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ECONOMIC, FINANCIAL and STRATEGY CONSULTANTS

THE ECONOMIC IMPACTS OF THE REGIONAL GREENHOUSE GAS INITIATIVE ON NINE NORTHEAST AND MID-ATLANTIC STATES

Review of RGGI's Third Three-Year Compliance Period (2015-2017)

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THE RGGI PROJECT SERIES

Acknowledgments

This is an independent report on the economic impacts of RGGI program implementation, primarily covering the third three-year period of the program (2015-2017), which is known as Compliance Period 3. This Report complements two previous studies completed by Analysis Group in November 2011 and July 2015 on RGGI's Compliance Periods 1 and 2 (2009-2011 and 2012-2014, respectively). The analytic method and structure of this Report follow closely upon those used in the prior reports in order to ensure methodological consistency and provide continuity in focus, content and the consideration of lessons learned. Where relevant in this Report, we include data, information and observations particular to the 2015-2017 period, and elsewhere summarize developments and outcomes in all three Compliance Periods, covering all nine years of RGGI (2009-2017).

This Report is part of the RGGI Project Series: a series of independent and nonpartisan research and analysis projects to inform and assist leaders and stakeholders in the Northeast and other states.

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About Analysis Group

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1. EXECUTIVE SUMMARY

Overview and Context

In 2009, ten Northeastern and Mid-Atlantic states launched the Regional Greenhouse Gas Initiative ("RGGI"), the country's first market-based program to reduce emissions of carbon dioxide ("CO_2") from existing and new power plants.[1] The scope of RGGI is significant: the current set of RGGI states account for more than one-eighth of the population in the U.S. and more than one-seventh of the nation's gross domestic product. It is thus important to evaluate and understand the program's performance and outcomes. Through their development and implementation of the RGGI program, these states have gained first-mover policy experience and have collaborated to form a multi-state emission-control policy that has reduced CO_2 emissions from the power sector and operated seamlessly with well-functioning and reliable electricity markets.

Recently, other states have expressed interest in implementing carbon-control programs that are similar in structure to RGGI's approach. One option for those states would be for active collaboration to allow for trading of CO_2 allowances among affected sources in these states and the current RGGI states.[2] Insights and observations gleaned from an analysis of RGGI's performance could thus be valuable not only to the RGGI states as they consider future policy recommendations but also to other states and regions as they develop their own plans to reduce CO_2 emissions.

This Report analyzes the economic impacts of RGGI's most recent three-year compliance period, which spanned 2015 through 2017. This analysis follows our two prior reports on the economic impacts of RGGI: the 2011 Report (hereafter "AG 2011 Report") which assessed the economic impacts of RGGI's first three-year compliance period (2009-2011), and the 2015 Report (hereafter "AG 2015 Report") which assessed the economic impacts of RGGI's second three-year compliance period (2012-2014).[3]

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[1] The ten original RGGI states were Connecticut, Delaware, Massachusetts, Maryland, Maine, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. New Jersey participated in the first three years of the RGGI program, and withdrew its participation at the end of 2011.

[2] See, *e.g.*, the recent statement by Ben Grumbles, Secretary of the Maryland Department of the Environment and Chair of the RGGI, Inc. Board of Directors, regarding RGGI's interest in sharing information "…with any state that is interested, and especially look forward to further discussions with Virginia and New Jersey." (See https://rggi.org/sites/default/files/Uploads/Auction-Materials/39/PR031618_Auction39.pdf)

[3] Paul J. Hibbard, Susan F. Tierney, Andrea M. Okie, and Pavel G. Darling, *The Economic Impacts of the Regional Greenhouse Gas Initiative on Ten Northeast and Mid-Atlantic States*, November 2011 (available at http://www.analysisgroup.com/uploadedfiles/content/insights/publishing/economic_impact_rggi_report.pdf); and, Paul J. Hibbard, Andrea M. Okie, Susan F. Tierney, and Pavel G. Darling, *The Economic Impacts of the Regional Greenhouse Gas Initiative on Nine Northeast and Mid-Atlantic States*, July 2015 (available at http://www.analysisgroup.com/uploadedfiles/content/insights/publishing/analysis_group_rggi_report_july_2015.pdf). The analytic method and structure of this Report were modeled closely on those of the prior reports, and in this report we carry forward observations from RGGI's first six years (to the extent still relevant), so as to support methodological consistency and continuity in focus, content and the consideration of lessons learned.

There have been a number of relevant developments since our last economic review of RGGI in 2015. The electric industry has experienced changes in power-generation economics, emission-control requirements, and wholesale market structures in the RGGI region. In addition, absent federal requirements, a number of states continue to seek to address greenhouse-gas ("GHG") emissions through an assortment of policy mechanisms. Finally, the RGGI states have undertaken a second comprehensive Program Review, completed in December 2017, which led to modified elements of the program including adopting a 30-percent reduction in the regional cap between 2020 and 2030.

In this Report, we examine RGGI's recent economic performance under these changing economic and regulatory realities. We hope that the results of our assessment and lessons learned are useful not only to the RGGI states but also to others that have expressed interest in establishing carbon control programs (including with the possibility of linking to or participating in the RGGI program).[4]

RGGI has now been operating for over nine years. In every year, CO_2 emission allowances have entered the market through coordinated (centralized) regional auctions. Owners of fossil-fueled power plants have spent nearly $2.8 billion to buy CO_2 allowances over the nine years. In turn, offer prices in the regional wholesale electricity markets reflect these purchases, and grid operators in these regions use these offer prices to dispatch power plants economically while maintaining system reliability.

Since 2009, the RGGI states have received virtually all of the nearly $2.8 billion in proceeds from CO_2-allowance auctions and disbursed them back into the economy in various ways, including through expenditures on: energy efficiency ("EE") measures and programs; renewable energy ("RE") projects; GHG-emission reduction measures; direct electricity consumer bill assistance, including for low-income households; and education and job training programs. These local investments keep more of the RGGI states' energy dollars in their region, and reduce the amount of dollars that leave the region to pay for fossil fuel resources produced outside the RGGI states.

What We Study in this Report:
The Economic Impacts of RGGI (2015-2017)

Our analysis tracks the path of RGGI-related dollars over the past three years as they leave the pockets of fossil-fuel power generators to buy CO_2 allowances, show up in electricity prices and customer bills, make their way into state expenditure accounts, and then roll out into the economy through the expenditure of the allowance auction proceeds.

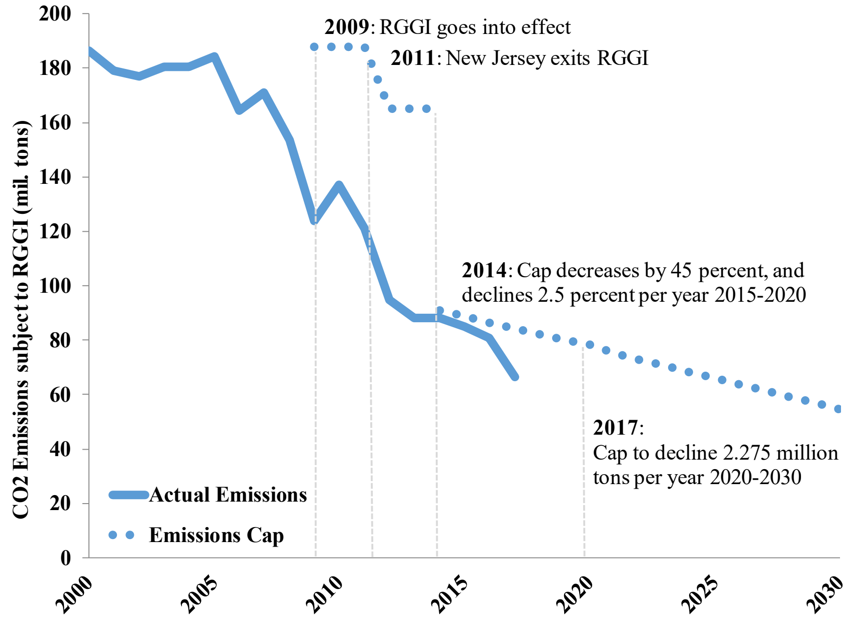
Our analysis thus focuses on the actual economic activity that results from RGGI: known CO_2 allowance prices; observable CO_2 auction results; dollars distributed from the auction to the states; actual state-government decisions about how to spend the allowance proceeds; measurable reductions in energy use from energy-efficiency programs funded by RGGI dollars; traceable impacts of lower energy use on wholesale power prices; and concrete value added to the economy.

By carefully examining the RGGI states' implementation of the program to date, based on real historic data, we hope to provide a foundation for observations that can be used by others in the design of CO_2 control programs going forward.

[4] See, *e.g.*, RGGI Inc., Statement on Proposed Virginia Greenhouse Gas Rule, November 9, 2017.

Throughout the RGGI program's implementation, power system reliability has been maintained. And as shown in Figure ES-1, CO_2 emissions from power generation have decreased in the RGGI region (due to RGGI program design and implementation but also broader economic and industry factors).[5]

Figure ES-1
Actual CO_2 Emissions in the RGGI States and Evolution of the RGGI CO_2 Emissions Cap



Source: RGGI, Inc. data from the RGGI CO_2 Allowance Tracking System (COATS), accessed March 2, 2018.

With these many insights, we address several questions in this Report: What happened to the roughly $1 billion in proceeds from the sale of CO_2 allowances over the 2015-2017 period? Has the RGGI program produced net economic benefits to these states in Compliance Period 3 (as it did in the first two compliance periods)? Are there new learnings from the outcomes of the RGGI program to date beyond those identified and described in our prior reports?

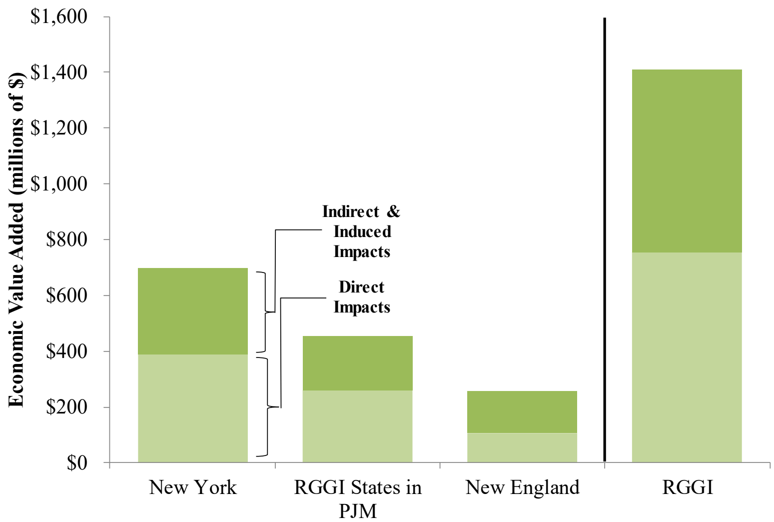
Finally, in this Report we consider the implications of our analysis for continued implementation in the RGGI states, and for states considering development of their own carbon reduction programs and/or coordination with a broader CO_2 trading region.

[5] RGGI, Inc. data show that CO_2 emissions from RGGI electric generation sources decreased by 75.8 million short tons, or *53.3 percent* compared to the average baseline emissions between 2006 and 2008. Note that these figures exclude New Jersey, which was a RGGI member during the first compliance period. Data available at https://www.rggi.org/allowance-tracking/rggi-coats, accessed April 4, 2018.

Results

Over the last three years (2015-2017), the RGGI program led to $1.4 billion (net present value ("NPV")) of net positive economic activity in the nine-state region.[6] Each RGGI state's electricity consumers and local economy also experienced net benefits from the RGGI program. When spread across the region's population, these economic impacts amount to nearly $34 in net positive value added per capita. Figure ES-2 shows the net economic value to the nine-state RGGI region as a whole, with results also broken out by power system region (with the six New England states participating in the ISO-New England electrical region, with New York participating in the one-state NYISO system, and with Maryland and Delaware participating in the multi-state PJM power system).

Figure ES-2
Net Economic Impact of the Implementation of RGGI During the 2015-2017 Period (NPV, 2018$)



Notes: [1] Figures are reported in 2018 dollars (NPV), converted using a 3-percent public discount rate. [2] Total economic value added reflects the impacts of state spending of RGGI proceeds, including net electric sector impacts to consumers and power plant owners, non-electric benefits, and the economic impact of program spending.

RGGI's net positive economic outcome results in large part from the states' decisions to sell CO_2 allowances via a centralized auction and then to use the auction proceeds in various ways that address state policy objectives. This approach has been in place in all three RGGI compliance periods. As in the prior years, during the 2015-2017 period the states received and spent the roughly $1.0 billion in auction proceeds primarily on EE measures, community-based RE projects, customer bill assistance, other GHG-emission reduction measures, and on research, education and job training programs.

[6] All results for Compliance Period 3 are reported in 2018 dollars, with results reported using a 3-percent "public" discount rate. See the Appendices for a discussion of public and private discount rates.

These economic benefits reflect the complex ways that RGGI dollars interact within local economies.

Compared to energy-related dollar flows that would occur in the absence of the RGGI program, energy-related expenditures with RGGI lead to more purchases of goods and services in the RGGI states' local economies. Take the use of the auction proceeds on EE measures, for example: Such expenditures include payments for engineering services for energy audits, sales of energy-efficient equipment, dollars spent to train those installers, and state taxes collected on all of these activities. Together, these dollar flows have direct and indirect multiplier effects locally and regionally.

The size of RGGI's economic impacts varies by state and region, in large part because the states spent their RGGI auction proceeds differently.[7] Different expenditures have different direct and indirect effects on their economies and on their electric systems. For example, a state's use of RGGI dollars to pay for EE measures that reduce electricity consumption and to invest in RE facilities with low operating costs both served to lower electricity prices in wholesale power markets (as compared to a "without-RGGI" scenario). This in turn lowers consumers' electricity bills over time.

Local investment of RGGI dollars on energy efficiency and renewable energy offset the impact on electricity prices resulting from CO_2 allowance costs.

On the one hand, the inclusion of the cost of CO_2 allowances in wholesale prices tends to increase wholesale electricity prices in the RGGI region at the beginning of the 2015-2017 period. But these near-term impacts are more than offset during these years and beyond, because the states invest a substantial amount of the RGGI auction proceeds on EE programs that reduce overall electricity consumption and on RE projects that reduce the use of higher-priced power plants. Consumers gain because their overall electricity bills go down. Since RGGI's commencement in 2009, energy and dollar savings resulting from all states' investments in EE and RE has more than offset the wholesale market price increases associated with inclusion of allowance costs in market bids.

Energy consumers enjoy a net gain of $220 million as a result of the RGGI program (2015-2017), as their overall energy bills drop over time.

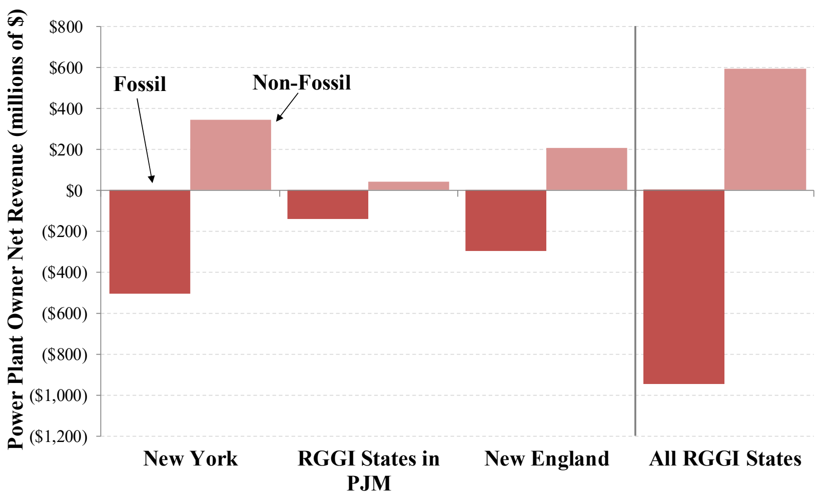
Net benefits accrue to residential, commercial and industrial customers. Consumers of electricity save $99 million, and consumers of natural gas and heating oil save $121 million. These amounts are in addition to the economic benefits they receive as members of the local economies of the RGGI states where the allowance auction proceeds are spent.

[7] Overall, the distribution of spending across the RGGI states was as follows: 52% on EE; 18% on RE projects; 13% on bill-payment assistance to consumers; 7% on program administration; 4% on GHG-emission reduction programs; 3% on clean technology research and development; 2% on education, outreach, and job training; and 1% for payments into a general fund. Individual state expenditures varied significantly across these categories.

Power system changes that result from RGGI include: different dispatch order of power plants; plants with lower CO_2 emissions having a competitive advantage; and owners of emitting power plants recovering the costs of CO_2 allowances in the short run while experiencing lower output and revenues in the long run.

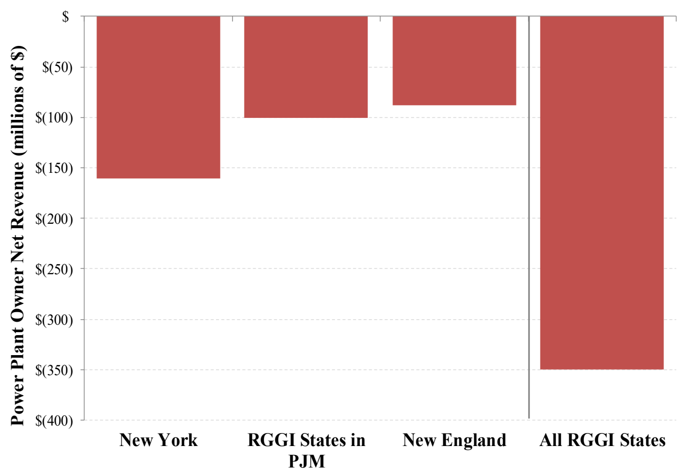
Including a price on CO_2 emissions tends to shift the power plant dispatch order and increase output of lower- and zero-carbon-emitting sources of power. Although RGGI requires owners of emitting power plants to purchase CO_2 allowances, power plant owners as a group recover all of their early expenditures on CO_2 allowances through the increase in wholesale electricity prices in the near term. But the net effect of the program tends to reduce the revenues of owners of plants over time as a result of RGGI expenditures on EE, which lower the demand for power. Plants with relatively high carbon emissions (*e.g.*, coal-fired or oil-fired units) collect less revenues over time while owners of zero-carbon generating sources (*e.g.*, nuclear, wind, solar, hydro) get the benefit of being paid higher wholesale market prices that reflect CO_2 allowance costs, without having to buy allowances. Figure ES-3 shows the changes in net revenues for power plant owners as a result of the RGGI program, with results broken out by location and by power-plant fuel type. Carbon-emitting power plant owners generally lose revenue ($940 million), while owners of nuclear and renewable resources gain ($590 million). On an NPV basis, total revenues to the power-generation sector drop by nearly $350 million through our forecast period (ending in 2027), as shown in Figure ES-4.

Figure ES-3
Net Revenue Change to Power Plant Owners (by Power-Plant Fuel Type and Electrical Region) as a Result of RGGI Implementation During the 2015-2017 Period (NPV, 2018$)



Notes: [1] Figures are reported in 2018 dollars (NPV), using a 3-percent public discount rate. [2] Figures include PROMOD outputs for energy prices and revenues and for capacity-market revenue changes that are calculated separately. [3] “Fossil” includes natural gas, oil, and coal-fired generators. “Non-fossil” includes nuclear, hydro, pumped storage, wind, solar, and biomass.

Figure ES-4
Net Revenue Change Across All Power Plant Owners, by Region, as a Result of RGGI Implementation During the 2015-2017 Period (NPV, 2018$)

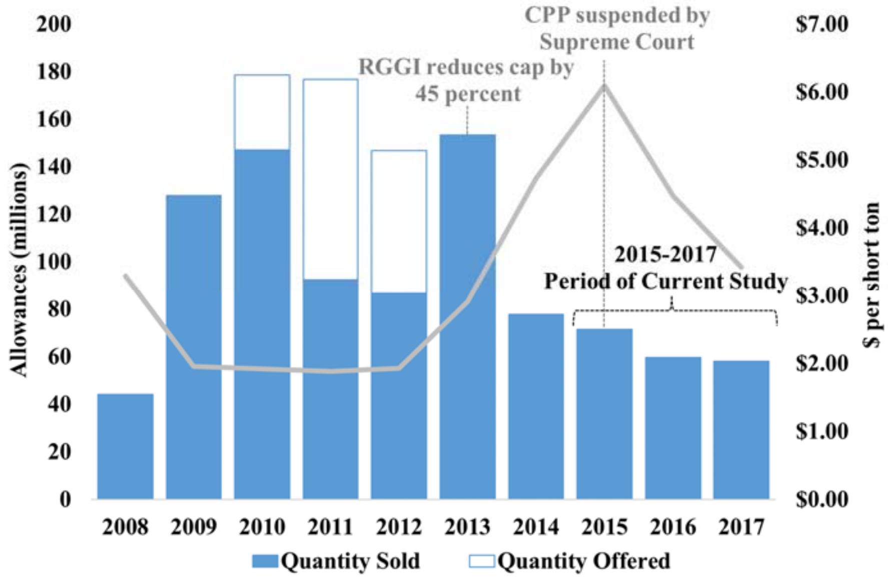


Notes: [1] Figures are reported in 2018 dollars (NPV), using a 3-percent public discount rate. [2] Figures include PROMOD outputs for energy prices and revenues and for capacity market revenue changes calculated separately.

Compared to RGGI's earlier two compliance periods (2009-2011 and 2012-2014), the amount of CO_2 allowances sold dropped in recent years, while clearing prices were on average higher, which had a mostly offsetting effect on the relative magnitudes of economic effects experienced in Compliance Period 3.

The RGGI states lowered the regional CO_2 emissions cap by 45 percent in 2014 and further tightened it by 2.5 percent per year thereafter, during the current study period (see Figure ES-1). The current compliance period was the first that involved a significantly tightened and declining cap (see Figure ES-1). This tightening supply of CO_2 allowances, in combination with other market and policy factors, initially elevated the price of allowances and, in turn, the wholesale power prices in the different parts of the RGGI region. Total auction proceeds in Compliance Period 3 ended up being only slightly lower than in each of the prior two periods (by less than ten percent), reflecting the offsetting impact of higher allowance prices and lower allowance volumes sold (as shown in Figure ES-5).

Figure ES-5
RGGI Auction Allowances and Clearing Prices



Notes:
[1] Clearing prices are weighted averages, based on number of allowances sold.
[2] In 2014 and 2015, the Cost Containment Reserve ("CCR") trigger price was exceeded and additional allowances above what were originally offered into the market were ultimately presented and sold to market participants. In 2014 and 2015, 5 million and 10 million additional allowances were sold, respectively.
Source: RGGI, Inc., http://www.rggi.org/market/co2_auctions/results.

Observations

Based on these results as well as those in our prior assessments of the first two RGGI compliance periods, we have a number of observations that we summarize here. We hope that these provide useful information for the RGGI states as they consider how the program is performing relative to its original goals and for other states and stakeholders who are interested in carbon emission-control policies and programs.

As in its first six years, the RGGI program's third three-year compliance period continued to generate substantial economic benefits for the states while reducing CO_2 emissions.

Economic value added

Our analysis of RGGI impacts over the past three years took into consideration the program's effects on power system dispatch, costs to consumers, revenues to electric generators, and overall performance of the economies in the participating states. Even taking into account decreased revenues to the owners of emitting power plants (and to power-plant owners as a whole), we found positive macroeconomic impacts to the states due to the net benefits to electric consumers and the expenditures of the CO_2 allowance proceeds. RGGI led to approximately $1.4 billion in economic value added (NPV, 2018$) as a result of program implementation in the 2015-2017 period. Thus, the RGGI program continues to generate economic value for its member states.

Jobs

Taking into account the gains and losses to consumers and producers, RGGI Compliance Period 3 led to overall job increases amounting to thousands of new jobs over time. Some of the RGGI job impacts may be permanent, while others may be part-time or temporary. According to our analysis, the net effect is that RGGI activity during the 2015-2017 period leads to over 14,500 new job-years, cumulative over the study period, with each of the nine states experiencing net job-year additions. Jobs that result from RGGI-related expenditures occur in many parts of the economy, with examples including workers who perform efficiency audits and who install energy efficiency measures in residences and commercial buildings, and staff performing training on energy issues.

Fossil-fuel production and imports

Over the past three years, RGGI helped to lower the total number of dollars (by $1.37 billion (NPV, 2018$)) its member states sent outside their region in the form of payments for fossil fuels for power generation and other purposes. Most of the RGGI states' electricity comes from fossil fuels, even though these states produce little coal, natural gas, or oil. Because the RGGI program lowered these nine states' total fossil-fired power production and also reduced their use of natural gas and oil for heating, RGGI reduced the total dollars sent out of state for these energy resources.

Continuation of RGGI program benefits above and beyond the first six years

Our findings on economic impacts of RGGI's third three-year compliance period are consistent with the findings and observations we made with respect to the first and second three-year compliance periods. Those prior assessments revealed net economic benefits to the states participating in the program, including growth in economic output, increased jobs, reinvestment of energy dollars in local/state economic activity, long-run wholesale electricity cost reductions, and CO_2 emission reductions.

Many factors have changed in the electric industry and the economy since we completed our economic analyses of the RGGI program for Compliance Period 1 (2009-2011) and for Compliance Period 2 (2012-2014). These changes have affected the conditions (*e.g.*, lower gas prices, generation retirements and additions) analyzed in our assessment of Compliance Period 3.

For many reasons (such as the different vintages of each of our studies and notably the year in which we report NPV results), the results of our three studies are not directly additive. Even so, across the three studies, we have found net economic benefits to the RGGI states. Recognizing that these studies have reported outcomes in different-year dollar values, each of our assessments has found positive benefits for the participating RGGI states: $1.6 billion (NPV, in 2011$), $1.3 billion (NPV, in 2015$), and $1.4 billion (NPV, in 2018$) for Compliance Periods 1, 2, and 3 respectively.[8] Our studies have also found that the RGGI-related expenditures led to job creation in each of the three

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[8] In addition to our prior studies of the RGGI program, RGGI, Inc. and others have conducted studies of the economic impacts of the program. We discuss the differences in these studies later on in this report.

compliance periods of approximately: 16,000 job-years (as of 2011); 14,200 job-years (as of 2015); and 14,500 (as of 2018), respectively.[9]

Thus our modeling of the three compliance periods indicates that, its first decade, RGGI's carbon cap-and-trade program has generated net positive economic value for the participating states' economies on the order of $4 billion dollars.[10] States' participation in RGGI has led to tens of thousands of job-years while also helping to reduce carbon emissions in the RGGI states' electric sector. At the same time, annual carbon-emissions have dropped nearly 50 percent since the program's start in 2009 (for many reasons, including implementation of RGGI).

RGGI's first nine years (2009-2017) provide empirical evidence that carbon-control programs for the power sector can provide positive economic outcomes.

Review of the nation's first multi-state CO_2 emission-control program provides useful information for states that are considering emission-reduction options.

Despite a recent lack of progress at the federal level, many state policymakers continue to focus their attention on the various alternatives for reducing emissions of CO_2 from the electricity sector (and other sectors). A wide range of alternatives are available including cap-and-trade programs, carbon tax/pricing approaches, energy research and development ("R&D") funding, consumer-funded procurements of low- and zero-carbon energy sources, rate policies supporting distributed-energy resource development, and funding of energy efficiency measures. The diverse set of policy options used reflects many states' interest in finding cost-effective and workable ways to cut CO_2 emissions. Lessons learned from RGGI's implementation can inform states as they consider their options.

The experience of the RGGI states, including their initial efforts that began in 2003 to work together to develop a multi-state, market-based CO_2 control program, through the nine years of program administration to date, provides a wealth of information. Their experience provides many lessons, most notably that states can collaborate successfully in developing programs to control CO_2 emissions, and market-based CO_2-allowance trading programs – combined with state-driven centralized auctions of CO_2 allowances and with local reinvestment of auction proceeds – can help states meet emission-reduction targets while generating positive economic benefits.

RGGI's positive impacts on state economies are additive to the purpose and expected benefits of the program.

RGGI is not and never was meant to be an economic development program. RGGI's purpose is to reduce CO_2 emissions from power generation in order to help mitigate the economic, social, and environmental risks of climate change. As shown in Figure ES-1, RGGI has contributed to

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[9] These reflect "job-years," and do not identify what portion of these numbers are associated with permanent versus temporary jobs. Job-years are reported cumulatively over the full study period.

[10] As noted earlier, while the economic results from our three studies are not directly additive, we have used the same foundational analytic methods, assumptions, and data sources across all three studies in order to ensure consistency in study results. While changes in the assumptions used in our earlier studies – *e.g.*, to reflect current market conditions and expectations – could change the results (in either direction), we expect such changes would be small given the consistency in the level of allowance proceeds collected and used by the RGGI states and in the benefits we have found across our studies.

significant reductions in emissions of CO_2 across the RGGI region. In our economic analysis of the RGGI program, however, we do not attempt to quantify the potential long-term benefits of reducing the risks of climate change. The focus of our analysis is specific and narrow: to review the direct impacts of program implementation on the economies of the RGGI states, in order to test the presumption that controlling emissions of CO_2 will somehow lead to negative consequences for states that take action. Our results – which instead reveal positive economic impacts – should be viewed as additive to whatever other benefits flow from reducing climate-change risks.

The RGGI model has successfully achieved CO_2 reductions through a cooperative multi-state framework that preserves state authority.

The states that comprise the RGGI region are highly diverse in many ways: their political settings and policy objectives vary widely across the states and have even changed significantly *within* states over time; their electric-generating portfolios differ substantially in size, technologies, fuel mix, and age; their economic bases vary; and the states have unique legal and regulatory structures that oversee energy, utility, and environmental policies. Despite these differences, however, the RGGI states' experience confirms the possibility that states can work together, particularly when doing so is likely to lower compliance costs and generate economic benefits. The states have designed a multi-state CO_2 program consistent with sound economic principles, completed the stakeholder, legislative, and regulatory steps necessary to adopt and implement the program, and smoothly administered the program and integrated it with wholesale electricity markets. In addition, over just ten years the states have completed two top-to-bottom programmatic reviews and agreed upon major changes to the framework. The RGGI states continue to implement the RGGI platform with an eye towards inclusion and a willingness to collaborate with other states outside the current nine-state region.

Mandatory, market-based carbon-control mechanisms are functioning properly in wholesale electricity markets and have not adversely affected system reliability.

RGGI's nine years of experience supports a conclusion that market-based CO_2 emission-control programs can produce positive economic impacts and meet emission objectives while dovetailing smoothly into the normal operation of power systems. RGGI's implementation has not adversely affected power system reliability in New England, New York, or PJM. Further, RGGI provides an important example of how states' public policies can be integrated into federally regulated competitive wholesale markets – an issue with which FERC, state regulators, and the courts are actively wrestling.

The design of the CO_2 market in the RGGI states has allowed for the creative use of public assets in support of diverse state energy/environmental policy and economic outcomes.

The joint decision by the RGGI states to make their CO_2 allowances available to the market through a unified auction has generated substantial revenues for public use. This approach transferred the value of emissions allowances from the public sector to the private sector at a monetary cost. Had the allowances been given away for free, the states would not have had the benefit of the auction proceeds and instead would have transferred away significant public economic value to owners of power plants (which in the RGGI region are merchant generators, not owned by electric distribution utilities). The states' use of allowance proceeds helped them meet a wide variety of social, fiscal, and environmental policy goals, such as assisting low-income customers, achieving advanced energy policy goals, and restoring wetlands, among other things. Notably, however, auctioning of allowances is not necessary for the efficient and effective functioning of the cap-and-trade program design itself. Individual states may still determine their preferred method of moving allowances into the market, which could include auctions, direct allocation, and other mechanisms that may move allowances into the market while transferring or consigning auction value in whole or in part to other entities (such as electric distribution utilities or generating asset owners).

> How allowance proceeds are used affects their economic impacts: Use of auction proceeds to invest in energy efficiency produces the biggest economic bang per buck, in terms of net positive benefits to consumers and to the economy.

The RGGI Memorandum of Understanding ("MOU") fully supports the reality that states place different weights on various goals they hope to accomplish through participation in the program, and that the states will make their own decisions about how to allocate allowances to the market and how to use the proceeds from allowance auctions. But from a strictly economic perspective, some uses of proceeds clearly deliver economic returns more readily and substantially than others. For example, RGGI investment in EE leads to lower electrical demand, lower wholesale power prices, and lower consumer electricity bills. These savings remain in the pockets of electricity users, and the EE investments also produce positive macroeconomic impacts locally as more dollars stay in and contribute to the local economy. We observe that use of the RGGI dollars provides positive multiplier effects in the RGGI states' economies, especially compared to other uses of the auction proceeds.

The RGGI states' experience during 2015-2017 differed along a number of dimensions relative to the first six years of the program.

The RGGI program as implemented during the 2015-2017 period took place in the context of a changing industry and regulatory landscape and with significant changes adopted and implemented by RGGI states. Specifically:

- During 2017, the RGGI states used the six years of prior program experience as they undertook a top-to-bottom review of RGGI, and made a number of changes in the program.
- Many states adjusted how they spent RGGI auction proceeds over time, shifting the use of allowance revenues to reflect changing program and state objectives.
- Fossil fuel prices changed significantly since the start of the program, with natural gas prices (and in turn, wholesale electricity prices) having decreased substantially.
- Electric resources have shifted, with accelerated retirements of older and less efficient (and in most cases, higher-emitting) generating units, and with distributed and central-station renewable energy resources growing at a rapid pace in many of the RGGI states.

Such factors have the potential to influence the administration of RGGI and associated power system and economic impacts. For example, the lower average natural gas prices in 2015-2017 relative to the prior six years led to lower electricity prices in wholesale power markets, which had the effect of reducing the economic value of RGGI-funded EE programs for electricity and heating consumers. Also, the tightening of RGGI's CO_2 emissions cap contributed to an increase in allowance prices, the operating costs of affected generating units, and impacts on wholesale electric prices. The lower number of allowances available to the market, however, was in part offset by higher allowance prices, and thus only slightly reduced auction proceeds available to RGGI states during the 2015-2017 period.

Despite the shifting context for RGGI, the core elements of the program – including a declining CO_2 emissions cap, allowance auctions, reinvestment of auction proceeds, active trading of allowances, monitoring of program administration, participation and outcomes, and cooperation among a diverse set of states and stakeholders – operate in ways that continue to produce positive economic and programmatic results for the participating states.

2. THE REGIONAL GREENHOUSE GAS INITIATIVE

Overview and Purpose

With the first auction of CO_2 allowances in late 2008, ten states in the Northeast and Mid-Atlantic regions initiated RGGI, a multi-state market-based program to reduce emissions of CO_2.[11] In doing so, the states created the country's first mandatory program to cap emissions of CO_2 from power generation sources, with the cap set initially at 188 million short tons of CO_2 annually across the ten-state RGGI region. The regional cap is apportioned to states in a manner based generally on emissions from the affected sources (*i.e.*, fossil fuel power plants that are 25 megawatts or more in size), and in accordance with specific state allowance budgets agreed upon by the states.

As originally designed, the cap would decline by 2.5 percent per year beginning in 2015, to reach an overall reduction of 10 percent of CO_2 emissions by 2018.[12] Under the Revised Model Rule, released in February 2013 and discussed further below, the RGGI states revised the regional emissions cap downward to 91 million tons in 2014 and maintained the original 2.5-percent per-year reduction to the regional cap for the years 2015 through 2020. Under the 2017 Model Rule, released in December 2017, the cap will be further reduced by an additional 30 percent between 2020 and 2030.

Although they had the option to distribute allowances for free, each state decided at the outset of the program in 2009 to distribute the vast majority of CO_2 emission allowances into the market through a centralized auction, administered by RGGI, Inc., the non-profit organization set up by the states to run the program.

The states developed the RGGI program over several years starting in late 2003 to begin to address the risks associated with climate change. Given the electric sector's significance as a source of CO_2 emissions, the states focused attention on the goal of designing and implementing a program to reduce CO_2 emissions from power generation within the signatory states. The states acted more than a decade ago, commencing with their December 2005 Memorandum of Understanding ("MOU"), in which they concluded that: (1) climate change is occurring; (2) it poses serious potential risks to human health and the environment; (3) delay in addressing CO_2 emissions will make later investments in mitigation and adaptation more difficult and costly; and (4) a market-based carbon allowance trading program will create strong incentives for the development of lower-emitting energy sources and energy efficiency, and reduce dependence on imported fossil fuels.[13]

Market-Based Mechanism

RGGI is an emissions-control program based on market principles. Similar to that of other market-based programs administered for control of nitrogen oxides (NO_x) and sulfur dioxide (SO_2), the

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[11] The ten states are Connecticut, Delaware, Massachusetts, Maryland, Maine, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. New Jersey participated in the first three years of the RGGI program, withdrawing its participation at the end of 2011.

[12] Information on RGGI is drawn from various fact sheets on the website of RGGI, Inc., the non-profit organization established by the states to administer the RGGI program. (See http://www.rggi.org/)

[13] Regional Greenhouse Gas Initiative Memorandum of Understanding, December 20, 2005 (hereafter referred to as "MOU"), pages 1-2.

foundation of the RGGI program is an annual cap on emissions of CO_2 in aggregate for all affected sources in the states that participate in the program. Affected or "regulated" sources in a given state generally include all fossil-fueled electric power generators with a capacity of equal to or greater than 25 megawatts. Program compliance is relatively straightforward: shortly after the end of each three-year compliance period (*e.g.*, with Compliance Period 3 covering 2015, 2016 and 2017), every affected source must retire a number of allowances equal to the total tons of CO_2 emissions from the source over the three-year compliance period (one allowance equals one ton of emissions). Affected units may obtain allowances at various points in time prior to the end of the compliance period.

The states' selection of a market-based control program for CO_2 emissions from the power sector reflects the history and success within this region of market-based programs established under the federal Clean Air Act for control of SO_2 and NO_x emissions. It is also a natural fit for the electric industry given the ease with which allowance costs can be incorporated into competitive wholesale electricity market pricing systems.[14] Affected sources obtain (*e.g.*, purchase) allowances, which then becomes part of their cost to produce power at their generating unit and is included as part of their offer prices to participate in wholesale markets. This mechanism allows wholesale prices to reflect carbon prices, leading over time to industry operational decisions (relating to power plant dispatch) and asset investment decisions that reflect the most efficient compliance path for individual regulated entities as well as for the industry as a whole. In this context, the use of a market-based control program for CO_2 encourages efficiency in power dispatch decisions and long-run efficiency for achieving compliance with the market-based cap on emissions.

The CO_2 emissions cap is administered through limiting the quantity of allowances issued into the market in a given year. For example, 188 million allowances were available for the year 2009, and 84.3 million were available for 2017. The owners of affected power plants generally obtain CO_2 allowances by purchasing them through the initial auctions (held quarterly), or by purchasing or otherwise transferring them in a secondary market.

RGGI allows for flexible compliance in a number of ways. First, recognizing the long-lived nature of CO_2 in the atmosphere, compliance is required not annually, but on a three-year basis. That is, sources can purchase, bank, and use allowances bought at any auction for a given compliance period within the three-year compliance period, and need only demonstrate compliance (through retiring allowances in amounts equal to emissions) shortly after the end of that same period. In fact, allowances can be purchased and banked for use beyond the compliance period in which they were purchased. Second, sources can meet up to 3.3 percent of their CO_2 compliance obligation through

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[14] The bulk-power electric systems of the nine RGGI states are part of the centrally administered wholesale markets and integrated grids operated by three entities, called Regional Transmission Organizations ("RTOs"): ISO-New England (for the six New England states); the New York Independent System Operator (NYISO) (which is a single-state market); and PJM (for Delaware and Maryland). (PJM also includes power systems in 11 other states and the District of Columbia, which are not part of the RGGI program.) In each of these three RTOs, the wholesale power market has evolved over time into a comprehensive electricity market construct (including energy, capacity, and ancillary services) that shapes the operations of the fleet of power plants in an efficient and reliable way in real time. This electricity market construct also affects the near-term and long-term incentives for the addition of new generating capacity (or the retirement of existing capacity).

the purchase of offsets – that is, GHG-reduction projects outside the power sector.[15]

Allowance Disbursement to the RGGI States and into the Market

In each year, the amount of allowances in the regional cap have been apportioned to the participating states according to an agreed-upon ratio that roughly reflects each state's relative share of regional CO_2 emissions from the power sector as of a historical time period.[16] Under the original terms of the 2005 MOU, the RGGI states agreed that each state would be allowed to determine how it would allocate its share of allowances among owners of power plants and other potentially interested parties, so long as 25 percent of the state's allowances are allocated "for a consumer benefit or strategic energy purpose."[17] As it turned out, all of the participating states decided to disburse virtually all of their allowances through a joint allowance-auction process.

Allowances move into the market in the first instance through a central auction process conducted quarterly by RGGI, Inc. on behalf of the RGGI states.[18] An independent market monitor assesses the performance of the auctions to ensure that they are administered according to auction rules, and that there is no anti-competitive behavior in the market. Participation in the auctions is open to any entity meeting qualification requirements (*e.g.*, financial security requirements), with a ceiling of 25 percent placed on purchases by a single buyer or group of affiliated buyers in each auction.

Proceeds from the quarterly auctions – which are determined by quantities sold and auction clearing price (subject to a reserve (floor) price that is currently $2.15 per allowance)[19] – are distributed to states, and states determine how to use the funds. The final auction in the study period occurred in December 2017, with all of the approximately 14.7 million allowances offered for sale selling at an auction clearing price of $3.80 per allowance.[20] Figure 1 shows RGGI proceeds by state and region over the first three compliance periods.

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[15] The Revised Model Rule released in February 2013 provides a new offset category known as "sequestration of carbon due to reforestation, improved forest management or avoided conversion" that RGGI states may adopt in lieu of the previous "afforestation" category.

[16] See, for example, the original apportionment in the 2005 MOU, Section 2.C.

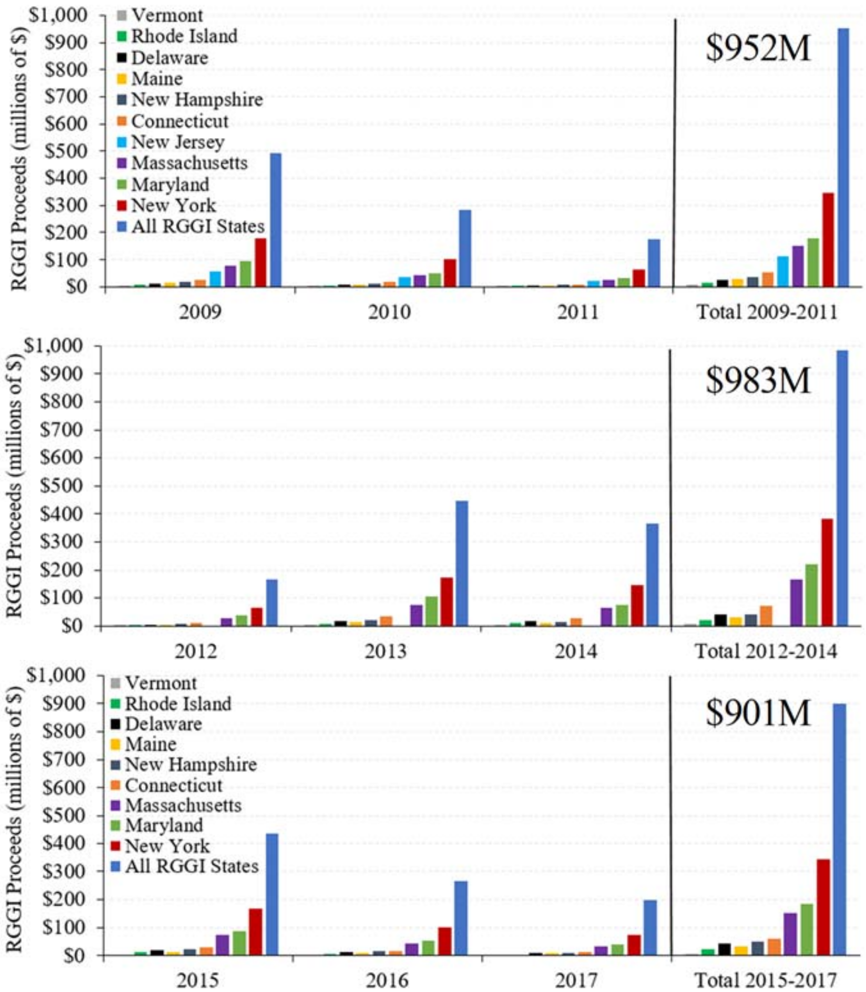
[17] "Consumer benefit and strategic energy purposes include the use of the allowances to promote energy efficiency, to directly mitigate electricity ratepayer impacts, to promote renewable or non-carbon-emitting energy technologies, to stimulate or reward investment in the development of innovative carbon emissions abatement technologies with significant carbon reduction potential, and/or to fund administration of this Program;" MOU, Section 2.G.

[18] After the allowances are in the hands of market participants, they may be bought and sold on the secondary market (without revenues flowing to the RGGI states).

[19] The minimum reserve price in 2014 was set at $2.00 and, per the RGGI Model Rule, was set to increase by 1.025 percent each year thereafter. (See https://www.rggi.org/sites/default/files/Uploads/Program-Review/12-19-2017/Model_Rule_2017_12_19.pdf)

[20] In addition, 10 million cost-containment-reserve ("CCR") allowances were also available for sale in Auction 38, none of which have been sold. (See https://www.rggi.org/auction/38). The CCR is a fixed additional supply of allowances that only becomes available for sale if CO_2 allowance prices exceed a certain "trigger" price level, which was $10 in 2017, rising 2.5 percent each year thereafter through 2020 (to account for inflation). After 2020, the trigger price will rise by 7 percent in each subsequent year. (See https://www.rggi.org/sites/default/files/Uploads/Program-Review/12-19-2017/Model_Rule_2017_12_19.pdf)

Figure 1
RGGI CO_2-Allowance Auction Proceeds by State by Compliance Period



Notes: [1] Figures include Auctions 1-38. Auction proceeds from Auctions 1 and 2 (occurring in 2008) are included in 2009. All other values are expressed in nominal dollars in the year the auction proceeds were generated. [2] Figures do not include fixed-price sales proceeds.
Source: RGGI, Inc.

Use of Auction Proceeds and Other Allowance Revenues

The use of auction proceeds varies by state, consistent with enabling state legislation, regulation and policy. Examples of how the states used their funds include investment in EE programs, investment in community-based or private-sector installation of RE or advanced power generation systems, credits to reduce consumers' electricity bills,[21] funding of state government operations through

[21] Note that our study focuses on changes in wholesale electricity prices. Although we recognize that other factors affect the extent to which *retail* electricity prices and electricity bills reflect changes in the world of retail ratemaking, we use the change in wholesale prices as a proxy for changes in consumers' payments for electricity.

allocation to state general funds, education and job training programs, and administration of the RGGI program or other GHG-reduction initiatives. The ways the states used the auction proceeds during the time period reviewed in this study (Compliance Period 3, covering 2015-2017) are discussed in detail below.

RGGI Program Reviews

The RGGI program was designed with a number of specific elements of review and evaluation. The original MOU provided for a comprehensive review to occur in 2012 that would include an evaluation of program successes, program impacts, the potential for additional reductions, imports and emissions leakage, and offsets. That program review took place in 2012. A second program review was conducted in 2017. Each of these reviews culminated in a revised Model Rule, which reflected the outcome of an extensive regional stakeholder process that engaged the state agencies, the regulated community, environmental groups, consumer and industry advocates, and other interested organizations with technical expertise in the design of cap-and-trade programs.

The states' 2012 program review revealed: (1) a significant excess supply of allowances relative to actual emission levels in the region; and (2) a finding that the then-current cost-control measures in the program, which were based upon expansion of the percentage of offset allowances allowable for compliance, would likely be ineffective in controlling costs if the emissions cap was made binding. As a result, the RGGI states revised the original program cap downward[22] and established a Cost Containment Reserve ("CCR") through the release of an Updated Model Rule.[23] These changes were implemented by the RGGI states.

The RGGI states' 2017 program review similarly resulted in: (1) a 30-percent reduction in the cap between 2020 and 2030 (a decline of 2.275 million tons per year); (2) additional adjustments to the cap to account for banked allowances at the end of 2020; (3) setting the size of the CCR to be equal to 10 percent of the cap, and increasing the trigger price to be equal to $13.00 in 2021; and (4) implementation of an Emissions Containment Reserve ("ECR") in 2021, through which states

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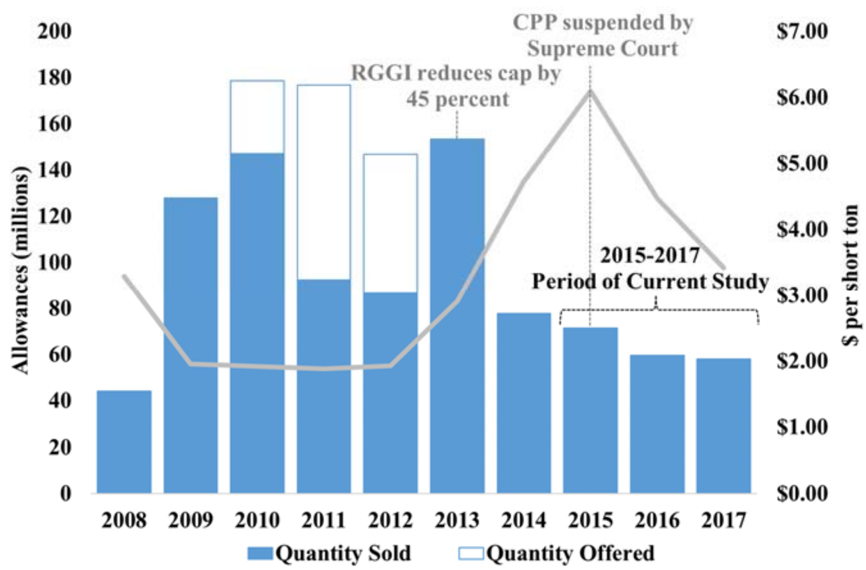
[22] Under the 2013 Updated Model Rule, the regional emissions cap was set equal to 91 million tons for 2014. Afterwards, the regional emissions cap and each RGGI state's individual emissions budget was set to decline 2.5 percent each year from 2015 through 2020. The 2013 Updated Rule also addressed the bank of allowances held by market participants with two interim adjustments for banked allowances: The first adjustment was to be made over a 7-year period (2014-2020) for the first control period private bank of allowances and a second adjustment was to be made over a 6-year period (2015-2020) for the 2012-2013 period private bank of allowances. (See https://rggi.org/sites/default/files/Uploads/Design-Archive/2012-Review/2013-02-11/Recommendations_Summary.pdf and https://rggi.org/sites/default/files/Uploads/Design-Archive/Model-Rule/2012-Program-Review-Update/Summary_of_Model_Rule_Changes_02_07_13.pdf)

[23] The Updated Model Rule established a CCR, which is a reserved quantity of allowances additional to the cap and that is only available to be released into the market if defined allowance price triggers are exceeded. In 2014, the amount of additional allowances in the CCR equaled 5 million short tons, and 10 million short tons were provided each year thereafter.

withhold allowances to achieve emissions reductions if prices fall below the established trigger price, which will start at $6.00.[24]

These reductions in RGGI's cap have resulted in several outcomes in recent years. Fewer allowances are being offered and sold. The auctions are producing higher clearing prices (and thus higher compliance costs). And together, the lower number of allowances at higher prices have led to slightly lower auction proceeds to RGGI states when compared to the first and second compliance periods. As summarized in Figure 2, over 128 million fewer allowances were sold in Compliance Period 3 at a cost of $1.67 more per allowance as compared to Compliance Period 2. Auction proceeds sent to states participating in RGGI decreased to approximately $901 million during Compliance Period 3, down from $983 million in Compliance Period 2 and $952 million in Compliance Period 1.

Figure 2
Summary of RGGI CO_2-Allowance Auction Results: Clearing Prices and Amounts Offered and Sold



Notes: [1] Clearing prices are weighted averages, based on number of allowances sold. [2] In 2014 and 2015, the Cost Containment Reserve ("CCR") trigger price was exceeded and additional allowances above what were originally offered into the market were ultimately presented and sold to market participants. In 2014, 5 million additional allowances were sold, and in 2015, 10 million additional allowances were sold.
Source: RGGI, Inc., http://www.rggi.org/market/co2_auctions/results.

Prior Analysis Group Reviews of the RGGI Program

Prior Reports on Economic Impacts of RGGI's First & Second Compliance Periods

Analysis Group has previously measured the economic impacts of RGGI's first six years (*i.e.*, Compliance Periods 1 and 2). Our 2011 and 2015 Reports presented the results of our analysis,

[24] See "RGGI States Announce Proposed Program Changes," August 23, 2017, https://rggi.org/sites/default/files/Uploads/Program-Review/8-23-2017/Announcement_Proposed_Program_Changes.pdf.

which led us to make the following observations about the RGGI experience with respect to Compliance Periods 1 and 2:

- *Mandatory, market-based carbon control mechanisms are functioning properly and can deliver positive economic benefits.* During the initial six years of experience with RGGI, the pricing of carbon in Northeast and Mid-Atlantic electricity markets was seamless from an operational point of view, and generated economic value added to the RGGI region of roughly $1.6 billion and $1.3 billion, respectively, in each of the two compliance periods.[25]
- *The RGGI Model has successfully achieved CO_2 reductions through a cooperative framework that preserves state authority*. The states that comprise the RGGI region are highly diverse, including politically and in their state policies, and have continued to change over the course of the RGGI program. Despite these differences, the RGGI states have successfully navigated the complications that can arise from efforts to coordinate regulatory and policy objectives across state lines. RGGI confirms the possibility that states can work together, particularly when doing so is likely to lower compliance costs and generate economic benefits.
- *The states used CO_2 allowance proceeds creatively – supporting diverse policy and economic outcomes.* The states' use of allowance proceeds not only provides economic benefits, but also has helped them meet a wide variety of social, fiscal, and environmental policy goals.
- *RGGI reduces the region's payments for out-of-state fossil fuels.* RGGI helped to lower the total dollars these states sent outside their region in the form of payments for fuel, as the fuels that power the region's fossil-fueled generators come from outside the region. Implementation of RGGI and the use of auction proceeds for EE and RE power production, through reducing generation and shifting the generation mix towards non-fossil resources, reduces the flow of dollars that essentially pay for fossil fuels used in power production in the RGGI states.
- *The design of the CO_2 market in the RGGI states affected the size, character, and distribution of public benefits.* The joint decision by the RGGI states to make their CO_2 allowances available to the market through a unified auction generates substantial revenues for public use. This approach transferred emissions rights from the public sector to the private sector at a monetary cost (rather than transferring them for free). Had these allowances been given away for free, the states would not have had the benefit of the auction proceeds and instead would have transferred that economic value to owners of power plants.
- *How allowance proceeds are used has affected their economic impacts.* The RGGI states used their RGGI allowance proceeds very differently, in ways that affect the net benefits within the electric sector and in the larger state economy. From a strictly economic perspective, some uses of proceeds clearly deliver economic returns more readily and substantially than others. For example, RGGI-funded expenditures on EE depress regional electrical demand, power prices, and consumer payments for electricity. This benefits all consumers through downward

[25] Given the vintages of those prior studies, all Compliance Period 1 results are reported in 2011 dollars (as described in our 2011 report), while all Compliance Period 2 results are in 2015 dollars (as described in our 2015 report). The results are presented on a net present value basis using a public discount rate of 3 percent. For additional results see the AG 2011 and AG 2015 Reports.

pressure on wholesale prices, even as it particularly benefits those consumers that actually take advantage of such programs, implement EE measures, and lower both their overall energy use and monthly energy bills. These savings stay in the pockets of electricity users directly. But there are also positive macroeconomic impacts as well: the lower energy costs flow through the economy as collateral reductions in natural gas and oil in buildings and increased consumer disposable income (from fewer dollars spent on energy bills), lower payments to out-of-state energy suppliers, and increased local spending or savings. Consequently, there are multiple ways that investments in EE lead to positive economic impacts; this reinvestment thus stands out as the most economically beneficial use of RGGI dollars. Other uses also provide macroeconomic benefits, even if they do not show up in the consumers' pockets in the form of lower energy bills.

- *States have demonstrated the capability to manage RGGI program costs and benefits in a way that is fair and protects low-income customers.* The RGGI states have done this by focusing both public policy objectives and normal ratemaking practices on fair outcomes when considering how to invest RGGI proceeds. Proceeds spent on direct customer bill assistance and EE programs targeted to low-income populations, for example, achieve these goals. Market-based mechanisms, such as RGGI, also offer unique opportunities to minimize overall social costs while reducing CO_2 emissions, by providing flexibility in how reductions are achieved, which ensures the lowest possible cost to consumers.
- *RGGI produced new jobs.* Taking into account consumer gains, power plant owners' losses, and net positive economic impacts, RGGI implementation led to overall job increases, estimated to be between 14,000-16,000 job-years in both Compliance Periods 1 and 2.
- *Timing differences in program costs versus benefits affects results.* Positive economic impacts associated with the distribution and spending of allowance proceeds tend to lag cost incurrence (and price impacts) by a year or more in many states. States can improve economic impacts by ensuring quick and efficient use of allowance revenues.
- *Value added in the economy for states' funding of various programs strongly outweighs the direct and induced effects of power-generator revenue loss.* RGGI's impacts affect many part of states' economies. RGGI proceeds were spent on economic activities affecting the electric sector, other energy uses (*e.g.*, natural gas use in buildings), support for low-income residents to meet their energy bills, educational activities, and general fund support. The positive economic multipliers associated with these expenditures contributed to net positive effects of the program in the RGGI states. On an NPV basis, these gains are larger than the direct impacts on the electric sector, where there were net positive electric consumer impacts but net revenue losses to power plant owners.
- *A region's pre-existing generating mix affects economic impacts.* Since power generation resources have different CO_2 emission impacts – with coal-fired generation having higher combustion-related CO_2 emissions than other electricity generating resources – the amount of coal in a particular state's generating mix affects the costs of the RGGI program.

2017 Report on Voluntary Cooperation on Allowance Trading Among States

A July 2017 Analysis Group report entitled "RGGI and Emission Allowance Trading, Summer 2017 Update"[26] reviewed the rationale and potential mechanisms for expansion of emission-allowance trading opportunities between sources in RGGI states and in other states that might be considering participation in or otherwise linking to the RGGI program and trading platform. This issue remains relevant, in light of Virginia moving forward with legislative priorities to participate with RGGI states, and New Jersey recently issuing an executive order to reinstate its prior participation in RGGI.[27] Moreover, the RGGI states have indicated their willingness to engage in discussions with other states – and, in particular, with Virginia and New Jersey – that may want to participate in RGGI in whole or in part.[28]

The AG 2017 Report reviewed the possibility of expanded CO_2-allowance trading among states, and considered the various design features that could accompany an expanded trading platform. In particular, this study considered the rationale for maximizing the size of the trading region, noting that a "…tradeable-allowance structure operates well in both regulated and competitive electric-industry contexts and integrates seamlessly with electricity market operations…[and] a broader trading market with more participants creates the opportunity to lower overall costs of compliance."[29] That report noted that while expanding RGGI to include other states might affect the level of state auction revenues (since, all else equal, expanding the compliance footprint should lower the marginal cost of CO_2 control and thus lower the price of auctioned allowances), this potential effect is part of a program that achieves the longer-run benefits of a broader allowance trading footprint.[30]

Finally, the AG 2017 Report identified and reviewed a set of key emission-allowance trading considerations and specific allowance-trading design considerations, which we summarize here in Tables 1 and 2.[31]

[26] Paul Hibbard and Ellery Berk, "RGGI and Emission Allowance Trading, Summer 2017 Update," July 2017 (hereafter "AG 2017 Report") (available at http://www.analysisgroup.com/uploadedfiles/content/news_and_events/news/ag_white_paper_rggi_trading_july_2017.pdf).

[27] See http://www.nj.gov/governor/news/news/562018/approved/20180129a_eo.shtml and https://governor.virginia.gov/newsroom/newsarticle?articleId=22095, accessed April 4, 2018.

[28] "This auction underscores how RGGI participation helps our states to reinvest in a cleaner and more resilient energy system. Recently, new states have become interested in participating in our program and sharing these benefits," said Ben Grumbles, Secretary of the Maryland Department of the Environment and Chair of the RGGI, Inc. Board of Directors. "The RGGI states are eager to share information about our program with any state that is interested, and especially look forward to further discussions with Virginia and New Jersey." (See https://rggi.org/sites/default/files/Uploads/Auction-Materials/39/PR031618_Auction39.pdf)

[29] AG 2017 Report, page 2.

[30] AG 2017 Report, page 2.

[31] Tables reproduced from AG 2017 Report, pages 3 and 7.

Table 1: Key Emission-Allowance Trading Considerations

Threshold Issue	Description	Key Considerations
Larger Trading Region	RGGI is a nine-state program with a large share of the U.S. economy with demonstrated ability to reduce CO_2 emissions in the affected region. Additional states' participation in RGGI states is likely to achieve additional cost-effective control of carbon emissions from the power plants.	Emission-control programs based on allowance trading in the broadest possible region support least-cost compliance and provide appropriate signals to market participants for infrastructure investment and power plant operation. Broader trading also reduces the likelihood of market monopoly or illiquid trading. Expanded trading may impact auction revenues to RGGI states as a short-term effect of a longer-term reduction in emission-control compliance costs.
The Importance of Regional Trading Considerations and External Collaboration	RGGI is uniquely positioned to support the expansion of a multi-state CO_2 trading market in the U.S.	RGGI is a flexible program that provides for low-cost CO_2-emissions reduction that could benefit from trading emissions across an expanded geographic region. RGGI states' decisions about key program designs and trading rules can affect other states' decisions about whether to join this program.
Auction Revenue Considerations	RGGI initially disburses almost all carbon allowances into the market through a central auction, and returns auction revenues to state governments. The states use those revenues to further GHG-emission reduction goals. Expanded trading may reduce auction revenues because allowance prices would likely fall with broader trading.	The RGGI states have effectively used auction revenues to further CO_2-emission-reduction and EE goals, among other uses. Although broader trading could improve overall efficiency of carbon-reduction approaches, it could also reduce revenues to RGGI states as a result of lowered allowance prices. While short-term revenues may fall, the long-term efficiencies and cost decreases of broader trading will likely outweigh the impacts of short-term revenue reductions.

Table 2: Specific Market-Based Carbon-Control Program-Design Considerations

Threshold Issue	Description	Key Considerations
Program Structure and Minimum Requirements	RGGI operates according to a core set of compliance and reporting obligations established in the MOU and the Model Rule, and according to state regulations. RGGI will likely need to establish a set of similar requirements for non-RGGI trading partners.	Key considerations related to program structure and minimum requirements for additional participants in the program include the emissions caps that trading partners adopt, the sources covered under CO_2 regulation, the method of disbursing allowances, and emissions-reporting and compliance guidelines.
Allowance Comparability	The RGGI states have achieved substantial reductions in regional CO_2 emissions over time, resulting in increasing allowance values. RGGI also employs a CCR and price floor and is considering an ECR.	In considering how to ensure fungibility of CO_2 allowances across trading regions, RGGI states need to consider whether and how to require other new states (that seek to join and/or link up with the RGGI trading program) to set CO_2 caps that match the stringency of the current RGGI cap, and whether to require that trading partners abide by price floors and have their own CCR and ECR reserves are issues. To facilitate broader trading regions, RGGI could proactively identify a strategy for setting comparable emissions caps and therefore creating fungible allowances with new trading partners.
Allowance Distribution	RGGI does not dictate how allowances are initially distributed, although RGGI recommends that states reserve at least a portion of allowances for public purposes. In practice, nearly all RGGI allowances are distributed initially through a central auction.	Initial disbursement of allowances does not affect the value or "opportunity cost" of allowances in the market, and thus does not affect the aggregate cost of compliance or the price of electricity generation. Thus, there is little reason to condition trading on the distribution of allowances. The method of distributing allowance into the market does, however, affect who gets the value of the allowances, with some approaches (*e.g.*, free distribution) potentially leading to potential "windfalls" to particular entities while other approaches (*e.g.*, auctions) retaining value for the public.
Emission Allowance Tracking	RGGI uses a standardized system to track the creation, trading, and retirement of emissions allowances.	RGGI could allow non-RGGI trading partners to participate in RGGI allowance auctions and in the secondary markets, tracking their activity through RGGI CO_2 Allowance Tracking System (COATS), or RGGI could require partner states to demonstrate substantial equivalence between other tracking programs and COATS.
Market Monitoring	RGGI requires careful monitoring of the allowance market to guard against hoarding and other forms of market manipulation.	RGGI's market monitoring has provided a great deal of comfort to states in the program that the program performs well as a market-based approach. Such oversight of market activities is arguably more important with broader trading regions and more market participants. RGGI may want to consider conditioning any new state partnerships upon those states relying on some form of market oversight or assurance mechanism.

Observations from the Implementation of RGGI to Date (2009-2017)

Based on these several studies, we observe that well-designed CO_2 pollution control programs (1) can operate with modest impacts on electricity rates in the first instance, and (2) can produce long-term benefits in the form of lower electricity bills and positive economic value to state and regional economies. A multi-state approach to carbon control can integrate seamlessly into the reliable performance of electric systems and can lead to efficient price signals affecting power plant dispatch, reducing emissions, and providing opportunities for cost-effective compliance costs for producers, to the benefit of consumers.

RGGI's success in producing these outcomes can in part be attributed to many program design and implementation features:

- *Program design and revision process* – The initial RGGI design and the subsequent revisions adopted by the RGGI states in 2013 (under the Updated Model Rule) occurred through collaborative processes involving a diverse set of states and other stakeholders. Participation included representatives not only from state agencies, but also from industry, environmental groups, experts and think tanks, and other organizations. Each state that elected to join RGGI obtained authority to do so through its legislature and/or regulatory mechanisms (as appropriate in each state). RGGI developed a 'model rule' that outlined the core design elements of the program, and then each state adopted its own enabling authority to allow it to participate. This meant that the participating states did not need to adopt a formal interstate compact under federal law, while still allowing the participating states to establish a coordinated and common mechanism for incorporating a carbon price into their power-system dispatch and operations;

- *Careful attention to policy design* – The process leading up to RGGI's initial design and subsequent implementation and revisions over time took care to address various elements of the program: establishing emission limits and allocation approaches; establishing processes to auction allowances; allowing for the free trade of allowances subsequent to their initial movement into the market; establishing periodic demonstrations of compliance; and allowing flexibility for states to use auction revenues in a manner consistent with their own policy objectives;

- *Common auction and trading platforms* – Ultimately, each RGGI state voluntarily decided to distribute the vast majority of its CO_2 emission allowances through a common, centralized auction administered by the organization (RGGI, Inc.) set up by states to run the program. This centralized administration and tracking of allowance ownership (which allowed for allowances to change hands subsequent to the initial auction) provides participating RGGI states with ease of implementation, allows for shared governance, and supports effective and efficient monitoring of a single allowance trading market; and

- *State allowance revenue decisions* – The use of auction proceeds has varied across the states and over time, consistent with agreements among the states and with each state's enabling authority. In practice, however, the majority of RGGI auction proceeds have been reinvested in EE and RE projects in part reflecting the states' interest in mitigating the impact of the program on wholesale electricity prices and consumer electricity costs. This practice is the source of many of the electricity and economic benefits we find in our analysis.

Comparability of Different Studies of RGGI Program Impacts

The methods used in this Report's analysis are solely focused on measures of *economic* impacts. They trace the dollars collected through the RGGI auctions and measure the full range of economic impacts in the electric markets and on states' economies that result from state spending of RGGI's CO_2 allowance auction proceeds. The results reflect a comparison of a world with and without these RGGI-related effects, holding all else equal. This approach does not take into account other potential measures of economic benefits (such as climate risk mitigation and air quality or other human health and environmental impacts), and thus differs from other studies of RGGI's impacts in this regard.

For example, RGGI, Inc. has developed reports reviewing the impacts of the use of RGGI auction proceeds in 2014 and 2015 ("Benefits Studies"). These reports differ from our study in a number of important ways, including:

- The Benefits Studies focused on the community-level impacts (*e.g.*, the number of participating households and businesses, energy bill savings, and the number of workers trained) of how RGGI dollars are spent locally.
- The Benefits Studies characterize the magnitude of potential environmental benefits by estimating and reporting CO_2 emissions avoided, equivalence to other mitigation actions (*e.g.*, taking cars off the road), MWh saved, and MMBtu saved;
- The Benefits Studies evaluate impacts in aggregate over the full course of RGGI program administration (as opposed to a single Compliance Period), and report impacts by investment categories (*e.g.*, EE, Clean and Renewable Energy, GHG Abatement);
- The Benefits Studies do not attempt to capture power-system dispatch impacts or induced impacts on RGGI states' economies.

Such differences between the Benefits Studies and our analysis make it difficult (if not inappropriate) to directly compare their results. Similarly, the methods applied in other independent reports are not comparable to the focus or analytic approach here. Each study has its own objectives and methods, applies varied analytic approaches, model platforms, and/or timeframes, and seeks to inform a different set of questions. It is important to understand these distinct elements when comparing results across studies.

3. PURPOSE AND METHOD FOR THE ANALYSIS OF COMPLIANCE PERIOD 3

Overview

From 2015 through 2017 (*i.e.*, Compliance Period 3), the auction of RGGI CO_2 emission allowances has resulted in the collection and disbursement to states of approximately $901 million. (See Figure 1) This Compliance Period 3 revenue is slightly less than the amounts collected in prior Compliance Periods: $952 million collected in Compliance Period 1 (2009-2011) and $983 million collected in Compliance Period 2 (2012-2014).[32]

Consistent with how we conducted our assessments in our AG 2011 and 2015 Reports, our analysis of Compliance Period 3 follows the allowance auction revenues and identifies the economic impacts of its use. Namely, we track the path of RGGI-related dollars as they leave the pockets of power plant owners who buy CO_2 allowances to demonstrate compliance, show up in electricity prices and customer bills, make their way into state expenditure accounts, and then roll out into the economy in one way or another. This analysis focuses on the actual impacts of verifiable economic activity: known CO_2 allowance prices as reflected in actual auction prices over time; observable CO_2 allowance auction proceeds (nearly $901 million in Compliance Period 3); dollars distributed to the RGGI states as a result of each auction; actual state-government decisions about how to spend the allowance proceeds; measurable reductions in energy use from EE programs funded by RGGI dollars; traceable impacts of such expenditures on prices within the power sector; and concrete economic activity and value added to the states' economies. By carefully examining the states' implementation of RGGI to date, based on real data about expenditures inside and outside of the electric sector and our calculation of value added from RGGI program implementation, we track the extent to which RGGI program implementation represents a positive or negative impact on the economies of the RGGI states.

There are four major elements of our review, each of which is discussed in more detail in the sections that follow:

1. We first established the **scope and overall framework of the analysis**, to create an integrated analytic framework that separates and highlights RGGI state impacts based on known historical program implementation data (*i.e.*, during Compliance Period 3), from other factors and impacts outside the region or associated with forecasts or projections. This scope of analysis thus included modeling of actual funds received and spent by the states, and actual impacts on electricity markets, as well as an assessment of the impacts of RGGI program expenditures on the larger economy.
2. Next we conducted a thorough review of **data and information on each state's use of revenues collected from the sale of RGGI allowances**. We initially received data from RGGI detailing each state's programs that received RGGI funding, and how much RGGI funding each program received in each year of Compliance Period 3. We supplemented this

[32] The dollars reported here are in nominal dollars. For comparison purposes, we have converted these amounts into real dollars (2018$), by inflating them based on the Consumer Price Index. With these conversions into real dollars (2018$), Compliance Period 1 proceeds amounted to $1.08 billion, Compliance Period 2 proceeds were $1.05 billion and Compliance Period 3 proceeds totaled $0.94 billion.

information as needed by researching individual programs to understand the specific activities that were being funded, and by relying in some instances on the work done in our prior studies. The purpose of this step was to track how RGGI revenues were disbursed (from RGGI, Inc. to the states) as a result of auctions occurring during Compliance Period 3, how disbursed funds were used by the states, and what impacts resulted from associated program implementation. Part of this analysis resulted in information about the use of allowance proceeds that affected activity in the electric sector (*e.g.*, how expenditures on EE programs affected the level of energy use in various portions of the day and in different seasons of the year) and in other parts of the economy (*e.g.*, how different program expenditures provided job training, or purchases of equipment, as described further below).

3. Third, we modeled **electric sector outcomes** from both the incurrence of increased costs associated with affected facilities' compliance obligations (namely, the purchase of allowances and changes in the electric supply offers and wholesale market clearing prices consistent with those CO_2 allowance costs), and the effect of changes in electric generation and demand associated with the use of funds to spur investment in EE and advanced energy technologies. Our electric sector analysis was conducted using the PROMOD model.[33]

4. Fourth, we modeled **macroeconomic outcomes**, combining electric sector outcomes – positive and negative – with expenditures in all sectors of the economy associated with the use of RGGI funds in the nine states. This produced an overall picture of how RGGI program implementation has affected the economy, including multiplier effects associated with the impacts on consumer electricity payments, power plant owners' costs and revenues, and the flow of RGGI-related dollars through other sectors of the economy. Our macroeconomic analysis was conducted using the IMPLAN model.[34]

It is clear from our program research and results that different investment portfolios by states resulted in different impacts from both economic and non-economic perspectives. Because our analysis focuses only on economic impacts, it does not shed light on the core objectives of the RGGI program – namely, addressing the economic, social, health and environmental risks associated with climate change, health benefits associated with ancillary reductions in other pollutants, or reduced health and environmental impacts associated with other effects of fossil-fuel generation. While we recognize that these were the key motivators of states acting to control emissions of CO_2, our focus was more narrowly on the economic (monetized) impacts of RGGI program implementation.

[33] The PROMOD model and our analysis of electric sector impacts are described in detail in the Appendix of this Report. Note that PROMOD allowed for estimation of electric-energy market impacts while capacity-market impacts were calculated separately.

[34] The IMPLAN model and our analysis of macroeconomic impacts are described in detail in the Appendix of this Report.

Scope of Analysis

Overview

To carry out our analysis of economic impacts of RGGI, we ran power-system dispatch models and macroeconomic models under two scenarios: the "RGGI case," which is effectively the world as it actually occurred during Compliance Period 3; and the counterfactual "no-RGGI case," which involves changes to model inputs and assumptions to create conditions depicting a world in which the RGGI program had not been in place as of the beginning of 2015. The difference in economic impacts between the two cases reflects RGGI's incremental impacts during Compliance Period 3.

In constructing the scope of our analysis, we were guided by three key objectives: first, we wanted to focus on impacts only within the RGGI states (the geographic perspective). Second, we wanted to identify near-term and longer-term impacts associated only with RGGI's implementation during Compliance Period 3 (2015-2017) (the temporal perspective). Third, we wanted results that were grounded as much as feasible in actual, known expenditures, programs, and impacts (the empirical perspective).

From a geographic perspective, we focused our analyses on the activities and impacts exclusively within the RGGI states. While some money from RGGI spending that flows outside of the RGGI states affects the economies of states outside the RGGI region (for example, for the manufacture of light bulbs or insulation used in energy efficiency programs, or flows of dollars to the federal government associated with changes in income), we did not try to report those out-of-region impacts in our analysis. Similarly, in the power-system modeling, our evaluation of impacts on power plant owners (also referred to as producers or generators here) and energy consumers was limited to those groups located within RGGI states.

From a temporal perspective, we focused our analysis on the third RGGI Compliance Period. We isolated the impacts of RGGI-related dollars associated with Compliance Period 3 only (2015-2017). This means that we included in power pricing the cost to power producers of obtaining RGGI allowances in the third three years of the program, and we included in power and economic sectoral investments only RGGI revenues that were spent during the third three years of the program.

Focusing on these three years of RGGI dollars, we tracked actual dollars collected from power producers during the 12 auctions that have occurred during Compliance Period 3, taking place from March 2015 through December 2017. The funds from these auctions flowed to the states immediately, with states spending them (or programming them for later expenditures, or spending previously collected dollars) during the 2015-2017 time period. Within the electric system, the impacts of these initial auctions also show up during the 2015-2017 period, as power plant owners priced the value of CO_2 allowances into prices they offer in regional wholesale markets. The macroeconomic impacts occur over the time period that allowance proceeds are collected and spent (2015-2017), but there are longer-term effects associated with the imprint of EE and RE project expenditures made during that period on energy use for the following decade (through 2027[35]). We

[35] As described in more detail later in this report, we assume a ten-year lifetime for installed EE measures and RE projects and conservatively truncate our modeling period after 10 years despite these resources having impacts (in the case of EE) and useful lives (in the case of RE) beyond then.

thus track these direct effects of RGGI to date in the near term (*i.e.*, Compliance Period 3), and in the long term track secondary impacts from expenditure of RGGI dollars by the states (for EE-related expenditures from 2015-2017, and from the implications of those EE measures on electricity use from 2015-2027).

From the perspective of modeling data and assumptions, we focus our analysis on known quantities associated with actual results from the third three years of the program. That is, we do not forecast allowance prices; we use actual allowance prices as they revealed themselves through the auctions. We do not estimate future program revenues, since we were focused on actual RGGI auction proceeds to date. We do not project how future revenues will be spent by states, since we rely entirely upon how the states have actually decided to spend allowance proceeds received to date. We make no assumptions about states' participation in RGGI going forward. Nor do we project impacts associated with programs funded through RGGI dollars collected in future years.

The goal of our analysis is thus to identify those incremental economic impacts associated with implementation of RGGI during Compliance Period 3: known allowance prices and revenues; known distribution of revenues to states; actual or committed expenditures associated with state proceeds; and observable impacts associated with RGGI-funded program implementation. In this sense, our analysis should be viewed as a snapshot of impacts associated with a finite period – Compliance Period 3 – of RGGI program administration, and not a projection or forecast of how RGGI may, could or should evolve.

To accomplish our goal, however, we had to establish what these programs meant from an economic perspective, in order to create the "no-RGGI" counterfactual case, against which we compare the actual economic outcomes during the 2015-2017 time period (which included RGGI).

Data Collection and Processing

Overview

Our analysis began with the collection and processing of data related to RGGI program implementation in each of the nine states. Identifying and tracking the use of RGGI proceeds is fundamental to our analysis, and has been facilitated by states' reporting of their expenditures to RGGI, Inc. on a quarterly basis. This process also involved the translating of expenditures on EE measures and new RE projects into impacts on power-system energy consumption and electricity peak loads in various seasons and days of the year.

In the end, we were able to obtain most of the necessary data from the information reported to and by RGGI, Inc. Where information was missing or incomplete, we took successively deeper steps to fill in data gaps, sort out inconsistencies, establish proxy values, and/or arrive at a workably complete data set for use in the study.

Data Gathering

Approach

The first anchor point for our data analysis is the level of revenues collected through the quarterly auctions of allowances (approximately $901 million) during Compliance Period 3. We collected data on the sales of allowances into the market and on the allocation of those auction revenues to states. Total revenue allocations to states are shown in Figure 1.

Participating RGGI states report their spending of RGGI proceeds to RGGI, Inc. on a quarterly basis. RGGI, Inc. publishes these data and breaks expenditures down into the following seven investment categories: EE, clean and renewable energy, GHG abatement, direct bill assistance, administration, RGGI, Inc. administration, and transfers to the general fund.

Using these data, we traced and categorized in detail the actual use of RGGI auction proceeds for funding to various types activities, and identified the effects of the funded activities, programs, and investments. By "effects" we mean the tangible results of the expenditures that are significant or important from the standpoint of measuring power system dispatch and economic impact through the PROMOD and IMPLAN modeling effort. For example, what are the annual household electricity savings, on- and off-peak, associated with specific EE measures? How many MWh of generation will flow annually from an installed solar photovoltaic ("PV") systems using RGGI dollars? Identifying such effects involved (1) collecting data and estimates by RGGI, Inc. on such effects, and (2) applying best-practice estimation methods where data across states were missing, incomplete or inconsistent.

Process

Our process for cataloguing the collection, allocation, disbursement, and use of RGGI allowance revenues involved three basic steps:

- We first collected and reviewed data on expenditures of RGGI auction proceeds and on the estimated effects of RGGI-funded programs from public sources. The public sources of information included publicly available reports on RGGI and/or separately on state energy efficiency programs.
- Using the existing data, we organized it to format the data for input into the PROMOD and IMPLAN models.

Based on our review of the data, the similarities in spending vehicles across RGGI states, and the levels of disaggregation needed for model inputs, we divided program spending into seven categories. These categories are described below, and expenditures by category for each electric market region (New England, New York, and PJM RGGI states), as well as for the entire RGGI footprint, are presented in Table 2 and Figure 3, below.

1) *Energy Efficiency and Other Utility Programs* – Because much of the RGGI funds were spent on EE measures, and because different measures lead to different impacts on consumers' demand for electricity, we grouped information on EE programs into residential retrofit/new construction and commercial retrofit/new construction categories.

2) *Renewable Investment* – This includes grants to programs and investments focused on the development, distribution, and installation of renewable or advanced energy technologies. We assume that this investment was largely supporting solar PV installations.

3) *Education and Job Training* – This includes monies used for programs (i) to educate business and residential consumers about energy consumption and the availability of programs to reduce consumption, and (ii) train workers with new skills and knowledge in industries and activities that contribute to lowering energy use (*e.g.*, installation of EE measures) or the production and distribution of renewable or other advanced energy technologies.

4) *Clean Technology Research/Development* – This includes grants and other funding to support research or other public/private groups focused on the furthering R&D related to GHG emissions (*e.g.*, clean technologies, alternative transportation, carbon sequestration).

5) *Direct Energy Bill Assistance* – This includes use of RGGI funds to provide payment credits or other means to reduce bills paid by consumers for electricity and heating/cooling. In some cases, investments in this category are targeted to low-income households.

6) *GHG Reduction Programs* – The GHG reduction programs include a variety of expenditures aimed at reducing GHG emissions (*e.g.*, R&D grants for CO_2- emission abatement technologies, direct investment in "green" start-up companies, efforts to reduce vehicle miles traveled, climate change adaption measures, investments in existing fossil-fuel fired power plants to make them cleaner and/or more efficient).

7) *Program Administration* – RGGI Program Administration refers to RGGI auction proceeds used by each RGGI state to cover costs associated with the administration of the state's CO_2 Budget Trading Program and/or related consumer benefit programs.

The amounts of funds spent by program category (by RGGI state, by electrical region for the RGGI states and for the nine-state RGGI region as a whole) are show in Table 3 and Figure 3, below.[36]

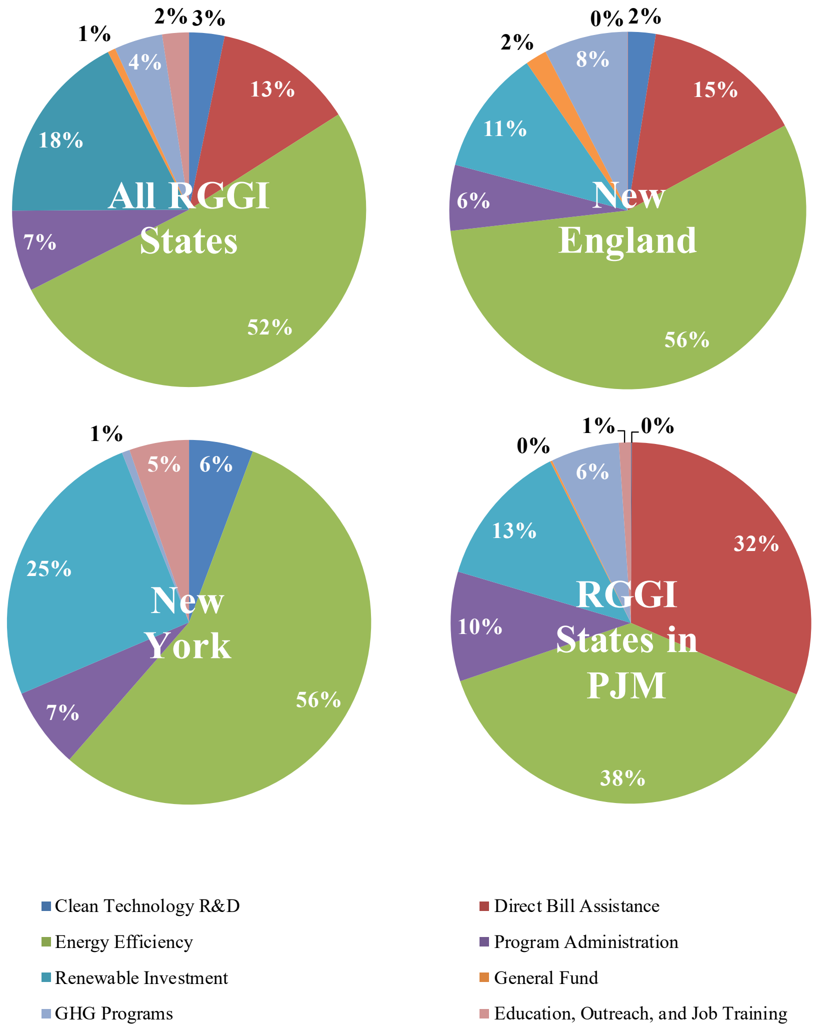
[36] Between 2015 and 2017, the RGGI states spent more on RGGI-related programs than the revenues collected during Compliance Period 3 auctions. The analysis presented in this study models the full amount of state spending on RGGI programs during this period.

Table 3
Spending of RGGI Proceeds by Category and by State, Electrical Region and RGGI Region
Compliance Period 3 (in $ millions)

	Energy Efficiency	Clean Technology R&D	Direct Bill Assistance	GHG Programs	Program Administration	Renewable Investment	Education, Outreach, and Job Training	General Fund	**Total**
Connecticut	41.7	-	-	-	4.1	25.4	-	7.0	**78.3**
Maine	30.3	0.2	6.6	-	1.6	-	-	0.5	**39.2**
Massachusetts	114.0	9.1	-	28.9	12.2	12.9	-	-	**177.1**
New Hampshire	9.7	-	39.9	-	1.0	-	-	-	**50.5**
Rhode Island	10.7	0.3	9.2	0.1	3.4	4.9	0.0	-	**28.8**
Vermont	7.5	-	-	-	0.4	-	-	-	**7.9**
New England Subtotal	**214.0**	**9.6**	**55.7**	**29.1**	**22.7**	**43.2**	**0.0**	**7.5**	**381.8**
New York	253.4	25.9	-	3.2	32.6	115.5	24.1	-	**454.8**
New York Subtotal	**253.4**	**25.9**	**-**	**3.2**	**32.6**	**115.5**	**24.1**	**-**	**454.8**
Delaware	38.1	-	2.3	0.1	6.5	13.9	-	0.5	**61.3**
Maryland	66.7	0.2	83.6	16.7	20.4	21.7	2.9	-	**212.3**
RGGI States in PJM Sub	**104.8**	**0.2**	**85.9**	**16.8**	**26.9**	**35.6**	**2.9**	**0.5**	**273.6**
All RGGI States	**572.2**	**35.8**	**141.6**	**49.0**	**82.2**	**194.3**	**27.1**	**8.0**	**1,110.2**

Source: Analysis of state-level proceeds spending data reported to RGGI, Inc.

Figure 3
Summary of RGGI Proceed Spending by Region



Source: Analysis of state-level proceeds spending data reported to RGGI, Inc.

Modeling Approach

Overview

Since our goal was to track the incremental impact on the economy resulting from the purchase and use of RGGI allowances and from the states' use of those RGGI allowance proceeds during Compliance Period 3, we needed to (1) construct a counterfactual electric system that did not reflect RGGI impacts and (2) develop an analysis that followed the flow of RGGI dollars through the economy. We provide the details of our assessment tools in the Appendix of this Report, which describes the IMPLAN and PROMOD models in greater detail.

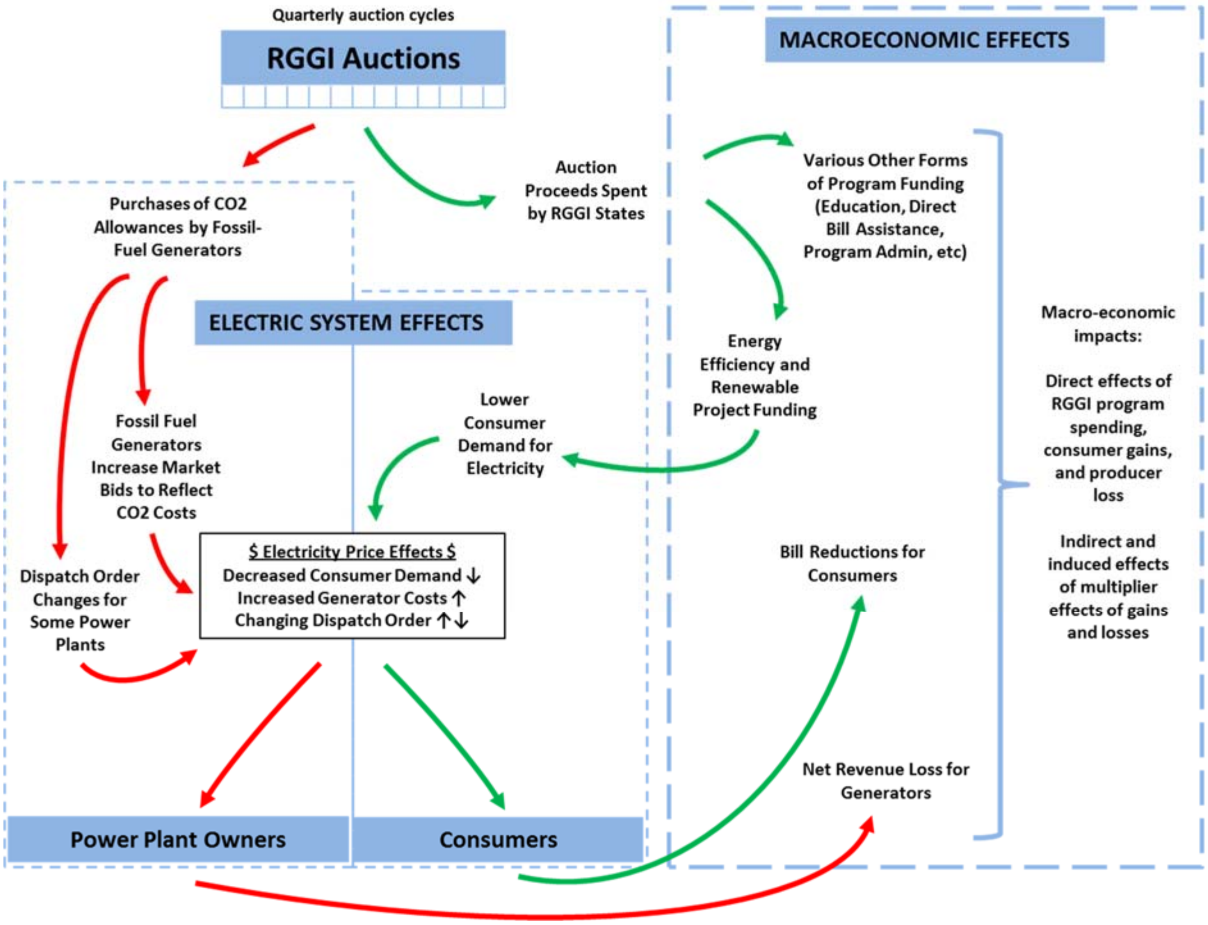
With respect to impacts on the general economy, RGGI allowance proceeds have two effects. First, when the states use RGGI proceeds to fund an activity (such as EE) those monies have a direct impact in the form of purchases of goods and services in the economy. Second, in one way or another, many states reinvest allowance proceeds to affect costs in the power sector (*e.g.*, to facilitate cost-effective reductions in power-sector emissions of CO_2, and/or to mitigate the impact of the RGGI program on consumers' electricity costs). Thus, both the compliance obligation and the use of RGGI proceeds create changes in the power sector, in the form of changes in power plant owners' costs, offer prices bid into wholesale electricity markets, and consumer spending on electricity bills. In aggregate, these changes in spending lead to revenue gains and losses (to power plant owners) and gains and losses (to consumers), which, in turn, affect economic flows in the economy.

To estimate these impacts on the economies of RGGI states, we model changes to the electric system and macroeconomic outcomes. The general flow of data and modeling outcomes is depicted in Figure 4.

Our modeling approach combines analysis of power sector effects (through modeling using PROMOD), and analysis of macroeconomic effects (through use of IMPLAN). The foundation of our modeling analysis is, in effect, a comparison between two scenarios run through the models. In the PROMOD model, we run a dispatch of the regional power systems "with" and "without" RGGI, and include in each run the same core conditions: power system infrastructure both in place and as it evolves over the modeling period (that is, transmission configurations and power plant additions and retirements); local and regional forecasts of electric energy and peak load by service territory over the modeling period; and projections of fuel prices and allowance prices for NO_x and SO_2; and so forth.[37] In the IMPLAN analysis, we start with economic relationships that exist among providers and users of goods and services in the nine RGGI states, and then we introduce the direct expenditures (RGGI proceeds) and the revenue gains and losses to electricity consumers and power producers (from the PROMOD model).

[37] Forecasts of load, fuel and other prices are needed for the period after 2017 to analyze the impact of the energy efficiency and renewable investments made during the 2015-2017 period.

Figure 4
Flow of Data and Modeling Outcomes in our Analysis of RGGI's Impacts on the Electric System and State Economies



The two cases in PROMOD can be described as follows:

- RGGI Scenario – In the RGGI scenario, the power system is modeled as it is. That is, the RGGI case represents the world as it has evolved with RGGI in place and operating as it did during Compliance Period 3. It includes all of the programs, measures, investments, and funding that are associated with the third RGGI compliance period, and all of the impacts on the power system and economy associated with the use of RGGI funds.
- No-RGGI Scenario – In order to create the counterfactual against which we compare and contrast the RGGI case, we create a scenario configured to represent the power system and economy as it would have progressed absent expenditure of RGGI-related dollars in Compliance Period 3. In order to do this, we relied on all of the data and representations of RGGI investments and associated effects described in the previous section, and removed those investments and effects from the RGGI scenario. But for these changes, all elements of the modeling process are identical across cases.

We then traced the dollar differences in these two PROMOD runs (with and without RGGI) through the macroeconomic IMPLAN model to capture the impacts of these electric sector outcomes; we also injected funds related to the states' direct expenditures of RGGI program dollars in IMPLAN.

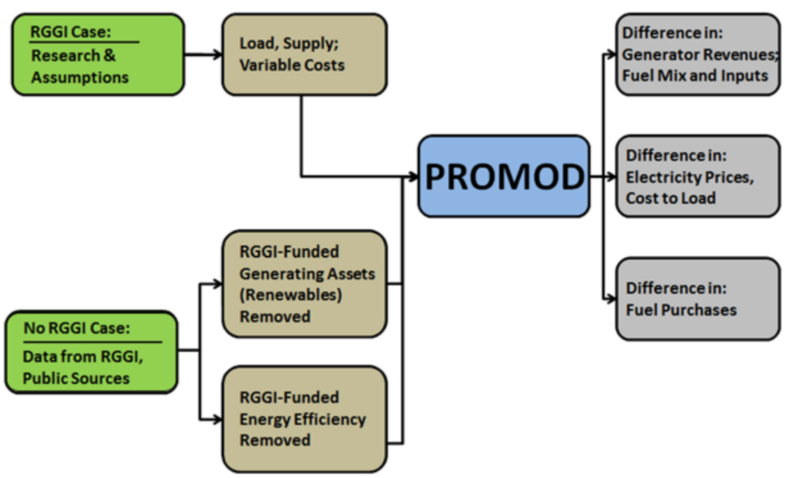
In the following sections, we summarize the power system and macroeconomic models, and highlight a few key factors of the modeling approach that help to interpret the results. More detail is available in the Appendix.

Power Sector Analysis

RGGI has two primary effects in wholesale power markets. First, marginal power prices are at times increased by the additional CO_2 allowance cost to affected (fossil-fired) power generating facilities. Second, demand and marginal prices are at times decreased by the amount and type of EE measures and RE projects installed as a result of spending RGGI allowance proceeds.

Using the PROMOD power system dispatch simulation model, we quantified these net impacts on regional and local electric-system loads, power prices, and revenues to power producers associated with implementation of the RGGI program in the third compliance period. (See the Appendix for a detailed description of the PROMOD modeling platform, the core logic for which is explained briefly below.) These relationships are summarized in Figure 5. Using PROMOD, we created the "with RGGI" case (benchmarking the modeling results to the actual electric output that was observed in 2015-2017) and then constructed a counterfactual "no-RGGI" case. Comparing the results of the two cases provided information about the incremental effect of RGGI's Compliance Period 3 on power system users and producers.

Figure 5
Diagram of PROMOD Modeling Inputs and Outputs for RGGI Impacts on the Electric System



Traditional cost-minimizing strategies in the dispatch of power systems involve use of production-cost information to determine which power plants operate at different times of the day to meet changing load conditions. In competitive wholesale electric market regions like the Northeast and Mid-Atlantic regions, decisions on which power plants to turn on and off are made based primarily on bids submitted by power plant owners indicating the price at which they are willing to supply power into the markets. Provided the market is sufficiently competitive, price bids should approximate marginal production costs of the facilities in the system. Generally, prices in wholesale markets are set hourly based on the last generating unit dispatched – that is, the most expensive unit that was needed to meet hourly load.

The PROMOD power system model is configured to comprehensively simulate the dispatch of the power system on an hourly level based on power plant marginal costs, subject to various operational and transmission system constraints that can alter dispatch order (and thus prices) in real time. The PROMOD model simulates system dispatch based on, and reflecting: (1) the operational characteristics and marginal production costs of every generating facility in the power region being studied (in this case, New England, New York, and PJM); (2) the configuration of and limits on transfers of power across the transmission system, comprising every transmission line and other system components in place; and (3) algorithms designed to reflect the operational constraints of power plants, such as the time it takes to start units and to ramp them up to various power levels, the minimum time they must be on, and the minimum time they must be off. Given the level of detail in how PROMOD represents the power system – that is, down to very small power plants and specific transmission system components and limits – it is able to simulate and produce power prices, unit output, emissions, costs to loads (*e.g.*, wholesale supply to consumers), producer revenues, and other factors. PROMOD calculates these metrics on an hour-by-hour basis, and with a high degree of geographic resolution (that is, down to a utility's service territory, or a specific substation).

Given this level of detail, we are able to model investments in EE and the development of new generation using RGGI funds at a detailed state- and utility-specific level. This allowed us to capture the impact of such investments on the wholesale prices that consumers pay – and that power producers are paid – on hourly and locational bases. As shown conceptually in Figure 5 above, we simulated the dispatch of the three regional power systems that contain the RGGI states for each hour of the modeling period (January 2015 through December 2027) for both the "with RGGI" and "no-RGGI" cases.[38] Based on the output of those two cases, we calculate changes in (1) unit dispatch, (2) wholesale electric prices, (3) payments to power producers, and (4) payments by consumers.

We used the PROMOD output and associated calculations of changes in generator and consumer prices, revenues, and payments in two ways. First, the data are used to describe the impacts on generators and consumers from the perspective of the electric system only – that is, how much more or less do power plant owners get paid as a result of RGGI program investment effects? How much more or less do consumers pay for electricity as a result of RGGI program investment effects? How does that differ by region? How do these electric system impacts change with time? The impact on power plant owners and consumers associated with the RGGI program – which is focused on the electric sector only – is an important consideration in program design and effectiveness.

Secondly, we use the output data from PROMOD as inputs to the IMPLAN model. From a macroeconomic perspective, the end result of changes in power-system costs, revenues, and payments are (a) changes in economic conditions for power plant owners (affecting their ability to spend and save in the general economy), and (b) changes in the level of disposable income enjoyed by consumers as a result of RGGI's impact on wholesale electricity prices which affects their spending

[38] See the Appendix for more information about PROMOD and the modeling area.

and saving in the general economy. Consequently, changes in these two factors serve as inputs to the general economic model (described below), along with other categories of RGGI program investment.

Macroeconomic Model

As previously noted, changes in power producer revenues and consumer incomes associated with electric-system impacts lead to these larger direct and indirect impacts in the economy as a whole. Other economic impacts also need to be taken into account: those related to the actual direct spending of RGGI auction proceeds by government agencies (and in turn, indirectly by the recipients of the RGGI-funded grants). Additionally, these other impacts result from the multiplier effects of these changes in consumer income and producer revenues and from the purchases of goods and services in the economy by those who receive RGGI-related spending from the states.

Consequently, in order to model macroeconomic impacts, we combine the changed revenues and spending that come from the PROMOD model with all categories of the direct investment of RGGI allowance revenues in the macroeconomic model, IMPLAN. IMPLAN is a social accounting/input-output model that attempts to replicate the structure and functioning of a specific economy (*e.g.*, a state or a country), and is widely used in public and private sector economic impact analyses. It estimates the effects on a regional economy of a change in economic activity by using baseline information capturing the relationships among businesses and consumers in the economy based on historical economic survey data that track flows of money through the economy. IMPLAN tracks dollars spent in a region, including dollars that circulate within it (*e.g.*, transfers of dollars from consumers to producers), dollars that flow into it (*e.g.*, purchases of goods and services from outside the local economy), and dollars that flow outside of it (*e.g.*, payments to the federal government). The model thus examines inflows, outflows, and interactions within the economy under study.

The IMPLAN model allows one to investigate interactions in the RGGI region and the individual states within it, and to calculate various economic impacts in that economy when a new activity (such as investments in EE or use of funds to support a state's general fund or assistance to help consumers pay their energy bills or lost revenues for owners of power plants) involves money flows around the economy. Specifically, the model captures various impacts, including:

- *Employment impacts* (the total number of jobs created or lost);
- *Income impacts* (the total change in income to employees that results from the economic activity); and
- *"Value-added" impacts* (the total economic value added to the economy, which reflects the gross economic output of the area less the cost of the inputs).

Although we report employment impacts of our analysis, we focus primarily on the "value-added" impacts produced by the model, reflecting the combination of the following economic effects of the change in money flow associated with RGGI:

- *Direct effects:* the initial set of inputs that are being introduced into the economy. In our study, these include the direct effects of RGGI on owners of power plants as a whole, on energy consumers (end users of electricity, natural gas and heating oil), and use of RGGI proceeds to buy goods and services in the economy (*e.g.*, investment in EE, work training programs, bill payment assistance for low-income consumers).

- *Indirect effects:* the new demand for local goods, services and jobs that result from the new activity. Examples include the spending on labor to retrofit buildings with EE measures, or to train workers in these skills. Some RGGI auction proceeds lead to payments for things to suppliers located outside the local region (*e.g.*, the purchase of efficient lighting equipment or solar panels manufactured outside of the RGGI region); IMPLAN traces those dollars that do not stay within the local economy when dollars are spent on RGGI-related activities.
- *Induced effects:* the increased spending of workers resulting from income earned from direct and indirect economic activity.

Modeling Factors

To calculate the impacts of RGGI, we needed to make a number of assumptions about the systems and economies that we are studying. These assumptions relate to: (1) the relevant boundaries (*e.g.*, geographic, temporal) of the analysis, (2) the methods for putting dollar flows occurring during different time periods into a common economic framework; (3) key modeling parameters in the power system; and so forth. We highlight a few of these below and explain them further in the Appendix.

Focus on Compliance Period 3

First, the analysis does not specifically control for any RGGI-funded investments in EE or supply before 2015 or after the program's third compliance period. For modeling purposes alone, and in order to isolate the incremental effects only of Compliance Period 3, we made no assumptions about RGGI continuing beyond 2017, nor did we attempt to isolate (and remove) the impacts of RGGI-related activity that occurred during the program's first six years. Further, we do not assume that there is a price on carbon through other regional, state, or federal legislation at any point during the modeling period (through half of 2027). Neither assumption should be interpreted as a judgment or expectation about the likelihood one way or the other of continued RGGI program implementation, or the emergence of a national carbon-pricing regime. Constructing the analysis in this way is specifically intended to allow for focus on the specific incremental impacts of RGGI implementation during Compliance Period 3, holding all else equal.

Timing of Economic Impacts that Affect the Power Sector

The focus on actual expenditures and impacts in only the third three years of program implementation, in combination with the application of a discount rate, ends up highlighting the fact that RGGI benefits lag behind RGGI costs. The costs show up in electric system impacts to wholesale prices immediately, during the first three years of the modeling period (*i.e.*, Compliance Period 3), while the benefits to a certain extent flow to consumers over the entire study period (starting at the beginning of 2015 and then through 2027). Conversely, the benefits flow to owners of power plants early on (when marginal power prices are higher), with outer-year effects diminishing those net positive revenues received during the three years of the third compliance period.

Indeed, there is a lag between the incurrence of costs in the "with RGGI" case and the timeframe in which installation of EE measures funded through RGGI allowance revenues begin to affect demand, supply, and prices in the outer years.

Representation of Energy Efficiency Programs

Given the various uses of RGGI funds for EE, there are two major analytic challenges in the PROMOD modeling effort: First, we needed to determine an assumed duration or lifetime for savings from particular measures (for example, for how long does installation of insulation continue to produce savings?). Second, we needed to develop a way to map annual energy and peak load savings onto estimates of impacts on load in every hour of the year.

In all of the RGGI states where EE programs are in place, there is substantial documentation of estimates of annual energy savings and, in some cases, contributions to reductions in peak loads. There is a long history of EE implementation and measurement and verification efforts to support engineering and statistical estimates of how the installation of a given EE measure actually translates into annual savings, distribution of savings across the hours of the year, and measure lifetimes. A number of entities summarize these figures, and we relied on these data to calculate the lifetime and load-impact characteristics of the various EE programs funded by RGGI dollars.[39]

As part of our AG 2011 Report of RGGI's first compliance period, we reviewed where available (and on a program-by-program and measure-by-measure basis) the estimates of measure lives developed by states and utilities and currently used in programs, based on the past few decades of experience in administering EE programs. We calculated weighted average measure life assumed by states and utilities across the range of measures, and found that virtually all programs have measure lives in excess of ten years; on average, measure lives were 12-13 years. In our modeling, we conservatively truncated measure savings at ten years. Consistent with that approach, we adopted the same ten-year measure life for our analysis of the third compliance period.[40] In some areas of the RGGI region, states have estimated how EE-related savings break down on a seasonal basis (summer or winter) and on a daily basis (on- or off-peak). We used the analysis done in our AG 2011 and 2015 Reports for the same purpose here, using information about specific programs and breakdowns of timing for when savings occurred.[41]

Using these characterizations of EE program impacts, we calculated hourly adjustments to load for each EE program, and in aggregate for all programs used these to adjust hourly load in the PROMOD model.

[39] Specifically, we relied on data from the Northeast Energy Efficiency Partnership's (NEEP) Regional Energy Efficiency Database (REED). (See http://www.neep.org/initiatives/emv-forum/regional-energy-efficiency-database)

[40] For this analysis, we confirmed this assumption using data from NEEP. We found that the weighted average measure life across all RGGI states in 2015 and 2016 was approximately 11 years.

[41] For this analysis, we confirmed this assumption using Energize Connecticut, "Connecticut Program Savings Document: 12th Edition for 2017 Program Years," October 31, 2016, page 313 (available at https://www.energizect.com/sites/default/files/2017%20CT%20Program%20Savings%20Document_Final.pdf).

4. RESULTS

Overview

Focusing exclusively on economic impacts of the RGGI program during Compliance Period 3, our report sheds considerable light on how the cap-and-trade program affects prices in electricity markets and in the economies of the participating states. As noted previously, the report does not address the many other objectives that underpinned the RGGI states' adoption of the program, or economic impacts that flow over time from reducing damages associated with climate change.[42]

The states implemented the RGGI program by distributing virtually all of the CO_2 allowances through quarterly auctions, with auction revenues distributed to states in accordance with the RGGI state budget allocation.[43] This approach had an important impact on program outcomes because it meant, in effect, that the public benefitted by transferring the value of allowances to the market at market prices (rather than for free, as was largely done in other SO_2 and NO_x allowance-trading programs). The public received the benefits associated with the allowance value, through the states' use of auction proceeds to pursue specific energy- and non-energy-related public policies, including providing an opportunity to both address some of the potential cost impacts of RGGI program implementation, and to pursue other key public policy objectives.

RGGI auctions for the Compliance Period 3 generated approximately $901 million. These auction revenues were distributed to (or held by) states in the following amounts:[44]

- $61.8 million for Connecticut
- $43.4 million for Delaware
- $32.2 million for Maine
- $182.7 million for Maryland
- $154.3 million for Massachusetts
- $50.6 million for New Hampshire
- $345.1 million for New York
- $23.9 million for Rhode Island
- $6.9 million for Vermont

(Figure 1 (above) shows the proceeds received in each year by the nine states in each of the three compliance periods.)

These dollars have three types of economic impacts:

[42] The RGGI States' MOU has a preamble that recognizes the common objectives of the states' own policies "to conserve, improve, and protect their natural resources and environment in order to enhance the health, safety, and welfare of their residents consistent with continued overall economic growth and to maintain a safe and reliable electric power supply system." The MOU also declares a common goal of the states of "reducing our dependence on imported fossil fuels will enhance the region's economy by augmenting the region's energy security and by retaining energy spending and investments in the region…" Additionally, the original RGGI MOU states that delay in addressing GHG emissions will make later investments in mitigation and adaptation more difficult and costly, and that a market-based carbon allowance-trading program will create strong incentives for the development of lower-emitting energy sources and energy efficiency. (MOU, pages 1-2).

[43] Where allowances were not distributed via auction, they were sold directly to affected sources, again retaining the value of the allowances sold for public purpose.

[44] Between 2015 and 2017, the RGGI states spent more on RGGI-related programs than the revenues collected during Compliance Period 3 auctions. The analysis presented in this study models the full amount of state spending on RGGI programs during this period.

1. *Impact on the general economy*. Our "bottom line" finding is that RGGI has produced positive results for the economies of the RGGI states. This finding reflects two primary contributing factors:
    - the direct investment of RGGI allowance auction proceeds in various economic activities); and
    - the *net* impact on two countervailing effects: net losses to power plant owners (in the form of lower revenues over time as a result of RGGI spending), and net gains to electricity consumers (in the form of lower electricity bills over time).

    These economic "value added" impacts flow from both the direct, indirect and induced effects of injecting RGGI dollars into various economic activities.

2. *Impact on the electric system.* Observable electric-sector impacts include overall changes to power plant owner revenue streams (from both increased costs for obtaining and using CO_2 allowances, and from changes in the price and quantity of power sales); and overall changes to payments by electric consumers for the purchase of electricity (resulting from lowering total electricity demand and from changes in market prices).

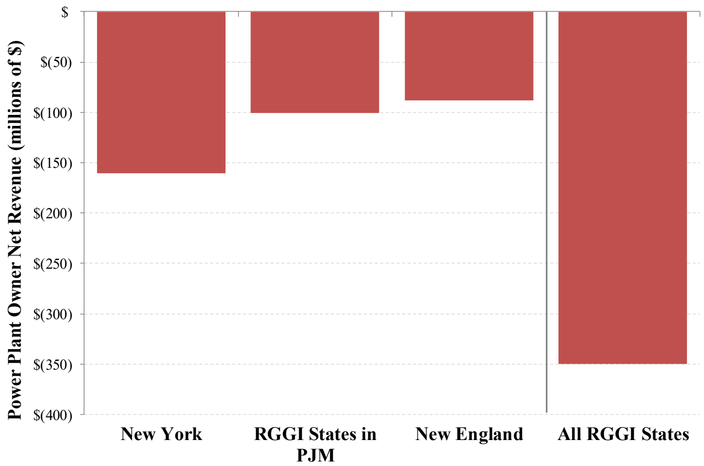
3. *Other effects.* These include changes in employment and payments for fuel that flow from the impacts of the use of RGGI allowance revenues in the electric system and the local economy.

Impacts on the RGGI States Combined

Impact on Electric Producers

From the perspective of the power generation sector, the RGGI program as implemented during the 2015-2017 period led to an overall drop in electric market revenues to owners of generating assets of just less than $350 million (on an NPV basis). Although owners of emitting power plants had to purchase CO_2 allowances, as a group they recovered all of their early expenditures during the 2015-2017 period; in the long run, however, RGGI-driven EE leads to lower sales of electricity than would otherwise occur without RGGI in place and this ends up eroding power plant owners' electric market revenues over time. The net impact to electric power plant owners as a group is summarized by region in Figure 6.

Figure 6
Net Revenue Change Across All Power Plant Owners, by Region, as a Result of RGGI Implementation During the 2015-2017 Period (NPV, 2018$)

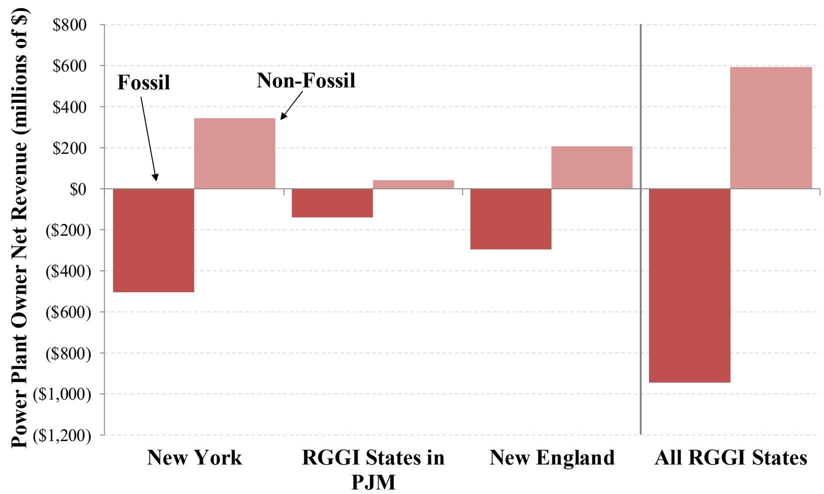


Notes: [1] Figures are reported in 2018 dollars (NPV), converted using a 3-percent discount rate. [2] Figures include PROMOD outputs and capacity market loss calculations calculated separately.

These impacts, however, are not distributed equally across power plant owners. RGGI affords a competitive advantage to power plants with CO_2 emissions lower than their competitors'. In the near term, while owners of emitting resources recover their costs to operate – including the cost of CO_2 allowances – the net effect of the program can reduce profits for owners of plants with relatively high carbon emissions (*e.g.*, coal-fired power plants).[45] On the other hand, owners of low- or zero-carbon generating sources (*e.g.*, nuclear, wind, solar, hydro) get the benefit of being paid higher market prices that reflect CO_2 allowance costs, without having to buy allowances. See Figure 7, which shows the breakdown by fuel type of changes in net revenues for power plant owners. As one would expect, carbon-emitting power plant owners generally lose revenue, while owners of nuclear and renewable resources gain during the three years of program implementation.

[45] Note that clearing prices in the three electrical regions we modeled reflect the opportunity cost of CO_2 allowances of the marginal generator in each hour. To the extent that an owner of a relatively high-emitting generating unit purchased an allowance at a higher cost than the opportunity cost of the marginal producer, and has a higher carbon intensity for a given unit of electricity produced, that owner may not fully recover its cost to purchase CO_2 allowances through energy-market revenues.

Figure 7
Net Revenue Change to Power Plant Owners (by Power-Plant Fuel Type and Electrical Region) as a Result of RGGI Implementation During the 2015-2017 Period (NPV, 2018$)

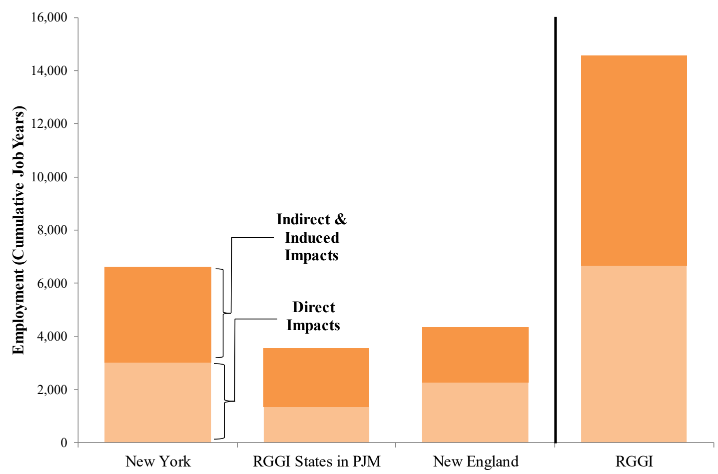


Notes: [1] Figures are reported in 2018 dollars (NPV), converted using a 3-percent discount rate. [2] Figures include PROMOD outputs and capacity market revenue changes calculated separately. [3] Fossil includes natural gas, oil, and coal fired generators. Non-fossil includes nuclear, hydro, pumped storage, wind, solar, and biomass.

Employment and Reduced Payments for Fossil Fuels

In addition to an economic benefit, the use of RGGI proceeds results in a positive employment impact through an increase of over 14,500 new job-years (see Figure 8), and reduced payments to out-of-region providers of fossil fuels by nearly $1.37 billion (NPV) as a result of RGGI's operations during Compliance Period 3.

Figure 8
Net Employment Impact to RGGI States as a Result of RGGI Implementation During the 2015-2017 Period (Cumulative Job Years)



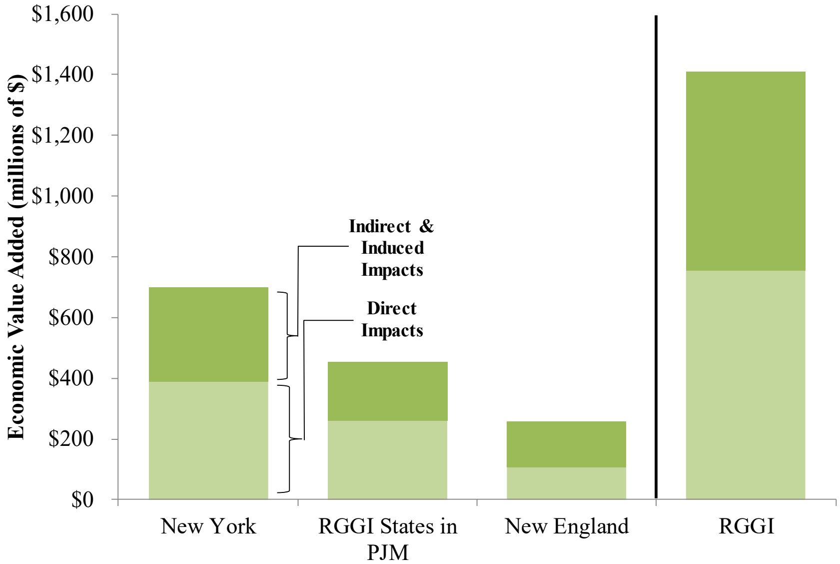
Note: Figures represent employment in terms of cumulative job-years over the study period.

Contributions to Economic Impact

As noted above, RGGI's third compliance period produced a net positive economic benefit of $1.4 billion ($NPV). As previously mentioned, this includes net electric sector impacts to electric consumers and power plant owners, in addition to the non-electric benefits and program spending that result from state spending of RGGI proceeds.[46] As these individual impacts ripple through the economy, they have the net effect of producing positive economic value.

This can be seen in Figure 9, which shows the direct, indirect, and induced economic impacts to the nine-state region from the individual components described above.

Figure 9
Net Economic Impact to RGGI States as a Result of RGGI Implementation During the 2015-2017 Period (NPV, 2018$)



Note: [1] Figures are reported in 2018 dollars (NPV), converted using a 3-percent discount rate. [2] Total economic value added includes the impacts of state spending of RGGI proceeds, including net electric sector impacts to consumers and power plant owners, non-electric benefits, and the economic impact of program spending.

[46] Note that analyzing the economic value added means that a dollar of direct spending does not translate into a direct effect of one dollar of value added. For example, if a dollar is spent in a state on light bulbs, the direct value added is only the net revenue and income of the retail store where the light bulb was purchased, thus excluding the manufacturing costs of the light bulb itself if it was manufactured outside the state. The same holds true for the direct revenue change to power plant owners. Direct electric consumer bill impacts are assumed to be equal to the value added to electric consumers given that any reduction in electric spending equates to a proportional increase in actual value to electric consumers.

5. OBSERVATIONS AND CONCLUSIONS

Based on these results as well as those in our prior assessments of the first two RGGI compliance periods, we have a number of observations that we summarize here. We hope that these provide useful information for the RGGI states as they consider how the program is performing relative to its original goals and for other states and stakeholders who are interested in carbon emission-control policies and programs.

As in its first six years, the RGGI program's third three-year compliance period continued to generate substantial economic benefits for the states while reducing CO_2 emissions.

Economic value added

Our analysis of RGGI impacts over the past three years took into consideration the program's effects on power system dispatch, costs to consumers, revenues to electric generators, and overall performance of the economies in the participating states. Even taking into account decreased revenues to the owners of emitting power plants (and to power-plant owners as a whole), we found positive macroeconomic impacts to the states due to the net benefits to electric consumers and the expenditures of the CO_2 allowance proceeds. RGGI led to approximately $1.4 billion in economic value added (NPV, 2018$) as a result of program implementation in the 2015-2017 period. Thus, the RGGI program continues to generate economic value for its member states.

Jobs

Taking into account the gains and losses to consumers and producers, RGGI Compliance Period 3 led to overall job increases amounting to thousands of new jobs over time. Some of the RGGI job impacts may be permanent, while others may be part-time or temporary. According to our analysis, the net effect is that RGGI activity during the 2015-2017 period leads to over 14,500 new job-years, cumulative over the study period, with each of the nine states experiencing net job-year additions. Jobs that result from RGGI-related expenditures occur in many parts of the economy, with examples including workers who perform efficiency audits and who install energy efficiency measures in residences and commercial buildings, and staff performing training on energy issues.

Fossil-fuel production and imports

Over the past three years, RGGI helped to lower the total number of dollars (by $1.37 billion (NPV, 2018$)) its member states sent outside their region in the form of payments for fossil fuels for power generation and other purposes. Most of the RGGI states' electricity comes from fossil fuels, even though these states produce little coal, natural gas, or oil. Because the RGGI program lowered these nine states' total fossil-fired power production and also reduced their use of natural gas and oil for heating, RGGI reduced the total dollars sent out of state for these energy resources.

Continuation of RGGI program benefits above and beyond the first six years

Our findings on economic impacts of RGGI's third three-year compliance period are consistent with the findings and observations we made with respect to the first and second three-year compliance periods. Those prior assessments revealed net economic benefits to the states participating in the program, including growth in economic output, increased jobs, reinvestment of energy dollars in local/state economic activity, long-run wholesale electricity cost reductions, and CO_2 emission reductions.

Many factors have changed in the electric industry and the economy since we completed our economic analyses of the RGGI program for Compliance Period 1 (2009-2011) and for Compliance Period 2 (2012-2014). These changes have affected the conditions (*e.g.*, lower gas prices, generation retirements and additions) analyzed in our assessment of Compliance Period 3.

For many reasons (such as the different vintages of each of our studies and notably the year in which we report NPV results), the results of our three studies are not directly additive. Even so, across the three studies, we have found net economic benefits to the RGGI states. Recognizing that these studies have reported outcomes in different-year dollar values, each of our assessments has found positive benefits for the participating RGGI states: $1.6 billion (NPV, 2011$), $1.3 billion (NPV, 2015$), and $1.4 billion (NPV, 2018$) for Compliance Periods 1, 2, and 3 respectively.[47] Our studies have also found that the RGGI-related expenditures led to job creation in each of the three compliance periods of approximately: 16,000 job-years (as of 2011); 14,200 job-years (as of 2015); and 14,500 (as of 2018), respectively.[48]

Thus our modeling of the three compliance periods indicates that, its first decade, RGGI's carbon cap-and-trade program has generated net positive economic value for the participating states' economies on the order of $4 billion dollars.[49] States' participation in RGGI has led to tens of thousands of job-years while also helping to reduce carbon emissions in the RGGI states' electric sector. At the same time, annual carbon-emissions have dropped nearly 50 percent since the program's start in 2009 (for many reasons, including implementation of RGGI).

RGGI's first nine years (2009-2017) provide empirical evidence that carbon-control programs for the power sector can provide positive economic outcomes.

Review of the nation's first multi-state CO_2 emission-control program provides useful information for states that are considering emission-reduction options.

Despite a recent lack of progress at the federal level, many state policymakers continue to focus their attention on the various alternatives for reducing emissions of CO_2 from the electricity sector (and other sectors). A wide range of alternatives are available including cap-and-trade programs, carbon tax/pricing approaches, energy research and development ("R&D") funding, consumer-funded procurements of low- and zero-carbon energy sources, rate policies supporting distributed-energy

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[47] In addition to our prior studies of the RGGI program, RGGI, Inc. and others have conducted studies of the economic impacts of the program. We discuss the differences in these studies later on in this report.

[48] These reflect "job-years," and do not identify what portion of these numbers are associated with permanent versus temporary jobs. Job-years are reported cumulatively over the full study period.

[49] As noted earlier, while the economic results from our three studies are not directly additive, we have used the same foundational analytic methods, assumptions, and data sources across all three studies in order to ensure consistency in study results. While changes in the assumptions used in our earlier studies – *e.g.*, to reflect current market conditions and expectations – could change the results (in either direction), we expect such changes would be small given the consistency in the level of allowance proceeds collected and used by the RGGI states and in the benefits we have found across our studies.

resource development, and funding of energy efficiency measures. The diverse set of policy options used reflects many states' interest in finding cost-effective and workable ways to cut CO_2 emissions. Lessons learned from RGGI's implementation can inform states as they consider their options.

The experience of the RGGI states, including their initial efforts that began in 2003 to work together to develop a multi-state, market-based CO_2 control program, through the nine years of program administration to date, provides a wealth of information. Their experience provides many lessons, most notably that states can collaborate successfully in developing programs to control CO_2 emissions, and market-based CO_2-allowance trading programs – combined with state-driven centralized auctions of CO_2 allowances and with local reinvestment of auction proceeds – can help states meet emission-reduction targets while generating positive economic benefits.

RGGI's positive impacts on state economies are additive to the purpose and expected benefits of the program.

RGGI is not and never was meant to be an economic development program. RGGI's purpose is to reduce CO_2 emissions from power generation in order to help mitigate the economic, social, and environmental risks of climate change. As shown in Figure ES-1, RGGI has contributed to significant reductions in emissions of CO_2 across the RGGI region. In our economic analysis of the RGGI program, however, we do not attempt to quantify the potential long-term benefits of reducing the risks of climate change. The focus of our analysis is specific and narrow: to review the direct impacts of program implementation on the economies of the RGGI states, in order to test the presumption that controlling emissions of CO_2 will somehow lead to negative consequences for states that take action. Our results – which instead reveal positive economic impacts – should be viewed as additive to whatever other benefits flow from reducing climate-change risks.

The RGGI model has successfully achieved CO_2 reductions through a cooperative multi-state framework that preserves state authority.

The states that comprise the RGGI region are highly diverse in many ways: their political settings and policy objectives vary widely across the states and have even changed significantly *within* states over time; their electric-generating portfolios differ substantially in size, technologies, fuel mix, and age; their economic bases vary; and the states have unique legal and regulatory structures that oversee energy, utility, and environmental policies. Despite these differences, however, the RGGI states' experience confirms the possibility that states can work together, particularly when doing so is likely to lower compliance costs and generate economic benefits. The states have designed a multi-state CO_2 program consistent with sound economic principles, completed the stakeholder, legislative, and regulatory steps necessary to adopt and implement the program, and smoothly administered the program and integrated it with wholesale electricity markets. In addition, over just ten years the states have completed two top-to-bottom programmatic reviews and agreed upon major changes to the framework. The RGGI states continue to implement the RGGI platform with an eye towards inclusion and a willingness to collaborate with other states outside the current nine-state region.

Mandatory, market-based carbon-control mechanisms are functioning properly in wholesale electricity markets and have not adversely affected system reliability.

RGGI's nine years of experience supports a conclusion that market-based CO_2 emission-control programs can produce positive economic impacts and meet emission objectives while dovetailing smoothly into the normal operation of power systems. RGGI's implementation has not adversely affected power system reliability in New England, New York, or PJM. Further, RGGI provides an important example of how states' public policies can be integrated into federally regulated competitive wholesale markets – an issue with which FERC, state regulators, and the courts are actively wrestling.

> The design of the CO_2 market in the RGGI states has allowed for the creative use of public assets in support of diverse state energy/environmental policy and economic outcomes.

The joint decision by the RGGI states to make their CO_2 allowances available to the market through a unified auction has generated substantial revenues for public use. This approach transferred the value of emissions allowances from the public sector to the private sector at a monetary cost. Had the allowances been given away for free, the states would not have had the benefit of the auction proceeds and instead would have transferred away significant public economic value to owners of power plants (which in the RGGI region are merchant generators, not owned by electric distribution utilities). The states' use of allowance proceeds helped them meet a wide variety of social, fiscal, and environmental policy goals, such as assisting low-income customers, achieving advanced energy policy goals, and restoring wetlands, among other things. Notably, however, auctioning of allowances is not necessary for the efficient and effective functioning of the cap-and-trade program design itself. Individual states may still determine their preferred method of moving allowances into the market, which could include auctions, direct allocation, and other mechanisms that may move allowances into the market while transferring or consigning auction value in whole or in part to other entities (such as electric distribution utilities or generating asset owners).

> How allowance proceeds are used affects their economic impacts: Use of auction proceeds to invest in energy efficiency produces the biggest economic bang per buck, in terms of net positive benefits to consumers and to the economy.

The RGGI Memorandum of Understanding ("MOU") fully supports the reality that states place different weights on various goals they hope to accomplish through participation in the program, and that the states will make their own decisions about how to allocate allowances to the market and how to use the proceeds from allowance auctions. But from a strictly economic perspective, some uses of proceeds clearly deliver economic returns more readily and substantially than others. For example, RGGI investment in EE leads to lower electrical demand, lower wholesale power prices, and lower consumer electricity bills. These savings remain in the pockets of electricity users, and the EE investments also produce positive macroeconomic impacts locally as more dollars stay in and contribute to the local economy. We observe that use of the RGGI dollars provides positive multiplier effects in the RGGI states' economies, especially compared to other uses of the auction proceeds.

The RGGI states' experience during 2015-2017 differed along a number of dimensions relative to the first six years of the program.

The RGGI program as implemented during the 2015-2017 period took place in the context of a changing industry and regulatory landscape and with significant changes adopted and implemented by RGGI states. Specifically:

- During 2017, the RGGI states used the six years of prior program experience as they undertook a top-to-bottom review of RGGI, and made a number of changes in the program.
- Many states adjusted how they spent RGGI auction proceeds over time, shifting the use of allowance revenues to reflect changing program and state objectives.
- Fossil fuel prices changed significantly since the start of the program, with natural gas prices (and in turn, wholesale electricity prices) having decreased substantially.
- Electric resources have shifted, with accelerated retirements of older and less efficient (and in most cases, higher-emitting) generating units, and with distributed and central-station renewable energy resources growing at a rapid pace in many of the RGGI states.

Such factors have the potential to influence the administration of RGGI and associated power system and economic impacts. For example, the lower average natural gas prices in 2015-2017 relative to the prior six years led to lower electricity prices in wholesale power markets, which had the effect of reducing the economic value of RGGI-funded EE programs for electricity and heating consumers. Also, the tightening of RGGI's CO_2 emissions cap contributed to an increase in allowance prices, the operating costs of affected generating units, and impacts on wholesale electric prices. The lower number of allowances available to the market, however, was in part offset by higher allowance prices, and thus only slightly reduced auction proceeds available to RGGI states during the 2015-2017 period.

Despite the shifting context for RGGI, the core elements of the program – including a declining CO_2 emissions cap, allowance auctions, reinvestment of auction proceeds, active trading of allowances, monitoring of program administration, participation and outcomes, and cooperation among a diverse set of states and stakeholders – operate in ways that continue to produce positive economic and programmatic results for the participating states.

APPENDIX

MODELING OF ELECTRIC SYSTEM IMPACTS:

PROMOD

Electric System Model Overview: PROMOD

The PROMOD Model

PROMOD is an electric market simulation model marketed by Ventyx. PROMOD provides a geographically and electrically detailed representation of the topology of the electric power system, including generation resources, transmission resources, and load. This detailed representation allows the model to capture the effect of transmission constraints on the ability to flow power from generators to load, and thus calculates Locational Marginal Prices ("LMPs") at individual nodes within the system. PROMOD and similar dispatch modeling programs are used to forecast electricity prices, understand transmission flows and constraints, and predict generation output. Ventyx simulation-ready data includes data on Eastern Interconnection network structure, resources, fuel prices, basis differentials, and demand.

To calculate the impacts of RGGI on power system operations and outcomes, we used PROMOD to simulate the "with RGGI" and "without RGGI" systems that serve the nine RGGI states,[1] with the difference between the two simulations being the direct incremental impacts of RGGI on the power system. These two simulation runs otherwise maintained the same inputs, in terms of fuel prices, power plants available to be dispatched, power plant operational characteristics, NO_x and SO_2 allowance costs, baseline load levels, and so forth. The "with RGGI" case was benchmarked to actual power system operations in the historical months of the 2015-2017 time period (in New England, New York, PJM). With this as a starting point, several core assumptions (*e.g.*, load levels that change as a result of energy efficiency investments, removal of renewable resources resulting from RGGI investments, removal of the cost of RGGI CO_2 allowances) were changed, and the model re-run to simulate the "without RGGI" case. As described further below, the simulation period is the historical 2015-2017 period, along with a 10-year tail period (through July of 2027) to capture the implications of energy efficiency programs implemented through use of RGGI allowance proceeds generated to date. PROMOD outputs include changes in power plant operations (*e.g.*, revenues, costs), emissions, and prices.

Fuel Prices in the Power Sector

Natural Gas

Natural gas prices are calculated as a Henry Hub base price plus a regional Hub basis differential. From January 2015 through March 2017, the Henry Hub price is based on Ventyx/PROMOD data. From April 2017 through January 2018, the Henry Hub price is a monthly average of historical daily NYMEX spot prices. From February 2018 through

[1] As described below, we simulated these systems (PJM, NYISO, ISO-NE) using a database that also includes Canada's system (which is interconnected to NY and ISO-NE) and Midwest ISO (which is interconnected to PJM).

March 2019, the Henry Hub price is based on NYMEX futures prices. From April 2019 through December 2027, the base Henry Hub NYMEX price is grown at the rate of change in the Energy Information Administration's (EIA's) Annual Energy Outlook (AEO) Henry Hub spot price.[2] To capture the delivered price of natural gas into the region of interest, we use the regional basis price differentials from PROMOD throughout the whole study period. These basis differentials may change based on assumed infrastructure improvements over time.

Other Fuels

Distillate oil and Residual oil prices are based on Ventyx fuel price forecasts. Coal prices are based on Ventyx unit-level fuel price forecasts.

Power Plants: Existing Units, Unit Retirements and Additions

The set of power plants is based on actual plants operating within eastern PJM, NYISO, ISO-NE, Ontario, and MISO. We made changes to this dataset (identical in the "with RGGI" and "without RGGI" runs) to reflect unit retirements and power plant additions (*e.g.*, to meet the states' renewable portfolio standards (RPS)). Unit retirement decisions are based on assumed retirements in the PROMOD generator dataset, which rely on information from Ventyx as of April 2017. Some of these retirements have been adjusted as the result of a review of planning documents published by PJM, NYISO, and ISO-NE, along with press releases. Unit additions listed in PROMOD's generator dataset have not been adjusted.

Renewables

RPS MWh targets by state are sourced from Lawrence Berkeley National Labs (LBNL) for PJM and NYISO and from the updated ISO-NE RPS Workbook for ISO-NE. In NYISO and ISO-NE, beginning in 2018, we add renewable capacity sufficient to meet 50 percent of the renewable target in each region and assume that the other 50 percent of each state's RPS target is met through alternative compliance payments rather than new renewable energy. In PJM, this assumption would result in growth far above the historic levels observed. Thus, in PJM we assume that growth in RPS eligible resources continues at the recent historic rate of development and that any target not met with RPS eligible generation is met with an alternative compliance payment. In NYISO and ISO-NE, the composition of incremental renewable capacity is based on the proportional distribution of renewable technology types in the current interconnection queues of each region while in PJM the composition of incremental renewable capacity is based on the proportion of additions in recent years. To determine the incremental capacity required to meet this energy demand, average historical

[2] In all cases where NYMEX data is grown at an AEO growth rate, the method is as follows:

- The growth rate used is the rate of change between two specific AEO annual data points, rather than the overall AEO growth rate for a particular fuel.
- The growth rate is applied to the data point for the same month in the prior year, rather than the immediately preceding month.

capacity factors by technology type and by region were obtained from the SNL Financial power plant database.

Generic Capacity Additions to Meet Resource Adequacy

After the incremental addition of renewable capacity and retirement of units as discussed above, we analyzed the extent to which each region's capacity satisfied forecasted resource adequacy requirements in each year, based on each region's capacity planning process. This review determined that additional resources were required in NYISO during each scenario, so new capacity was added based on generic natural gas combined cycle and gas turbine plants. The operating characteristics of these new plants are assumed to be the same as recently built natural gas generating units. The units were placed on the high-voltage transmission network in each region to maximize deliverability. Combined cycle and gas turbine plants were both added to the system.

Emissions costs

RGGI-Related CO_2 Allowance Prices

Prices for CO_2 allowances were modeled for each month in Compliance Period 3 using the most-recent quarter's actual CO_2 allowance price as revealed by auction clearing prices for auctions 27 through 38. No CO_2 price was assumed after December 2017, in light of the assumption that all needed CO_2 allowances had been purchased as of the 38th auction to cover CO_2 emissions during the second three-year compliance period.

NO_x and SO_2 Allowance Prices

NO_x and SO_2 allowance prices are based on Ventyx price forecasts.

Load Forecasts

RTO-level load forecasts are provided by Ventyx, and based on RTO planning documents. ISO-NE data is based on adjusted (*e.g.*, for EE, PDR, and PV) load from the 2017 CELT Report. NYISO data is based on adjusted load from the 2017 Gold Book. PJM data is based on adjusted load from the 2017 PJM Load Forecast Report.

Load Profiles

To account for the impact of energy efficiency savings on hourly load in the "without RGGI" case (*i.e.*, when load is increased to account for the removal of RGGI-funded EE programs), data on energy efficiency spending from each RGGI state were aggregated by program type. Total energy savings from each program type were divided proportionally to load, based on a typical hourly profile of energy savings resulting from each program type. From here, hourly state savings for each year were determined and modeled in each RGGI zone. Similarly, state spending on renewables was assumed to be for distributed solar PV, and converted to state load savings using LBNL average solar costs and SNL capacity factors. Total state load savings were proportionally assigned to constituent service areas based on native load in each area.

General Adjustments

Outages

Random generator outages are calculated once using PROMOD’s algorithm, and fixed between the “with RGGI” and “without RGGI” cases.

Generator Maintenance

Scheduled generator maintenance is fixed between the “with RGGI” and “without RGGI” cases to fulfill unit maintenance requirements.

MODELING OF MACROECONOMIC IMPACTS:

IMPLAN

Macroeconomic Model Overview: IMPLAN

Our analysis of macroeconomic impacts of RGGI uses the "IMPLAN" model. IMPLAN (which stands for "IMpact analysis for PLANning") is a social accounting/input-output ("I/O") model that attempts to replicate the structure and functioning of a specific economy.[3] IMPLAN is widely used for economic impact assessments in the public and private sectors.

Input/output models are based on long-standing, well-established and broadly accepted methodologies designed to estimate the impacts on a regional economy of a change in economic activity. Such models are based on a methodology established decades ago by economists for tracking the effects on changes in the inputs or outputs of an industry (or some other segments of an economy) as they ripple through the economy.

The broad conventional approach to examining these economic flows is to rely on national economic input-output account survey data. These data are based on census information collected from businesses that track the flows of dollars into and out of enterprises. The data make up the basis for the input/output tables that reflect the movement of dollars within an economy and the multiplier effects that reflect the role of dollars in influencing different multiplier effects in different segments of economies. The Bureau of Economic Analysis within the U.S. Department of Commerce collects information related to these relationships among different segments of regional economies. Over the years, these economic accounts are verified and serve as the basis for a wide variety of macroeconomic metrics (such as Gross Domestic Product, Gross State Product, and countless other economic variables). The IMPLAN databases used for the RGGI region (and the nine RGGI states individually) are rooted in these national economic account information sources.

The IMPLAN model allows one to investigate various interactions in a defined economy (in this case, the RGGI region and the individual states within it), and to calculate various economic impacts in that economy when a new activity affects money flows around the economy (such as investments in energy efficiency, assistance in helping customers pay their energy bills, lost revenues for owners of power plants, etc.).

IMPLAN relies on a detailed system of accounting for relationships among different parts of the economy, and relies on national economic data for the specified region. The model tracks dollars spent in a region, including dollars that circulate within it (*e.g.*, transfers of dollars from consumers to producers), dollars that flow into it (purchases of goods and services from outside the local economy), and dollars that flow outside of it (*e.g.*, payments to the federal government). The model thus examines inflows, outflows, and interactions within the economy under study.

Specifically, the model captures various effects, including:

[3] Information provided on IMPLAN's website, available at http://www.implan.com/. IMPLAN (now known as IMPLAN Pro) is a proprietary tool with accompanying data files for different regions which provides the ability to create complete, extremely detailed Social Accounting Matrices and Multiplier Models of local economies.

- *Employment effects* (the total number of job-years created or lost);
- *Income effects* (the total change in income to employees that results from the economic activity); and
- *"Value-added" effects* (the total economic value added to the economy, which reflects the gross economic output of the area less the cost of the inputs).

In our analysis, we focused on added value, since this is the overall measure of change in macroeconomic activity.

There are various ways in which the new activity creates impacts, each of which is separately tracked by the model:

- *Direct effects:* the initial set of inputs that are being introduced into the economy. In our study, this included the direct effects of RGGI on owners of power plants ("producers") as a whole, on energy "consumers" (consumers of electricity, natural gas and heating oil), and use of RGGI proceeds to buy goods and services in the economy (*e.g.*, investment in energy efficiency, work training programs, bill-payment assistance for low income consumers, etc.).
- *Indirect effects:* the new demand for local goods, services and jobs as a result of the new activity, such as the purchase of labor to retrofit buildings with energy efficient measures, or to train workers in these skills. Some RGGI auction proceeds may lead to payments for things outside the local region (*e.g.*, the purchase of efficient lighting equipment or solar panels manufactured outside of the RGGI region), and thus represents a way that such funds do not stay within the local economy after having been generated by power plant owners' purchases of CO_2 allowances.
- *Induced effects:* the increased spending of workers resulting from income earned from direct and indirect economic activity.

Direct effects are determined by an "Event" as defined by the user (*i.e.*, a $10 million dollar purchase of worker training is a $10 million dollar direct effect; a $10 million dollar contribution to clean energy R&D is a different $10 million dollar direct event).[4] The indirect effects are determined by the amount of the direct effect spent within the study region on supplies, services, labor and taxes. Finally, the induced effect measures the money that is re-spent in the study area as a result of spending from the indirect effect. Each of these steps recognizes an important leakage from the economic study region spent on purchases outside of the defined area. Eventually these leakages will stop the cycle.

[4] Note that analyzing the economic value added means that a dollar of direct spending does not translate into a direct effect of one dollar of value added. For example, if a dollar is spent in region on light bulbs, the direct value added is only the net revenue and income of the retail store where the light bulb was purchased, thus excluding the manufacturing costs of the light bulb itself.

More specifically, the effects are:

- *Direct effects* - The set of expenditures applied to the predictive model (*i.e.*, I/O multipliers) for impact analysis. It is a series of (or single) production changes or expenditures made by producers/consumers as a result of an activity or policy. These initial changes are determined to be a result of this activity or policy. Applying these initial changes to the multipliers in an IMPLAN model will then display how the region will respond, economically, to these initial changes.
- *Indirect effects* - The impact of local industries buying goods and services from other local industries. The cycle of spending works its way backward through the supply chain until all money leaks from the local economy, either through imports or by payments to value added.
- *Induced effects* - The response by an economy to an initial change (direct effect) that occurs through re-spending of income received by a component of value added. IMPLAN's default multiplier recognizes that labor income (employee compensation and proprietor income components of value added) is not a leakage out of the regional economy. This money is recirculated through the household spending patterns causing further local economic activity.

State Economic Database

Our IMPLAN analysis of the RGGI states was based on the most recent state data files (2016) for each of the nine states, as available from IMPLAN. These state-level data files include information for a set of highly disaggregated industries, sorted generally by their 4 and 5 digit NAICS codes.[5]

IMPLAN data files are compiled from a wide variety of sources including the U.S. Bureau of Economic Analysis, the U.S. Bureau of Labor, and the U.S. Census.[6] They include information about regional employment, income, value-added, household and government consumption. Examples include: employee compensation; proprietary income; federal, state and local taxes affecting income, sales, real estate, and so forth; personal consumption expenditures at nine income levels; federal government purchases (military and non-military) and investments; purchases by local and state governments (including educational institutions); inventory purchases; capital formation; foreign exports; and inter-institutional transfers. They also include unique national input-output structural matrices and unique annual trade flow models.

[5] NAICS codes are tied to the North American Industry Classification System, which is the standard used by Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy.

[6] The IMPLAN data files use federal government data sources including the following federal programs: Bureau of Economic Analysis Benchmark I/O Accounts of the US and Output Estimates; Bureau of Labor Statistics Covered Employment and Wages (ES202) Program and Consumer Expenditure Survey; Census Bureau County Business Patterns, Decennial Census and Population Surveys, Censuses and Surveys; Department of Agriculture Crop and Livestock Statistics; and US Geological Survey.

Expenditure Categories Used in IMPLAN Modeling

In our IMPLAN analysis, we assigned RGGI expenditures into a variety of IMPLAN sector categories, based on assumptions about the character of the economic activity tied to each particular category of RGGI programs.

For example, expenditures on energy efficiency were modeled mainly as either residential (construction of new single- or multi-family structures, or maintenance and repair of residential structures) or commercial/industrial (construction of new commercial structures or maintenance and repair of non-residential structures). Other non-energy efficiency examples include RGGI-related expenditures on: education and outreach programs (modeled as other educational services); electric consumer bill changes and direct bill assistance (modeled based on IMPLAN defined demand for electricity in a particular state); revenue changes to power plant owners (modeled as electric power generation); administration (modeled as other administrative services); and renewable generation development (modeled as construction of new power and communication structures).

DISCOUNT RATE

Discount Rate Overview

Our analysis involves the assessment of costs (*e.g.*, expenditures and investments, decreases in revenues) and benefits (*e.g.*, lower electricity bills for consumers, added value in the economy) that occur in different periods of time. We examine the flow of dollars associated with the purchase of CO_2 emissions allowances in the RGGI auctions that took place in 2015 through 2017, the impact of these allowances in electricity prices during this time period, and the impact of RGGI-funded programs on electric system outcomes and the macro-economy from 2015-2027. Thus the study period, in one way or another, spans from 2015 to 2027.

To compare these benefits and costs properly, we discount all dollar flows into net present values as of 2018. We calculate the net present value by applying an appropriate discount rate to dollar flows in different years, and then subtracting the sum total of discounted costs from the sum total of discounted benefits.

The discount rate is the tool that accounts for the time value of money – the concept that a dollar today is typically worth more than the same amount of money in the future because of the opportunity cost of money. A dollar today could be put into an investment or an interest-bearing activity that will typically cause it to grow in value, so that dollar today is worth more to its holder than a dollar received in the future. Further, inflation diminishes the purchasing power of dollars over time. And uncertainty about future economic outcomes, combined with a preference for nearer-term gratification, typically causes a dollar in hand today to be worth more than one tomorrow. The higher the discount rate, the lower is the present value of future cash flows.

Our analysis required choosing an appropriate discount rate. Our analysis reflects dollars in the hands of producers, who are largely private enterprises, and consumers, made up of households, businesses, government energy users, and others. RGGI-funded activities add value to the macro-economy of a wide range of actors in the nine RGGI states in the Northeastern and Mid-Atlantic region. The choice of an appropriate discount rate needs to properly reflect the opportunity costs of these various private and public entities in society.

There is a deep literature on the proper discount rate to use in analyzing certain public policies or activities involving society rather than particular producers or consumers.

- **A private discount rate** is used when analyzing the investment options of private enterprises. The appropriate private discount rate varies, depending upon whether the economic analysis focuses on a single company (where that company's weighted average cost of capital would be appropriate) versus a group of companies (where the appropriate discount rate would reflect their collective opportunity costs).

- **A different discount rate** may be appropriate for use by government agencies when they analyze investments, when consumers look at their economic options, or when evaluating the rate at which society as a whole is willing to trade off present for future benefits.

- **Government discount rate**: For example, in 1992, the federal government's Office of Management and Budget issued OMB Circular No. A-94, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs." This document established guidance for discount rates used in benefit-cost and other types of economic analysis by federal agencies, with updates on certain discount rates to use when the interest rate and inflation assumptions in the budget are changed. Because "public investments and regulations displace both private investment and consumption," OMB's recommended discount rate for public investments was a real discount rate of 7 percent, which "approximates the marginal pretax rate of return on an average investment in the private sector in recent years."[7] Various analyses that involve "internal government investments" with effects on increased government revenues or decreased government costs (like "an investment in an energy-efficient building system that reduces Federal operating costs") should use a discount rate reflecting a Treasury bond with a comparable maturity to the investment. But where a government activity provides "a mix of both Federal cost savings and external social benefits," where possible the "Federal cost savings and their associated investment costs may be discounted at the Treasury rate, while the external social benefits and their associated investment costs should be discounted at the 7 percent real rate." At the time the circular was written in 1992, a 10-year Treasury was 7 percent nominal and 3.6 percent real. Over the last decade, these Treasury rates on average were 2.9 percent nominal and 1.0 percent real.[8]

- **Consumption discount rate:** Real-world conditions create differences between opportunity costs of consumers relative to private actors and governments: "Among other things, private sector returns are taxed (often at multiple levels), capital markets are not perfect, and capital investments often involve risks reflected in market interest rates. These factors drive a wedge between the *social rate* at which consumption can be traded through time (the pre-tax rate of return to private investments) and the rate at which *individuals* can trade consumption over time (the post-tax consumption rate of interest). …[For example:] …Suppose the market rate of interest, net of inflation, is 5%, and that taxes on capital income amount to 40 percent of the net return. In this case, private investments will yield 5%, of which 2% is paid in taxes to the government, with individuals receiving the remaining 3%. From a social perspective, consumption can be traded from the present to the future at a rate of 5%. But individuals effectively trade consumption through time at a rate of 3% because they owe taxes on investment earnings. As a result, the

[7] OMB Circular No. A-94 (1992), "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs." See http://www.whitehouse.gov/omb/circulars_a094/.

[8] OMB Budget Assumptions – Nominal and Real Treasury Interest Rates for Different Maturities (from the annual budget assumptions for the first year of the budget forecast), November 27, 2017. See https://www.whitehouse.gov/wp-content/uploads/2017/11/DISCHIST-2018-1.pdf.

consumption rate of interest is 3%, which is substantially less than the 5% social rate of return on private sector investments (also known as the social opportunity cost of private capital)."[9]

- **Social discount rate**: "Social discounting… is discounting from the broad society-as-a-whole point of view that is embodied in benefit-cost analysis (BCA). *Private discounting*, on the other hand, is discounting from the specific, limited perspective of private individuals or firms. Implementing this distinction can be complex… using a given private discount rate instead of a social discount rate can bias results as part of a BCA."[10]

Recent guidance provided by the U.S. Environmental Protection Agency makes the following recommendations for discount rates to use in analyzing programs that involve flows to various entities in society over different periods of time, especially when "there is a significant difference in the timing of costs and benefits, such as with policies that require large initial outlays or that have long delays before benefits are realized."[11]

> "Calculate the NPV using the consumption rate of interest. This is appropriate for situations where all costs and benefits occur as changes in consumption flows rather than changes in capital stocks, *i.e.*, capital displacement effects are negligible. As of the date of this publication, current estimates of the consumption rate of interest, based on recent returns to Government-backed securities, are close to 3%. Also calculate the NPV using the rate of return to private capital. This is appropriate for situations where all costs and benefits occur as changes in capital stocks rather than consumption flows. The Office of Management and Budget estimates a rate of 7% for the opportunity cost of private capital."[12]

For these various reasons, we used a 3 percent ("public" or "social") discount rate in our analysis.

[9] US Environmental Protection Agency (National Center for Environmental Economics, Office of Policy), "Guidelines for Preparing Economic Analyses," EPA 240-R-10-001, December 17, 2010 (updated May 2014)" ("EPA Guidelines"), page 6-6.

[10] EPA Guidelines, page 6-1.

[11] EPA Guidelines, page 6-4.

[12] EPA Guidelines, page 6-19.