the generation and delivery of electricity (expanded upon below). If the cost of RGGI CO_2 compliance on a per MWh basis is lower than the aggregate per MWh price signal of mitigating market factors, which are discussed below, no net market dynamic driving emissions leakage would be expected to occur. Market factors that may impact the economics of importing incremental power in response to a CO_2 allowance price signal include[29]:

> ***Existing Generator Economics****:* Including a CO_2 compliance cost into the generation costs of an individual electric generator may make that generator uneconomic relative to a competitor. However, whether this occurs depends on the operating costs of each electric generator, both with and without CO_2

[26] New York State Energy Research and Development Authority (NYSERDA), *Relative Effects of Various Factors on RGGI Electricity Sector CO_2 Emissions: 2009 Compared to 2005*, November 2010; available at Retrospective_Analysis_Draft_White_Paper.pdf.
[27] Murray, Brian C. and Peter T. Maniloff. "Why Have Greenhouse Emissions in RGGI States Declined? An Econometric Attribution to Economic, Energy Market, and Policy Factors." *Energy Economics*. August 2015.
[28] Congressional Research Service. *The Regional Greenhouse Gas Initiative: Lessons Learned and Issues for Congress,* May 2017, available at https://fas.org/sgp/crs/misc/R41836.pdf.
[29] Some of these factors may also impact the economics of shifting dispatch to smaller in-region fossil fuel-fired electric generation in the nine-state RGGI region that is not subject to regulation of CO_2.

compliance costs. Key factors that influence electric generator operating costs include fuel prices, generator heat rate (Btu of fuel input per kWh of electric generation output), and costs for air pollutant emissions (nitrogen oxides (NO_X), sulfur dioxide (SO_2), and CO_2). As a result, inclusion of a CO_2 allowance cost must be sufficient to supplant any preexisting generator cost differentials in order to shift generation from a RGGI source to a non-RGGI source.

Existing Locational Generation Price Differentials: Locational Marginal Pricing (LMP) can be expected to affect the market response to the imposition of a CO_2 allowance cost adder to generation in the RGGI region. LMP is based on the principle that the generation of power has different values at different points in the electric power network. LMP is the cost of supplying the last MWh of generation dispatched at a specific location, which reflects transmission constraints and the marginal cost of generation units. Transmission resources are finite, and transmission "congestion" occurs when available, low-cost electric generation supply cannot be delivered to the demand location due to transmission network limitations. When electricity from the least-cost electric generation source in a region cannot be delivered to electricity load in a transmission-constrained area, higher cost units in this constrained area are dispatched to meet that load. The result is that the wholesale price of electricity in the constrained area is higher than in the unconstrained area.

Differential LMPs between regions represent the presence of transmission constraints and line losses that require the dispatch of higher priced electric generation in a certain region. Electricity demand, in particular, can have a large impact on LMPs in a specific region. For example, in 2017 the real-time average LMP by jurisdiction in MD was $2.65 per MWh above the average PJM LMP, indicating the presence of some existing transmission congestion and line losses.[30]

Congestion Charges: Congestion charges and the standard cost of transmitting electricity may make significant incremental imports into the RGGI region uneconomic as a response to a modest generation price differential resulting from RGGI CO_2 allowance costs. As an example, in PJM, power transmission is subject to congestion charges, which are based on the difference between LMPs at the source (generator location, or "generator bus") and LMPs at the sink (electric distribution utility location, or "load serving entity (LSE) bus"). Thus, in addition to standard transmission charges, entities importing power into the RGGI region would need to pay congestion charges based on the differential between LMPs in the uncapped non-RGGI region where the generator is located and LMPs in the capped RGGI region where the electricity is delivered.[31]

Line loss charges: The greater the distance that electricity is transmitted, and the more power transmitted through a power line, the greater the loss of the power initially put into the line, based on the physics of the electricity

[30] Monitoring Analytics, *2017 State of the Market for PJM*; Volume 2, Energy Market pp. 167; and Monitoring Analytics, *2017 State of the Market for PJM*; Appendix C pp. 645.

[31] As an example, the congestion component of the 2017 average day-ahead, load weighted LMP in the Delmarva Power & Light zone (Delaware and Maryland) zone of PJM was $0.45 per MWh. For the Baltimore Gas & Electric zone (Maryland), the congestion component was $2.72 per MWh. See, Monitoring Analytics, *2017 State of the Market for PJM*; Section 11, Table 11-5, p. 507.

transmission network. As a result, the costs of transmission line-losses impact the economics of importing power. For example, in PJM line losses are accounted for in the calculation of LMP through the application of a line loss “penalty factor.” If the dispatch of an electric generator would result in an increase in system line losses in a certain location, a positive penalty factor is applied to the generator’s bid into the wholesale market, making the unit look less economically attractive to dispatch.[32]

Long-Term Contracts: Existing long-term power purchase agreements can be expected to mitigate emissions leakage. These agreements mandate the purchase of power from particular sources for pre-set time periods, delaying the response to changes in market conditions.

Reliability Constraints: Reliability constraints also play a role in determining the dispatch of electric generation units, to the extent that units supply needed generation capacity and ancillary services in a specified region or location on the electricity grid.

Other Factors: Other relevant factors may include standard transmission pricing; relative fuel prices; natural gas supply and costs which can be influenced by pipeline constraints; and relative heat rates of generation units.[33]

VII. Conclusions

This report presents data and trends for electricity generation, net electricity imports, and related CO_2 emissions of electric generation serving load in the nine-state RGGI region, without assigning causality to any one of the factors influencing observed trends. Monitoring results show that there has been an increase in the amount of non-RGGI electric generation serving load in the RGGI region, combined with a decrease in the CO_2 emissions rate of this generation. These two trends largely offset one another. Overall, the monitoring results show that there has been a 4.6 percent decrease in average annual CO_2 emissions from non-RGGI electric generation serving load in the RGGI region during the period of 2015 to 2017, compared to the annual average annual CO_2 emissions during the base period of 2006 to 2008.

Emissions leakage may manifest through an increase in CO_2 emissions from this aggregate category of non-RGGI electric generation, all other factors being equal. However, given that the monitoring results presented in this report do not address causality, the results should be evaluated in context with market dynamics. Changes in factors such as electricity demand, relative fossil fuel prices, and wholesale electricity prices, can also play a role in changing emissions and generation trends.

When taking only costs into account and not including RGGI’s economic benefits, the average CO_2 allowance price in 2017 represented approximately 5.4 percent or less of the average wholesale electricity price and/or average all-in locational marginal price

[32] As an example, the line loss component of the 2017 average day-ahead, load weighted LMP in the Delmarva Power & Light (Delaware and Maryland) zone of PJM was $0.52 per MWh. Similarly, for the Baltimore Gas & Electric zone (Maryland), the line loss component of LMP was $0.92 per MWh. See, Monitoring Analytics, *2017 State of the Market for PJM*; Section 11, Table 11-5, p. 507.
[33] Heat rate is a measure of electric generator energy efficiency, represented as Btu of fuel input per kWh of electricity output.

in the three ISOs fully or partially subject to RGGI. The monitoring results are consistent with market dynamics given the CO_2 allowance prices that result in CO_2 compliance costs on a per MWh basis. The price signal from RGGI allowances prices is likely lower than the aggregate per MWh price signal of mitigating market factors discussed in this report that would counter emissions leakage.

This report is the ninth in a series of annual monitoring reports, as called for in the 2005 RGGI MOU. Ongoing monitoring will further evaluate changes in market and non-market drivers that impact CO_2 emissions related to electricity generation and imports in the RGGI region.

Appendix A. Nine-State ISO Monitoring Sources

Table 2. Summary of Data Sources for ISO-NE

	Electricity Demand (Annual)					*Electricity Generation (Annual)*				
Code	**A-1**	**A-2**	**A-2**	**A-2**	**A-3**	**B-1**	**B-2**	**B-3**	**B-4**	**B-5**
Monitoring Category	Total Electricity Use in ISO-NE	Net Electricity Imports - from New York	Net Electricity Imports - from Quebec	Net Electricity Imports - from New Brunswick	Total Net Electricity Imports - from All Adjoining ISOs	RGGI-Affected Units	Non-RGGI Units (Fossil Fuel-Fired)	Non-RGGI Units (Non-Fossil Fuel-Fired)	All Non-RGGI Units (Fossil and Non-Fossil)	All Units
MWh	ISO-NE[1]	NYS PSC Calculation (2014-2017)	ISO-NE[1]	ISO-NE[1]	Sum of A2s	NEPOOL-GIS[2]	NEPOOL-GIS[2]	NEPOOL-GIS[2]	Sum of B-2 and B-3	ISO-NE[1]
CO_2 Tons	Sum of A-3 and B-5	MWh multiplied by CO_2/MWh	MWh multiplied by CO_2/MWh	MWh multiplied by CO_2/MWh	Sum of A-2s	State reported data for 2005-2008; RGGI COATS for 2009 to 2016.[4] Includes only sources subject to a state CO_2 Budget Trading Program CO_2 allowance compliance obligation. Does not include biomass-derived CO_2 emissions.	NEPOOL-GIS[2]	NEPOOL-GIS[2]	Sum of B-2 and B-3	Sum of B-1 and B-4
CO_2 lb/MWh	CO_2 tons divided by MWh	NYISO A-2 in Table 3 below	Environment Canada[3]	Environment Canada[3]	CO_2 tons divided by MWh	CO_2 tons divided by MWh	CO_2 tons divided by MWh	CO_2 tons divided by MWh	CO_2 tons divided by MWh	CO_2 tons divided by MWh

Table Notes:
1. ISO-NE, Historical Data Reports, "Net Energy and Peak Load by Source" (Annual Summary). Available at http://www.iso-ne.com/isoexpress/web/reports/load-and-demand/-/tree/net-ener-peak-load. Note that B-5 MWh calculated as the sum of the above NEPOOL GIS-based B-1 to B-4 will differ from B-5 MWh from the ISO-NE website, as the website is updated if errors found, while NEPOOL GIS is frozen at time of certificate creation.
2. NEPOOL Generation Information System. Available at http://www.nepoolgis.com.
3. *National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in* Canada, Environment Canada, 2019. In Part 3. Available at https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/national-inventory-submissions-2019. Note that New Brunswick and Quebec emission factors are updated for every year, as compared to the previous year's report.
4. Historical 2005 – 2008 CO_2 emissions data reported by RGGI participating states compiled from CO_2 emissions data reported to U.S. EPA pursuant 40 CFR Part 75 and from CO_2 emissions and fuel use data reported to state emissions statement programs. 2009 through 2017 CO_2 emissions data is from data reported to the RGGI CO_2 Allowance Tracking System (RGGI COATS), available at rggi-coats.org.

Table 3. Summary of Data Sources for NYISO

	Electricity Demand (Annual)						*Electricity Generation (Annual)*				
Code	**A-1**	**A-2**	**A-2**	**A-2**	**A-2**	**A-3**	**B-1**	**B-2**	**B-3**	**B-4**	**B-5**
Monitoring Category	Total Electricity Use in NYISO	Net Electricity Imports - from Hydro Quebec	Net Electricity Imports - from ISO-NE	Net Electricity Imports - from Ontario	Net Electricity Imports - from PJM	Total Net Electricity Imports - from All Adjoining ISOs	RGGI-Affected Units	Non-RGGI Units (Fossil Fuel-Fired)	Non-RGGI Units (Non-Fossil Fuel-Fired)	All Non-RGGI Units (Fossil and Non-Fossil)	All Units
MWh	NYS PSC Calculation (2005-2015); NYGATS from NYISO data feeds (2016-2017)	Hydro Quebec[1] (2005-2015); NYGATS from NYISO data feeds (2016-2017)	ISO-NE[2] (2005-2015); NYGATS from NYISO/NEPOOL GIS data feeds (2016-2017)	Ontario Independent Electricity System Operator[3]	PJM Annual State of the Market Report[4]	Sum of A-2s	NYS PSC Calculation[5] (2005-2015); NYGATS from NYISO data feeds (2016-2017)	NYS PSC Calculation[5,8] (2005-2015); NYGATS from NYISO data feeds (2016-2017)	NYS PSC Calculation[5] (2005-2015); NYGATS from NYISO data feeds (2016-2017)	Sum of B-2 and B-3	Sum of B-1 and B-4
CO_2 Tons	Sum of A-3 and B-5	MWh multiplied by CO_2/MWh	MWh multiplied by CO_2/MWh	MWh multiplied by CO_2/MWh	MWh multiplied by CO_2/MWh	Sum of A-2s	MWh multiplied by CO_2/MWh	MWh multiplied by CO_2/MWh	MWh multiplied by CO_2/MWh	Sum of B-2 and B-3	Sum of B-1 and B-4
CO_2 lb/MWh	CO_2 tons divided by MWh	Environment Canada[6]	ISO-NE system average (2005-2015); NYS PSC Calculation(2014-2017)	Environment Canada[6]	PJM GATS[7]	CO_2 tons divided by MWh	NYS PSC Calculation	NYS PSC Calculation	NYS PSC Calculation	CO_2 tons divided by MWh	CO_2 tons divided by MWh

Table Notes:
1. Hydro Quebec response to information request.
2. ISO-NE, Historical Data Reports, "Net Energy and Peak Load by Source" (Annual Summary). Available at http://www.iso-ne.com/isoexpress/web/reports/load-and-demand/-/tree/net-ener-peak-load.
3. Ontario IESO response to information request.

4. Monitoring Analytics, *State of the Market for PJM* (2005 through 2017 reports).
5. NYS PSC calculation based on MWh for each generator reported by NYISO and assignment of each generator to appropriate monitoring classification.
6. *National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in* Canada, Environment Canada, 2019. In Part 3. Available at https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/national-inventory-submissions-2019. Note that New Brunswick and Quebec emission factors are updated for every year, as compared to the previous year's report.
7. PJM Generation Attribute Tracking System, accessible at http://www.pjm-eis.com.
8. MWh and CO_2 emissions data include Linden Cogeneration, units 005001 – 009001, and Bayonne Energy Center, units CTG1 – CTG8, as these units are physically located in New Jersey, but dispatch electricity into NYISO.

Table 4. Summary of Data Sources for RGGI PJM

	Electricity Demand (Annual)				*Electricity Generation (Annual)*				
Code	**A-1**	**A-2**	**A-2**	**A-3**	**B-1**	**B-2**	**B-3**	**B-4**	**B-5**
Monitoring Category	Total Electricity Use in RGGI PJM	Net Electricity Imports - from Non-RGGI PJM	Net Electricity Imports - from NYISO	Total Net Electricity Imports - from All Adjoining ISOs	RGGI-Affected Units	Non-RGGI Units (Fossil Fuel-Fired)	Non-RGGI Units (Non-Fossil Fuel-Fired)	All Non-RGGI Units (Fossil and Non-Fossil)	All Units
MWh	Sum of A-3 and B-5	PJM GATS[1]	PJM GATS[1]	Sum of A-2s	PJM GATS[1]	PJM GATS[1]	PJM GATS[1]	Sum of B-2 and B-3	Sum of B-1 and B-4
CO_2 Tons	Sum of A-3 and B-5	MWh multiplied by CO_2/MWh	MWh multiplied by CO_2/MWh	Sum of A-2s	State reported data for 2005-2008; RGGI COATS for 2009 through 2016. Includes only sources subject to a state CO_2 Budget Trading Program CO_2 allowance compliance obligation; does not include Maryland LIESA sources; does not include Linden Cogeneration units 005001-009001.[2,3]	PJM GATS[1]	PJM GATS[1]	Sum of B-2 and B-3	Sum of B-1 and B-4
CO_2 lb/MWh	CO_2 tons divided by MWh	PJM GATS[1]	B-5	CO_2 tons divided by MWh	CO_2 tons divided by MWh	CO_2 tons divided by MWh	CO_2 tons divided by MWh	CO_2 tons divided by MWh	CO_2 tons divided by MWh

Table Notes:
1. PJM Generation Attribute Tracking System, accessible at <http://www.pjm-eis.com>.
2. Historical 2005 – 2008 CO_2 emissions data reported by RGGI participating states compiled from CO_2 emissions data reported to U.S. EPA pursuant 40 CFR Part 75 and from CO_2 emissions and fuel use data reported to state emissions statement programs. 2009 through 2017 CO_2 emissions data is from data reported to the RGGI CO_2 Allowance Tracking System (RGGI COATS), available at rggi-coats.org.
3. MWh and CO_2 emissions data do not include Maryland Limited Industrial Exemption Set-aside (LIESA) sources. LIESA sources for 2009-2017 include Severstal Sparrows Point LLC and Luke Paper Company. LIESA sources refer to certain industrial cogenerators under Maryland's CO_2 Budget Trading Program regulations that are subject to alternative CO_2 compliance obligations under certain conditions in lieu of submission of CO_2 allowances.

Appendix B. ISO-Specific Monitoring Results

Detailed monitoring results for ISO-NE, NYISO, and the RGGI portion of PJM are presented below.[34]

ISO-NE

Monitoring results for ISO-NE for 2005 through 2017 are summarized below in Table 5 and Figures 11 through 15.

Table 5. 2005 – 2017 Monitoring Summary for ISO-NE

MWh	Electricity Demand					Electricity Generation					*Summary Data*
	Total in ISO	Net Imports - from NYISO	Net Imports - from Quebec	Net Imports - from New Brunswick	Total Net Imports - from All Adjoining ISOs	RGGI-Affected Units	Non-RGGI Fossil Fuel-Fired Units	Non-Fossil Fuel-Fired Units	All Non-RGGI Units	All Units	Non-RGGI Generation Serving Load in ISO (Non-RGGI Generation within ISO + Net Imports)
2005	138,174,000	-115,000	4,792,000	1,620,000	6,297,000	73,032,078	7,932,957	51,043,242	58,976,199	131,877,000	65,273,199
2006	134,243,000	-877,000	6,023,000	1,047,000	6,193,000	66,235,352	7,994,499	54,056,195	62,050,694	128,050,000	68,243,694
2007	136,869,000	-2,477,000	7,727,000	896,000	6,146,000	69,488,412	8,430,445	53,020,870	61,451,315	130,723,000	67,597,315
2008	134,000,000	-1,529,000	9,495,000	1,285,000	9,251,000	66,518,558	5,416,213	52,665,469	58,081,682	124,749,000	67,332,682
2009	128,801,000	-3,031,000	10,826,000	1,569,000	9,363,000	60,473,925	6,443,028	52,979,865	59,422,893	119,437,000	68,785,893
2010	131,956,000	-4,412,000	9,214,000	737,000	5,539,000	65,238,708	8,074,341	53,893,367	61,967,708	126,416,000	67,506,708
2011	130,752,000	-2,262,000	11,558,000	846,000	10,142,000	62,957,969	7,886,924	51,306,677	59,193,601	120,610,000	69,335,601
2012	129,590,000	-1,073,000	13,077,000	643,000	12,648,000	62,129,238	4,314,475	53,144,056	57,458,531	116,942,000	70,106,531
2013	131,001,000	1,322,000	13,928,000	3,711,000	18,961,000	57,766,430	1,637,377	56,533,777	58,171,154	112,041,000	77,132,154
2014	127,176,000	3,908,078	13,212,403	3,527,050	20,647,531	53,539,784	1,739,519	57,802,685	59,542,204	108,357,000	80,189,735
2015	126,955,000	3,911,358	12,978,000	4,108,000	20,997,358	58,406,246	1,742,545	52,483,133	54,225,678	107,916,000	75,223,036
2016	124,416,000	1,335,255	12,285,000	4,842,000	18,462,255	55,090,362	2,024,903	53,702,585	55,727,488	105,572,000	74,189,743
2017	121,220,000	1,478,998	14,495,000	4,305,000	20,278,998	49,456,967	2,335,299	57,986,601	60,321,901	102,564,000	80,600,898

[34] The tons of CO_2 emitted and the lb of CO_2/MWh emission rates in this report do not represent total lifecycle reductions or contributions of greenhouse gases. Such analysis is outside the scope of this report.

CO_2	Electricity Demand					Electricity Generation					*Summary Data*
	Total in ISO	Net Imports - from NYISO	Net Imports - from Quebec	Net Imports - from New Brunswick	Total Net Imports - from All Adjoining ISOs	RGGI-Affected Units	Non-RGGI Fossil Fuel-Fired Units	Non-Fossil Fuel-Fired Units	All Non-RGGI Units	All Units	Non-RGGI Generation Serving Load in ISO (Non-RGGI Generation within ISO + Net Imports)
2005	65,211,430	-56,275	19,544	714,298	677,567	54,223,939	3,807,116	6,502,808	10,309,924	64,533,863	10,987,491
2006	42,202,458	-404,953	26,557	547,053	168,657	47,783,423	2,294,218	9,049,196	11,343,414	59,126,837	11,512,070
2007	50,079,316	-1,155,569	25,468	455,316	-674,785	49,434,978	2,963,453	8,586,395	11,549,849	60,984,826	10,875,064
2008	54,286,213	-671,104	26,166	736,564	91,627	44,508,400	1,820,953	8,425,083	10,246,036	54,754,436	10,337,663
2009	44,334,489	-1,287,840	42,961	968,535	-276,344	38,815,561	2,733,899	9,198,068	11,931,967	50,747,528	11,655,623
2010	49,139,981	-1,932,583	25,392	406,202	-1,500,990	41,682,538	3,331,687	10,359,631	13,691,318	55,373,857	12,190,329
2011	43,513,964	-933,856	29,303	410,324	-494,228	35,599,032	3,294,100	11,029,838	14,323,938	49,793,256	13,829,710
2012	38,748,137	-410,272	38,920	297,690	-73,661	31,657,173	1,815,918	11,240,839	13,056,757	44,713,885	12,983,095
2013	45,985,934	522,082	30,706	1,186,296	1,739,082	30,173,526	604,510	13,469,005	14,073,514	44,247,040	15,812,597
2014	45,016,852	1,054,224	20,390	1,088,614	2,163,233	27,665,118	584,114	14,605,525	15,189,639	42,854,758	17,352,872
2015	45,213,688	1,011,086	15,736	1,313,206	2,340,028	28,867,519	609,582	13,155,735	13,765,317	42,632,836	16,105,345
2016	42,138,496	414,597	16,250	1,761,339	2,192,186	26,013,525	635,083	13,123,557	13,758,641	39,772,166	15,950,827
2017	40,398,875	421,514	19,174	1,471,090	1,911,777	23,990,894	677,682	13,818,521	14,496,203	38,487,097	10,987,491

lbs CO_2/ MWh	Electricity Demand					Electricity Generation					*Summary Data*
	Total in ISO	Net Imports - from NYISO	Net Imports - from Quebec	Net Imports - from New Brunswick	Total Net Imports - from All Adjoining ISOs	RGGI-Affected Units	Non-RGGI Fossil Fuel-Fired Units	Non-Fossil Fuel-Fired Units	All Non-RGGI Units	All Units	Non-RGGI Generation Serving Load in ISO (Non-RGGI Generation within ISO + Net Imports)
2005	944	979	8	882	215	1,485	960	255	350	979	337
2006	629	923	9	1,045	54	1,443	574	335	366	923	337
2007	732	933	7	1,016	-220	1,423	703	324	376	933	322
2008	810	878	6	1,146	20	1,338	672	320	353	878	307
2009	688	850	8	1,235	-59	1,284	849	347	402	850	339
2010	666	876	6	1,102	-542	1,278	825	384	442	876	361
2011	666	826	5	970	-97	1,131	835	430	484	826	399

2012	598	765	6	926	-12	1,019	842	423	454	765	370
2013	702	790	4	639	183	1,045	738	476	484	790	410
2014	708	540	3	617	210	1,033	672	505	510	791	433
2015	712	517	2	639	223	989	700	501	508	790	428
2016	677	621	3	728	237	944	627	489	494	753	430
2017	667	570	3	683	189	970	580	477	481	750	407

The monitoring results indicate that the annual average electricity load in ISO-NE for 2015 to 2017 decreased by 10.8 million MWh, or 8.0 percent, compared to the annual average for the baseline period of 2006 to 2008. Electric generation from all sources in ISO-NE decreased by 16.9 million MWh, or 13.2 percent, when comparing the 2006 to 2008 annual average to the 2015 to 2017 annual average.

Annual average electric generation from RGGI generation in ISO-NE decreased by 13.1 million MWh during this period, or 19.4 percent, and annual average CO_2 emissions from RGGI electric generation in ISO-NE decreased by 21.0 million short tons of CO_2, or 44.3 percent. The CO_2 emission rate of RGGI electric generation decreased by 433.6 lb CO_2/MWh, or 30.9 percent. Annual average electric generation from non-RGGI electric generation sources located in ISO-NE decreased by 3.8 million MWh, or 6.2 percent, during this period, and CO_2 emissions from this category of electric generation increased by 3.0 million short tons of CO_2, an increase of 26.8 percent. The annual average CO_2 emission rate of non-RGGI electric generation located in ISO-NE increased by 129.3 lb CO_2/MWh, an increase of 35.4 percent.

Compared to the annual average during the 2006 to 2008 base period, 2017 total electricity load in ISO-NE decreased by 13.8 million MWh, or 10.2 percent. Compared to the 2006 to 2008 annual average, 2017 total electric generation in ISO-NE decreased by 18.2 million MWh, or 14.2 percent.

When the 2015 to 2017 annual average is compared to the 2006 to 2008 base period annual average, electric generation from all non-RGGI electric generation serving load in ISO-NE increased by 8.9 million MWh, or 13.2 percent. When the 2006 to 2008 base period annual average is compared to the 2015 to 2017 annual average, CO_2 emissions from this category of electric generation increased by 5.2 million short tons of CO_2, or 48.1 percent, and the CO_2 emission rate increased by 99.6 lb CO_2/MWh, or 30.9 percent. (See Figures 11, 12, and 13).

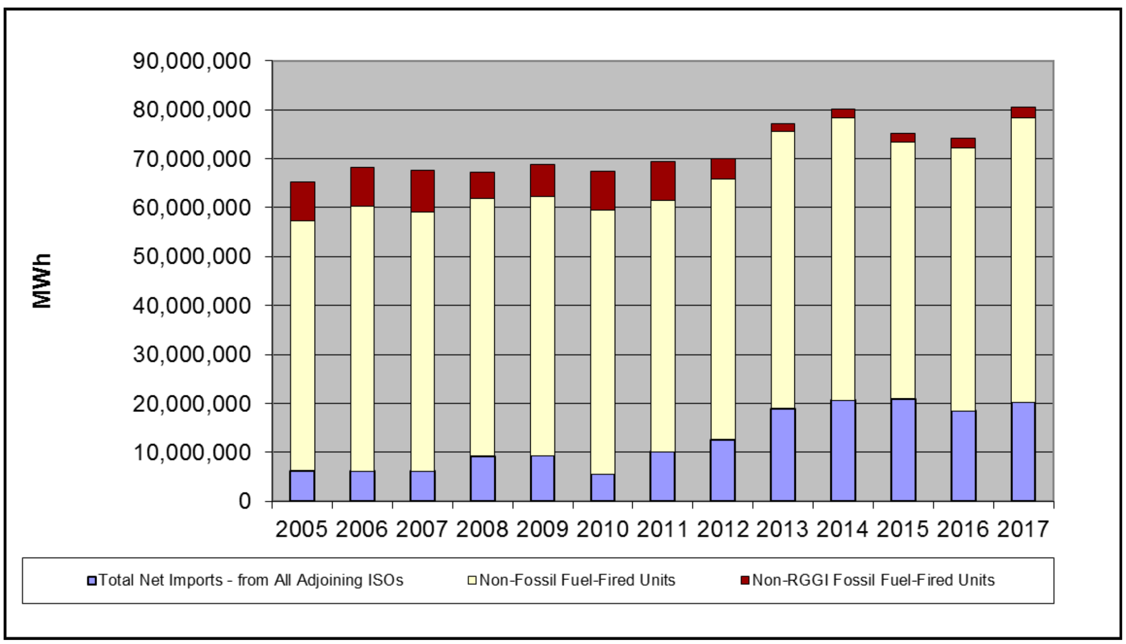

Figure 11. Non-RGGI Generation Serving Load in ISO-NE (MWh)

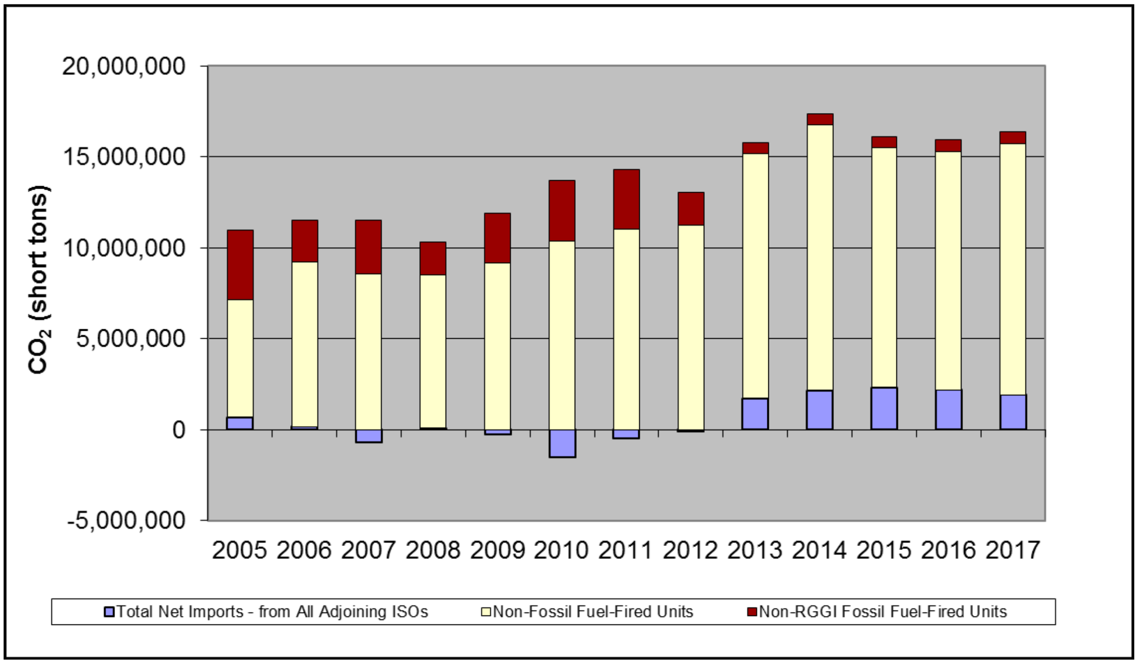

Figure 12. CO_2 Emissions from Non-RGGI Generation Serving Load in ISO-NE (short tons CO_2)

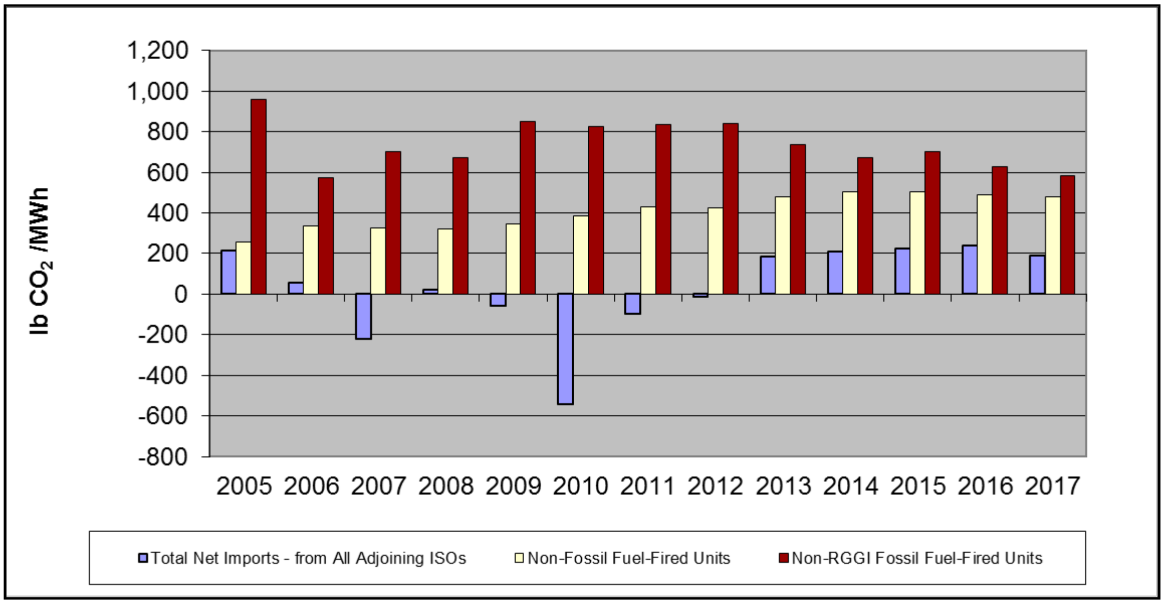

Figure 13. CO_2 Emission Rate for Non-RGGI Generation Serving Load in ISO-NE (lb CO_2/MWh)

Annual average net electricity imports into ISO-NE for 2015 to 2017 increased by 12.7 million MWh, compared to the base period annual average for 2006 to 2008. Annual average CO_2 emissions related to these net electricity imports increased by 2.3

million short tons of CO_2 during this period.[35] The annual average CO_2 emission rate of the electric generation supplying these imports increased by 264.7 lb CO_2/MWh.

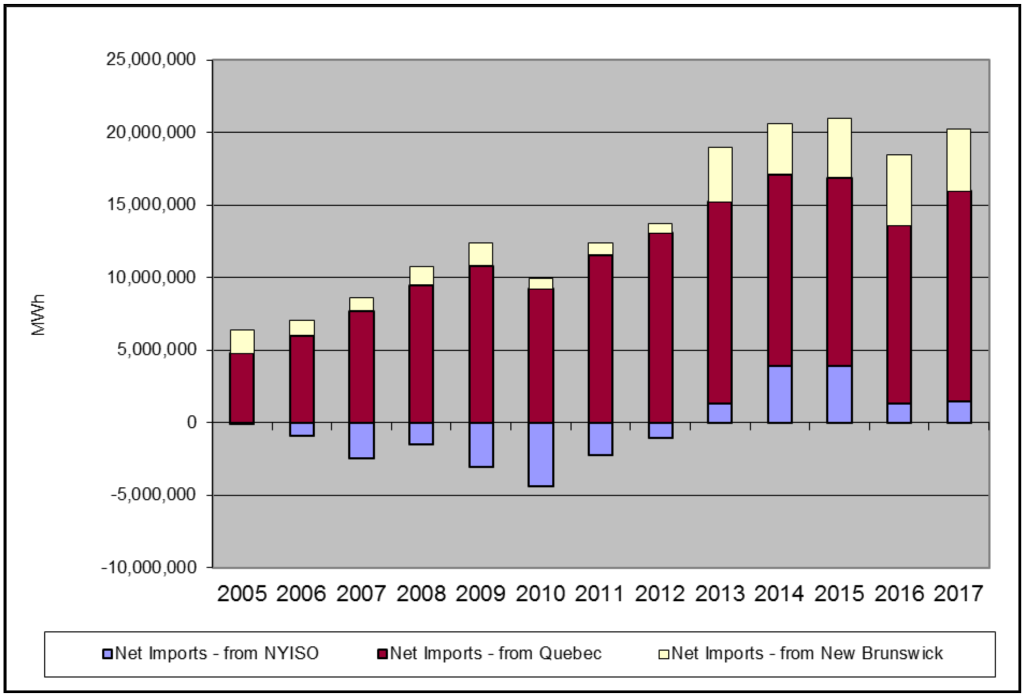

Figure 14. Net Electricity Imports to ISO-NE (MWh)

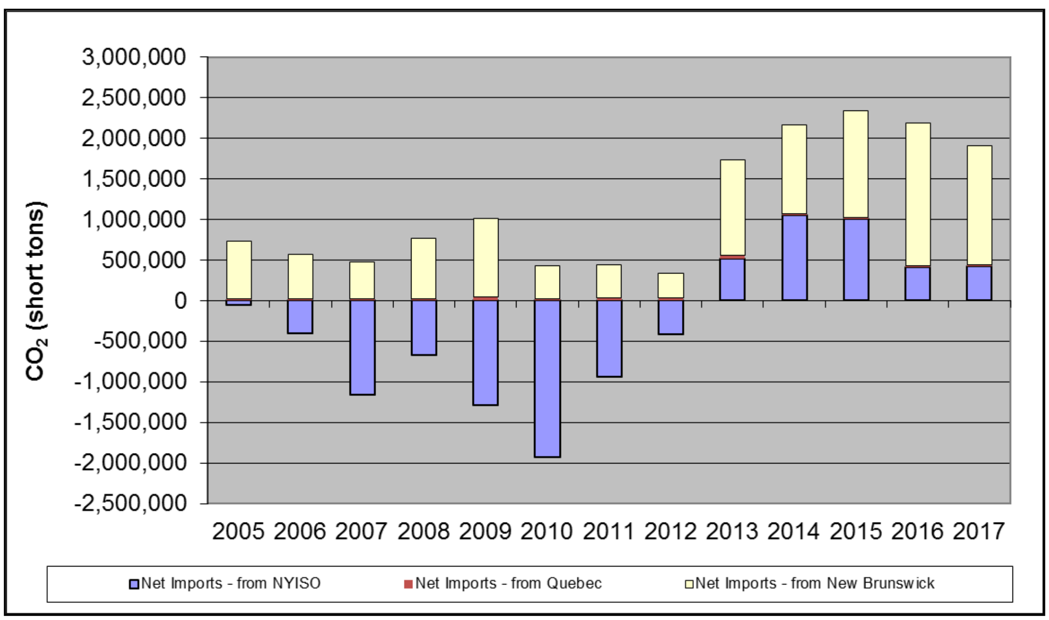

Figure 15. CO_2 Emissions Related to Net Electricity Imports to ISO-NE (short tons CO_2)

[35] ISO-NE net exports to NYISO doubled from 2008 to 2009, and increased again in 2010. Negative values for MWh and CO_2 tons indicate that more MWh were exported (from New England to New York) than imported. As a result, the increase in net exports to NYISO in 2009 and 2010 increased the amount of CO_2 emissions debited from the ISO-NE net import total, resulting in a negative CO_2 emissions value for total CO_2 emissions related to total net electricity imports in 2009, 2010, 2011, and 2012 for ISO-NE. In 2013, the trend was reversed as NE imported more than was exported to NY.

Compared to the annual average during the base period of 2006 to 2008, electric generation in 2017 from all non-RGGI electric generation sources serving load in ISO-NE increased by 12.9 million MWh, an increase of 19.0 percent. Compared to the 2006 to 2008 annual average, 2017 CO_2 emissions from this category of electric generation increased by 5.5 million short tons of CO_2, an increase of 50.4 percent, and the CO_2 emission rate increased by 85.0 lb CO_2/MWh, an increase of 26.4 percent.

Compared to the annual average during the 2006 to 2008 base period, 2017 electric generation from RGGI generation in ISO-NE decreased by 18.0 million MWh, or 26.6 percent, and CO_2 emissions from RGGI generation in ISO-NE decreased by 23.3 million short tons of CO_2, or 49.2 percent. The CO_2 emission rate of RGGI electric generation decreased by 431.1 lb CO_2/MWh, a reduction of 30.8 percent. Compared to the 2006 to 2008 annual average, 2017 electric generation from non-RGGI generation located in ISO-NE decreased by 206.0 thousand MWh, or 0.3 percent, and CO_2 emissions from this category of electric generation increased by 3.4 million short tons of CO_2, an increase of 31.2 percent. The CO_2 emission rate of non-RGGI electric generation located in ISO-NE increased by 115.8 lb CO_2/MWh, an increase of 31.8 percent.

Compared to the annual average during the 2006 to 2008 base period, 2017 net electricity imports into ISO-NE increased by 13.1 million MWh. CO_2 emissions related to these net electricity imports increased by 2.0 million short tons of CO_2 during this period. The CO_2 emission rate of the electric generation supplying these imports increased by 237.0 lb CO_2/MWh.

NYISO

Monitoring results for NYISO for 2005 through 2017 are summarized below in Table 6 and Figures 16 through 20.

Table 6. 2005 – 2017 Monitoring Summary for NYISO

MWh	Electricity Demand						Electricity Generation					*Summary Data*
	Total Annual Electricity Load in NYISO	Net Imports - from Quebec	Net Imports - from ISO-NE	Net Imports - from Ontario	Net Imports - from PJM	Total Net Electricity Imports	Annual Electric Generation - RGGI-Affected Units	Annual Electric Generation - Non-RGGI Fossil Fuel-Fired Units	Annual Electric Generation - Non-Fossil Fuel-Fired Units	Annual Electric Generation - All Non-RGGI Units	Total Annual Electric Generation - All Units	Non-RGGI Generation Serving Load in ISO (Non-RGGI Generation within ISO + Net Imports)
2005	164,783,642	2,583,317	115,000	1,898,020	7,604,000	12,200,337	67,835,907	7,029,219	77,718,179	84,747,398	152,583,305	96,947,735
2006	166,654,413	2,959,749	877,000	3,672,282	9,559,000	17,068,031	66,864,341	7,322,844	75,399,197	82,722,041	149,586,382	99,790,072
2007	169,932,177	4,185,292	2,477,000	2,637,442	10,225,000	19,524,734	71,336,352	6,648,463	72,422,628	79,071,091	150,407,443	98,595,825
2008	168,646,767	5,646,014	1,529,000	6,162,902	10,690,000	24,027,916	64,620,511	4,618,782	75,379,558	79,998,340	144,618,851	104,026,256
2009	160,565,962	6,239,805	3,031,000	6,463,657	8,331,000	24,065,462	56,246,945	3,750,738	76,502,817	80,253,555	136,500,500	104,319,017
2010	164,282,144	4,335,209	4,412,000	3,872,635	12,305,000	24,924,844	62,527,452	3,686,768	73,143,080	76,829,848	139,357,300	101,754,692
2011	163,818,485	7,123,204	2,262,000	3,318,681	11,150,000	23,853,885	59,098,130	3,252,477	77,613,993	80,866,470	139,964,600	104,720,355
2012	163,689,994	9,235,689	1,073,000	5,749,461	8,408,800	24,466,950	61,313,672	3,736,023	74,173,349	77,909,372	139,223,044	102,376,322
2013	166,412,302	10,638,017	-1,322,000	7,593,954	9,190,966	26,100,937	59,652,799	3,963,738	76,694,828	80,658,566	140,311,365	106,759,503
2014	160,598,000	8,839,775	-3,908,078	7,180,281	8,721,704	20,833,682	58,403,922	4,612,684	76,747,712	81,360,396	139,764,318	102,194,078
2015	160,650,689	9,397,396	-3,911,358	8,302,624	7,558,163	21,346,825	57,328,298	4,627,476	77,348,090	81,975,566	139,303,864	103,322,391
2016	160,798,000	9,558,000	-1,335,255	7,668,000	8,399,813	24,290,558	57,581,414	4,889,216	74,479,557	79,368,773	136,950,187	103,659,331
2017	156,370,000	10,795,091	-1,478,998	7,720,948	7,948,559	24,985,600	47,011,708	5,134,132	79,238,560	84,372,692	131,384,400	109,358,292

CO_2	Electricity Demand						Electricity Generation					*Summary Data*
	Total Annual Electricity Load in NYISO	**Net Imports - from Quebec**	**Net Imports - from ISO-NE**	**Net Imports - from Ontario**	**Net Imports - from PJM**	**Total Net Electricity Imports**	**Annual Electric Generation - RGGI-Affected Units**	**Annual Electric Generation - Non-RGGI Fossil Fuel-Fired Units**	**Annual Electric Generation - Non-Fossil Fuel-Fired Units**	**Annual Electric Generation - All Non-RGGI Units**	**Total Annual Electric Generation - All Units**	**Non-RGGI Generation Serving Load in ISO (Non-RGGI Generation within ISO + Net Imports)**
2005	74,759,800	10,536	56,275	460,286	4,912,184	5,439,281	62,718,683	5,933,822	668,014	6,601,836	69,320,519	12,041,117
2006	69,807,908	13,050	404,953	769,120	5,983,934	7,171,057	53,638,129	6,319,357	2,679,365	8,998,722	62,636,851	16,169,779
2007	71,578,150	13,794	1,155,569	604,715	6,349,725	8,123,803	55,717,151	5,430,598	2,306,598	7,737,196	63,454,347	15,860,999
2008	63,062,489	15,559	671,104	1,154,884	6,520,900	8,362,447	48,348,177	2,676,684	3,675,181	6,351,865	54,700,042	14,714,312
2009	48,529,762	24,762	1,287,840	712,496	4,736,174	6,761,271	37,861,408	1,931,753	1,975,329	3,907,082	41,768,490	10,668,354
2010	55,583,232	11,947	1,932,583	554,950	7,179,968	9,679,448	42,113,171	1,944,024	1,846,589	3,790,613	45,903,784	13,470,061
2011	48,275,690	18,060	936,289	336,556	6,389,108	7,677,579	37,148,379	1,683,269	1,764,030	3,447,299	40,595,678	11,127,311
2012	44,898,580	27,488	410,272	602,081	4,212,809	5,252,649	35,640,442	2,008,494	1,996,995	4,005,489	39,645,930	9,258,138
2013	42,408,932	23,453	-522,082	795,236	4,871,212	5,167,821	33,476,561	1,485,213	2,279,339	3,764,552	37,241,113	8,932,371
2014	42,040,391	13,642	-1,105,986	603,144	4,827,463	4,338,263	34,028,752	1,946,553	1,726,824	3,673,376	37,702,326	8,011,639
2015	40,890,195	11,395	-1,011,086	697,420	3,831,989	3,529,718	32,550,962	2,745,481	2,064,034	4,809,515	37,334,037	8,339,233
2016	39,501,402	12,643	-414,597	337,392	4,162,107	4,097,546	30,666,015	2,823,920	1,913,921	4,737,841	35,403,858	8,835,387
2017	33,305,807	14,279	-421,514	298,260	3,918,639	3,809,665	24,577,905	2,897,654	2,020,583	4,918,237	29,496,143	8,727,902

lbs CO_2/MWh	Electricity Demand						Electricity Generation					*Summary Data*
	Total Annual Electricity Load in NYISO	**Net Imports - from Quebec**	**Net Imports - from ISO-NE**	**Net Imports - from Ontario**	**Net Imports - from PJM**	**Total Net Electricity Imports**	**Annual Electric Generation - RGGI-Affected Units**	**Annual Electric Generation - Non-RGGI Fossil Fuel-Fired Units**	**Annual Electric Generation - Non-Fossil Fuel-Fired Units**	**Annual Electric Generation - All Non-RGGI Units**	**Total Annual Electric Generation - All Units**	**Non-RGGI Generation Serving Load in ISO (Non-RGGI Generation within ISO + Net Imports)**
2005	907	8	979	485	1,292	892	1,849	1,688	17	156	909	248
2006	838	9	923	419	1,252	840	1,604	1,726	71	218	837	324
2007	842	7	933	459	1,242	832	1,562	1,634	64	196	844	322
2008	748	6	878	375	1,220	696	1,496	1,159	98	159	756	283

2009	604	8	850	220	1,137	562	1,346	1,030	52	97	612	205
2010	677	6	876	287	1,167	777	1,347	1,055	50	99	659	265
2011	589	5	826	203	1,146	644	1,257	1,035	45	85	580	213
2012	549	6	765	209	1,002	429	1,163	1,075	54	103	570	181
2013	510	4	790	209	1,060	396	1,122	749	59	93	531	167
2014	524	3	566	168	1,107	416	1,165	844	45	90	540	157
2015	509	2	517	168	1,014	331	1,191	1,187	53	117	536	161
2016	491	3	621	88	991	337	1,108	1,155	51	119	517	170
2017	426	3	570	77	986	305	1,112	1,129	51	117	449	160

The monitoring results indicate that the annual average electricity load in NYISO for 2015 to 2017 decreased by 9.1 million MWh, or 5.4 percent, compared to the annual average for the baseline period of 2006 to 2008. Annual average electric generation from all sources in NYISO decreased by 12.3 million MWh, or 8.3 percent, when comparing the period of 2015 to 2017 with the base period of 2006 to 2008.

Annual average electric generation from RGGI generation in NYISO decreased by 13.6 million MWh during this period, or 20.2 percent, and annual average CO_2 emissions from RGGI electric generation in NYISO decreased by 23.3 million short tons of CO_2, or 44.3 percent. The annual average CO_2 emission rate of RGGI electric generation decreased by 417.1 lb CO_2/MWh, a reduction of 26.8 percent. Annual average electric generation from non-RGGI sources located in NYISO increased by 1.3 million MWh, or 1.6 percent, during this period, and average annual CO_2 emissions from this category of electric generation decreased by 2.9 million short tons of CO_2, a decrease of 37.3 percent. The annual average CO_2 emission rate of non-RGGI electric generation located in NYISO decreased by 72.9 lb CO_2/MWh, a decrease of 38.2 percent.

Compared to the annual average during the 2006 to 2008 base period, 2017 electric load in NYISO decreased by 12.0 million MWh, or 7.1 percent, and electric generation from all sources in NYISO in 2016 decreased by 16.8 million MWh, or 11.3 percent.

The annual average non-RGGI electric generation serving load in NYISO for 2015 to 2017 increased by 4.6 million MWh, or 4.6 percent, compared to the annual average during the base period of 2006 to 2008. Annual average CO_2 emissions from this category of electric generation decreased by 6.9 million short tons of CO_2, or 44.6 percent, and the annual average CO_2 emission rate decreased by 145.3 lb CO_2/MWh, a decrease of 47.0 percent. (See Figures 16, 17, and 18.)

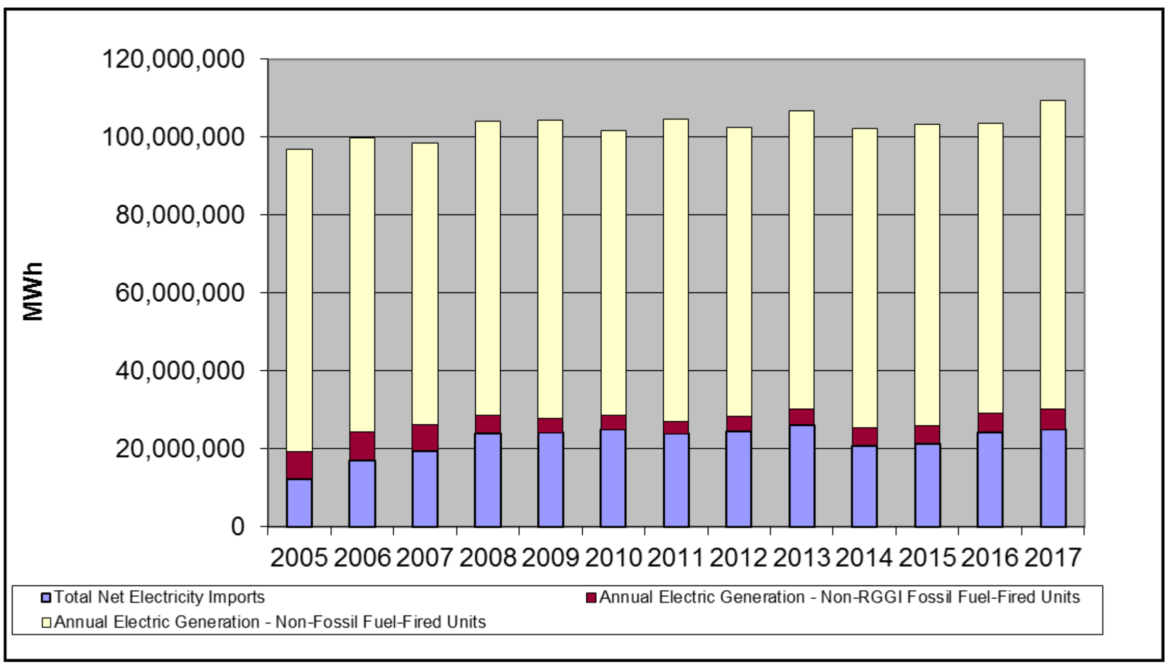

Figure 16. Non-RGGI Generation Serving Load in NYISO (MWh)

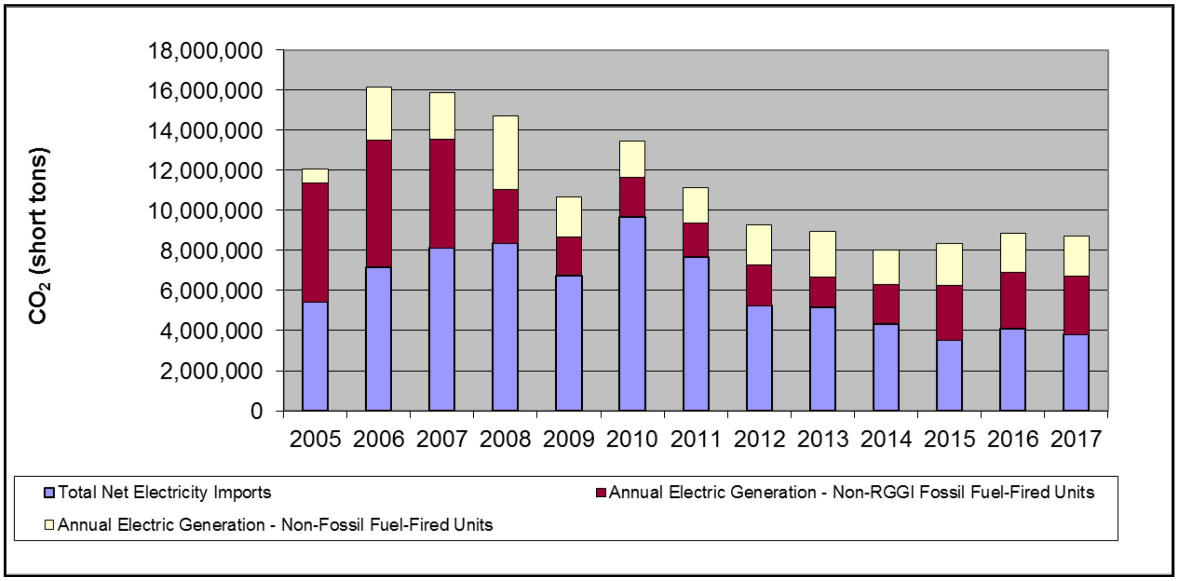

Figure 17. CO_2 Emissions from Non-RGGI Generation Serving Load in NYISO (short tons CO_2)

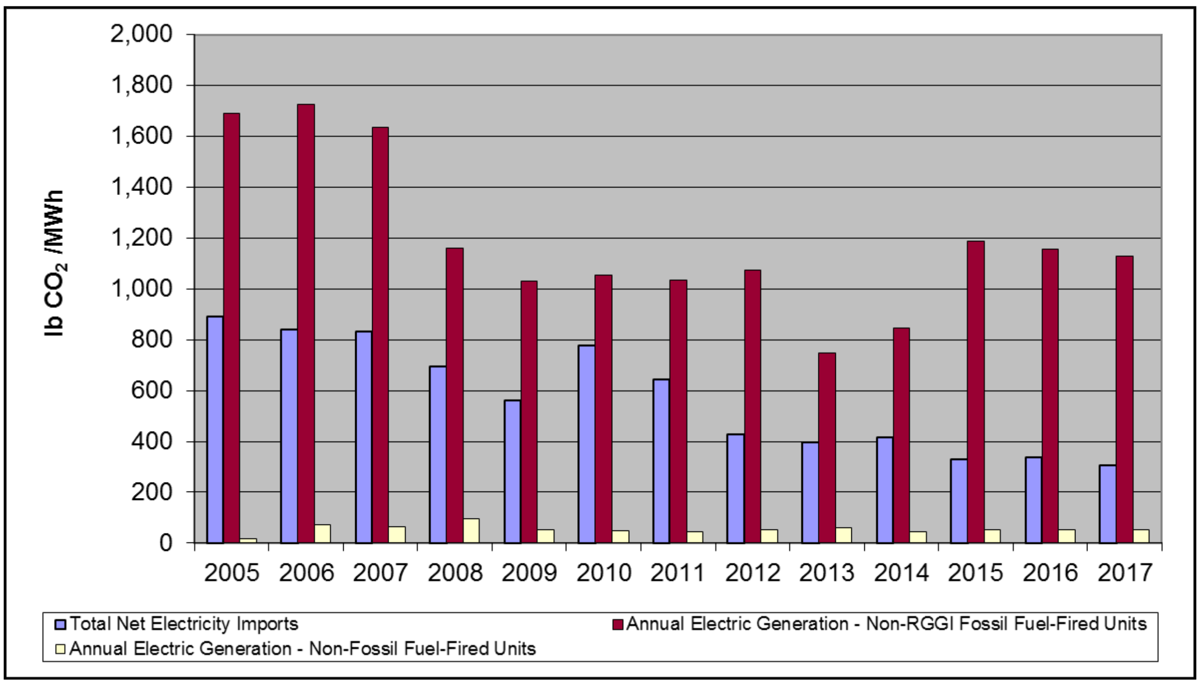

Figure 18. CO_2 Emission Rate for Non-RGGI Generation Serving Load in NYISO (lb CO_2/MWh)

Net electricity imports into NYISO increased by 3.3 million MWh, when comparing the annual average for the base period of 2006 to 2008 to the annual average for 2015 to 2017. Annual average CO_2 emissions related to these net electricity imports decreased by 4.1 million short tons of CO_2, or 51.7 percent, during this period.

The annual average CO_2 emission rate of the electric generation supplying these imports decreased by 465.2 lb CO_2/MWh, a decrease of 58.9 percent. (See figures 19 and 20).

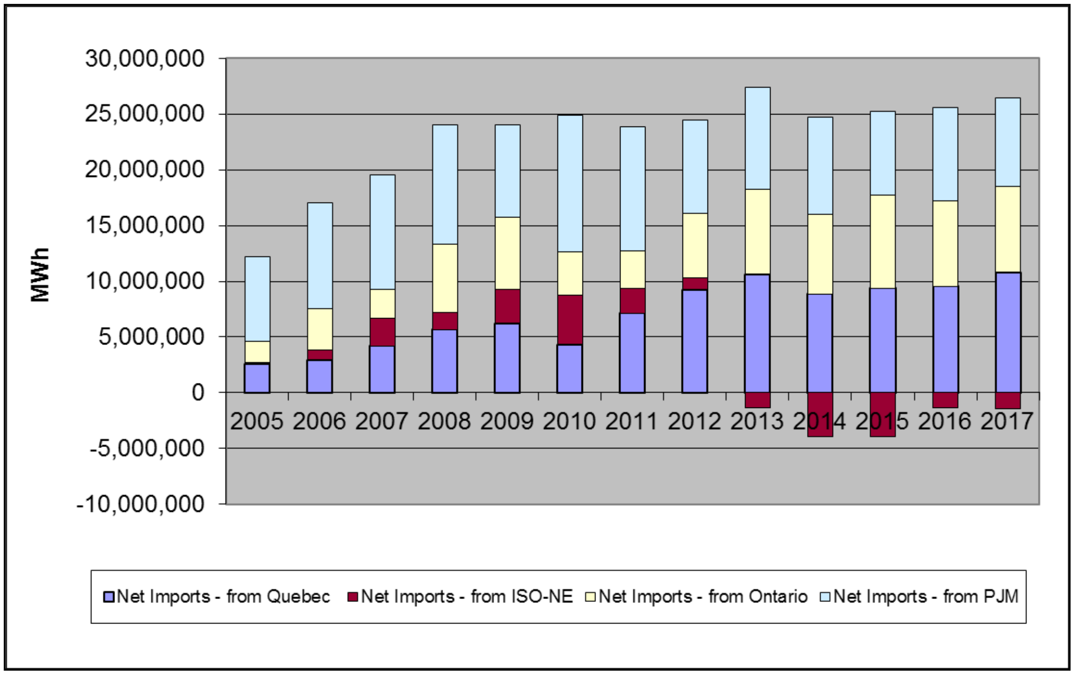

Figure 19. Net Electricity Imports to NYISO (MWh)

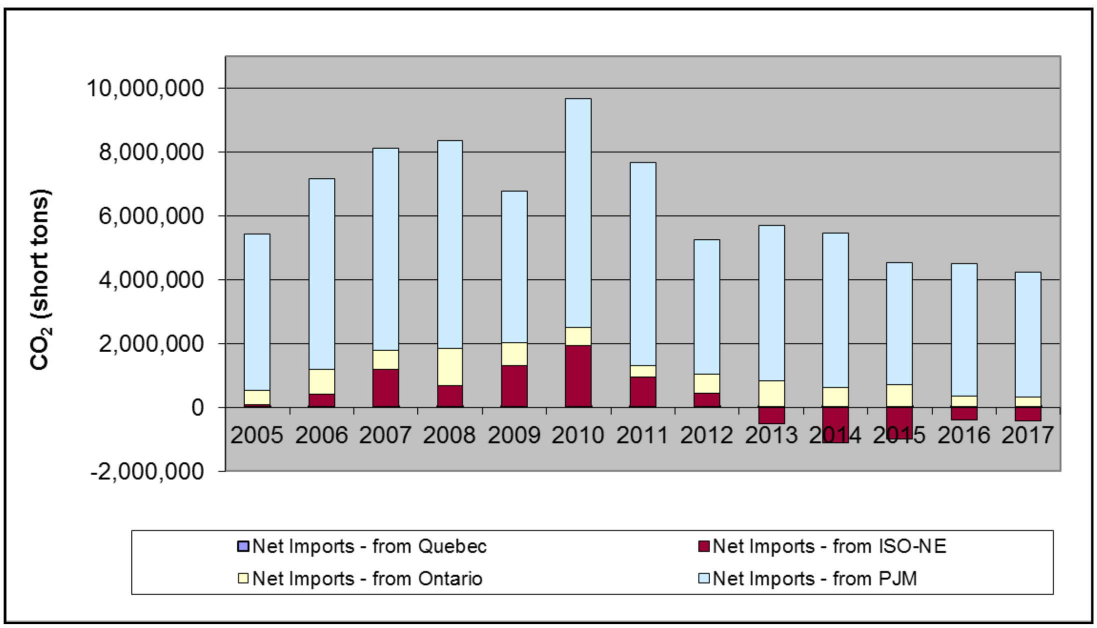

Figure 20. CO_2 Emissions Related to Net Electricity Imports to NYISO (short tons CO_2)

Compared to the annual average during the base period of 2006 to 2008, electric generation in 2017 from all non-RGGI electric generation sources serving load in NYISO increased by 8.6 million MWh, an increase of 8.5 percent. Compared to the annual average for 2006 to 2008, 2017 CO_2 emissions from this category of electric generation decreased by 6.9 million short tons of CO_2, a reduction of 44.0 percent, and the CO_2 emission rate decreased by 149.5 lb CO_2/MWh, a reduction of 48.4 percent.

Compared to the annual average during the 2006 to 2008 base period, 2017 electric generation from RGGI generation in NYISO decreased by 20.6 million MWh, or 30.5 percent, and CO_2 emissions from RGGI generation in NYISO decreased by 28.0 million short tons of CO_2, a reduction of 53.2 percent. The CO_2 emission rate of RGGI electric generation decreased by 442.1 lb CO_2MWh, a reduction of 28.4 percent. Compared to the 2006 to 2008 annual average, 2017 electric generation from non-RGGI generation located in NYISO increased by 3.8 million MWh, or 4.7 percent, and CO_2 emissions from this category of electric generation decreased by 2.8 million short tons of CO_2, a reduction of 36.1 percent. The CO_2 emission rate of non-RGGI electric generation located in NYISO decreased by 74.1 lb CO_2/MWh, a reduction of 38.9 percent.

Compared to the annual average during the 2006 to 2008 base period, 2017 net electricity imports into NYISO increased by 4.8 million MWh. CO_2 emissions related to these net electricity imports decreased by 4.1 million short tons of CO_2, or 51.7 percent. The CO_2 emission rate of the electric generation supplying these imports decreased by 484.6 lb CO_2/MWh, a reduction of 61.4 percent.

PJM (RGGI Portion)

Monitoring results for PJM for 2005 through 2017 are summarized below in Table 7 and Figures 18 through 22. Note that for PJM, the data presented below is for the RGGI geographic portion of PJM (Delaware and Maryland referred to below as "RGGI PJM"). Net "imports" represent inferred flows of electricity from the non-RGGI geographic portion of PJM (Non-RGGI PJM) to the RGGI geographic portion of PJM (RGGI PJM) to make up for shortfalls in electric generation relative to total electricity load for this subset of PJM.[36]

Table 7. 2005 – 2017 Monitoring Summary for RGGI PJM

MWh	Electricity Demand				Electricity Generation					*Summary Data*
	Total Annual Electricity Load in ISO	Net Imports - from Non-RGGI PJM	Net Imports - from NYISO	Total Net Electricity Imports - from All Adjoining ISOs	Annual Electric Generation - RGGI-Affected Units	Annual Electric Generation - Non-RGGI Fossil Fuel-Fired Units	Annual Electric Generation - Non-Fossil Fuel-Fired Units	Annual Electric Generation - All Non-RGGI Units	Total Annual Electric Generation - All Units	Non-RGGI Generation Serving Load in ISO (Non-RGGI Generation within ISO + Net Imports)
2005	90,177,482	31,878,151	-636,765	31,241,386	41,472,196	393,587	17,070,313	17,463,900	58,936,096	48,705,286
2006	84,096,149	30,716,157	-721,101	29,995,056	37,230,890	267,732	16,602,471	16,870,203	54,101,093	46,865,259
2007	84,442,034	28,944,540	-772,843	28,171,697	39,254,875	298,635	16,716,827	17,015,462	56,270,337	45,187,159
2008	80,387,398	28,386,914	-772,644	27,614,270	35,340,119	150,718	17,282,291	17,433,009	52,773,128	45,047,279
2009	79,481,311	33,089,871	-570,096	32,519,775	29,732,886	147,837	17,080,813	17,228,650	46,961,536	49,748,425
2010	82,485,086	35,142,720	-815,714	34,327,006	31,641,822	129,655	16,386,603	16,516,258	48,158,080	50,843,264
2011	80,738,794	34,250,993	-697,456	33,553,537	28,980,019	216,967	17,988,271	18,205,238	47,185,257	51,758,775
2012	78,802,312	34,442,085	-482,148	33,959,937	28,350,888	190,940	16,300,547	16,491,487	44,842,375	50,451,424
2013	77,458,942	35,843,247	-490,493	35,352,754	24,775,215	81,428	17,249,545	17,330,973	42,106,188	52,683,727
2014	76,359,729	32,656,507	-482,178	32,174,329	26,733,539	71,744	17,380,117	17,451,861	44,185,400	49,626,190
2015	77,903,165	35,680,933	-413,286	35,267,647	24,839,927	57,076	17,738,515	17,795,591	42,635,518	53,063,238
2016	77,822,567	33,910,113	-462,876	33,447,237	26,504,789	51,481	17,819,060	17,870,541	44,375,330	51,317,778
2017	75,384,095	35,770,266	-397,466	35,372,800	21,208,131	28,228	18,774,936	18,803,164	40,011,295	54,175,964

[36] This data is compiled from PJM GATS, which reports data for both the non-RGGI and RGGI geographic portions of PJM. Inferred net imports are based on total MWh load in the RGGI geographic portion of PJM minus total electric generation in the RGGI geographic portion of PJM. Any shortfall in generation relative to load is assumed to be met through an inferred "import" of electricity from the non-RGGI geographic portion of PJM into the RGGI geographic portion of PJM.

CO_2	Electricity Demand				Electricity Generation					*Summary Data*
	Total Annual Electricity Load in ISO	**Net Imports - from Non-RGGI PJM**	**Net Imports - from NYISO**	**Total Net Electricity Imports - from All Adjoining ISOs**	**Annual Electric Generation - RGGI-Affected Units**	**Annual Electric Generation - Non-RGGI Fossil Fuel-Fired Units**	**Annual Electric Generation - Non-Fossil Fuel-Fired Units**	**Annual Electric Generation - All Non-RGGI Units**	**Total Annual Electric Generation - All Units**	**Non-RGGI Generation Serving Load in ISO (Non-RGGI Generation within ISO + Net Imports)**
2005	63,407,937	20,408,108	-469,658	19,938,450	42,345,258	284,222	840,007	1,124,229	43,469,487	21,062,679
2006	58,224,181	19,059,750	-529,065	18,530,684	38,502,576	206,808	984,113	1,190,921	39,693,497	19,721,605
2007	59,369,215	17,766,431	-579,349	17,187,082	40,637,296	221,499	1,323,338	1,544,837	42,182,133	18,731,919
2008	54,585,448	17,172,335	-555,899	16,616,436	36,518,184	152,927	1,297,901	1,450,828	37,969,012	18,067,264
2009	48,909,286	18,682,706	-371,449	18,311,256	29,281,274	147,125	1,169,631	1,316,756	30,598,030	19,628,012
2010	53,575,513	20,361,849	-572,275	19,789,574	32,258,228	129,412	1,398,299	1,527,711	33,785,939	21,317,285
2011	49,662,062	19,504,235	-452,458	19,051,778	28,850,034	171,564	1,588,686	1,760,250	30,610,284	20,812,028
2012	45,342,236	18,627,737	-290,358	18,337,379	25,436,501	212,964	1,355,392	1,568,356	27,004,857	19,905,735
2013	43,873,524	19,867,713	-282,938	19,584,774	22,968,475	101,584	1,218,691	1,320,275	24,288,750	20,905,049
2014	43,832,735	17,971,031	-285,333	17,685,699	24,836,448	82,905	1,227,683	1,310,588	26,147,036	18,996,287
2015	40,731,169	17,989,208	-222,606	17,766,601	21,569,214	60,038	1,335,315	1,395,353	22,964,567	19,161,954
2016	40,573,262	16,699,087	-251,655	16,447,433	22,374,470	52,701	1,698,659	1,751,360	24,125,830	18,198,793
2017	34,169,771	17,052,989	-171,742	16,881,247	15,922,332	26,383	1,339,809	1,366,192	17,288,524	18,247,439

lbs CO_2/ MWh	Electricity Demand				Electricity Generation					*Summary Data*
	Total Annual Electricity Load in ISO	**Net Imports - from Non-RGGI PJM**	**Net Imports - from NYISO**	**Total Net Electricity Imports - from All Adjoining ISOs**	**Annual Electric Generation - RGGI-Affected Units**	**Annual Electric Generation - Non-RGGI Fossil Fuel-Fired Units**	**Annual Electric Generation - Non-Fossil Fuel-Fired Units**	**Annual Electric Generation - All Non-RGGI Units**	**Total Annual Electric Generation - All Units**	**Non-RGGI Generation Serving Load in ISO (Non-RGGI Generation within ISO + Net Imports)**
2005	1,406	1,280	1,475	1,276	2,042	1,444	98	129	1,475	865
2006	1,385	1,241	1,467	1,236	2,068	1,545	119	141	1,467	842
2007	1,406	1,228	1,499	1,220	2,070	1,483	158	182	1,499	829
2008	1,358	1,210	1,439	1,203	2,067	2,029	150	166	1,439	802
2009	1,231	1,129	1,303	1,126	1,970	1,990	137	153	1,303	789

2010	1,299	1,159	1,403	1,153	2,039	1,996	171	185	1,403	839
2011	1,230	1,139	1,297	1,136	1,991	1,581	177	193	1,297	804
2012	1,151	1,082	1,204	1,080	1,794	2,231	166	190	1,204	789
2013	1,133	1,109	1,154	1,108	1,854	2,495	141	152	1,154	794
2014	1,148	1,101	1,184	1,099	1,858	2,311	141	150	1,184	766
2015	1,046	1,008	1,077	1,008	1,737	2,104	151	157	1,077	722
2016	1,043	985	1,087	983	1,688	2,047	191	196	1,087	709
2017	907	953	864	954	1,502	1,869	143	145	864	674

The monitoring results indicate that the annual average electricity load in PJM for 2015 to 2017 decreased by 5.9 million MWh, or 7.2 percent, compared to the annual average for the base period of 2006 to 2008. Annual average electric generation from all sources in PJM decreased by 12.0 million MWh, or 22.1 percent, when comparing the 2006 to 2008 annual average to the 2015 to 2017 annual average.

Annual average electric generation from RGGI generation in PJM decreased by 13.1 million MWh during this period, or 35.1 percent, and annual average CO_2 emissions from RGGI electric generation in PJM decreased by 18.6 million short tons of CO_2, or 48.2 percent. The annual average CO_2 emission rate of RGGI electric generation decreased by 426.3 lb CO_2/MWh, a reduction of 20.6 percent. Annual average electric generation from non-RGGI electric generation sources located in PJM increased by 1.1 million MWh, or 6.1 percent, during this period, and annual average CO_2 emissions from this category of electric generation increased by 108.8 thousand short tons of CO_2, an increase of 7.8 percent. The annual average CO_2 emission rate of non-RGGI electric generation located in PJM increased by 3.0 lb CO_2/MWh, an increase of 1.8 percent.

Compared to the annual average during the 2006 to 2008 base period, 2017 electricity load in RGGI PJM decreased by 7.6 million MWh, or 9.1 percent. Compared to the 2006 to 2008 annual average, 2017 electric generation from all sources in RGGI PJM decreased by 14.4 million MWh, or 26.4 percent.

The annual average electric generation from all non-RGGI electric generation serving load in PJM for 2015 to 2017 increased by 7.2 million MWh, or 15.7 percent, compared to the annual average during the 2006 to 2008 base period. Annual average CO_2 emissions from this category of electric generation decreased by 304.2 thousand short tons of CO_2, a decrease of 1.6 percent, and the annual average CO_2 emission rate decreased by 122.8 lb CO_2/MWh, an decrease of 14.9 percent. (See Figures 21, 22, and 23).

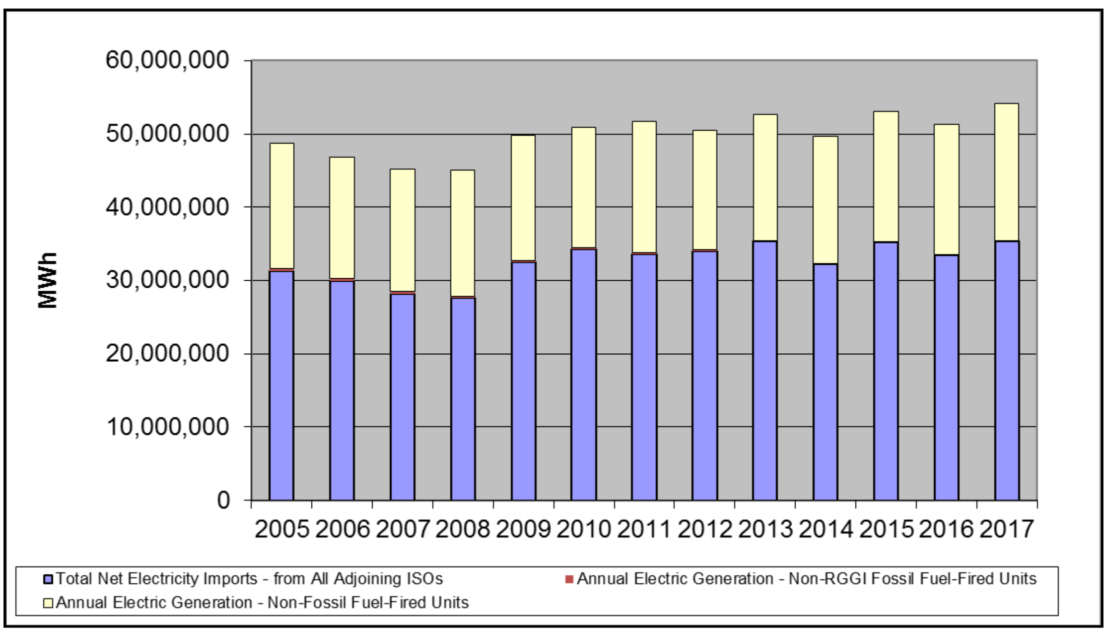

Figure 21. Non-RGGI Generation Serving Load in RGGI PJM (MWh)

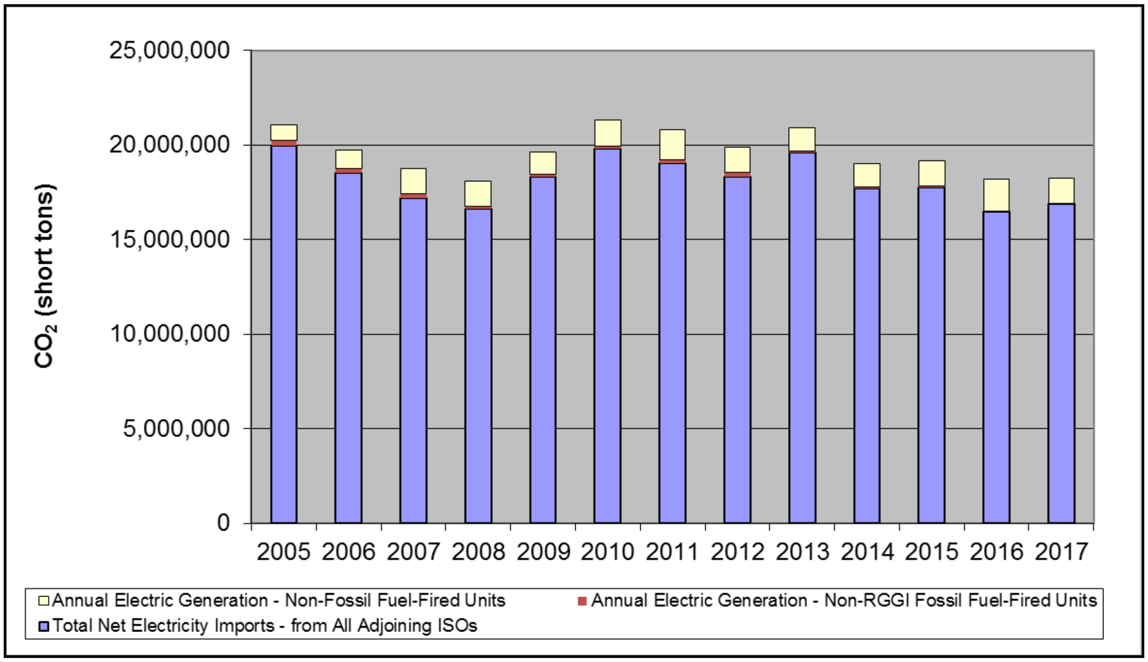

Figure 22. CO_2 Emissions from Non-RGGI Generation Serving Load in RGGI PJM (short tons CO_2)

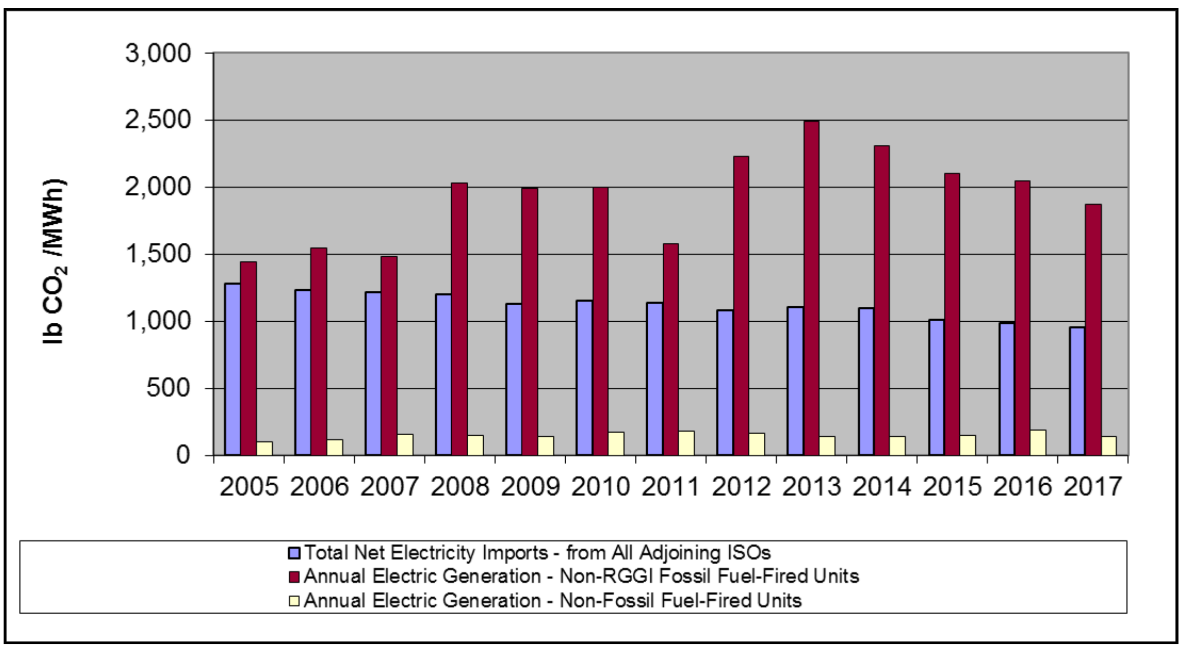

Figure 23. CO_2 Emission Rate for Non-RGGI Generation Serving Load in RGGI PJM (lb CO_2/MWh)

Net electricity imports into PJM increased by 6.1 million MWh, when comparing the annual average during the base period of 2006 to 2008 to the annual average for 2015 to 2017. Annual average CO_2 emissions related to these net electricity imports decreased by 413.0 thousand short tons of CO_2, or 2.4 percent, during this period. The annual average CO_2 emission rate of the electric generation supplying these imports decreased by 237.9 lb CO_2/MWh, a decrease of 19.5 percent. (See Figures 24 and 25).

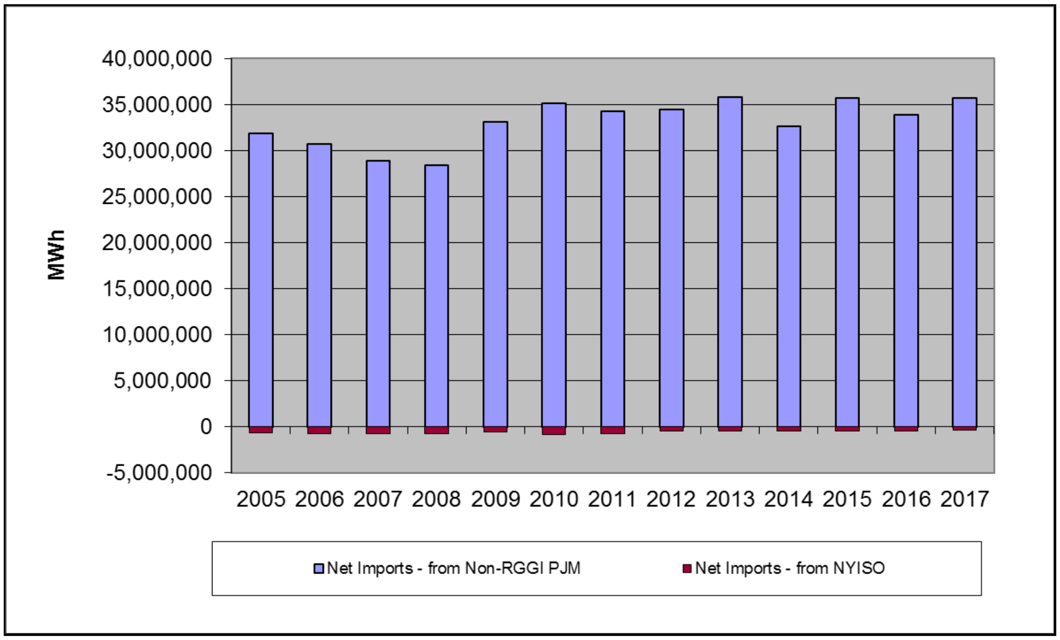

Figure 24. Net Electricity Imports to RGGI PJM (MWh)

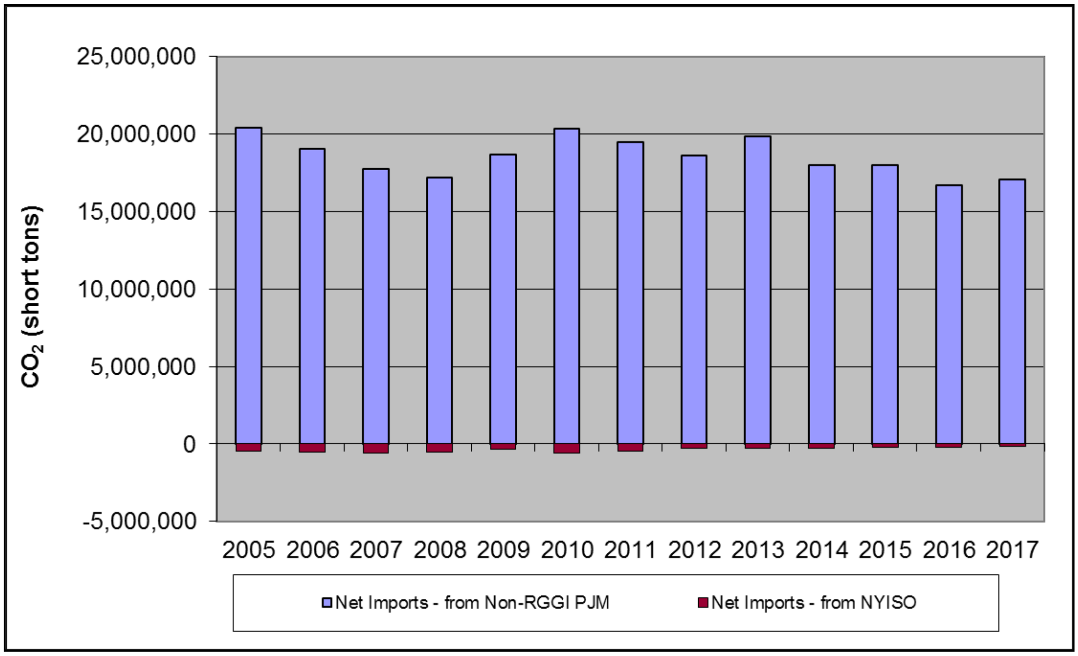

Figure 25. CO_2 Emissions Related to Net Electricity Imports to RGGI PJM (short tons CO_2)

Compared to the annual average during the base period of 2006 to 2008, electric generation in 2017 from all non-RGGI electric generation sources serving load in RGGI PJM increased by 8.5 million MWh, an increase of 18.5 percent. Compared to the 2006 to 2008 annual average, 2017 CO_2 emissions from this category of electric generation decreased by 592.8 thousand short tons of CO_2, a decrease of 3.1 percent, and the CO_2 emission rate decreased by 150.9 lb CO_2/MWh, a reduction of 18.3 percent.

Compared to the annual average during the 2006 to 2008 base period, 2017 electric generation from RGGI generation in RGGI PJM decreased by 16.1 million MWh, or 43.1 percent, and CO_2 emissions from RGGI generation in RGGI PJM decreased by 22.6 million short tons of CO_2, or 58.7 percent. The CO_2 emission rate of RGGI electric generation decreased by 566.9 lb CO_2/MWh, a reduction of 27.4 percent. Compared to the 2006 to 2008 annual average, 2017 electric generation from non-RGGI generation located in RGGI PJM increased by 1.7 million MWh, or 9.9 percent, and CO_2 emissions from this category of electric generation decreased by 29.3 thousand short tons of CO_2 a reduction of 2.1 percent. The CO_2 emission rate of non-RGGI electric generation located in RGGI PJM decreased by 17.8 lb CO_2/MWh, a decrease of 10.9 percent.

Compared to the annual average during the 2006 to 2008 base period, 2017 net electricity imports into RGGI PJM increased by 6.8 million MWh. CO_2 emissions related to these net electricity imports decreased by 563.5 thousand short tons of CO_2, or 3.2 percent, during this period, indicating a reduction in the average CO_2 emission rate of the electric generation supplying these imports of 265.3 lb CO_2/MWh, a reduction of 21.7 percent.

Appendix C. Monitoring Trends

Detailed monitoring trends for the Nine-State RGGI Region, ISO-NE, NYISO, and the RGGI portion of PJM are presented in Tables 8 through 11. The tables summarize the comparison between the 2006 to 2008 base period and the three years of program operation, 2015 to 2017.

Nine-State RGGI Region

Table 8. Monitoring Trends for Nine-State RGGI Region

	Non-RGGI Generation (In-Region)			RGGI Generation			Net Imports		
	MWh	CO_2 Emissions	lb CO_2/MWh	MWh	CO_2 Emissions	lb CO_2/MWh	MWh	CO_2 Emissions	lb CO_2/MWh
Annual average for 2006-2008 (base period)	158,231,279	20,137,889	254	172,296,470	138,362,771	1,605	55,997,235	25,224,000	904
Annual average for 2015-2017	156,820,464	20,332,887	259	132,475,948	75,510,945	1,138	78,149,759	22,940,043	588
Difference from base period	-1,410,815	194,997	5	-39,820,522	-62,851,826	-468	22,152,525	-2,283,957	-317
% change from base period	-0.9%	1.0%	2.0%	-23.1%	-45.4%	-29.1%	39.6%	-9.1%	-35.0%
2017	163,497,757	20,780,632	254	117,676,806	64,491,131	1,096	80,637,398	22,455,673	557
Difference from base period	5,266,478	642,743	0	-54,619,664	-73,871,640	-509	24,640,163	-2,768,327	-348
% change from base period	3.3%	3.2%	-0.1%	-31.7%	-53.4%	-31.7%	44.0%	-11.0%	-38.4%

	Non-RGGI Generation (In-Region + Net Imports)			In-Region Generation	In-Region Load
	MWh	CO_2 Emissions	lb CO_2/MWh	MWh	MWh
Annual average for 2006-2008 (base period)	214,228,514	45,361,889	423	330,527,749	386,423,646
Annual average for 2015-2017	234,970,224	43,272,930	369	289,296,412	360,506,506
Difference from base period	20,741,710	-2,088,959	-55	-41,231,337	-25,917,141
% change from base period	9.7%	-4.6%	-13.0%	-12.5%	-6.7%
2017	244,135,154	43,236,305	354	281,174,563	352,974,095
Difference from base period	29,906,641	-2,125,584	-69	-49,353,186	-33,449,551
% change from base period	14.0%	-4.7%	-16.4%	-14.9%	-8.7%

ISO-NE

Table 9. Monitoring Trends for ISO-NE

	Non-RGGI Generation (In-Region)			RGGI Generation			Net Imports		
	MWh	CO_2 Emissions	lb CO_2/MWh	MWh	CO_2 Emissions	lb CO_2/MWh	MWh	CO_2 Emissions	lb CO_2/MWh
Annual average for 2006-2008 (base period)	60,527,897	11,046,433	365	67,414,107	47,242,267	1,401	7,196,667	-138,167	-48
Annual average for 2015-2017	56,758,355	14,006,720	494	54,317,859	26,428,969	973	19,912,870	2,147,997	216
Difference from base period	-3,769,542	2,960,288	129	-13,096,249	-20,813,298	-429	12,716,204	2,286,164	265
% change from base period	-6.2%	26.8%	35.4%	-19.4%	-44.1%	-30.6%	176.7%	[37]	[38]
2017	60,321,901	14,496,203	481	49,456,967	23,990,894	970	20,278,998	1,911,777	189
Difference from base period	-205,996	3,449,770	116	-17,957,140	-23,251,372	-431	13,082,331	2,049,945	237
% change from base period	-0.3%	31.2%	31.8%	-26.6%	-49.2%	-30.8%	181.8%	[39]	[40]

	Non-RGGI Generation (In-Region + Net Imports)			In-Region Generation	In-Region Load
	MWh	CO_2 Emissions	lb CO_2/MWh	MWh	MWh
Annual average for 2006-2008 (base period)	67,724,564	10,908,266	322	127,942,004	135,037,333
Annual average for 2015-2017	76,671,226	16,154,717	422	111,076,214	124,197,000
Difference from base period	8,946,662	5,246,452	100	-16,865,790	-10,840,333
% change from base period	13.2%	48.1%	30.9%	-13.2%	-8.0%
2017	80,600,898	16,407,980	407	109,778,868	121,220,000
Difference from base period	12,876,335	5,499,715	85	-18,163,136	-13,817,333
% change from base period	19.0%	50.4%	26.4%	-14.2%	-10.2%

[37] ISONE changed from a net exporter to a net importer from NY in 2013. This percent change was not reconciled.
[38] See footnote 36
[39] See footnote 36
[40] See footnote 36[41] The nine-state RGGI region does not completely align with the geographic footprint of wholesale electricity markets in the greater Northeast and Mid-Atlantic region, and electric power can flow across multiple wholesale markets in North America.

NYISO

Table 10. Monitoring Trends for NYISO

	Non-RGGI Generation (In-Region)			RGGI Generation			Net Imports		
	MWh	CO_2 Emissions	lb CO2/MWh	MWh	CO_2 Emissions	lb CO2/MWh	MWh	CO_2 Emissions	lb CO2/MWh
Annual average for 2006-2008 (base period)	80,597,157	7,695,928	191	67,607,068	52,567,819	1,554	20,206,894	7,885,769	790
Annual average for 2015-2017	81,905,677	4,821,865	118	53,973,807	29,256,148	1,137	23,540,994	3,812,309	324
Difference from base period	1,308,520	-2,874,063	-73	-13,633,261	-23,311,671	-417	3,334,101	-4,073,460	-465
% change from base period	1.6%	-37.3%	-38.2%	-20.2%	-44.3%	-26.8%	23,540,994	3,812,309	324
2017	84,372,692	4,918,237	117	47,011,708	24,577,905	1,112	24,985,600	3,809,665	305
Difference from base period	3,775,535	-2,777,690	-74	-20,595,360	-27,989,914	-442	4,778,706	-4,076,104	-485
% change from base period	4.7%	-36.1%	-38.9%	-30.5%	-53.2%	-28.4%	23.6%	-51.7%	-61.4%

	Non-RGGI Generation (In-Region + Net Imports)			In-Region Generation	In-Region Load
	MWh	CO_2 Emissions	lb CO_2/MWh	MWh	MWh
Annual average for 2006-2008 (base period)	100,804,051	15,581,697	309	148,204,225	168,411,119
Annual average for 2015-2017	105,446,671	8,634,174	164	135,879,484	159,272,896
Difference from base period	4,642,620	-6,947,523	-145	-12,324,742	-9,138,223
% change from base period	4.6%	-44.6%	-47.0%	-8.3%	-5.4%
2017	109,358,292	8,727,902	160	131,384,400	156,370,000
Difference from base period	8,554,241	-6,853,795	-150	-16,819,825	-12,041,119
% change from base period	8.5%	-44.0%	-48.4%	-11.3%	-7.1%

RGGI-PJM

Table 11. Monitoring Trends for RGGI-PJM

	Non-RGGI Generation (In-Region)			RGGI Generation			Net Imports		
	MWh	CO_2 Emissions	lb CO2/MWh	MWh	CO_2 Emissions	lb CO2/MWh	MWh	CO_2 Emissions	lb CO2/MWh
Annual average for 2006-2008 (base period)	17,106,225	1,395,529	163	37,275,295	38,552,685	2,068	28,593,674	17,444,734	1,220
Annual average for 2015-2017	18,156,432	1,504,302	166	24,184,282	19,955,339	1,642	34,695,895	17,031,760	982
Difference from base period	1,050,207	108,773	3	-13,091,012	-18,597,347	-426	6,102,220	-412,974	-238
% change from base period	6.1%	7.8%	1.8%	-35.1%	-48.2%	-20.6%	21.3%	-2.4%	-19.5%
2017	18,803,164	1,366,192	145	21,208,131	15,922,332	1,502	35,372,800	16,881,247	954
Difference from base period	1,696,939	-29,337	-18	-16,067,164	-22,630,354	-567	6,779,125	-563,487	-265
% change from base period	9.9%	-2.1%	-10.9%	-43.1%	-58.7%	-27.4%	23.7%	-3.2%	-21.7%

	Non-RGGI Generation (In-Region + Net Imports)			In-Region Generation	In-Region Load
	MWh	CO_2 Emissions	lb CO_2/MWh	MWh	MWh
Annual average for 2006-2008 (base period)	45,699,899	18,840,263	825	54,381,519	82,975,194
Annual average for 2015-2017	52,852,327	18,536,062	702	42,340,714	77,036,609
Difference from base period	7,152,428	-304,201	-123	-12,040,805	-5,938,585
% change from base period	16%	-1.6%	-14.9%	-22.1%	-7.2%
2017	54,175,964	18,247,439	674	40,011,295	75,384,095
Difference from base period	8,476,065	-592,823	-150.9	-14,370,224	-7,591,099
% change from base period	19%	-3.1%	-18.3%	-26.4%	-9.1%

Appendix D. Concept of "Emissions Leakage"

"Emissions leakage" is the concept that the RGGI CO_2 compliance obligation and related CO_2 compliance costs for electric generators could result in a shift of electricity generation from CO_2-emitting sources subject to the RGGI CO_2 Budget Trading Program to CO_2-emitting sources not subject to RGGI. Key to this concept is that the cause of such a shift would be due to the RGGI CO_2 Budget Trading Program, rather than other factors that influence electric power sector CO_2 emissions. The concept of emissions leakage presumes that an increase in electricity production costs for certain electric generators due to RGGI CO_2 compliance costs would be the driver of changes in the operation of the electric power system that result in an increase in CO_2 emissions from electric generation that is not subject to the RGGI CO_2 Budget Trading Program.

Factors that Influence Electric Generator Dispatch and CO_2 Emissions

In the Northeast and Mid-Atlantic, electric generation is deregulated and subject to competitive wholesale electricity markets. In the simplest terms, wholesale electricity markets are used to determine which power plants run to meet electricity demand and determine the wholesale price of electricity. Electric generators bid into day-ahead and real-time auctions for generation supply, in which the lowest priced plants are selected one by one until electricity demand is met. The last plant selected, or "dispatched," to meet demand is referred to as the marginal unit, and sets the wholesale clearing price. A number of elements factor in to the bid offers made by individual electric generators, including fuel prices, operation and maintenance costs, and environmental compliance costs. For this latter category, certain environmental compliance costs are represented by the market value of emissions allowances, such as CO_2, NO_X, and SO_2 allowances. The market value of these emission allowances influences the production costs of individual electric generators in a similar manner as fuel costs, and therefore play a role in influencing the dispatch of electric generators and the wholesale market clearing price of electricity.

In addition to the production costs of electric generators, such as natural gas supply and costs which can be influenced by pipeline constraints, the dispatch of electric generators and wholesale electricity prices are also influenced by electricity demand and electricity transmission constraints. Since electricity cannot be stored, it must be delivered instantaneously to where it is needed. In locations where electric demand is high, transmission capability may be constrained, meaning that electric generation has different values in different areas – because the lowest cost electric generation cannot always be delivered to where it is needed based on transmission limitations. As a result, wholesale electricity prices also differ by location, a concept referred to as locational marginal pricing.

All of the above, including production costs, market factors, and physical limitations, impact the dispatch of electric generation, and related CO_2 emissions, through a highly dynamic wholesale electricity market.

The concept of emissions leakage assumes a scenario in which only a subset of CO_2-emitting electric generators are subject to a CO_2 allowance requirement.[41] As a result, certain electric generators are subject to an additional production cost – the cost of CO_2 allowances – that is not faced by other CO_2-emitting electric generators. In theory, this could result in a shift in electric generation to emitting units that do not face a

[41] The nine-state RGGI region does not completely align with the geographic footprint of wholesale electricity markets in the greater Northeast and Mid-Atlantic region, and electric power can flow across multiple wholesale markets in North America.

CO_2 compliance cost. If such a shift results in an increase in CO_2 emissions from electric generation as a whole, such an increase is referred to as emissions leakage.

If emissions leakage were to occur, it would result from an increase in dispatch (and related CO_2 emissions) from: (a) in-region non-RGGI units (i.e., small fossil fuel-fired units in the nine-state RGGI region with a capacity less than 25 MWe, which are not subject to RGGI); (b) electric generation outside the nine-state RGGI region (represented as electricity imports); or (c) a combination of the two, both of which are referred to in this report as “non-RGGI generation”.