RGGI's Economic Benefits for Pennsylvania

Exploring the benefits of the Regional Greenhouse Gas Initiative

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AUTHORS

Jason Frost
Pat Knight
Selma Sharaf
Lucy Metz
Shelley Kwok

Synapse Energy Economics, Inc.

485 Massachusetts Avenue, Suite 3
Cambridge, Massachusetts 02139

617.661.3248 | www.synapse-energy.com

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EXECUTIVE SUMMARY

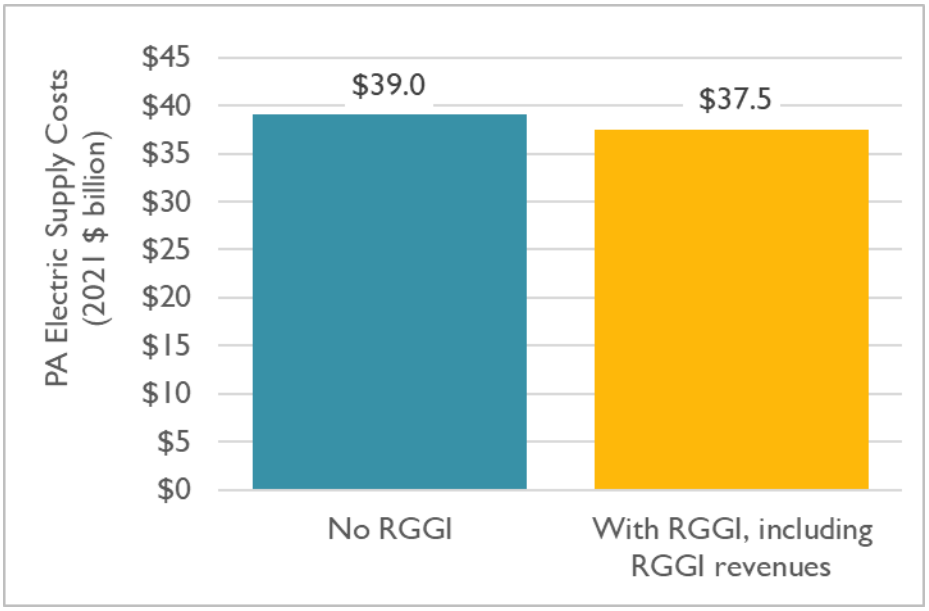
Pennsylvania is poised to decarbonize its power sector. Commonwealth climate goals, falling renewable costs, and federal tax incentives from the Inflation Reduction Act (IRA) have positioned Pennsylvania to make significant progress in accelerating its transition to clean energy. Implementing the commonwealth's Regional Greenhouse Gas Initiative (RGGI) regulation effectively will allow the Pennsylvania to take full advantage of this opportunity. RGGI is a multi-state program aimed at curbing greenhouse gas emissions from power plants and raising revenue for clean energy programs. By implementing RGGI, Pennsylvania stands for its residents to benefit from billions of dollars in consumer benefits.[1] This strategy will help bring the commonwealth in line to meet Governor Josh Shapiro's goals of achieving 30 percent renewable electricity by 2030 and net-zero emissions in Pennsylvania by 2050.[2]

Evergreen Collaborative hired Synapse Energy Economics, Inc. (Synapse) to perform an economic evaluation of Pennsylvania's potential participation in RGGI, as well as other policies designed to bolster a transition to clean energy, including an increase to Pennsylvania's Alternative Energy Portfolio Standard (AEPS) or a transition to a Clean Electricity Standard (CES). Synapse is releasing early findings from its analysis of the Regional Greenhouse Gas Initiative due to the ongoing and accelerated deliberations taking place regarding Pennsylvania's membership in RGGI. The expanded analysis will be released in the coming months and will include more information regarding the public health benefits and projected reductions in carbon emissions associated with both RGGI and an increased AEPS or CES. Using a state-of-the-art power-sector model, in conjunction with other modeling tools, we performed a detailed evaluation of electric grid operation and system costs, and estimated what impacts these changes would have in terms of customer bills, public health benefits, federal funding opportunities, and other benefits. We find that Pennsylvania ratepayers stand to realize $1.5 billion in statewide electric *savings* between 2025 and 2030 through participation in RGGI, in addition to the significant benefits they will gain from improved air quality, access to federal funding, and increased investment in a clean energy economy (see Figure 1). Further, because Pennsylvania participates in the regional PJM market, the energy and capacity prices experienced by Pennsylvania ratepayers are already impacted by neighboring states' participation in RGGI.

[1] On April 23, 2022, the commonwealth's RGGI regulations were published in the *Pennsylvania Bulletin*, thereby establishing Pennsylvania as a RGGI member and empowering it to fully participate in the program. Those regulations have been challenged in court and were subsequently stayed through a preliminary injunction. If the commonwealth prevails upon the resolution of that litigation, the rule would immediately become in force again. For more, see https://www.pacodeandbulletin.gov/Display/pabull?file=/secure/pabulletin/data/vol52/52-17/625.html.

[2] "Tracking Pennsylvania Gov. Josh Shapiro's biggest campaign promises." *The Philadelphia Inquirer*. Updated February 11, 2023. Available at https://www.inquirer.com/politics/pennsylvania/spl/pennsylvania-shapiro-environment-justice-economy-elections-20230211.html.

Figure 1. Change in total cumulative electricity supply costs, 2025–2030



We find:

- **RGGI saves Pennsylvanians $1.5 billion in energy costs between 2025 and 2030.** Pennsylvania's participation in RGGI would provide an estimated $1.5 billion in net statewide savings on energy costs after accounting for all the impacts associated with RGGI participation. Modeled benefits resulting from RGGI revenues include $1.7 billion for residential programs, $190 million for commercial and industrial programs, and $1 billion in funding for clean transportation; research and development; and municipal, commonwealth, and community programs. These benefits more than offset impacts on wholesale electricity prices.

- **RGGI decreases residential electricity bills.** We estimate the total financial impact of RGGI participation to the average residential customer is a net ***decrease*** in electricity costs of $2 per month, or $24 annually. RGGI impacts bills through (1) wholesale power prices and (2) generating revenue that funds programs that then lower energy costs. Before accounting for the benefits of RGGI, RGGI's impact on wholesale electric prices puts slight upward pressure on electric rates. This impact is limited because (1) Pennsylvania rates are already being impacted by neighboring states' participation in RGGI and (2) the delivery component of electricity rates—which makes up half of the monthly price—does not change as a result of Pennsylvania's participation in RGGI. Impacts to wholesale power prices are more than offset by RGGI revenues that can go toward consumer benefits, such as incentives for efficiency and clean energy. By participating in RGGI, Pennsylvania stands to collect $3.2 billion in RGGI revenues from 2025 to 2030 that can fund beneficial programs for Pennsylvania residents and provide a net reduction in electricity-related expenditures.

- **RGGI rate impacts are minimal relative to fossil fuel-driven price volatility.** From 2021 to 2022, residential electricity rates in Pennsylvania increased by 9 percent due in part to volatile natural gas prices. This is six times larger than the projected impact of RGGI on residential rates in our analysis.

- **Participation in RGGI brings $930 million of additional federal funding through IRA tax credits that would not come to Pennsylvania if policymakers withdraw from the compact.** RGGI makes renewable energy more competitive relative to fossil fuels because renewables do not produce emissions and thus do not need to purchase allowances. Greater renewable deployment brings in more federal tax credits from the IRA to reduce the costs of solar, wind, and battery storage projects. These tax credits can help power local economies and fund clean energy jobs while keeping consumer energy costs low.

Overall, Pennsylvania participation in RGGI would provide an estimated $1.5 billion in statewide electricity savings and a *decrease* in residential electricity costs of $2 per month.

1. BACKGROUND

Pennsylvania's RGGI program will help the commonwealth maintain its position as a leading U.S. energy producer. Pennsylvania currently exports the most electricity of any state, but it also has the third-highest power sector emissions. [3,4] In 2021, Pennsylvania generated 65 percent of its electricity from fossil fuels.[5] To meet Governor Shapiro's goals of 30 percent renewable electricity by 2030 and net-zero emissions for Pennsylvania by 2050, the commonwealth will need to build out zero-emissions electricity capacity rapidly.[6] This will also be essential for maintaining regional competitiveness, since many of the states to which Pennsylvania exports electricity have ambitious climate goals: Maryland is aiming to reach net zero emissions by 2045, New York must achieve net zero by 2050, and New Jersey targets 100 percent clean energy by 2035.[7,8,9]

Technological innovation has dramatically lowered costs for wind, solar, and storage in recent years.[10,11] The 2022 *Inflation Reduction Act* (IRA) further increased the cost-effectiveness of renewable electricity by making hundreds of billions of dollars of funding available from the federal government for clean energy projects. Pennsylvania can use these federal funds to catalyze clean energy expansion, especially since many parts of the commonwealth are likely to qualify as energy communities and so will be eligible for tax credit bonuses.[12] Projects can qualify for energy community tax credit bonuses if they are built on a brownfield, in regions with a certain amount of fossil fuel employment and higher than average unemployment, or near recently closed coal mines or coal plants.

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[3] U.S. Energy Information Administration. 2022. "State Energy Data System consolidated data file 1960-2020." Available at: https://www.eia.gov/state/seds/seds-data-complete.php?sid=US#CompleteDataFile

[4] U.S. Energy Information Administration. 2022. "Table 3: State energy-related carbon dioxide emissions by sector." Available at: https://www.eia.gov/environment/emissions/state/.

[5] U.S. Energy Information Administration. 2022. "Pennsylvania Electricity Profile 2021: Full Tables 1--17." Available at: https://www.eia.gov/electricity/state/pennsylvania/.

[6] Pennsylvania Department of Environmental Protection. 2021. Pennsylvania Climate Action Plan. Available at: https://www.dep.pa.gov/Citizens/climate/Pages/PA-Climate-Action-Plan.aspx.

[7] Climate Solutions Now Act of 2022. Article II, Section 17(b) of the Maryland Constitution - Chapter 38. (2022) Available at: https://mgaleg.maryland.gov/mgawebsite/Legislation/Details/sb0528?ys=2022RS.

[8] New York Climate Action Council 2022. Scoping Plan. Available at: https://climate.ny.gov/resources/scoping-plan/.

[9] Governor's Office of the State of New Jersey. 2023. Executive Order No. 315. Available at: https://nj.gov/infobank/eo/056murphy/pdf/EO-315.pdf.

[10] Lazard. 2023. "Lazard's Levelized Cost of Energy Analysis—Version 16.0." Available at: https://www.lazard.com/research-insights/2023-levelized-cost-of-energyplus/.

[11] U.S. Energy Information Administration. 2021. "Battery Storage in the United States: An Update on Market Trends." Available at: https://www.eia.gov/analysis/studies/electricity/batterystorage/.

[12] U.S. Department of Energy. 2023. "Mapping Tool: Energy Community Tax Credit Bonus." Available at: https://arcgis.netl.doe.gov/portal/apps/experiencebuilder/experience/?id=a2ce47d4721a477a8701bd0e08495e1d.

Commonwealth climate goals, falling renewable costs, and IRA incentives mean that Pennsylvania is poised to decarbonize its power sector. The Regional Greenhouse Gas Initiative (RGGI) is one key policy available to ensure that the commonwealth takes full advantage of this opportunity.[13]

1.1. What is the Regional Greenhouse Gas Initiative?

RGGI is a power sector cap-and-trade program that currently includes Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, and Virginia (Figure 2). Pennsylvania started the process of linking with RGGI in 2019 and finalized its regulations to participate in the program in April 2022. The outcome of legal challenges will determine Pennsylvania's future as a participant in RGGI.[14]

RGGI sets a declining cap on carbon dioxide (CO_2) emissions from all electric generators with capacity of 25 megawatts (MW) or greater. [15] The first emissions cap went into effect in 2009, and the program currently extends through 2030. Affected generators purchase allowances through regional auctions. Revenue then returns to the states, which reinvest it in a variety of energy efficiency, clean energy, and bill reduction programs. It is in the distribution of this returned revenue that states are seeing some of the greatest impacts from RGGI—though Pennsylvania has yet to determine how it would disburse that revenue.

Since the start of the RGGI program, each dollar of auction revenue has created almost four dollars of consumer energy bill savings on average.

Since the start of the program, each dollar of auction revenue in RGGI states has created almost four dollars of consumer energy bill savings on average.[16] An independent study in 2023 concluded that from 2018 to 2020, participating RGGI states gained $669 million in net economic benefits.[17] 2020 investments alone had a lifetime benefit of $2.0 billion in energy bill savings and 6.7 million short tons of CO_2 avoided.[18]

[13] For more on this debate, see Burtraw, D. et al. "The Prospects for Pennsylvania as a RGGI Member." Resource for the Future and Kleinman Center for Energy Policy at UPenn. May 2023. Available at https://kleinmanenergy.upenn.edu/wp-content/uploads/2023/05/Report-23-04.pdf.

[14] Executive Order 2019-07. "Commonwealth Leadership in Addressing Climate Change through Electric Sector Emissions Reductions." Available at: https://www.oa.pa.gov/Policies/eo/Documents/2019-07.pdf.

[15] The Regional Greenhouse Gas Initiative. 2023. "Elements of RGGI." Available at: https://www.rggi.org/program-overview-and-design/elements.

[16] The Regional Greenhouse Gas Initiative. 2022. The Investment of RGGI Proceeds in 2020. Pages 14–15. Available at: https://www.rggi.org/sites/default/files/Uploads/Proceeds/RGGI_Proceeds_Report_2020.pdf.

[17] Analysis Group. 2023. *The Economic Impacts of the Regional Greenhouse Gas Initiative on Ten Northeast and Mid-Atlantic States*. Available at https://www.analysisgroup.com/globalassets/insights/publishing/2023-ag-rggi-report.pdf.

[18] The Regional Greenhouse Gas Initiative. 2022. The Investment of RGGI Proceeds in 2020. Page 7. Available at: https://www.rggi.org/sites/default/files/Uploads/Proceeds/RGGI_Proceeds_Report_2020.pdf.

Figure 2. Map of current RGGI states (light green) and Pennsylvania (dark green)

One key factor for stakeholders to evaluate about RGGI is the impact the program would have on electricity bills in the commonwealth. When generators participate in cap-and-trade programs, the purchase of allowances tends to increase the price that they bid in energy markets, which puts upward pressure on the wholesale price of electric energy. However, power plants in the RGGI states also receive revenue through capacity markets. Because of the way capacity market prices are set, increases in energy market prices may be offset by decreases in capacity market prices. In essence, if power plants can recover more of their costs from the energy market, it may mean that they can rely less on the capacity market for revenues.

In addition, increases in wholesale energy market prices have limited impact on electric bills overall because energy costs represent just one component of electricity bills; the other two primary components (capacity and delivery costs) are either unaffected by a state's participation in RGGI, or are reduced by a state's participation in RGGI. So, for example, a one percent increase in wholesale energy market prices does not result in a one percent increase in the price that customers pay on a monthly basis. Further, because Pennsylvania participates in the regional PJM market, the energy and capacity prices experienced by Pennsylvania ratepayers are already impacted by neighboring states' participation in RGGI. In other words, Pennsylvania consumers are already paying the cost for RGGI but are not experiencing the benefits in terms of collected revenues.

Finally, in contrast with costs for fossil fuels, costs for RGGI allowances have limited volatility. RGGI auctions are structured to moderate allowance prices and avoid volatility, using two price stabilization mechanisms to help keep prices within a predetermined range. The cost containment reserve (CCR) releases additional allowances when the allowance price exceeds the trigger price. The emissions containment reserve (ECR) removes allowances from the cap when the allowance price drops below the trigger price.

2. METHODOLOGY

We modeled two core scenarios, each describing a different future for Pennsylvania:

- In the **No RGGI** scenario, we assume that Pennsylvania is not a part of RGGI.
- Conversely, in the **With RGGI** scenario, Pennsylvania is modeled as participating in RGGI auctions beginning in 2023.

By comparing the outputs in each scenario, we can estimate the benefits and costs associated with Pennsylvania's pending participation in RGGI.

For all scenarios, we performed detailed electric-sector analysis of the PJM, NYISO, and ISO New England balancing authorities from 2021 through 2030. We accounted for the IRA, passed in 2022, which offers expanded tax credits for renewable projects.[19] The EnCompass National Database provided information about whether each project would be most likely to adopt the Production Tax Credit (PTC) or the Investment Tax Credit (ITC). The PTC is generally favorable for solar and onshore wind projects, while offshore wind and battery projects generally choose the ITC. The IRA offers additional, stackable 10 percent tax credit bonuses for projects that meet specified domestic content requirements or are located in areas designated as energy communities. We anticipated that all wind projects will qualify for the domestic content adder based on current manufacturing trends.[20,21] As final energy community designations had not been released when we conducted this modeling, we applied the energy community adder within certain PJM zones based on external analysis.[22,23]

We also performed a gas price shock sensitivity analysis using 2030 as a test year for higher gas prices. To model this sensitivity, we replaced the U.S. Energy Information Administration (EIA) Annual Energy Outlook (AEO) 2023 Reference case with the Low Oil and Gas Supply case in 2030.[24]

In addition to the IRA, we modeled several other applicable environmental policies, including RGGI as it currently exists as well as state Renewable Portfolio Standard (RPS) policies and their regional impacts.

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[19] H.R.5376 – Inflation Reduction Act of 2022. Public Law No: 117-169 (08/16/2022).

[20] Stehly, T., Beiter, P., Duffy, P. 2020. 2019 Cost of Wind Energy Review: 7-8. National Renewable Energy Laboratory. Available at: https://www.nrel.gov/docs/fy21osti/78471.pdf.

[21] Lawrence Berkeley National Laboratory. 2022. Land-Based Wind Market Report: 2022 Edition: 18, 20-21. Prepared for U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy. Available at: https://www.energy.gov/sites/default/files/2022-08/land_based_wind_market_report_2202.pdf.

[22] Raimi, D., Pesek, S. 2022. "What Is an 'Energy Community'?" Resources. September 7. Available at: https://www.resources.org/common-resources/what-is-an-energy-community/.

[23] American Clean Power Association. 2022. "IRA Energy Communities". August 23. Available at: https://storymaps.arcgis.com/stories/844bd085378b4c1c9da9bf1081d5bb66.

[24] U.S. Energy Information Administration. 2023 Annual Energy Outlook. Available at: https://www.eia.gov/outlooks/aeo/.

This analysis does not include any consideration of U.S. EPA's Section 111 *Greenhouse Gas Standards and Guidelines for Fossil Fuel-Fired Power Plants*, which were issued after we completed the analysis.[25]

For details about key inputs and assumptions, see *Appendix A. Key scenario inputs*.

2.1. Modeling toolkit

We employed three modeling steps for estimating the cost, emissions, and health impacts associated with Pennsylvania's participation in RGGI.

Power sector modeling

Synapse conducted power sector modeling using EnCompass, a state-of-the-art electric capacity expansion and production cost model. Developed by Anchor Power Solutions, EnCompass is a fully integrated power system platform that allows for utility-scale generation planning and operations analysis. EnCompass is widely used by utilities across the country for IRP planning.[26] Synapse populated the model with the EnCompass National Database, created by Horizons Energy, and supplemented this dataset with publicly available information to provide further detail on power plant characteristics, resource costs, and fuel prices. Our EnCompass modeling produced outputs related to generation, capacity, emissions, system costs, and RGGI prices, based on least-cost optimization.

Rate and bill impacts

We conducted a rate and bill impact analysis using a combination of historical data and EnCompass modeling results to quantify the impacts of each scenario on Pennsylvania ratepayers. Synapse relied on EIA data to obtain historical sales, customers, and revenues across sectors, which we then used to calculate cost and load allocation.[27] We then combined this information with modeled energy and capacity prices to (1) estimate the portion of historical revenues associated with electric supply versus other components such as delivery and administrative fees and (2) calculate projected system costs. Our analysis used modeled energy and capacity costs to calculate the supply portion of the bill. We modeled bill impacts both with and without RGGI revenues, due to the current uncertainty about how RGGI revenues might be circulated in Pennsylvania.[28] In this analysis, we calculated RGGI revenues based on EnCompass outputs (RGGI allowance prices and number of allowances sold, scaled to Pennsylvania's

[25] Greenhouse Gas Standards and Guidelines for Fossil Fuel-Fired Power Plants. U.S. EPA. Accessed May 2023. Available at https://www.epa.gov/stationary-sources-air-pollution/greenhouse-gas-standards-and-guidelines-fossil-fuel-fired-power.

[26] For more information on EnCompass, its users, and capabilities, see: https://anchor-power.com/encompass-power-planningsoftware/.

[27] U.S. Energy Information Administration. 2022. "Annual Electric Power Industry Report, Form EIA-861 detailed data files." Available at: https://www.eia.gov/electricity/data/eia861/.

[28] In practice, recirculated RGGI revenues may lead to further benefits which are not modeled here. See footnote 31 for more on this topic.

share of the total RGGI cap) and allocated revenues to sectors of ratepayers based on historical data from other RGGI states.[29] We assumed that—absent RGGI revenues—rate impacts related to other factors such as energy efficiency, distributed generation, and renewable energy credits were consistent across the two scenarios and constant over time.

[29] Regional Greenhouse Gas Initiative, Inc. 2022. The Investment of RGGI Proceeds in 2020. Available at: https://www.rggi.org/sites/default/files/Uploads/Proceeds/RGGI_Proceeds_Report_2020.pdf.

3. RESULTS AND DISCUSSION

The following sections describe the results and implications of our analysis.

3.1. Improved rates and bills highlight the value of RGGI revenues

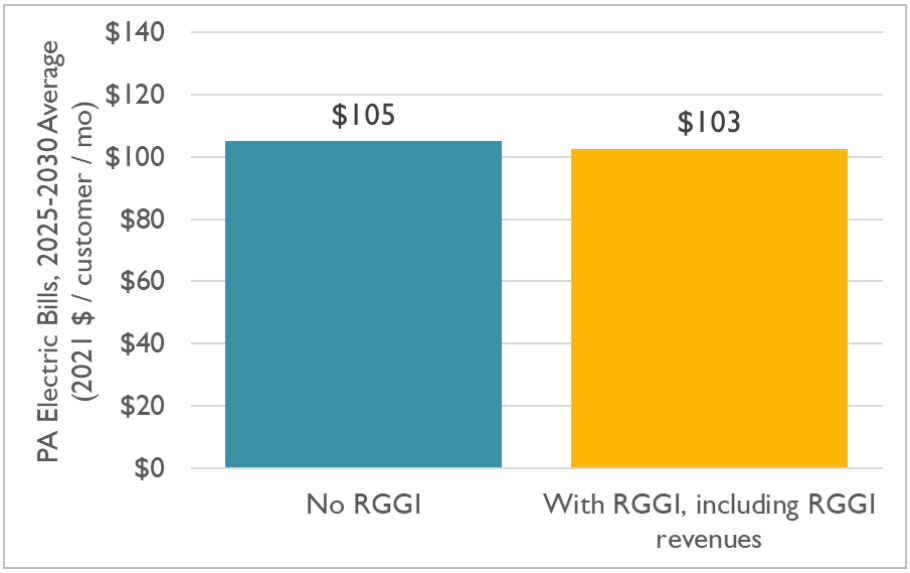
Pennsylvania's participation in RGGI would provide economic benefits for electric ratepayers. RGGI primarily impacts supply costs, which are driven by energy prices and capacity prices and make up approximately 50 percent of customer bills in Pennsylvania based on our analysis of total electric bills and historical energy and capacity prices. (In general, electricity rates include delivery and supply components. Delivery costs correspond to the distribution grid and other related costs, while supply covers the generation of wholesale energy.) Using a power-sector capacity expansion and production cost model, Synapse projected energy and capacity prices for Pennsylvania's PJM zones and used these price results to evaluate how RGGI participation would impact customer rates and bills.

As a RGGI participant, Pennsylvania would earn revenues from allowance auctions, providing economic benefits to Pennsylvanians by offsetting electricity bills and funding clean energy programs. Between 2025 and 2030, these revenues would total $3.2 billion. For purposes of making an estimate, we assume that the disbursement of revenues in Pennsylvania would follow the most recent revenue allocation data from states currently participating in RGGI auctions, about 52 percent of RGGI revenues (or $1.7 billion) between 2025 and 2030 would go toward residential or low-income customers, offsetting their electricity bills.[30] This could occur through programs such as energy efficiency, electrification, and distributed clean energy.[31] After accounting for the distribution of RGGI revenues back to customers, the net impact is that residential bills become 2.2 percent lower. This savings represents the actual net financial impact that the average customer would experience as a result of RGGI participation. Figure 3 shows how RGGI revenues more than offset the impacts of RGGI on wholesale power prices. While the wholesale power price impacts of RGGI, shown in the bar in the middle, put some upward pressure on electric rates, the distribution of RGGI revenues ensures that ratepayers ultimately see net savings on their electric bills, as illustrated by the bar on the right. As a result, bills in the With RGGI scenario (the bar on the right) are $2 per month lower than bills in the No RGGI scenario (the bar on the left).

[30] Regional Greenhouse Gas Initiative, Inc. 2022. The Investment of RGGI Proceeds in 2020. Available at: https://www.rggi.org/sites/default/files/Uploads/Proceeds/RGGI_Proceeds_Report_2020.pdf.

[31] We did not perform an iterative step investigating the impacts of these re-investments. It is possible that these reinvestments could further contribute to the benefits of RGGI beyond what is modeled in this report. We note that there may be challenges in Pennsylvania to implementing the kind of direct consumer refunds of RGGI revenues employed in other states; however, policy actions that provide energy efficiency rebates or financial incentives to clean energy would have the same impact in terms of reducing consumers' monthly electricity costs.

Figure 3. Reduction in residential electric bills due to RGGI revenues



Because many components of residential electricity rates (including the delivery charge) are not impacted by RGGI, and because wholesale electricity prices in Pennsylvania are already impacted by neighboring states' participation in RGGI, our rate and bill analysis reveals that participating in RGGI has little impact on residential rates. We find that the costs associated with RGGI's impact on wholesale energy prices would only increase monthly residential customer electricity rates by an average of 1.6 percent from 2025 to 2030 (as shown in the "With RGGI, excluding RGGI revenues" column in Table 1), and we find that the benefits of RGGI revenues more than offset these costs. Note that the "With RGGI, excluding RGGI revenues" column shows a step in the calculation of the total impacts of RGGI and does not represent a complete scenario. We assume in our analysis that Pennsylvania will distribute its RGGI revenues in ways that benefit residential electricity customers.

Table 1. Impact of RGGI revenues on residential rates and bills and system costs, 2025-2030 average

		No RGGI	With RGGI, excluding RGGI revenues	With RGGI, including RGGI revenues
Average residential rate	*2021 cents per kWh*	12.5	12.7	
Average monthly residential bill	*2021 $ per customer*	$105	$107	$103
Cumulative energy and capacity costs	*2021 $ billion*	$39.0	$40.3	$37.5
Statewide savings	*2021 $ billion*			$1.5

Similarly, the analysis assumed approximately $190 million is allocated to Pennsylvania's commercial and industrial customers, reducing the cost impacts of RGGI for these customers. This funding goes toward benefits including programs that support efficiency and clean energy projects for commercial and industrial customers. Finally, another $1.0 billion in RGGI revenues are assumed to go toward

initiatives including clean transportation; research and technology development; and municipal, commonwealth, and community programs.[32] When taken together, the cumulative benefits of RGGI revenues more than fully offset increases in wholesale power costs, producing $1.5 billion in statewide cost savings. [33]

3.2. RGGI benefits are maintained under a gas price shock

Recent historical volatility demonstrates the possibility of a sudden, unexpected increase in gas prices.[34] For example, between 2021 and 2022 annual average Henry Hub gas prices increased by 66 percent as a result of the Russian invasion of Ukraine.[35] Figure 4 shows how recent historical price volatility compares to the rate impacts of Pennsylvania participating in RGGI in future years, based on the moderate gas price scenario described in the prior section.

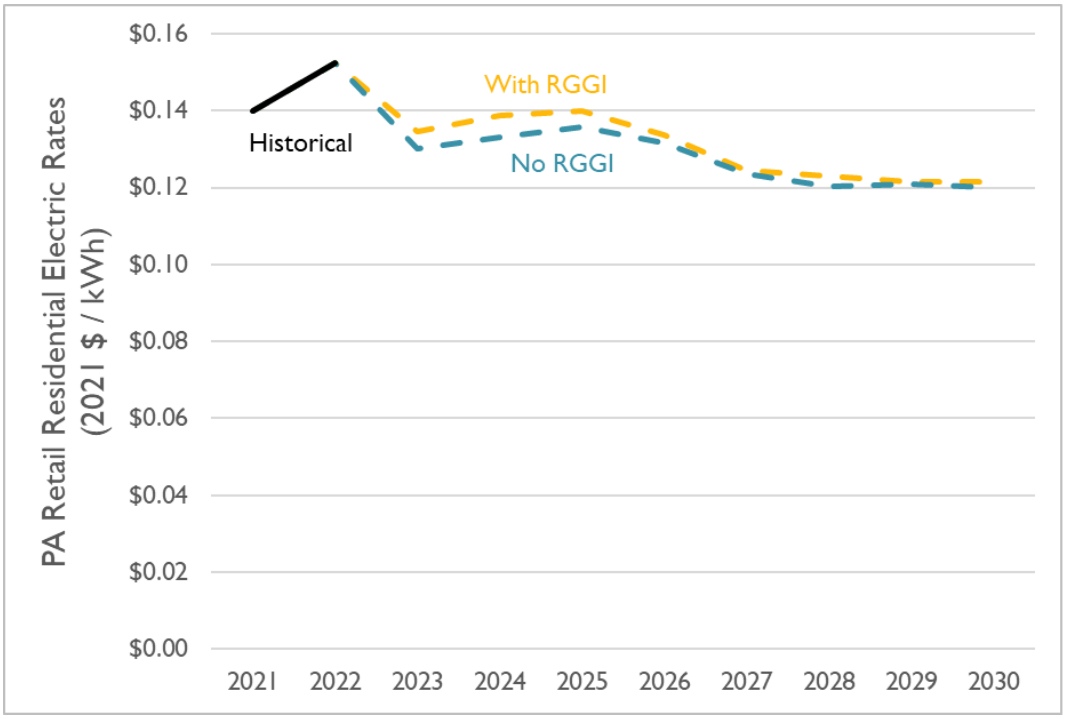
[32] We also assume that 11 percent of collected RGGI revenues are retained to administer the program, in line with administrative costs in the other participating RGGI states.

[33] We note that these findings are consistent with a May 2023 analysis of the impacts of Pennsylvania participating in RGGI, which found that RGGI participation would lead to an increase in residential electricity rates of 1 percent, and would lead to net savings for Pennsylvania consumers overall. For more, see Burtraw, D. et al. "The Prospects for Pennsylvania as a RGGI Member." Resource for the Future and Kleinman Center for Energy Policy at UPenn. May 2023. Available at https://kleinmanenergy.upenn.edu/wp-content/uploads/2023/05/Report-23-04.pdf.

[34] U.S. Energy Information Administration. 2022. "U.S. natural gas price saw record volatility in the first quarter of 2022". *Today in Energy*. August 24. Available at: https://www.eia.gov/todayinenergy/detail.php?id=53579.

[35] U.S. Energy Information Administration. 2023. "Henry Hub Natural Gas Spot Price." *Natural Gas*. May 24. Available at: https://www.eia.gov/dnav/ng/hist/rngwhhdA.htm.

Figure 4. Electric rate projections and recent historical rates in the moderate gas price scenario



To determine how the system costs would change as a result of a future gas price shock, we also performed a High Gas sensitivity analysis. The High Gas sensitivity evaluates the impacts of a single-year increase in gas prices in both the "No RGGI" and "With RGGI" scenarios in 2030. In this sensitivity, we re-evaluate the system costs resulting from modeling a gas price 72 percent higher than in the core scenarios.[36] We assume the same sets of resources that are in operation in each of the core scenarios.

In the High Gas price sensitivity, a 2030 gas price that is 72 percent higher than in the core scenarios translates into wholesale energy prices that are 68 percent higher. However, these translate into residential rate increases that are only 30 percent higher, as a result of other components of electricity rates (e.g., capacity costs, delivery charges). As a point of reference, this is about three times the magnitude of the recent electricity rate increases observed in 2021 to 2022 that resulted from high gas prices due in part to Russia's war in Ukraine.[37] We note that the 30 percent increase in electricity rates is 21 times as large as the difference observed between the core scenario's "With RGGI" and "No RGGI" findings, highlighting the minimal impact that RGGI is likely to have on consumers relative to other volatile dynamics inherent in energy markets.

[36] This value is based on the projection of gas prices in U.S. Energy Information Administration's "Low Oil and Gas Supply Case" from the 2023 Annual Energy Outlook. This represents a high estimate of what gas prices are likely to be in a future year constrained by limited gas supply.

[37] U.S. Energy Information Administration. 2022. "Electricity Data Browser." Available at: https://www.eia.gov/electricity/data/browser/.

In the High Gas price sensitivity, residential ratepayers see lower average bills with RGGI after accounting for RGGI revenues, as in the core scenarios. Given a sudden increase in gas prices in 2030, residential electricity bills in Pennsylvania under the "No RGGI" and "With RGGI" scenarios remain similar to each other, with RGGI revenues placing estimated 2030 "With RGGI" bills 1.9 percent below "No RGGI" bills (see Table 2).

Table 2. Residential rate and bill impacts and system costs, 2030, High Gas price sensitivity

		No RGGI	With RGGI, excluding RGGI revenues	With RGGI, including RGGI revenues
Average residential rate	*2021 cents per kWh*	15.6	15.7	
Average monthly residential bill	*2021 $ per customer*	$131	$132	$128

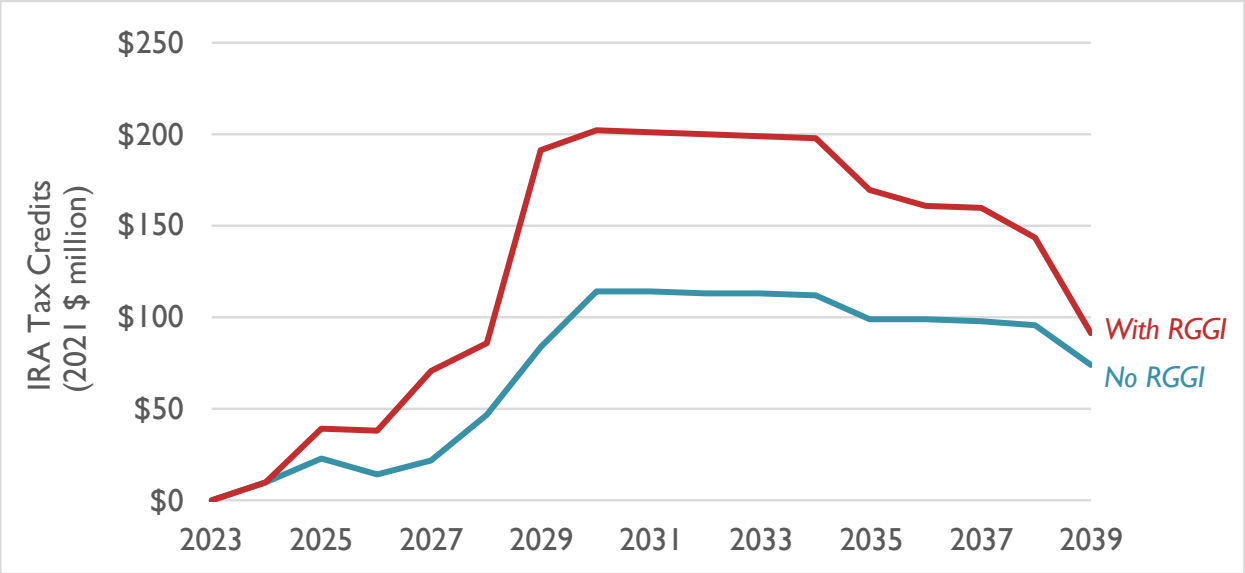
3.3. RGGI brings increased federal funding to Pennsylvania

RGGI would provide additional economic benefits by helping Pennsylvania take advantage of IRA funds. Under the IRA, clean energy projects can receive either the Investment Tax Credit (ITC) or Production Tax Credit (PTC). The ITC offers a credit of 30 percent of the installed cost of clean energy resources, and the PTC offers a credit of about $26 per megawatt-hour for clean electricity generation. The value of both tax credits are even greater for projects located in energy communities or built using domestic content.

RGGI makes renewable energy more competitive relative to fossil fuels because renewables do not produce emissions and thus do not need to purchase allowances. Greater renewable deployment brings in more federal tax credits, which can help power local economies and fund clean energy jobs while keeping consumer energy costs low.

Increased deployment of solar, wind, and battery storage resources in the "With RGGI" case brings $930 million of additional IRA tax credits to Pennsylvania that would not be realized if Pennsylvania were to withdraw from the program. In total, $2.2 billion in IRA tax credits come to Pennsylvania from the renewables constructed in the commonwealth between 2023 and 2030, including $2.0 billion in PTCs from wind and solar and $170 million in ITCs from battery storage (Figure 5). PTCs for projects built during the study period (through 2030) continue to accrue after 2030, because projects receive the PTCs for 10 years. One quarter of the PTCs and all of the ITCs accumulate in 2030 or before.

Figure 5. Annual IRA tax credits flowing into Pennsylvania associated with renewables constructed 2023–2030



These tax credits are in addition to the $3.2 billion in RGGI revenue that stands to be collected between 2025 and 2030, were Pennsylvania to participate in RGGI. Pennsylvania could further leverage these funds by seeding and developing a statewide green bank, as other participating RGGI states such as New Jersey, New York, and Connecticut have done.[38]

3.4. Other benefits

Although RGGI is unlikely to impact residential electricity bills in substantial ways, it is likely to provide benefits in terms of improved public health, reduced CO_2 emissions, and as a driver to the commonwealth's clean energy economy. More information regarding these additional benefits will be included in our full report.

[38] Coalition for Green Capital. April 2020. *New Jersey Announces Funding for a Green Bank*. Available at https://coalitionforgreencapital.com/new-jersey-announces-funding-for-a-green-bank/.

4. CONCLUSIONS

By implementing its RGGI program effectively, Pennsylvania can help its residents capture significant economic benefits, with few downsides. Through RGGI, Pennsylvania can reduce statewide electricity costs by $1.5 billion and leverage increased federal investment, all while advancing Pennsylvania's clean energy economy.

Through RGGI, Pennsylvania can reduce statewide electricity costs by $1.5 billion and leverage increased federal investment.

APPENDIX A. KEY SCENARIO INPUTS

Table 3 outlines the primary assumptions used in this study. The "No RGGI" and "With RGGI" scenario inputs are identical aside from Pennsylvania's participation in RGGI. We also modeled a "High Gas" price shock sensitivity for each of the core scenarios, affecting the gas fuel cost assumptions. See *Chapter 2. Methodology* for more explanation.

Table 3. Primary input assumptions

	Input name	Value, data source, or assumption
Modeling parameters	Topology	All of PJM, NYISO, and ISO New England
	Years modeled	2021-2030
	Temporal detail: capacity expansion	Typical weeks (12 per year) with 8 intervals per day (56 per week)
	Temporal detail: production cost	All 8,760 hours of each year
	Capacity expansion optimization period	Single-year optimization
Load	Baseload forecast	PJM, NYISO, and ISO New England forecasts
	Energy efficiency forecast	PJM, NYISO, and ISO New England forecasts
	Electrification forecast	PJM, NYISO, and ISO New England forecasts
Renewable Portfolio Standards	RPS requirements	Latest available data on RPS and CES requirements in each state; sources include LBNL *U.S. Renewable Portfolio Standards 2021 Status Update*, PJM Environmental Information Services, and state-specific sources
New conventional resources *(costs and tax credits, when allowed)*	Conventional gas	Allowed beginning in 2025, prices based on AEO 2022 adjusted by EPA regional cost factors
	Gas with CCS	Not modeled
	Coal with CCS	Not modeled
	Advanced nuclear reactors and SMRs	Not modeled
New utility-scale clean energy resources *(costs and tax credits, when allowed)*	Utility-scale solar	Allowed beginning in 2025, prices based on NREL's 2022 ATB adjusted by EPA regional cost factors; generally receives PTC ($25.50/MWh, plus 10 percent adder to $28.05/MWh in energy communities)
	Onshore wind	Allowed beginning in 2025, prices based on NREL's 2022 ATB adjusted by EPA regional cost factors; generally receives production tax credit ($28.05/MWh including domestic content adder, plus 10% adder to $30.50/MWh in energy communities)
	Utility-scale battery storage	4- and 8-hour storage allowed beginning in 2025, prices based on NREL's 2022 ATB adjusted by EPA regional cost factors; receives ITC (30 percent, plus 10 percent adder to 40 percent in energy communities)

	Input name	Value, data source, or assumption
	Offshore wind	List of known projects obtained primarily from U.S. Department of Energy *Offshore Wind Market Report: 2022* Edition; prices based on NREL's 2022 ATB adjusted by EPA regional cost factors; receives ITC (40 percent including domestic content adder, plus 10 percent adder to 50 percent in energy communities)
New distributed and demand-side energy resources	Distributed solar	Distributed solar capacity grows in line with each RTO's forecast
	Distributed storage	Distributed storage capacity grows in line with each RTO's forecast
	Demand response	Existing demand response remains constant over time
Fuel costs	Gas	NYMEX in the short term, AEO 2023 Reference Case in the long term, AEO 2023 Low Oil and Gas Supply Case in 2030 for High Gas sensitivities
	Coal	EnCompass National Database default
Existing fossil and nuclear and allowed retirements	Coal and gas	All plants currently listed as having an announced retirement retire no later than that date; plants are allowed to retire endogenously beginning in 2025
	Nuclear	Plants assumed to receive license extensions; IRA tax credits are assumed to prevent nuclear plants from retiring
Transmission	Within Pennsylvania	Modeling six distinct PJM zones (PPL and METED, PENE, ATSI, PECO, AD, APS) in Pennsylvania with limited transmission connections between them
	With regions adjacent to Pennsylvania	Modeling connections to other PJM and NYISO zones; all PJM, NYISO, and ISO New England zones are modeled and generally connected to adjacent zones by transmission links
Capacity markets	Demand curves	Modeling overall PJM, NYISO, and ISO-NE capacity market demand curves, as well as local capacity requirements in PJM's MAAC, EMAAC, and SWMAAC regions
	Resource capacity ratings: PJM	PJM average ELCC values
	Resource capacity ratings: NYISO and ISO-NE	Using default EnCompass National Database constraints that reduce renewable capacity contributions as penetration increases to reflect impact of NYISO and ISO New England marginal ELCC frameworks
Compliance with proposed U.S. EPA emissions rules	Section 111 Greenhouse Gas Standards and Guidelines for Fossil Fuel-Fired Power Plants	Not analyzed (rule was issued after analysis was completed)