THE CARBON BRIDGE COMPACT: ACCELERATING PJM-WIDE CARBON REDUCTIONS

VISTRA CORP.

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DISCLOSURES AND DISCLAIMERS

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GLOSSARY

AD Hub	AEP-Dayton Hub
BCA	Border-Carbon Adjustments
CAISO	California ISO
ComEd	Commonwealth Edison
EMAAC	Eastern Mid-Atlantic Area Council
FERC	Federal Energy Regulatory Commission
HB	House Bill
ISO	Independent System Operator
ISO-NE	ISO New England
LMP	Locational Marginal Price
NOx	Nitrogen Oxide
PJM	PJM Interconnection, LLC
REC	Renewable Energy Credit
RGGI	Regional Greenhouse Gas Initiative
RPS	Renewable Portfolio Standard
RTO	Regional Transmission Organization
SOx	Sulfur Oxide
WMAAC	Western Mid-Atlantic Area Council
ZEC	Zero Emission Credit

EXECUTIVE SUMMARY

The PJM market is at a crossroads. State efforts to address climate change through carbon pricing are confronted with the reality of emissions and cost leakage that occur when there are disparate carbon policies within a multi-state wholesale market. This creates suboptimal outcomes for states, consumers, and resources. As a result, states actively deploying decarbonization initiatives are seeing more costly outcomes for constituents without commensurate reductions in carbon emissions, states beginning their decarbonization journey are rightly wary of unintended outcomes for their economies, and other states are concerned about current movement towards decarbonization. Within this confederation of diverse interests, PJM stakeholders have struggled to find an equitable path forward that preserves the many benefits of the PJM marketplace.

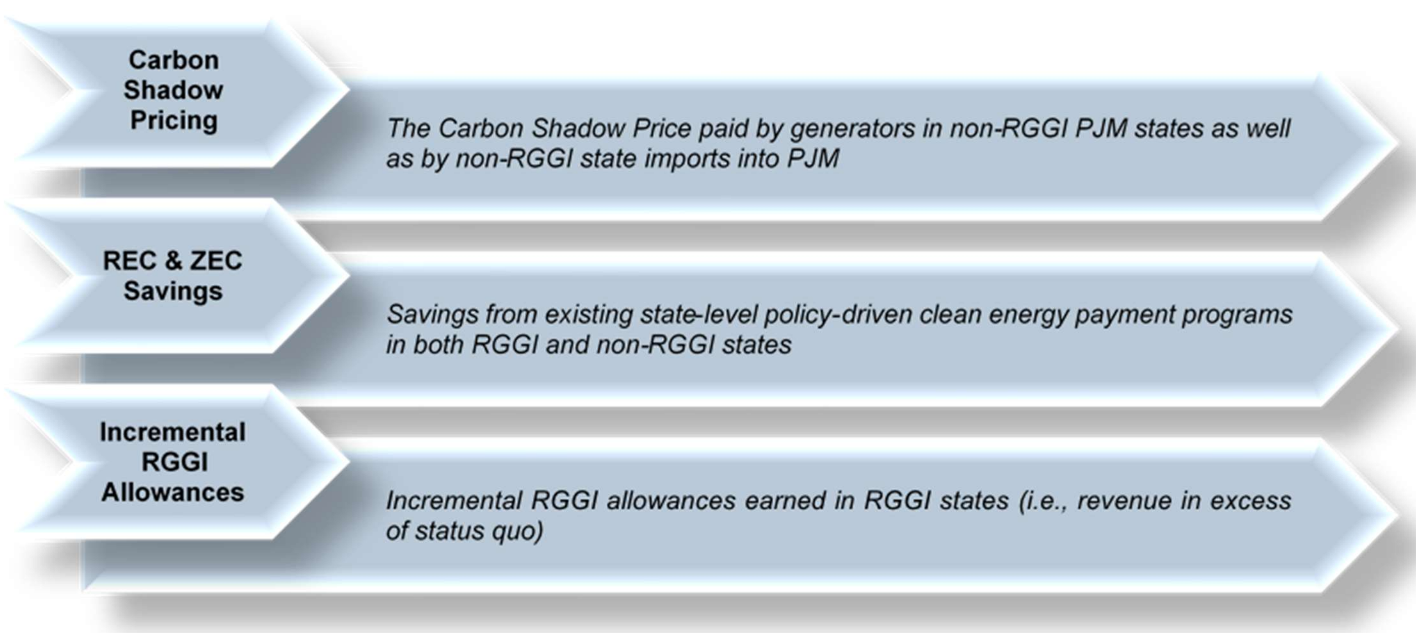
Vistra Corp. (Vistra), with independent analysis from PA Consulting Group, Inc. (PA), outlines a path forward to help PJM create a sustainable, competitive electric wholesale market. Realizing decarbonization policies, technologies, and goals are rapidly evolving, this paper analyzes a temporary "Carbon Bridge Compact" to better harmonize the diverse set of priorities across the PJM footprint. This compact would serve as a temporary agreement among PJM states that seeks to respect state sovereignty and, with a firm sunset and revisit date, provide individual states – alongside their respective legislatures and regulatory agencies – with a platform to meaningfully develop and evaluate long-term solutions.

Across the 2021-2025 study period, the Carbon Bridge Compact is projected to:

- *Drive a 9% reduction in carbon emissions throughout the PJM footprint compared with the status quo.*
- *Increase average customer energy costs by 0.42 cents/kWh in non-RGGI states and 0.29 cents/kWh in RGGI states.*
- *Generate Carbon Reduction Funds that cover ~90% of the increase in costs to serve non-RGGI states' load.*

The proposed market design (i.e., the Carbon Bridge Compact) creates a scenario in which all PJM states would agree to implement (or at least be subject to proxy) carbon pricing. Because some states may find the proposed design to be unpalatable the proposal includes measures to soften the economic impacts of a RTO-wide carbon price to non-RGGI states for a set period of time. This defined bridge period affords stakeholders an opportunity to discuss longer-term sustainable options for the RTO. Under the proposed market design, revenues could be collected from a variety of sources and redistributed to impacted stakeholders under the general discretion of those states' legislatures and regulatory bodies.

Carbon Reduction Fund Revenue Streams



More specifically, the Carbon Bridge Compact would introduce a "Carbon Shadow Price" across the PJM footprint for generators that are not currently subject to carbon costs. A national or regional carbon pricing mechanism would help mitigate emissions leakage from some – but not all – states employing carbon pricing and thus enable carbon pricing to perform its core purpose of driving emissions reductions. By successfully addressing emissions leakage, states could more easily achieve carbon emission reduction goals within the wholesale market framework. The Carbon Shadow Price would be included in all generator bids, based on the underlying carbon intensity of the generator. Direct results would be to increase power prices across the PJM footprint, alter dispatch patterns of controllable resources, and immediately decrease overall carbon emissions in the market.

For states with strong, existing decarbonization initiatives, the Carbon Bridge Compact would multiply the "purchasing power" of these existing programs for which state constituents already pay. For states without established carbon programs in place, the introduction of a Carbon Shadow Price would create a new monetary stream for participants in the form of Carbon Reduction Funds. States could utilize these Carbon Reduction Funds to mitigate consumer impacts and redeploy capital. This program could also serve as a transition mechanism to allow non-RGGI states to prepare for a national carbon pricing mechanism, with the burdens of that transition mitigated in the near-term.

In Vistra's view, a long-term competitive and vibrant wholesale electricity market like PJM can only be sustainable if it also incorporates state-level environmental goals while maintaining traditional reliability and least-cost requirements. With careful design, the proposed Carbon Bridge Compact would help address emissions and cost leakage by fully integrating carbon costs while still respecting individual state goals by utilizing Carbon Reduction Funds. This, in turn, would make carbon pricing more effective at reducing carbon emissions overall and would make less market-oriented approaches less necessary. While Carbon Reduction Funds could be used to mitigate the impact of higher costs to electric customers, Vistra finds states are in the best position to decide how to use these Carbon Reduction Funds – allowing states to remain in control of their energy future while still benefiting from PJM's multi-state RTO market.[1]

Importantly, with a firm sunset and revisit date, the Carbon Bridge Compact does not presuppose long-term outcomes for any state nor the broader PJM market. Rather, the Carbon Bridge Compact provides necessary breathing room for stakeholders as state and national policies evolve. At the same time, the Carbon Bridge Compact creates a platform to better position all states within the PJM footprint for this evolution.

This study set out to evaluate the effectiveness of the Carbon Bridge Compact by answering two key questions:

- **Does the Carbon Bridge Compact materially reduce carbon emissions compared with the status quo?**
- **Does the Carbon Bridge Compact generate enough Carbon Reduction Funds to allow states to meaningfully offset new costs borne by electric customers in non-RGGI states?[2]**

The answer to both questions is a resounding "yes."

The study finds that the Carbon Bridge Compact would lead to materially lower carbon emissions and be able to mitigate material stakeholder impacts through Carbon Reduction Funds.

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[1] Throughout this paper, "RTO" is used interchangeably with "ISO" (Independent System Operator) given their close similarities.
[2] This study uses increased customer costs in non-RGGI states as one example of a cost impact that states may wish to insulate from Carbon Bridge Compact costs via deployment of Carbon Reduction Funds.

1 INTRODUCTION

The PJM market is at a crossroads. State efforts to address climate change through carbon pricing are confronted with the reality of emissions and cost leakage that occur when there are disparate carbon policies within a multi-state wholesale market. This creates suboptimal outcomes for states, consumers, and resources. As a result, states actively deploying decarbonization initiatives are seeing more costly outcomes for constituents without commensurate reductions in carbon emissions; states beginning their decarbonization journey are rightly wary of unintended outcomes for their economies; and other states are concerned about current movement towards decarbonization. Within this confederation of diverse interests, PJM stakeholders have struggled to find an equitable path forward that preserves the many benefits of the PJM marketplace. In the absence of a leakage solution, states pursue less market-oriented strategies that can create tensions between state preferences and wholesale market outcomes.

In many ways, competitive wholesale electricity markets in the United States have been instrumental in allowing system operators to dispatch power plants more efficiently over large geographic footprints to the benefit of electric customers. At the same time, however, the very question of what it means to be a competitive market has become more complex as state-level policymakers are increasingly setting goals for their preferred resource mixes. In particular, as states self-procure more clean energy resources to meet state-level environmental objectives, the resulting impacts on market outcomes within multi-state competitive wholesale markets may create unnecessary distractions that come from the use of less market-oriented approaches.

In this paper, Vistra Corp. (Vistra), with independent analysis by PA Consulting Group, Inc. (PA), outlines a path forward for PJM's stakeholders. Realizing decarbonization policies, technologies, and goals are rapidly evolving, this paper analyzes a temporary "Carbon Bridge Compact" to better harmonize the diverse set of priorities across the PJM footprint. This compact would serve as a temporary agreement among PJM states that seeks to respect state sovereignty and, with a firm sunset and revisit date, provide individual states – alongside their respective legislatures and regulatory agencies – with a platform to meaningfully develop and debate long-term solutions. At the same time, the Carbon Bridge Compact will accelerate decarbonization across the PJM footprint, provide Carbon Reduction Funds for states just beginning their decarbonization journeys to soften impacts, and ensure that PJM remains a robust and transparent wholesale marketplace.

The Carbon Bridge Compact would introduce a "Carbon Shadow Price" across the PJM footprint for generators that are not currently subject to carbon costs. The Carbon Shadow Price would be included in all generator bids, based on the underlying carbon intensity of the generator. Direct results would be to increase power prices across the PJM footprint, alter dispatch patterns of controllable resources, and immediately decrease overall carbon emissions in the market. For states with strong, existing decarbonization initiatives, the Carbon Bridge Compact would multiply the "purchasing power" of these existing programs for which state constituents already pay.

Under the proposed market design, revenues could be collected from a variety of sources and redistributed to impacted stakeholders. Three potential funding sources could form a collective pool (together, the "Carbon Reduction Funds"): (i) the Carbon Shadow Price paid by generators in non-RGGI states, as well as by generators in non-RGGI states importing into PJM;[3] (ii) savings from more cost-effective implementation of existing state-level policy-driven clean energy payment programs in both RGGI and non-RGGI states;[4] and (iii) incremental RGGI allowances earned in RGGI states.[5]

To minimize impacts to non-RGGI states, the Carbon Reduction Funds would be redistributed to impacted stakeholders, at the general discretion of those states' legislatures and regulatory bodies. For example, Carbon Reduction Funds could be allocated to:

[3] For example, imports from New York would not have a Carbon Shadow Price imposed because generators within the state already incur RGGI compliance costs.

[4] Generally, clean energy resources would earn higher margins in PJM's markets and require lower subsidies. These programs could include ZECs in Illinois and New Jersey, as well as RECs in most PJM states. The long-term value of both RECs and ZECs is largely dependent on how much compensation – above energy and capacity payments – a given resource needs to earn to be made whole (aka: "missing money"). As energy margins increase under the proposed market design, the level of needed compensation is expected to shrink or be eliminated.

[5] Assuming no other changes to the existing market structure, region-wide carbon pricing throughout PJM would increase the dispatch of RGGI state generators (as they would no longer be disadvantaged from the uneven application of carbon pricing). If they were not able to operate more frequently due to limited allowances, it would put upward pressure on the price of allowances, which would similarly serve as an incremental RGGI allowance revenue source.

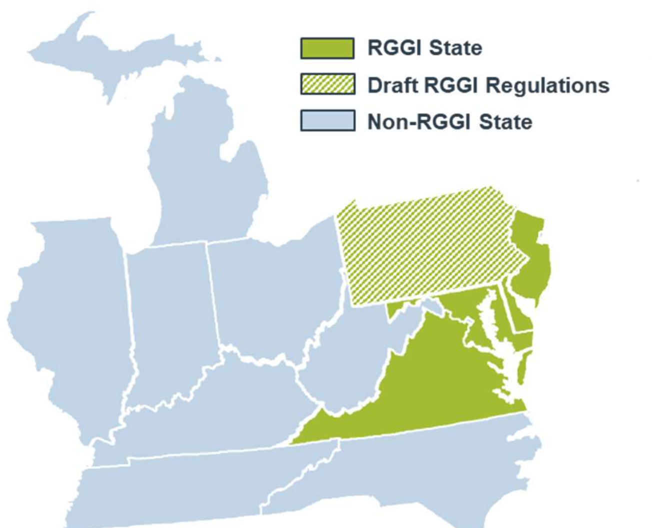
1. **Offset Higher Retail Customer Costs:** To the extent that a non-RGGI state's consumers are negatively impacted by the Carbon Bridge Compact; Carbon Reduction Funds could be allocated – either directly or indirectly[6] – to offset higher costs that retail customers would otherwise incur.
2. **Offset Impacts to Communities Exposed to High Emissions:** Similarly, Carbon Reduction Funds could be allocated to help offset reduced net margins experienced by higher carbon intensity generators in non-RGGI states and/or to soften economic impacts to communities impacted by decreased operations or plant retirements via employment retraining and/or deployment of clean energy capital in these jurisdictions.

Importantly, with a firm sunset and revisit date, the Carbon Bridge Compact does not presuppose long-term outcomes for any state nor the broader PJM market. Rather, the Carbon Bridge Compact provides necessary breathing room for stakeholders to develop long-term solutions as state and national policies evolve.

1.1 ISSUES WITH SUB-REGIONAL CARBON PRICING

Within the United States, regional cap-and-trade programs have been the primary means to implement a cost on carbon emissions. The Regional Greenhouse Gas Initiative (RGGI) is the "first mandatory market-based program in the United States to reduce greenhouse gas emissions" within the US power sector.[7] Eleven eastern states currently participate in the RGGI program via a cap-and-trade mechanism that sets the price of emission allowances through auctions, which allows the market to determine the most cost-effective means to comply with the emissions cap. However, a national carbon price has been elusive.

Figure 1-1: PJM State Participants in RGGI



While regional carbon programs may help states cost-effectively meet decarbonization objectives, there are significant concerns that such mechanisms may not achieve the desired outcome when emissions leakage is prevalent. Emissions leakage occurs when higher-emitting generators in regions without carbon pricing are called by the system operator to dispatch ahead of lower-emitting generators that are subject to carbon costs. In a competitive wholesale market like ISO-NE, where all states are members of RGGI, treatment of carbon pricing is generally equal across direct power market generators with limited emissions leakage.[8] In markets like PJM, however, only some states are members of RGGI, which results in an uneven application of carbon pricing across the region and potentially unintended consequences for stakeholders.

Current internal dispatch algorithms used within competitive wholesale electricity markets are exceptional at finding the lowest cost resources, subject to transmission and other reliability constraints, to meet system demand. In a market where there is uneven application of carbon pricing, however – due to some states being part of a regional carbon program and others that are not – there are, at least, four primary concerns:

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[6] For example, under the RGGI program, allowance auction revenues can be invested in energy efficiency programs to reduce consumer electricity usage, thereby indirectly decreasing RGGI program costs for consumers.
[7] https://www.rggi.org/.
[8] Importantly, in addition to its participation in RGGI, Massachusetts has enacted an economy-wide carbon price, and Connecticut has proposed a similar program. To the extent these additional carbon prices rise above RGGI clearing prices, similar emissions leakages could exist within ISO-NE.

	Economic	Environmental
Retail	*Customers in states without carbon pricing face increased electricity costs due to the actions of policymakers in other states - without representation in those decisions.*	*Customers in states with state-level clean energy programs may be paying for suboptimal results if the cost of carbon pricing does not result in lower emissions overall.*
Wholesale	*Efficient fossil generators may be displaced by an otherwise identical resource located in a state that does not price carbon, creating an uneven playing field between similar generators.*	*Environmental benefits may not be fully realized, as a lower-emitting resource that is subject to carbon pricing has the potential to be displaced by a higher-emitting resource with lower marginal costs.*

To-date, efforts to enhance PJM's current market structure to address leakage have primarily focused on border carbon adjustments (BCA) for power transmitted between RGGI and non-RGGI states. There is a growing body of evidence, however, suggesting that this type of approach is likely to be only partially successful and difficult to practicably implement.

1.2 THE BORDER ADJUSTMENT CHALLENGE

Under the current market structure in PJM, states participating in RGGI self-impose carbon pricing for carbon-emitting generators. While the governing RTO (PJM) accepts this carbon pricing as part of RGGI state generator dispatch costs, it does not impose these costs on generators in non-participating states. As a result, the RTO footprint is subdivided between carbon pricing states and non-carbon pricing states. While generators in carbon pricing states are entitled to recover carbon costs by raising their offer price, the resulting cost disparity among generators creates a natural shift in energy production from carbon-emitting generators in RGGI states to carbon-emitting generators in non-RGGI states. Thus, while subsections of the RTO footprint may adhere to carbon pricing and reduce overall emissions within a smaller footprint, emissions leakage can lead to increased emissions in non-carbon pricing areas, which may decrease or eliminate any carbon reduction benefits on a market-wide basis.

To combat emissions leakage, BCAs have been proposed as a solution. Essentially, a BCA would enable an RTO to regulate imports and exports of energy between carbon pricing and non-carbon pricing states or regions. In its most basic form, the BCA would mandate that a power generator located in a non-carbon pricing state/region pay a carbon tax at an assumed emissions rate for the commodity when exporting to a carbon pricing state. Overall emissions leakage would be reduced because generators "exporting" power from non-carbon pricing states/regions would essentially be subject to carbon costs whenever selling power into a carbon pricing state/region.[9]

Recognizing the value of reduced emissions leakage, PJM has proposed a "one-way border adjustment." Under this proposal, generators located in the carbon-pricing region (i.e., RGGI) would be dispatched using offers that include the cost of carbon. For generators located in the non-carbon pricing region (i.e., outside of RGGI), dispatch offers would depend on whether served load is located within a carbon pricing region. Under the proposal, if a generator in a non-carbon pricing region serves load in a non-carbon pricing region, it would be dispatched using offers that do *not* include

[9] While the RGGI program has not historically addressed emissions leakage issues using a BCA, other markets have shown its potential effectiveness. For example, California currently uses a BCA as part of its AB 32 cap-and-trade program, which requires owners/marketers of identified generators importing into the California energy market to submit AB 32 allowances based on each identified generator's carbon intensity (i.e., an incremental wheeling charge to access the California market). Marketers of unidentified generators must similarly submit AB 32 allowances based on a default carbon intensity (i.e., the emissions rate of an efficient natural gas-fired combined cycle generator). However, given its single-state RTO nature, California's BCA is effectively an external-only BCA (i.e., only directly affects generators selling "into" the California market), whereas an internal/intra-RTO BCA (i.e., focusing on leakage within different sub-regions of PJM) would introduce incremental operational complexities for the ISO.

the cost of carbon. When a non-carbon pricing region generator serves load in a carbon pricing region, however, it would be dispatched using offers that *do* include the cost of carbon.[10]

Though conceptually simple, several factors make the effective implementation of an intra-RTO BCA quite complex. For example, ideally an RTO would identify “exporters” and “importers” and appropriately impose a BCA on the power plants in non-carbon pricing states/regions that are exporting power to carbon pricing states/regions. Practically speaking, however, an RTO does not view available energy within the RTO footprint as being imported or exported; rather, the RTO simply dispatches all available generation within its footprint to serve load subject to transmission constraints and underlying dispatch costs of available generators (among other factors). More fundamentally, as the RGGI footprint grows to include more states (Virginia just joined in 2021, and Pennsylvania is in the midst of its regulatory review process), the RGGI portion of PJM may no longer be a net importer of power. In such a scenario, there may be no significant “imports” of electricity to RGGI states for BCA to attach a carbon price to achieve the leakage mitigation. However, this does not indicate that there is no leakage to address, as clearly the effects of the partial carbon pricing are suboptimal (partial carbon pricing simply shifting generation to non-carbon pricing states and not resulting in overall emissions reductions).

1.3 BROADENING THE SOLUTION

FERC encourages efforts of RTOs and their stakeholders to explore incorporating a state-determined carbon price in RTO markets.[11] PJM has noted that the current approach to price carbon in the region, which covers only generators in RGGI states, excludes many of the region’s coal-fired generators. Thus, as previously discussed, sub-divided regions of carbon pricing and non-carbon pricing states may not reduce emissions as intended, as emissions leakage inevitably results in cost disparity among generators and potentially increases energy production in non-carbon pricing states even under a market design that includes a BCA.

Without region-wide implementation, existing carbon pricing may fall short of achieving emissions reduction goals. For example, an E3 study of the PJM region acknowledged that sub-regional implementation of RGGI is “less effective than a comprehensive regional approach” and noted, “by encouraging expansion to additional states, particularly those with significant amounts of coal generation, RGGI can become more effective.”[12] CAISO has already used existing stakeholder processes to successfully incorporate carbon pricing and leakage mitigation in its markets and has received FERC approval.[13] Affected stakeholders have argued, “it is important that [FERC] continue to enable RTOs to work with states and their respective regional stakeholders to determine appropriate market mechanisms to integrate state and region-determined carbon pricing.”[14] Recent studies show the “little cost” of implementing a region-wide carbon pricing regime would be far outweighed by the resulting significant decrease in overall carbon emissions.[15]

Though some states will likely accept the “little cost” of region-wide carbon pricing, other states may require incentives or compensation to willingly participate. While a well-designed, region-wide price may mitigate impacts to certain stakeholders, there is no dispute that the environmental goals of one state may impact the costs borne in another. For example, region-wide carbon pricing would nonetheless subject states with no desire or requirement to achieve carbon emissions reductions to carbon pricing. Similarly, states already implementing state-wide carbon reduction initiatives may be subjected to additional costs as part of regional participation, which would result in higher energy prices. Thus, to avoid overburdening electric customers while respecting state-level rights, a successful regional carbon pricing regime may need to dampen the impact to states with different policy objectives.

This paper explores a potential solution, proposed by Vistra, to implement a “Carbon Bridge Compact.” A primary aim of the compact would be to transfer Carbon Reduction Funds to negatively affected states (from an economic perspective) during a defined bridge period to lessen any detrimental impacts, while affording stakeholders an opportunity to discuss longer-term sustainable options for the RTO.

Ultimately, this analysis demonstrates that the proposed regional solution would help reduce the impacts of unintended outcomes in the wholesale market, more effectively reduce carbon emissions compared with the status quo, and help insulate impacted parties in states with differing decarbonization aspirations.

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[10] *See, e.g.*, PJM Economic Dispatch and Border Adjustment Options (Aug. 26, 2019).

[11] Docket No. AD20-14-000, Policy Statement on Carbon Pricing in Organized Wholesale Electricity Markets, (Apr. 15, 2021).
[12] https://epsa.org/wp-content/uploads/2020/10/E3-Least_Cost_Carbon_Reduction_Policies_in_PJM-FINAL.pdf at 8.
[13] Joint CA Users at 3 (referencing California Independent System Operator Corporation, 165 FERC ¶ 61,050 (2018)).
[14] *See, e.g.,* Docket No. AD20-14-000, Joint CA Users Reply Comments at 3; IPPNY Reply Comments at 1.
[15] https://epsa.org/wp-content/uploads/2020/10/E3-Least_Cost_Carbon_Reduction_Policies_in_PJM-FINAL.pdf at 8 (noting a reduction in annual carbon emissions of nearly 100 MMT by 2030).

2 THE CARBON BRIDGE COMPACT

This section outlines the Carbon Bridge Compact, which is intended to (i) enhance market competitiveness by allowing for consistent dispatch signals throughout the PJM RTO; (ii) meaningfully lower carbon emissions within the PJM footprint; and (iii) respect the varying decarbonization policy priorities, if any, of individual states. By applying carbon pricing across the entire PJM footprint, the proposed design would not only better achieve the aims of RGGI, but it would also help soften impacts to states not currently subject to carbon pricing while more optimally dispatching generation to help achieve maximum decarbonization across the PJM footprint.

2.1 BASIC MARKET DESIGN

At a high level, the proposed Carbon Bridge Compact would divide states into two categories: (i) states that currently participate in RGGI (RGGI states), and (ii) states that do not currently participate (non-RGGI states). Generators located in RGGI states would see no direct change from the status quo in terms of the mechanics of carbon allowances. Generators in these states would continue to bid into PJM's markets at cost (consistent with current market power mitigation rules), with carbon costs bundled into bid prices. Generators in non-RGGI states, however, would become subject to a Carbon Shadow Price. The Carbon Shadow Price would represent an assumed cost per ton[16] of carbon emissions and would create consistent dispatch signals across all available generators. In the proposed design, this Carbon Shadow Price would be equivalent to the generator's emissions rate multiplied by the prevailing RGGI carbon allowance price.[17] To ensure meaningful comparison of bids, Carbon Shadow Prices would be collected directly from non-RGGI state generators so they have a strong incentive to include the cost as part of their bid structure. By imposing a direct charge rather than adding a carbon cost proxy, PJM could ensure accurate bid pricing from all non-RGGI state generators.

Due to the even application of carbon pricing across the RTO footprint, the LMP for every node within PJM would reflect a clearing price that incorporates a price on carbon. This would achieve a level RTO-wide carbon pricing regime capable of internalizing carbon emissions costs and thereby create an overall benefit for cleaner (lower-emitting) resources within the market. On average, LMPs would increase due to generators in non-RGGI states now being subject to a carbon price and thereby bidding at a higher cost. In most cases, application of a regional carbon price would result in greater overall energy margins for non-emitting resources and lower carbon intensity generators. For example, for lower carbon intensity generators, the revenue from increased market-clearing energy prices (set by higher-emitting generators) would generally outweigh the higher operating costs associated with the Carbon Shadow Price (given their efficient/inframarginal nature). Similarly, non-emitting resources would become more profitable by virtue of being exempt from carbon costs. Higher carbon intensity generators, however, would generally earn lower energy margins in the market due to two potential factors: (i) a lower capacity factor (for generators that clear the market less frequently given their higher bids); and (ii) higher variable costs imposed by the Carbon Shadow Price relative to the higher energy revenues they would earn in those hours.

2.1.1 Dampening the impacts to certain non-RGGI state stakeholders through Carbon Reduction Funds

The Carbon Bridge Compact creates a scenario in which all PJM states would agree to implement (or at least be subject to proxy) carbon pricing. Because this may be an unpalatable situation for some states, however, the proposed market structure includes measures to soften the economic impacts of a RTO-wide carbon price to non-RGGI states. Under the proposed market design, revenues could be collected from a variety of sources and redistributed to impacted stakeholders.

Three potential funding sources could form a collective pool (together, the "Carbon Reduction Funds") consisting of (i) the Carbon Shadow Price paid by generators in non-RGGI states, as well as by non-RGGI state imports[18] into PJM; (ii)

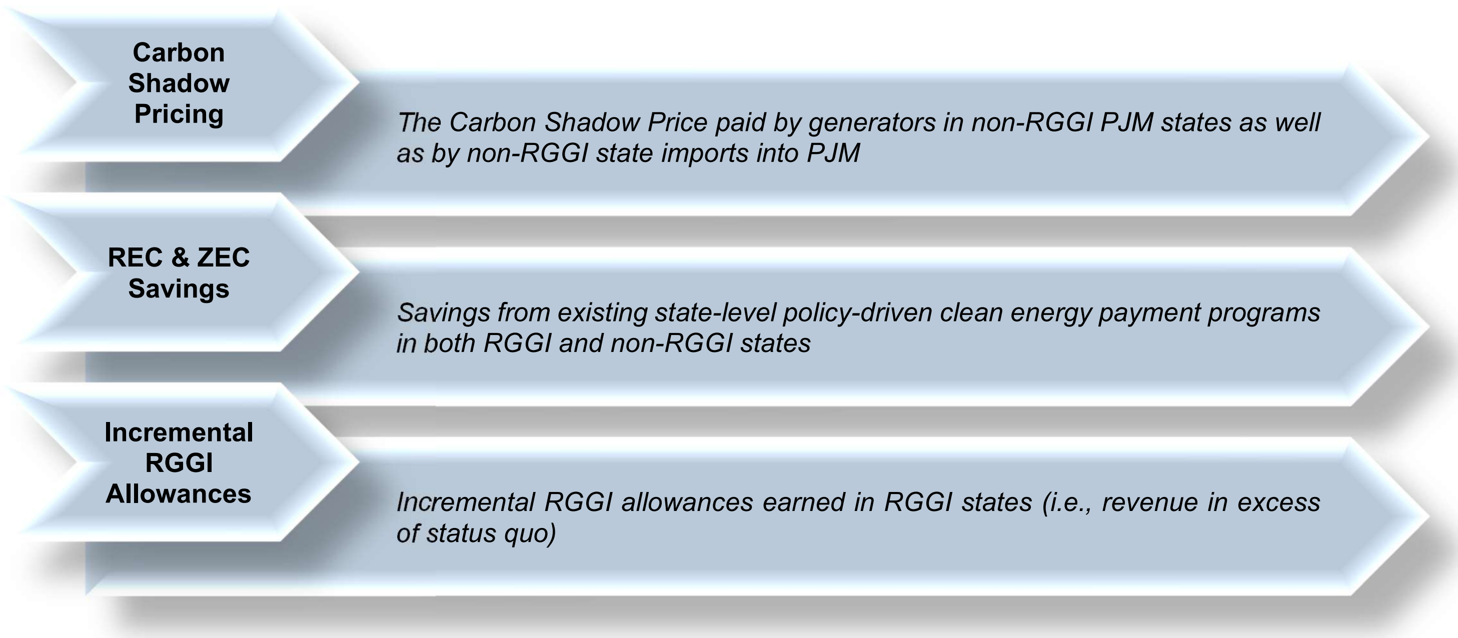
[16] All "tons" within the report reflect short tons vs metric tons.

[17] Carbon Shadow Prices would likely be set by the price for carbon dioxide allowances within RGGI based on the most recent auction clearing price or a published secondary market price.

[18] For example, imports from New York would not have a Carbon Shadow Price imposed because generators within the state already incur RGGI compliance costs.

savings from more cost-effective implementation of existing state-level policy-driven clean energy payment programs in both RGGI and non-RGGI states;[19] and, (iii) incremental RGGI allowances earned in RGGI states.[20]

Carbon Reduction Fund Revenue Streams



To minimize impacts to non-RGGI states, the Carbon Reduction Funds would be redistributed to impacted stakeholders, at the general discretion of those states' legislatures and regulatory bodies. For example, Carbon Reduction Funds could be allocated to:

- **Offset Higher Retail Customer Costs:** To the extent that a non-RGGI state's consumers are negatively impacted by the Carbon Bridge Compact, Carbon Reduction Funds could be allocated – either directly or indirectly[21] – to offset higher costs that retail customers would otherwise incur.
- **Offset High Carbon Generator Community Impacts:** Similarly, Carbon Reduction Funds could be allocated to help offset reduced net margins experienced by higher carbon intensity generators in non-RGGI states and/or to soften economic impacts to communities impacted by decreased operations or plant retirements via employment retraining and/or deployment of clean energy capital in these jurisdictions.

Both RGGI and non-RGGI states within PJM would ultimately need to jointly decide on a framework for collecting and allocating Carbon Reduction Funds in a reasonable and sufficient manner. After all states agree on a particular methodology, each individual state's designated entity could decide how they wish to disburse the money among stakeholders within its jurisdiction.

[19] Generally, clean energy resources would earn higher margins in PJM's markets and require lower subsidies. These programs could include ZECs in Illinois and New Jersey, as well as RECs in most PJM states. The long-term value of both RECs and ZECs is largely dependent on how much compensation – above energy and capacity payments – a given resource needs to earn to be made whole (aka: "missing money"). As energy margins increase under the new carbon pricing paradigm, the level of needed compensation is expected to shrink or be eliminated.

[20] Assuming no other changes to the existing market structure, region-wide carbon pricing throughout PJM would increase the dispatch of RGGI state generators (as they would no longer be disadvantaged from the uneven application of carbon pricing). If they were not able to operate more frequently due to limited allowances, it would put upward pressure on the price of allowances, which would similarly serve as an incremental RGGI allowance revenue source.

[21] For example, under the RGGI program, allowance auction revenues can be invested in energy efficiency programs to reduce consumer electricity usage, thereby indirectly decreasing RGGI program costs for consumers.

2.2 KEY EFFECTIVENESS QUESTIONS TO ANSWER

This study set out to evaluate the effectiveness of the Carbon Bridge Compact by answering two key questions:

- **Does the Carbon Bridge Compact materially reduce carbon emissions compared with the status quo?**
- **Does the Carbon Bridge Compact generate enough Carbon Reduction Funds to allow states to meaningfully offset new costs borne by electric customers in non-RGGI states?**[22]

This paper explores these two questions over a five-year study period, reflecting a potential five-year program length.

2.3 SUPPLEMENTAL CONSIDERATIONS

While the two key questions above help evaluate whether the basic market design is feasible, a key question remains: *would PJM states ever agree to this basic market structure design?* The answer to this question requires grappling with several considerations that will help inform the ultimate shape of the program beyond the basic market design. These factors may include:

- **Carbon Freeriding.** The proposed market structure may (or may not) create a perverse incentive for non-RGGI states to freeride on the proposed market structure rather than ever join RGGI. Relatedly, depending on the monetary transfers to which states agree, non-RGGI states with strong decarbonization aspirations may be less inclined to join RGGI if the Carbon Bridge Compact already leads to lower carbon emissions without impacting its electric customers.
- **Opportunity Costs.** Some RGGI states may question whether there are more cost-effective ways to fund carbon emission reductions, and may therefore be reluctant to contribute directly to the Carbon Reduction Funds to help enable the Carbon Bridge Compact.
- **Electric Customer Incentives.** Insulating customers from carbon costs via Carbon Reduction Funds may create a disincentive to reduce overall energy consumption. To preserve incentives for customers in non-RGGI states to continue to reduce overall consumption, the overall market design may benefit from a consideration of how the value received from the Carbon Reduction Funds and/or cost assigned as the Carbon Shadow Price compare with potential energy efficiency savings.
- **Legal and regulatory framework.** A workable legal and regulatory framework will be needed to durably memorialize the states' agreement and how future program changes would be negotiated. For example, the question of whether the proposed basic market design could work relies heavily on whether states could identify and agree upon durable processes to calculate and allocate sufficient funds to mitigate stakeholder impacts in non-RGGI states.
- **Program oversight and accounting.** It is important to determine how, and by whom, Carbon Reduction Funds would be calculated, and whether this function would best be carried out by PJM directly or by a new governing body. Additionally, from a carbon accounting perspective, determining who is responsible for carbon reductions – as well as how to calculate incremental RGGI revenue – would need to be determined.

[22] This study uses increased customer costs in non-RGGI states as one example of a cost impact that states may wish to insulate from Carbon Bridge Compact costs via deployment of Carbon Reduction Funds. However, as discussed in Section 5, the most appropriate use of Carbon Reduction Funds allocated to any particular state is best left to an individual state's decisionmakers.

3 MODELING METHODOLOGY

PA used its proprietary electricity market modeling processes to evaluate the benefits and cost-effectiveness of the Carbon Bridge Compact. The core of PA's modeling process uses the Aurora Forecasting Software (Aurora),[23] an industry-standard chronological dispatch simulation model, to simulate hourly operations in PJM and the broader Eastern Interconnection. The Aurora model is widely used by electric utilities, power market regulators, independent system operators, and other market consultants. Moreover, PA's subject matter experts have relied on Aurora to underpin the market analysis of hundreds of transactions and strategic efforts across North America since 2011.

PA's model is populated with PA's independent proprietary view of all key assumptions. The Aurora model enables PA to project hourly power prices, energy flows, and plant operations (including CO_2 emissions) across the entire Eastern Interconnection (in which PJM operates). For thermal generators, the addition of a carbon cost is similar to any other variable operating cost that would be included in a dispatch offer (as is already done for generators located in RGGI states), and the ability to analyze the impact of these carbon costs on wholesale power market outcomes is well established in both real-world and modeling contexts. All values within the report, unless otherwise stated, are in nominal dollars, assuming 2.2% per annum inflation.

3.1 OVERVIEW OF CASES

PA modeled the PJM market and the broader Eastern Interconnection under three discrete cases. These cases include a Baseline Case that represents PJM's current market structure (i.e., only generators in RGGI member states incur carbon costs), as well as two alternate scenarios that include and exclude CO_2 pricing across the entire PJM footprint. Aside from varying the assumption regarding which states' generators are subject to CO_2 pricing, PA has kept all other market assumptions (e.g., underlying CO_2 pricing levels and the generator build plan) consistent across all cases to facilitate meaningful comparison. This analysis does not evaluate second-order effects, such as changes to the pace of coal retirements or renewable buildout, which may result from different CO_2 pricing regimes across the PJM market. The analysis focuses on wholesale energy impacts and does not consider capacity price or other related market impacts.

Table 3-1: Summary of Cases

Case	Description	PJM States with CO_2 Pricing
Baseline Case (Status Quo)	This case represents the status quo environment within PJM. Generators in non-RGGI states are not subject to CO_2 emissions allowance costs.	DE, MD[24], NJ, VA
PJM-Wide CO_2 Case (Carbon Bridge Compact)	This case is designed to evaluate the impact of the proposed framework. All generators in PJM states, as well as imports into PJM from non-RGGI regions, are assigned a Carbon Shadow Price for CO_2 emissions at a cost equal to projected RGGI prices in the Baseline Case.	All PJM states, PJM imports from non-RGGI regions[25]
No CO_2 Case	This case is designed to establish a benchmark for evaluating the impact of CO_2 pricing within PJM in the Baseline Case by removing carbon allowance costs for power generators in DE, MD, NJ, and VA.	None

To promote price stability and certainty, RGGI prices are administratively bound by both a floor and ceiling price. The floor price, known as the Emission Containment Reserve trigger price, is set at $6.00/ton in 2021 and increases at 7% per year. The ceiling price, known as the Cost Containment Reserve trigger price, is set at $13.00/ton in 2021 and increases at 7% per year. Once a trigger price is reached, available allowances are introduced (or withdrawn) to ensure RGGI CO_2 prices stay within the predetermined range. PA's modeling for the Baseline Case indicates that generator emissions remain low enough (relative to the predetermined cap on allowances) that pricing will remain near the floor of $6.00/ton in 2021 and rise at 7% thereafter.[26]

[23] The Aurora Forecasting Software is a product of Energy Exemplar.
[24] PA's transmission topology includes the District of Columbia with Maryland.
[25] Imports into PJM were levied a Carbon Shadow Price based on the emissions rate for a 7,000 Btu/kWh natural gas-fired combined cycle. Imports from NYISO were not levied a Carbon Shadow Price due to New York and all of New England being subject to RGGI. Additionally, PA held imports/exports constant, on an average annual basis, between the PJM-Wide CO_2 Case and Baseline Case.
[26] Given the PJM-Wide CO_2 Case does *not* reflect an expansion of RGGI, but rather the introduction of a carbon cost based on the prevailing RGGI carbon price, there is no direct impact on RGGI CO_2 pricing in this scenario. Of course, changes in dispatch decisions (or potential longer-term changes in build plans and retirement decisions) could introduce second-order impacts on RGGI CO_2 pricing.

4 MODELING RESULTS

This study set out to evaluate the effectiveness of the Carbon Bridge Compact, over a five-year time horizon, by focusing on two key questions:

- **Does the Carbon Bridge Compact materially reduce carbon emissions compared with the status quo?**
- **Does the Carbon Bridge Compact generate enough Carbon Reduction Funds to allow states to meaningfully offset new costs borne by electric customers in non-RGGI states?[27]**

The answer to both questions is "yes".

> **Key Finding:**
>
> *The Carbon Bridge Compact (represented by the PJM-Wide CO_2 Case) would lead to materially lower carbon emissions across the PJM footprint while generating enough revenues to meaningfully offset costs borne by certain impacted parties during the evaluated five-year program life.*

PA finds that the expansion of carbon pricing across the PJM footprint would lead to modestly higher power prices throughout the RTO, as the Carbon Shadow Price increases the dispatch costs of carbon-emitting generators in non-RGGI states. This, in turn, impacts generation patterns, particularly for fossil generators, with total coal-fired generation decreasing and natural gas-fired generation increasing.

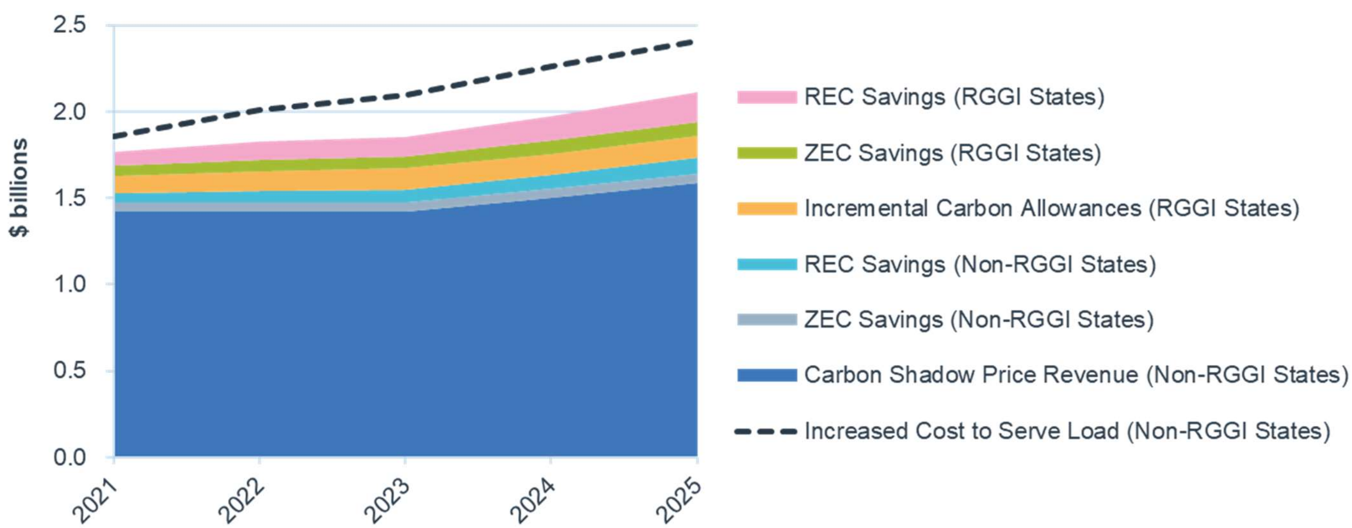
More specifically, over the study period (2021-2025):

- *The change in generation patterns is projected to drive a 9% reduction in carbon emissions throughout the PJM footprint compared with the status quo*.
- *Higher wholesale energy market prices are projected to drive increased costs to serve electric customer load. PA projects a 0.42 cents/kWh average increase in the cost to serve non-RGGI state customer load (before accounting for the application of the Carbon Reduction Funds) and a 0.29 cents/kWh average increase for RGGI state customer load.*
- *Revenues generated by the Carbon Reduction Funds would offset approximately 90% of the increase in costs to serve non-RGGI state electric customer load from 2021-2025, demonstrating that material stakeholder impacts could be mitigated.*

4.1 CARBON REDUCTION FUNDS VERSUS INCREASED COST TO SERVE LOAD

PA projects revenues generated by Carbon Reduction Funds would offset the increased costs to serve non-RGGI state electric customer load by approximately 90% from 2021-2025, demonstrating that material stakeholder impacts could be mitigated. See Figure 4-1.

Figure 4-1: Carbon Reduction Funds Versus Non-RGGI State Customer Costs



[27] This study uses increased customer costs in non-RGGI states as one example of a cost impact that states may wish to insulate from Carbon Bridge Compact costs via deployment of Carbon Reduction Funds. However, as discussed in Section 5, the most appropriate use of Carbon Reduction Funds allocated to any particular state is best left to individual states decisionmakers.

4.1.1 Carbon Reduction Funds seeding

The proposed Carbon Bridge Compact, as evaluated in this study, would generate three primary sources of revenue to seed the Carbon Reduction Funds (as discussed in Section 2.1.1):

- The Carbon Shadow Price paid by generators in non-RGGI states (as well as by non-RGGI state imports into PJM);
- Savings from the more cost-effective implementation of existing state-level policy-driven clean energy payment programs in both RGGI and non-RGGI states;[28] and
- Incremental RGGI allowances earned in RGGI states.[29]

Carbon Shadow Pricing

Collectively, this source of revenue comprises 77% of Carbon Reduction Funds generated under the Carbon Bridge Compact – $1.47 billion annually on average across the study period.

The largest contributor to Carbon Reduction Funds reflects the collection of revenues from Carbon Shadow Pricing generated by carbon-emitting resources in non-RGGI states within the PJM footprint. Additionally, a Carbon Shadow Price was levied on all non-New York located imports in each year at a rate equivalent to that of a 7,000 Btu/kWh heat rate natural gas-fired combined cycle; imports from New York did not incur Carbon Shadow Pricing costs due to New York and all New England states being members of RGGI.

ZEC & REC Savings

Collectively, this source of revenue comprises 17% of Carbon Reduction Funds generated under the Carbon Bridge Compact – $317 million annually on average across the study period.

Several states within PJM have renewable and nuclear support programs that subsidize generators for clean energy and renewable attributes. In general, compensation under these programs is impacted by prevailing wholesale energy and capacity market prices; all else equal, enhanced energy revenues will decrease the amount of subsidy needed for these programs. Within the Carbon Bridge Compact, increased energy pricing provides increased revenue for nuclear and renewable generators, decreasing the need for subsidization.

- **ZEC Savings (7% of overall Carbon Reduction Funds)**:
  - **Non-RGGI States:** Only Illinois has a nuclear support program; the affected generators would earn an additional $53 million annually on average from 2021-2025. This accounts for only the current Illinois ZEC program. Additional nuclear support, as is currently being considered in Illinois, would create the potential for additional savings.
  - **RGGI States:** Only New Jersey maintains a nuclear support program; the affected generators would earn an additional $68 million annually on average from 2021-2025.
  - In addition, the national nuclear PTC currently under consideration could be eliminated or reduced by this proposal.
- **REC Savings (10% of overall Carbon Reduction Funds)**:
  - **Non-RGGI States:** Illinois, Michigan, North Carolina, Ohio, and Pennsylvania each have RPS targets; based on increased revenues for renewable generation assets throughout PJM, these states could collectively reduce REC payments by $72 million annually on average from 2021-2025.
  - **RGGI States:** All four RGGI states (Delaware, Maryland, New Jersey and Virginia) have RPS programs with more aggressive renewable targets than any of those currently adopted by non-RGGI States; based on increased revenues for renewable generation assets throughout PJM, these states could collectively reduce REC payments by $124 million annually on average from 2021-2025.

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[28] Generally, clean energy resources would earn higher margins in PJM's markets and require lower subsidies. These programs could include ZECs in Illinois and New Jersey, as well as RECs in most PJM states. The long-term value of both RECs and ZECs is largely dependent on how much compensation – above energy and capacity payments – a given resource needs to earn to be made whole (aka: "missing money"). As energy margins increase under the proposed market design, the level of needed compensation is expected to shrink or be eliminated.

[29] Assuming no other changes to the existing market structure, region-wide carbon pricing throughout PJM would increase the dispatch of RGGI state generators (as they would no longer be disadvantaged from the uneven application of carbon pricing). If they were not able to operate more frequently due to limited allowances, it would put upward pressure on the price of allowances, which would similarly serve as an incremental RGGI allowance revenue source.

Incremental RGGI Allowances

***Collectively, this source of revenue comprises 6% of Carbon Reduction Funds generated under the Carbon Bridge Compact – $119 million annually on average across the study period*.**

The smallest contributor to Carbon Reduction Funds reflects RGGI allowances generated based on the *change* in RGGI state fossil generation under the PJM-Wide CO_2 Case relative to the Baseline Case. This revenue source recognizes that RGGI states currently utilize earned allowances in a variety of different ways, including enhancing energy efficiency, funding new renewable generation, and mitigating impacts to vulnerable electric ratepayers. As such, PA only included incrementally earned allowances above the Baseline Case in its analysis.

4.1.2 Mitigation of customer rate increases

PA projects the Carbon Bridge Compact to generate sufficient Carbon Reduction Funds to meet approximately 90% of retail customer cost increases in non-RGGI states.

PA's analysis projects that the three identified revenue streams would collectively generate nearly $1.8 billion of Carbon Reduction Funds in 2021, and over $2.1 billion by 2025. As noted in Section 2.1.1, these Carbon Reduction Funds could be redistributed to impacted stakeholders at the general discretion of those states' legislatures and regulatory bodies. While there are myriad ways in which the Carbon Reduction Funds could ultimately be distributed, this paper analyzes one potential option – the allocation of Carbon Reduction Funds to offset higher retail customer costs in non-RGGI states.[30]

Over the study period, PA projects the Carbon Bridge Compact to generate sufficient Carbon Reduction Funds to meet approximately 90% of retail customer cost increases in non-RGGI states. Carbon Reduction Funds are projected to be 5% lower than increased energy costs in 2021 (representing a deficit of approximately $93 million). However, over time, this shortfall is expected to increase, as the PJM generation mix becomes cleaner, generating Carbon Reduction Funds at a slightly slower rate than overall impacts to wholesale market prices; specifically, by 2025, Carbon Reduction Funds are projected to be 12% lower than increased energy costs, representing a deficit of approximately $294 million. If all the increase in cost to serve load in non-RGGI states were to be mitigated, PA's analysis projects the Carbon Reduction Fund would have a deficit of $1.10 billion across the study period, which is equivalent to $0.00028/kWh when normalized across PJM-wide customer demand.

4.2 WHOLESALE ENERGY MARKET PRICE IMPACTS

The Carbon Bridge Compact's expansion of carbon pricing from the current RGGI footprint to all PJM states is projected to put upward pressure on energy market prices across the RTO. This upward pressure is due to the Carbon Shadow Price increasing the variable operating costs of carbon-emitting generators in non-RGGI states, particularly coal- and natural gas-fired power plants, which are the primary fuels setting the price of power in PJM in most hours. All else equal, as the Carbon Shadow Price increases, energy market prices increase as well.

Figure 4-2 illustrates the change in all-hours energy market prices between the PJM-Wide CO_2 Case and the Baseline Case for four representative PJM pricing zones: (i) ComEd, the western-most zone in PJM; (ii) AEP-Dayton (AD) Hub, representing the central portion of PJM; (iii) WMAAC, representing the western mid-Atlantic region (much of Pennsylvania); and (iv) EMAAC, representing the eastern mid-Atlantic region, which includes portions of three RGGI states (New Jersey, Maryland, and Delaware) as well as some of eastern Pennsylvania.

A combination of each region's local generation mix (including changes over time), transmission constraints, and net imports or exports influences the relative price increases among these regions. While the introduction of the Carbon Shadow Price does impact generators that were not previously exposed to a carbon price, the generation mix in the PJM-Wide CO_2 Case is held constant to the Baseline Case for comparison purposes. The resulting relative price increases between regions are therefore not due to changing the generation mix but rather the impact of the carbon price on the variable costs of the given generation fleet. Specifically, in order of absolute impact:

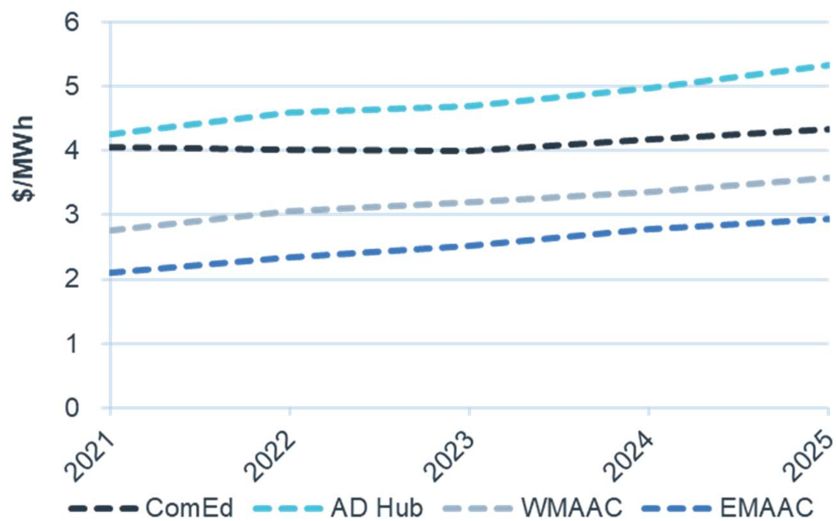
- **EMAAC** power prices are projected to increase the least of the four locations, averaging a $2.54/MWh (or 8%) increase from 2021-2025. Impacts are more moderate compared with WMAAC and AD Hub due to most of the EMAAC region presently being subject to RGGI carbon pricing; however, power prices still increase due to carbon prices impacting thermal generators in neighboring regions that may be dispatched to serve EMAAC load in certain circumstances and because generators currently subject to carbon pricing will be dispatched more.

[30] Notably, the increase in cost to electric customers only considers the change in wholesale energy prices flowing through to customer rates. It does not consider potential changes to capacity prices in the market; how price changes may be insulated by existing utility contracts for power (including hedges); or how utilities may respond by altering other components of their rates (e.g., transmission, distribution, riders).

- **WMAAC** power prices are projected to average a $3.19/MWh (or 11%) increase from 2021-2025. The price increase lies between AD Hub and EMAAC, as WMAAC is situated between those two pricing regions; the former is impacted more heavily by its large coal fleet and the latter is more insulated, in part, due to most generators already being subject to RGGI carbon pricing.
- **ComEd** power prices are projected to rise $4.12/MWh (or 17%) increase from 2021-2025. This is due to ComEd being a relatively small region within PJM that is subject to the impacts of transmission constraints into and out of the zone.
- **AD Hub** power prices are projected to rise the most of the four locations (on an absolute basis), averaging a $4.77/MWh (or 16%) increase from 2021-2025. The higher impact is driven by the greater prevalence of coal-fired generators around the Dayton, Ohio area, which are more acutely affected by carbon pricing and regional transmission congestion.

As discussed in subsequent sections, the change in energy market prices (which reflect both the introduction of the Carbon Shadow Price and changes in dispatch outcomes across the PJM footprint) results in changes to the costs to serve customer load, as well as the margins realized by different classes of generators in these regions. Unsurprisingly, these changes in dispatch dynamics also impact carbon emissions reduction outcomes across the RTO.

Figure 4-2: Increase in All-Hours Wholesale Energy Market Prices



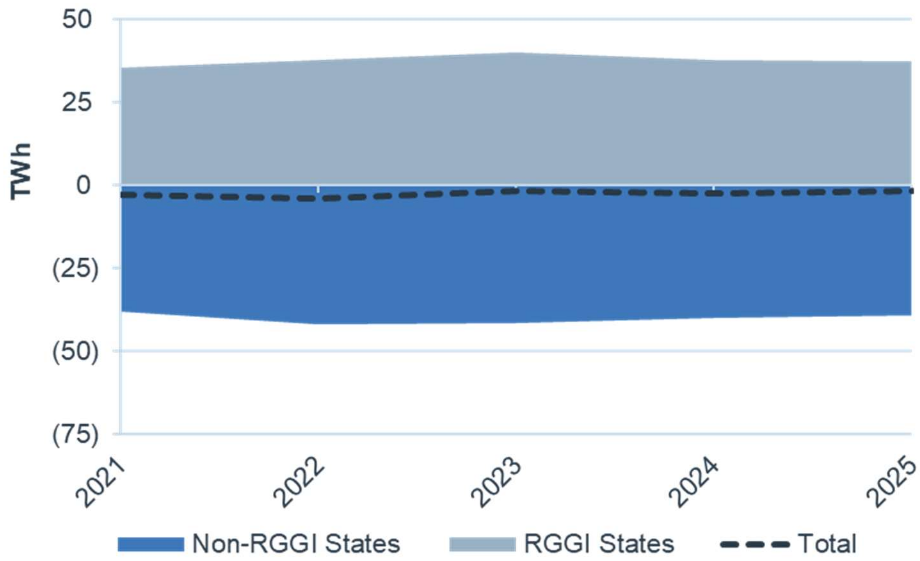
4.3 NET GENERATION IMPACTS

In addition to putting upward pressure on power prices, the Carbon Shadow Price also shifts the competitiveness of generators in the market. Higher-emitting generators (e.g., coal-fired assets, less efficient oil- and natural gas-fired peaking units, etc.) see higher carbon compliance costs and therefore bid into PJM's energy market at higher rates, resulting in them being called to dispatch less often. Conversely, lower-emitting thermal generators (e.g., best-in-class natural gas-fired combined cycles) experience relatively lower carbon compliance costs and therefore bid into the market more competitively. While the energy market bids of these resources still increase under the Carbon Shadow Price, when compared to the Baseline Case, the difference in carbon costs (relative to those experienced by higher-emitting generators) positions many lower-emitting generators ahead of a greater share of higher-emitting generators on the dispatch curve. This results in lower-emitting generators being dispatched more frequently under the Carbon Bridge Compact.

In the Baseline Case, only power generators in RGGI states are subject to carbon pricing. Because not all PJM states are members of RGGI, this dynamic results in an uneven playing field across PJM whereby fossil generators – all else equal – have a competitive advantage or disadvantage based only on whether the state in which they are geographically located is part of the RGGI program. However, perhaps more importantly, this structure can also create a phenomenon known as emissions leakage in which higher-emitting generators in neighboring non-RGGI states (e.g., coal-fired assets in West Virginia) may be called at times to dispatch ahead of lower-emitting generators in RGGI states (e.g., combined cycles in Virginia) due to the inclusion of RGGI carbon costs.

In the PJM-Wide CO_2 Case, carbon pricing is applied evenly, thereby leveling the competitive environment in PJM. PA projects the move to an RTO-wide carbon pricing to drive an average increase in PJM-wide natural gas-fired generation of 41 TWh per year and a net decrease in coal generation of 44 TWh per year from 2021-2025. See Figure 4-3.

Figure 4-3: Net Change in PJM Fossil Generation

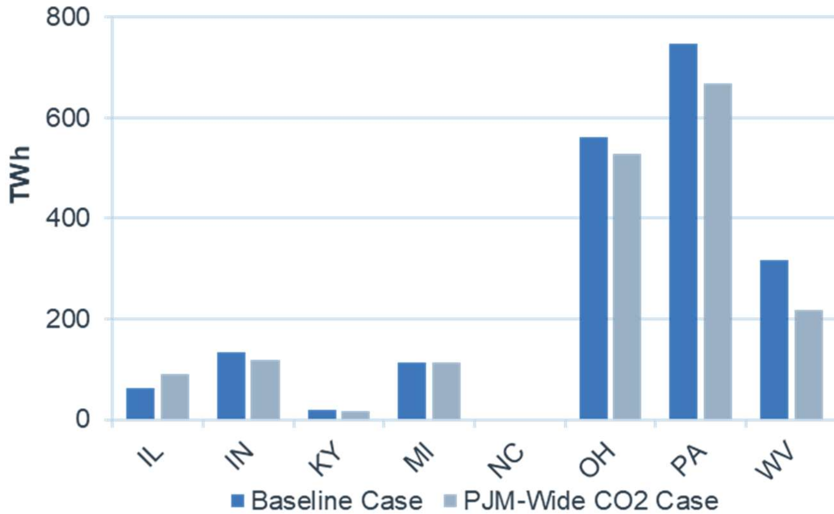


While the general trend across PJM is a net decrease in coal-fired generation and a net increase in natural gas-fired generation, generator impacts are not equally distributed at the state level.

- **Nuclear and Renewable Generators:** In general, renewables and nuclear generators are price-takers in PJM's wholesale energy market, thereby running as often as possible (i.e., being offline only when unavailable). As noted previously, within this analysis, the capacity mix (including nuclear and renewable generators) was held constant between the Baseline Case and the PJM-Wide CO_2 Case in order to isolate impacts to the existing fleet without introducing confounding variables.[31]
- **Fossil Generators (Non-RGGI States):** As shown in Figure 4-4, West Virginia sees the largest share of net reduction in fossil generation (99 TWh) from 2021-2025, due to its large base of coal-fired generators. Pennsylvania and Ohio are projected to follow, also due to their respectively large coal-fired fleets; however, these states' newer, lower-emitting natural gas-fired combined cycles fare better, mitigating the downward impact on fossil generation in these states.

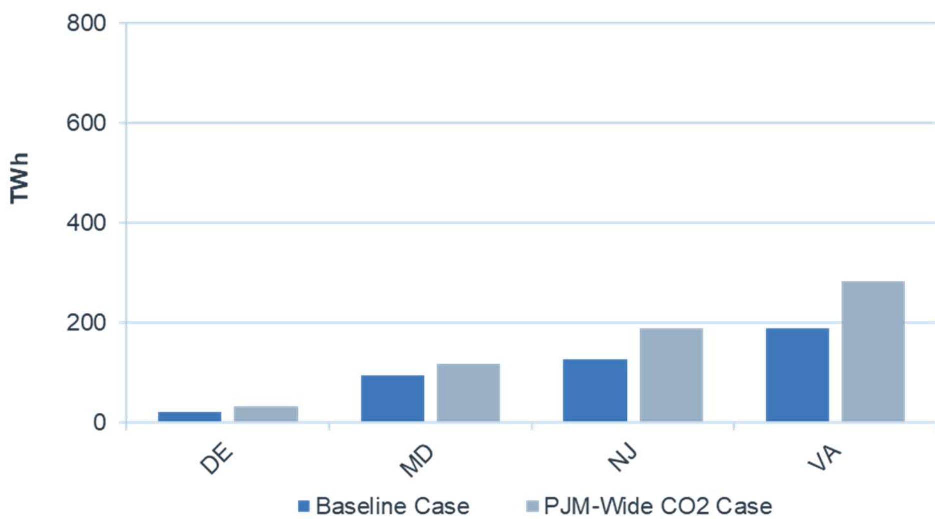
[31] PJM's capacity mix evolves over the study period in the Baseline Case, but this build plan (i.e., capacity mix by year) is then used as an input assumption in the PJM-Wide CO_2 Case. Additionally, while the resource mix was held constant between the three cases to facilitate comparisons, the introduction of an RTO-wide carbon price would likely drive additional clean energy capacity to enter the market. This clean energy generation would likely displace some state fossil generation and/or imports, as well as put additional downward pressure on energy market power prices. To the degree this occurs, the Carbon Bridge Compact would drive further emissions reductions than those described in this paper; however, these emissions reductions would come at the price of fewer Carbon Reduction Funds made available from the carbon fees assessed on non-RGGI state fossil generation and non-New York imports.

Figure 4-4: Cumulative PJM Fossil Generation by Non-RGGI State (2021-2025)[32]



- **Fossil Generators (RGGI States):** All RGGI states are projected to see an increase in fossil generation due to the leveled carbon playing field employed under the Carbon Bridge Compact. PA projects Virginia to experience the largest increase in fossil generation (93 TWh in total from 2021-2025) in the PJM-Wide CO_2 Case relative to the Baseline Case, primarily due to the state being home to a greater amount of fossil-fired capacity relative to the other RGGI states (See Figure 4-5).

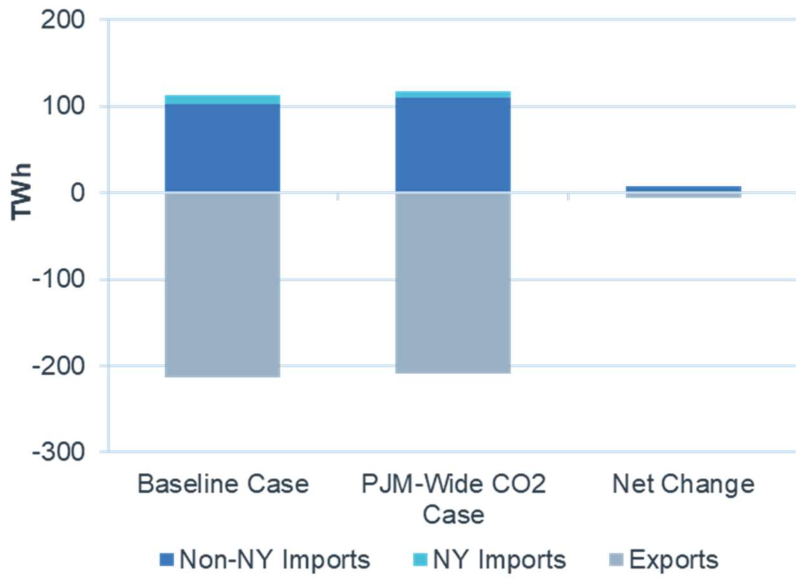
Figure 4-5: Cumulative PJM Fossil Generation by RGGI State (2021-2025)



- **Net Exports:** To proxy effective regional border adjustments that minimize leakage across RTO boundaries, PA Consulting effectively 'locked' annual average import/export power flows between PJM and neighboring RTOs. However, different hourly generation patterns led to slightly different flows between the cases. As shown in Figure 4-6, PA projects imports into PJM to increase by 5 TWh and exports out of PJM to decrease by 5 TWh relative to the Baseline Case.[33]

[32] PJM-based fossil generation in North Carolina is non-zero but is too small to discern on this figure.
[33] As noted previously, the analysis assumes all imports will be assessed a Carbon Shadow Price, with the exception of imports from the New York interface (as generators in New York and New England are already subject to RGGI).

Figure 4-6: Cumulative Change in Net Imports (2021-2025)



4.4 CARBON EMISSION REDUCTIONS

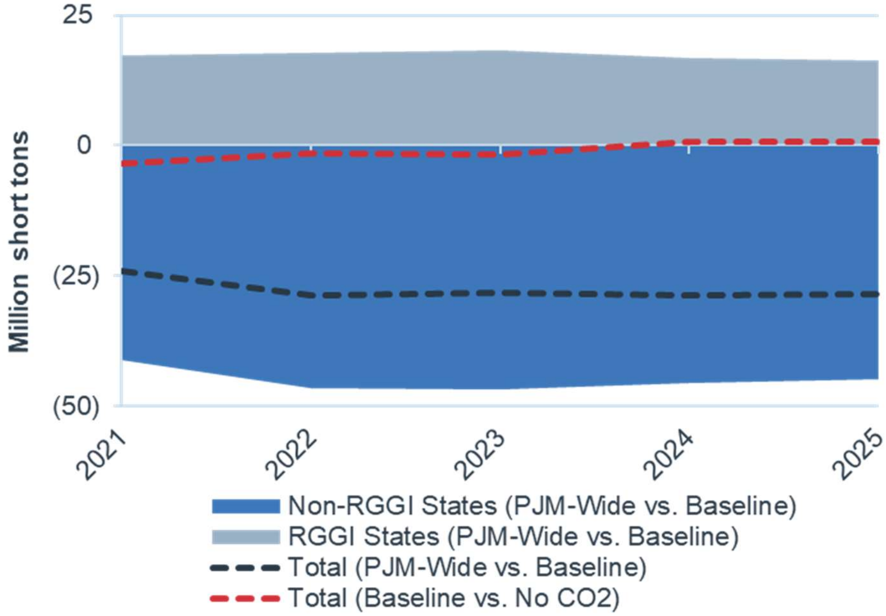
The analysis demonstrates that the Carbon Bridge Compact would lead to a material reduction in CO_2 emissions across the RTO footprint. The current sub-regional carbon pricing regime, where generators are only subject to carbon pricing in RGGI states, faces internal emissions leakage issues that greatly dampen the impact of the RGGI program on region-wide emissions. As shown in Figure 4-7, the Baseline Case (red dashed line) is projected to reduce carbon emissions by approximately 0.4% from 2021-2025 relative to the No CO_2 Case, where carbon pricing is fully removed from the PJM footprint. In fact, there are some years where the PJM footprint sees increased carbon emissions under the Baseline Case where only some states price carbon.

The PJM-Wide CO_2 Case, however, substantially reduces generation from the highest-emitting fossil generators on a system-wide basis, effectively addressing the leakage issue within the PJM footprint. That is, under the Carbon Bridge Compact, material carbon reductions are achieved across the PJM footprint relative to the Baseline Case. Specifically, PA projects an average reduction of 28 million tons of CO_2 emissions per year from 2021-2025 within PJM – a 9% drop relative to the Baseline Case.[34]

However, not all states within PJM will see direct carbon reductions. By creating a level playing field for fossil generators, there is an increase in fossil generation located within RGGI states, leading to a slight increase in emissions in those states that is more than offset by the decrease in carbon emissions across the rest of the footprint.[35] The relative difference in CO_2 emissions between the PJM-Wide CO_2 Case and Baseline Case is reasonably consistent across the 2021-2025 timeframe, with the rate of coal-fired generation displacement being relatively consistent.

[34] In comparison, the Baseline Case only reduces carbon emissions by an average 1.1 million tons from 2021-2025 relative to the No CO_2 Case (in which no generators in PJM are subject to CO_2 costs).
[35] As noted previously, this phenomenon could have unintended second order impacts on the RGGI program. However, these impacts – if any – are not explored in this paper.

Figure 4-7: Change in PJM CO_2 Emissions

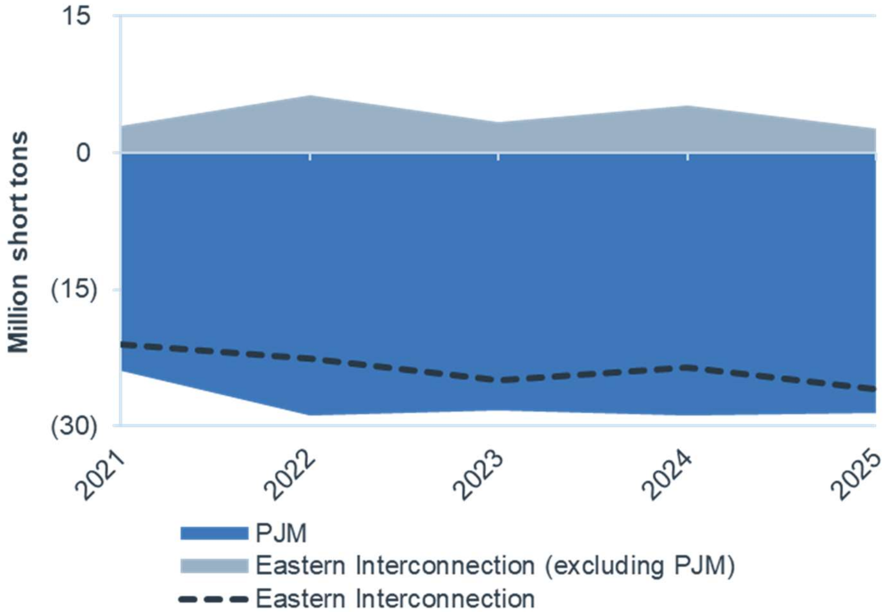


The small increase in net imports into PJM suggests that while the Carbon Bridge Compact would help reduce emissions leakage within PJM, emissions leakage may still occur outside of PJM (even with imports being assessed a Carbon Shadow Price and annual average imports/exports 'locked'). While this emissions leakage cannot be eliminated entirely without full carbon pricing across the entire Eastern Interconnection, this analysis demonstrates that significant carbon savings would still occur. While the Carbon Bridge Compact is projected to reduce carbon emissions within PJM by approximately 138 million tons from 2021-2025, the broader Eastern Interconnection (inclusive of PJM) would see a cumulative reduction of approximately 118 million tons over the same timeframe. See Figure 4-8.

Controlling overall flows between PJM and the rest of the RTO yielded less carbon emission reductions within PJM than the analysis otherwise would have shown. However, given that the Carbon Bridge Compact attempts to balance economic impacts to some regions with overall environmental gains, it would be inappropriate to cause more economic impact than is delivering actual environmental gain. Stated differently, without controlling import/export flows, a carbon price would effectively ramp-down coal production in West Virginia; however, coal production would then likely ramp up in RTOs without carbon pricing (i.e., MISO). Our modeling treatment of locking import/exports is an attempt to mitigate such leakage to other RTOs. If RTO-wide carbon pricing were implemented, PJM would need to evaluate how best to treat external transactions to avoid shifting generation and emissions to surrounding regions.[36]

[36] It should be noted that differing treatments of external generation could yield incremental emissions reductions within PJM without "shifting" emissions outside of the PJM footprint, further increasing the benefit of the Carbon Bridge Compact. For example, differentiated wheeling charges into PJM by technology type – similar to the approach that the state of California utilizes under AB 32 with regard to imported power – would potentially be a way for stakeholders to address this leakage issue while still allowing emissions-weighted economic flows between surrounding power regions.

Figure 4-8: Change in Eastern Interconnection CO_2 Emissions



4.5 ELECTRIC CUSTOMER IMPACTS

As discussed in Section 4.1, the introduction of the Carbon Bridge Compact increases wholesale energy market prices. In turn, this increases the gross cost to serve electric customer load, all else equal.[37] These costs can be divided into those borne in non-RGGI states (which this study is using as an example of the type of costs that can be mitigated via Carbon Reduction Funds) and those borne in RGGI states.

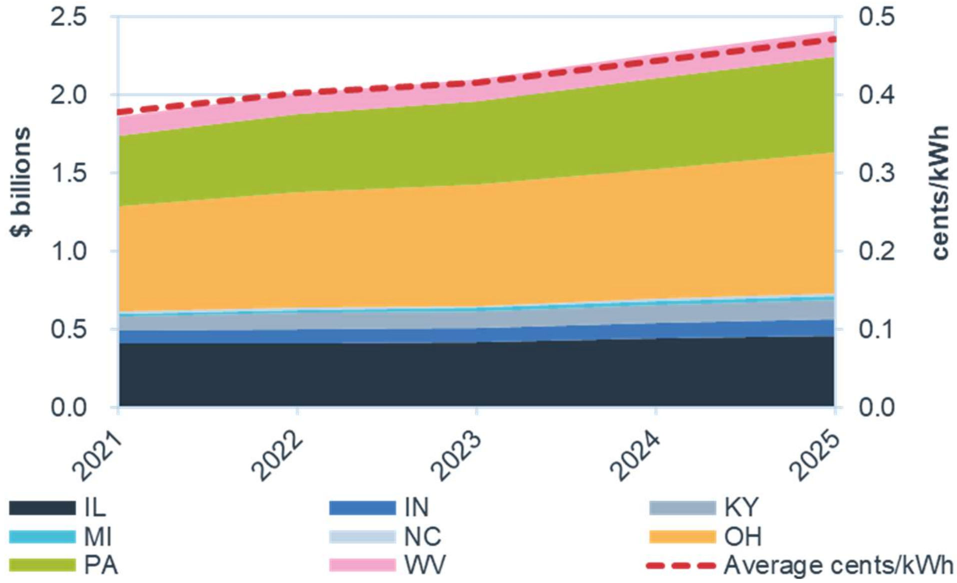
4.5.1 Non-RGGI states

In the PJM-Wide CO_2 Case, the gross cost to serve load in non-RGGI states is projected to be $1.9 billion higher than the Baseline Case in 2021, increasing to $2.4 billion by 2025. This compares to a $0.3 billion cost increase that non-RGGI states see today as a result of carbon pricing in RGGI states under the status quo, comparing the Baseline Case to the No CO_2 case. While retail rate structures are more complex than averages of wholesale power prices,[38] at a high level, this represents only a 0.42 cents/kWh average increase in the energy cost to serve non-RGGI states' customer

[37] Gross costs to serve customer load represent simplifications (not reflecting long-term PPAs, hedge contracts, etc. that specific LSEs may have in place) are strictly intended to show relative impacts on energy costs between cases.
[38] The increase in cost to electric customers only considers the change in wholesale energy prices flowing through to customer rates. As noted, it does not consider: potential changes to capacity prices in the market; how price changes may be insulated by existing utility contracts for power (including hedges); or how utilities may respond by altering other components of their rates (e.g., transmission, distribution, riders).

load from 2021-2025. These are the cost increases before accounting for the effects of the Carbon Reduction Funds. See Figure 4-9.

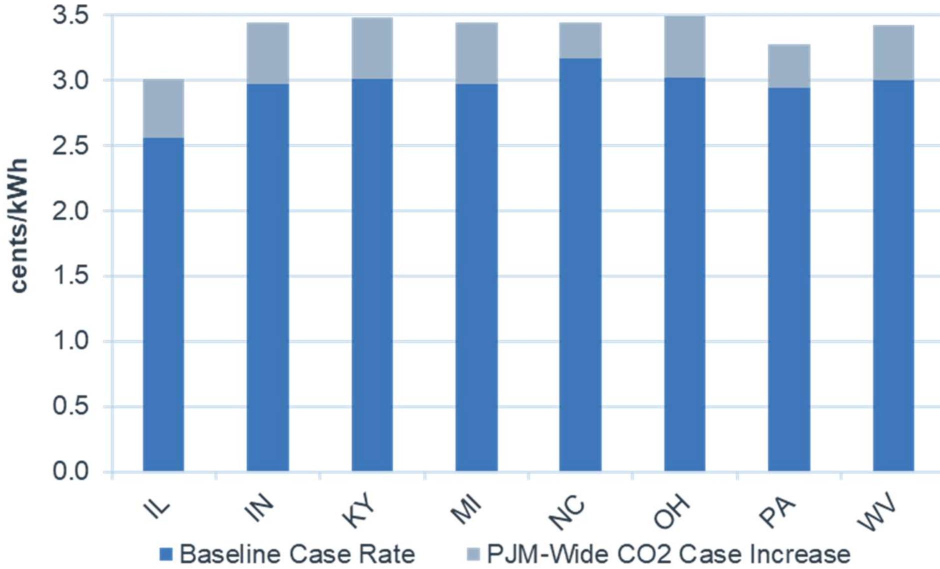
Figure 4-9: Increase in Cost to Serve Non-RGGI State Customer Load



There are several interrelated factors impacting electric cost burden for customers within each state, including transmission dynamics (affecting LMP costs borne by load) and each state's aggregate load:

- With the highest shares of load, Ohio and Pennsylvania are projected to bear the largest cost from 2021-2025 on an absolute basis.
- However, on a cents/kWh basis, customer cost increases in non-RGGI states fall within a narrow range – particularly when compared with the total size of the wholesale energy component of states' retail electric rates (as illustrated in Figure 4-10) – indicating that all non-RGGI state customers are similarly impacted when normalized for demand.
- More specifically, the change in rates is equivalent to less than half a penny across all eight non-RGGI states. North Carolina is projected to be at the low end of customer cost increases (0.27 cents/kWh), owing in part to its relatively small load within PJM; Kentucky is projected to be at the high end (0.47 cents/kWh) due in part to its dependence on – and proximity to (in neighboring states) – coal-fired generators.

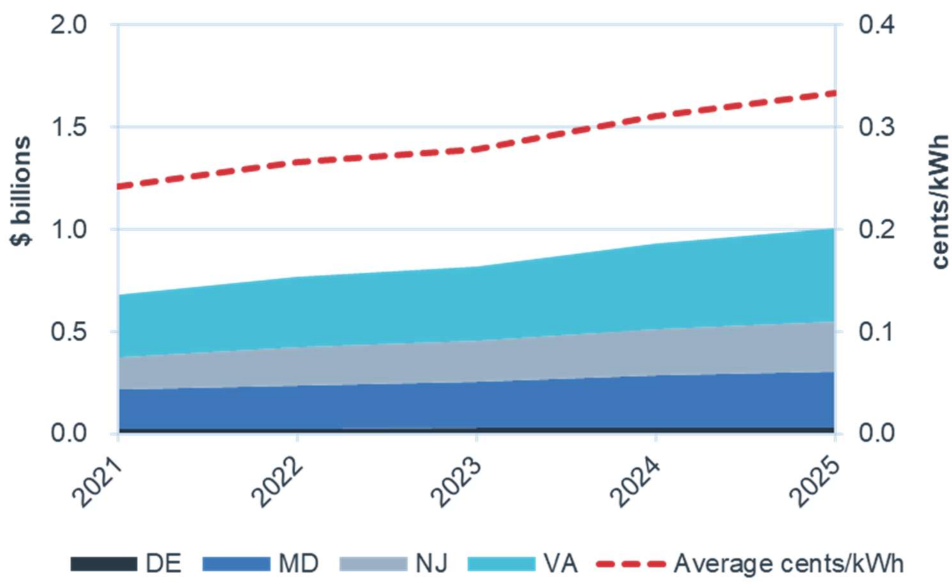
Figure 4-10: Average Increase in Wholesale Energy Costs to Serve Non-RGGI State Load by State (2021-2025)[39]



4.5.2 RGGI states

The gross cost to serve load in RGGI states is projected to increase by $0.7 billion in 2021 in the PJM-Wide CO_2 Case relative to the Baseline Case, with this cost increase rising to $1.0 billion by 2025. Cumulatively, this reflects a 9% increase in cost for electric customers in RGGI states over the five-year period and an average 0.29 cents/kWh increase to the cost to serve electric customer load. Notably, this increase is identical in concept to the cost increase that RGGI states would experience if all other PJM states joined RGGI in the 'traditional' manner (e.g., becoming RGGI members all at once rather than introducing the Carbon Bridge Compact) In other words, the observed cost increase is due to the general expansion of carbon pricing not because of a specific feature of the Carbon Bridge Compact.

Figure 4-11: Increase in Cost to Serve RGGI State Customer Load

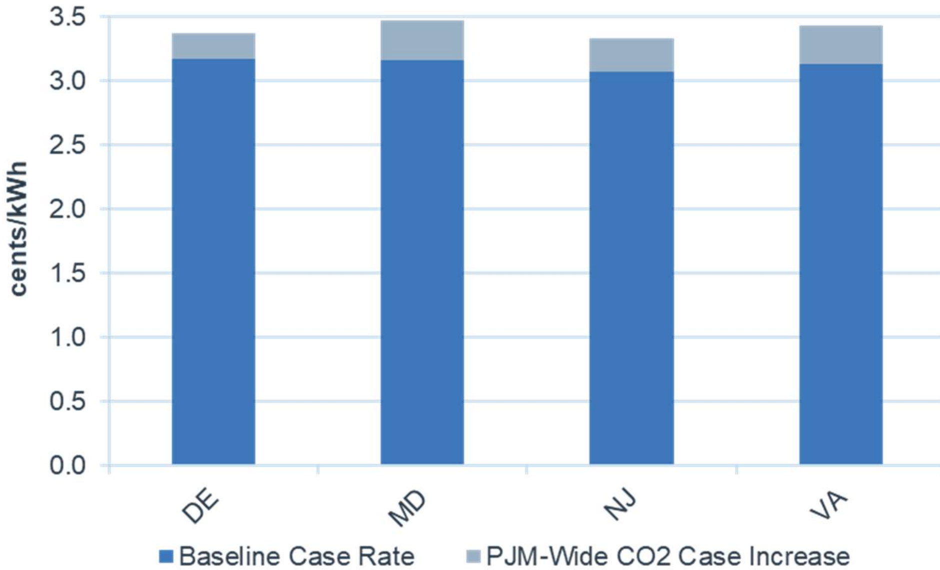


[39] The rates shown here only account for the wholesale energy component of electric customer rates, as modeled in this study; other market based product (e.g., capacity and ancillary services) as well as other components of retail rates (e.g., transmission, distribution, riders, hedges) are not assessed within this study.

Impacts to electric customer costs are also not equal across the RGGI states but follow a similarly tight band as those observed amongst the non-RGGI states:

- On an absolute basis, Virginia is projected to bear the greatest cost from 2021-2025 due to its high share of load as well as its relatively high concentration of fossil generators.
- However, on a cents/kWh basis, average customer cost increases in RGGI states fall within a narrow range (as illustrated in Figure 4-12). Delaware is projected to be at the low end of cost increases (0.20 cents/kWh), while Maryland is projected to be at the high end of cost increases (0.31 cents/kWh).

Figure 4-12: Average Increase in Wholesale Energy Cost to Serve RGGI State Load by State (2021-2025)[40]



4.6 GENERATOR ENERGY MARGIN IMPACTS

In addition to impacting generation patterns, the expansion of carbon pricing within any wholesale market will have diverse impacts on generator energy margins[41] depending on the asset class.[42] In general, clean energy technologies that do not emit carbon are likely to earn higher margins within the market due to increased energy pricing, while the least efficient carbon-emitting generators are likely to see a reduction in margins. However, depending on the overall efficiency of the market, highly-efficient fossil generators – such as best-in-class natural gas-fired combined cycles – may see an increase in energy margins if those generators are materially more efficient than the average price-setting technology. See Figure 4-13 and Figure 4-14.

[40] The rates shown here only account for the wholesale energy component of electric customer rates, as modeled in this study; other market based product (e.g., capacity and ancillary services) as well as other components of retail rates (e.g., transmission, distribution, riders, hedges) are not assessed within this study.

[41] Energy margins reflect wholesale market energy revenues net (i) fuel, (ii) carbon costs, and (iii) variable operation and maintenance expenses.

[42] PA did not project changes in capacity prices between the PJM-Wide CO_2 Case and Baseline Case.

Figure 4-13: Net Impact on Fossil Generator Energy Margins

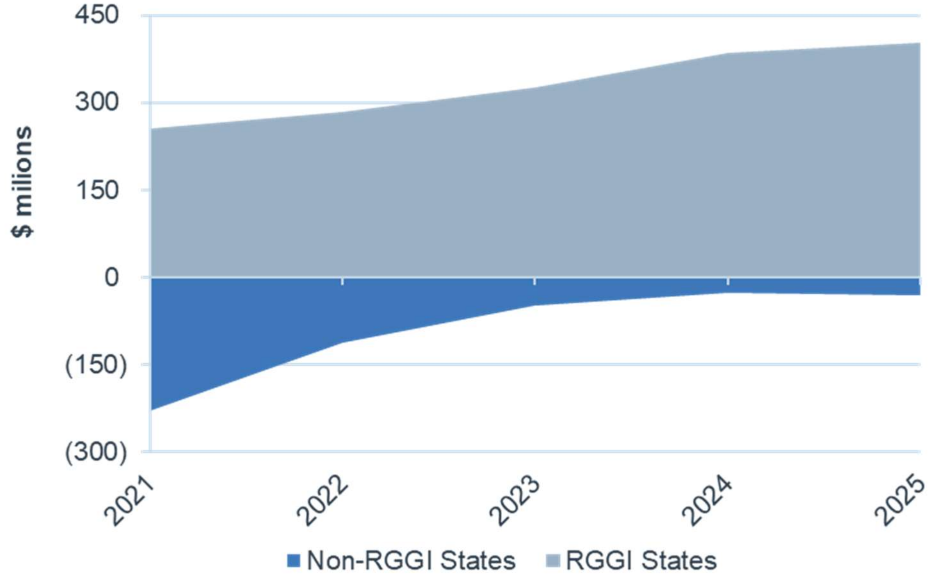
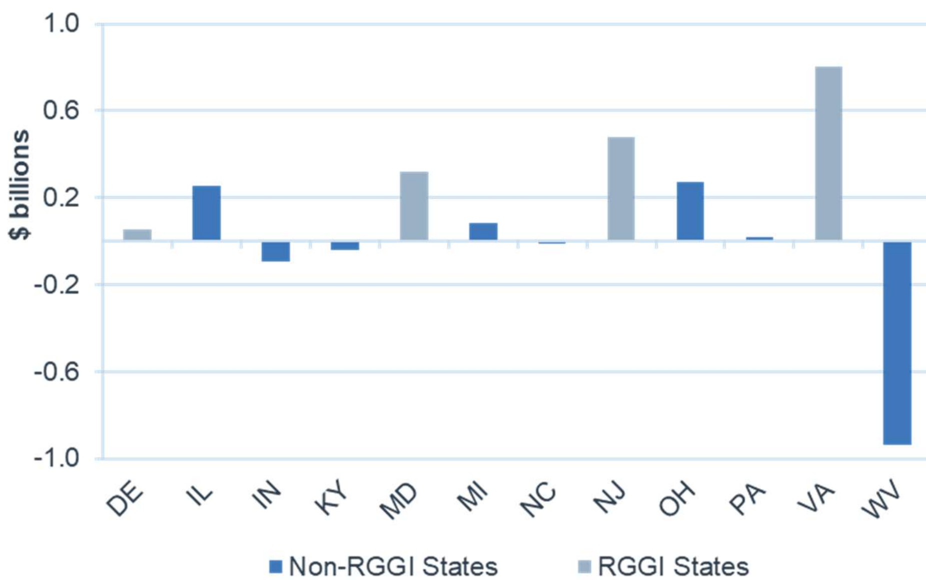


Figure 4-14: Cumulative Net Impact on Fossil Generator Energy Margins by State (2021-2025)



4.6.1 RGGI fossil generator energy margins

In aggregate, fossil generators in RGGI states would be positively impacted by the Carbon Bridge Compact, as these generators are already exposed to carbon pricing under RGGI.

- PA projects net fossil generator energy margins in these states to be, on average, $330 million higher per year from 2021-2025 under the PJM-Wide CO_2 Case relative to the Baseline Case. This increase is driven by both higher volumes of generation due to a leveling of the playing field (i.e., no longer facing a carbon pricing disadvantage relative to non-RGGI state fossil generators) as well as an overall increase in energy market prices.
- Additionally, the net increase in RGGI state fossil generator energy margins is projected to rise with time. This trend is due primarily to rising carbon compliance costs (both RGGI and the equivalent Carbon Shadow Price), which put upward pressure on energy market prices that can be captured by these assets. More specifically, the total net increase in energy margins increases from a $255 million gain (relative to the Baseline Case) in 2021 to a $403 million gain by 2025.

4.6.2 Non-RGGI fossil generator energy margins

Following a similar trend to changes in net generation patterns, as described in Section 4.3, in the aggregate, fossil generator energy margins in non-RGGI states are negatively impacted by the Carbon Bridge Compact.

- Net fossil generator energy margins in non-RGGI states are projected to be, on average, $90 million lower per year from 2021-2025 under the PJM-Wide CO_2 Case relative to the Baseline Case. This decrease is driven by both increased costs due to Carbon Shadow Pricing as well as a net reduction in the number of hours fossil generators operate.
- However, not all fossil generators are projected to see a decline. In particular, highly efficient, lower-emitting natural gas-fired combined cycles experience increased energy margins due to the rise in power prices that more than offsets Carbon Shadow Price costs.
- Additionally, the net reduction in non-RGGI state fossil generator energy margins is projected to decline over time. This trend is due, in part, to the already-planned retirement of coal-fired generators in the near- to medium-term across both cases, which reduces the total net loss in energy margins from $230 million (relative to the Baseline Case) in 2021 to a $31 million decrease in 2025.
- On a state-by-state basis, West Virginia is projected to account for the bulk of lower fossil net energy margins, owing to its legacy coal-fired fleet. See Figure 4-14.
- However, despite significant reductions in coal-fired generation, some non-RGGI states (e.g., Illinois, Ohio, and Pennsylvania) are projected to see fossil generators earn higher energy margins overall. Although coal-fired generators within these states will see net losses, each state’s fossil fleets also include substantial amounts of newer, highly efficient natural gas-fired combined cycles, which on the whole benefit from higher energy margins.

4.6.3 Nuclear generator energy margins

As shown in Figure 4-15 and Figure 4-16, nuclear generators across the PJM footprint are projected to benefit substantially from the Carbon Bridge Compact.

- Nuclear generators across all PJM states, in aggregate, are projected to earn an additional average $947 million per year in energy margins from 2021-2025 under the PJM-Wide CO_2 Case relative to the Baseline Case. Normalizing for generation, average energy margin upside is $2.77/MWh for RGGI state nuclear units, and $3.76/MWh for Non-RGGI state facilities.
- Relative to renewable generators (which also benefit from higher power prices without facing any carbon cost, as discussed in Section 4.6.4), nuclear generators have greater upside potential due to their around-the-clock baseload operations.
- The increase in nuclear generator energy margins has significant implications for state-level policy payments (i.e., ZEC payments) that are paid by states to incentivize the retention of carbon-free generation. That is, any state with a nuclear support program (Illinois and New Jersey) would theoretically be able to reduce such payments, all else equal, as increased revenues from the wholesale energy market would displace the need for this revenue stream.
- The relative difference in nuclear generator energy margins between states is primarily driven by the amount of nuclear capacity in each state, with Pennsylvania and Illinois home to most of PJM’s nuclear facilities.

Figure 4-15: Net Impact on Nuclear Generator Energy Margins

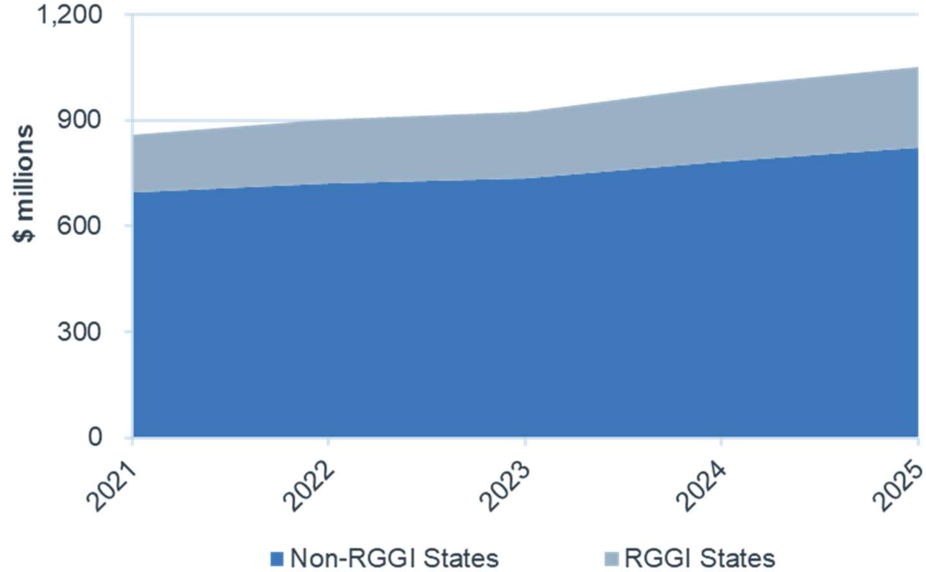
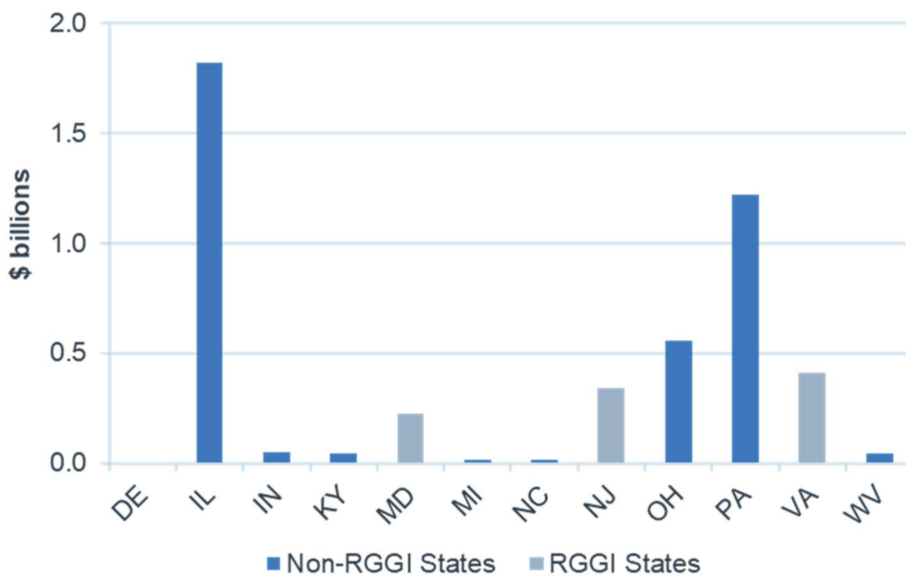


Figure 4-16: Cumulative Net Impact on Nuclear Generator Energy Margins by State (2021-2025)



4.6.4 Renewable generator energy margins

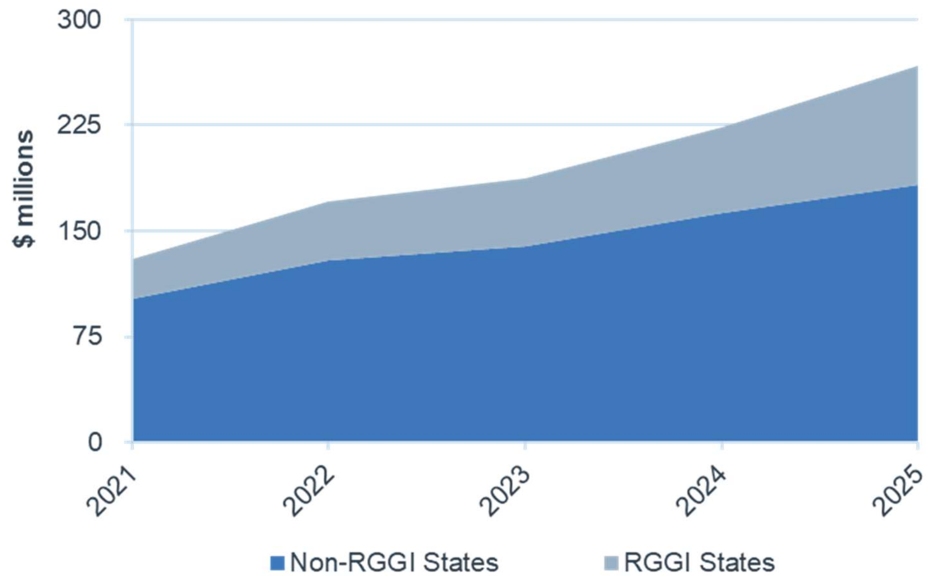
As shown in Figure 4-17, renewable generators across the PJM footprint are projected to benefit substantially from the Carbon Bridge Compact.

- Renewable generators across all PJM states, in aggregate, are projected to earn an additional average $196 million per year in energy margins from 2021-2025 under the PJM-Wide CO_2 Case relative to the Baseline Case. Normalizing for generation, average energy margin upside is $2.74/MWh for RGGI state renewable units and $4.10/MWh for Non-RGGI state facilities.
- Compared to nuclear generators (which also benefit from higher power prices without facing any carbon cost, as discussed in Section 4.6.3), renewable generators have less upside potential due to intermittent operations, lower capacity factors, and – on average – lower levels of installed capacity.
- The increase in renewable generator energy margins has significant implications for state-level policy payments (i.e., REC payments) that are paid by states to incentivize the buildout of new renewable capacity. That is, any state with an RPS program (all PJM states except for Indiana, Kentucky, and West Virginia) would theoretically

be able to reduce such payments, all else equal, as increased revenues from the wholesale energy market for renewable generation would displace the need for this revenue stream.

- Due to the general ability within PJM for Tier 1 RECs to be compliant in meeting state-level RPS requirements so long as the associated renewable facility is located within the RTO, PA builds new generic renewable generation in the most economic portions of the PJM footprint. This locational flexibility within PJM RPS compliance means that RECs paid by customers in one state may be used to fund a project physically located in another state. To accurately determine the program's impact on REC payments, PA therefore allocated increased renewable energy revenues based on RPS demand rather than the physical location of any particular renewable generator. To do this, PA aggregated the net increase in expected renewable margins across the PJM footprint into a central pool and then reallocated those revenues based on state-level RPS demand as a means to offset state-level REC payments.[43]

Figure 4-17: Net Impact on Renewable Generator Energy Margins



[43] Additionally, PA recognizes that renewables under contract may not have REC payments impacted, but analyzing the impact of this is beyond the scope of this paper.

5 DISCUSSION

This paper demonstrates that the Carbon Bridge Compact is one way to address emissions and cost leakage by fully integrating carbon costs within a multi-state wholesale market design while still respecting individual state priorities. By using Carbon Reduction Funds to ease the transition, the Carbon Bridge Compact helps alleviate tension between state and federal authority in US electric wholesale markets by enabling states to retain control over their own resource planning while limiting the impacts of actions taken in other states. Ultimately, by utilizing a construct similar to the outlined Carbon Bridge Compact, RTOs could maintain a sustainable, competitive wholesale electricity market that is also capable of delivering cost-effective, reliable power in a manner congruent with state decarbonization goals.

The success of any market-wide carbon pricing mechanism in PJM will require a consensus between RGGI and non-RGGI states regarding the appropriate path forward. Meaningful stakeholder conversations will need to not only rely on the aforementioned factors in this paper, but they will also benefit from several additional considerations.

5.1 THE IMPACTS ON LEGACY ENVIRONMENTAL ECONOMIC INCENTIVE PROGRAMS

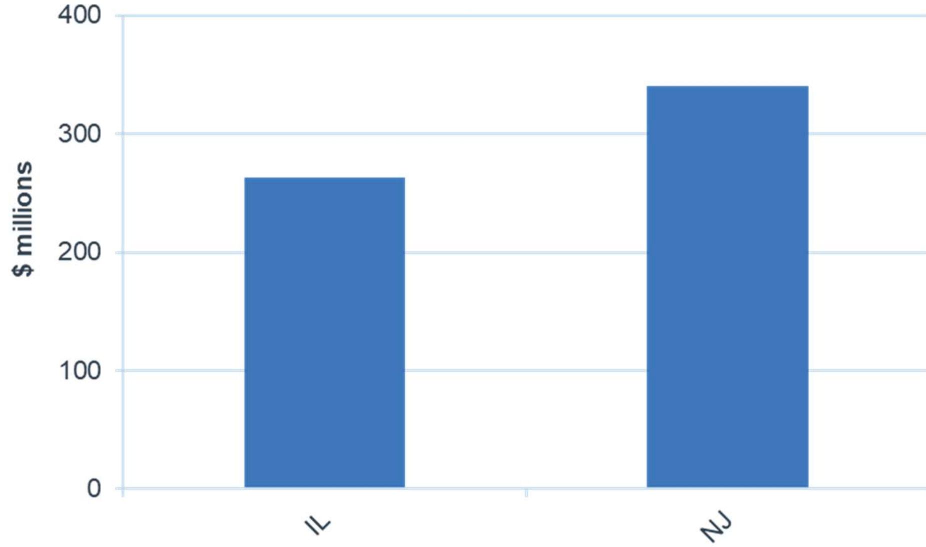
The principal two mechanisms utilized within US power markets to achieve decarbonization goals are (i) assigning a cost to carbon; and (ii) establishing renewable/clean energy standards. While these two strategies are not mutually exclusive, they have significantly different implications.

The central question is how much intervention is appropriate (or necessary) within wholesale markets to achieve state-level policy goals. Renewable portfolio and clean energy standards seek to ensure that a certain percentage of retail electric sales are attributed to clean energy resources. Such clean energy resources are typically compensated through payments outside of the energy market in a manner that indirectly values carbon reductions, which enables otherwise non-economic resources (from a wholesale market perspective) to enter the market (or stay in the market) and displace existing, higher marginal cost carbon-emitting power plants. As previously discussed, however, this has led to significant implications for competitive outcomes within current wholesale market designs.

Regional carbon pricing, on the other hand, has the potential to incentivize lower carbon emissions and allow the market to determine the most efficient means to reach decarbonization goals. However, as discussed, this solution has not been as effective as it could be due to emissions leakage. Potentially more importantly, states must give up a degree of planning control when entering into regional carbon programs – implicitly putting trust in the program to drive solutions that will be mutually beneficial for the environment and its populace. It would be easier to put trust in such programs when the functioning of the multi-state wholesale market does not undermine the emissions reduction benefits of carbon pricing.

This study demonstrates that the Carbon Bridge Compact would help shift the balance towards economic incentives to promote clean energy resources, while still allowing clean energy targets to remain as a procurement backstop. In general, compensation levels for state-level ZEC and REC programs are impacted by prevailing wholesale energy and capacity market prices. All else equal, enhanced energy revenues will decrease the amount of subsidy needed to entice nuclear facilities to remain in or renewable generators to enter the market. Higher energy prices under the Carbon Bridge Compact provides this enhanced wholesale energy revenue regime, resulting in an overall decreasing in the need for subsidization. For example, Figure 5-1 highlights the cumulative increase in energy market revenues ZEC-covered nuclear generators would receive under the Carbon Bridge Compact, which in turn would decrease the need for state-level support and implicitly frees up state budget allocations for usage in other areas. The states of Illinois and New Jersey – both of which have existing ZEC-type programs – should help inform this broader consideration.

Figure 5-1: Cumulative Increase in Energy Margins for Nuclear Units Receiving ZECs (2021-2025)



5.2 THE BENEFITS OF CONTINUED MEMBERSHIP BY RGGI STATES

The Carbon Bridge Compact effectively "asks" current RGGI member states in PJM to contribute towards Carbon Reduction Funds. In this study, these RGGI state contributions are proxied via incremental RGGI allowance sales and recycling REC/ZEC savings into the Carbon Reduction Funds. With this in mind, it is natural to question if this would disincentivize continued participation within the RGGI program.

RGGI was "established to reduce air pollutants related to climate change"[44] and explicitly recognizes carbon is a global pollutant that does not respect political boundaries. If a state joins RGGI with the goal of enhancing carbon outcomes, it is unlikely that the "ask" to contribute to Carbon Bridge Compact would disincentivize participation in RGGI. Rather, states are likely to participate in RGGI for two key reasons (i) cost effectiveness of carbon reductions; and (ii) demonstrated leadership in shaping future carbon outcomes.

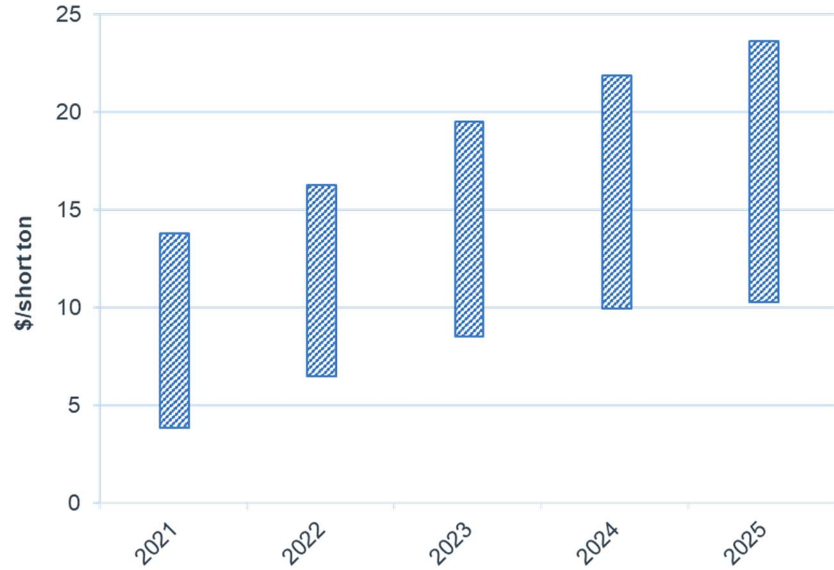
5.2.1 Cost effectiveness

Recognizing that state budgets to address carbon pollution are finite, numerous states across the United States have shown a desire to address carbon pollution in the most cost-effective means possible. All else equal, less costly means of reducing carbon pollution would generally be preferred over more expensive options. The Carbon Bridge Compact, as modeled, demonstrates that transfers of Carbon Reduction Funds from RGGI to non-RGGI states would be a highly cost-effective means to enhance decarbonization. It is important to recognize that the funds RGGI states are transferring to non-RGGI states exist only as a result of the Carbon Bridge Compact. In that sense, the RGGI states can be viewed as getting the emissions reduction benefit, but not retaining the financial benefit of the Carbon Bridge Compact.

Over the course of the study period, approximately 84% of proposed Carbon Reduction Funds are generated within non-RGGI states, and the remainder is generated within RGGI states via reductions in needed REC and ZEC funding as well as incremental allowance sales. This combined total would materially offset increased customer costs in non-RGGI states (i.e., offset 90% of potential increased costs). However, if fully offsetting ratepayer costs in non-RGGI states is necessary to implement the proposed market design, additional contributions from RGGI or non-RGGI states would still be cost effective. More specifically, these funds would allow the PJM region to unlock a 9% reduction in carbon emissions within its footprint. In other words, a relatively modest increase in contributions to the program from RGGI states results in material carbon emission reductions. Figure 5-2 shows the range of implied carbon reduction costs from RGGI states (i) absent contributions from RGGI state RECs, ZECs, and incremental allocated emissions (the upper range), and (ii) inclusive of contributions from RGGI state RECs, ZECs, and incremental allocated emissions (the lower range).

[44] https://www.rggi.org/sites/default/files/Uploads/RGGI-Inc-Documents/cert_of_inc.pdf.

Figure 5-2: Range of Implied Carbon Reduction Costs from RGGI States



5.2.2 Carbon leadership

All states that are current members of RGGI have demonstrated long-standing commitment towards climate leadership. While any state could be selected, New Jersey provides a prime example. Beyond being a member of RGGI, the state:

- Enacted its renewable portfolio standard in 1999 and strengthened it over time, with the most recent amendment seeking a 50% renewable target by 2030;
- Enacted its Global Warming Response Act in 2007;
- Established offshore wind targets through a series of Executive Orders in 2018 and 2019; and
- Called for 100% carbon-neutral electricity generation by 2050 through its 2019 New Jersey Energy Master Plan.

While this is an incomplete list, this type of climate leadership suggests the state seeks an active role in shaping future carbon outcomes. As members of RGGI, states such as New Jersey have a direct seat at the table to negotiate future carbon reduction goals under the RGGI program to ensure the evolution of the program will be consistent with each state's broader climate goals. In contrast, states that are a part of the Carbon Bridge Compact but not RGGI do not have a seat at the table for future negotiations on how carbon pricing may evolve. In other words, being members of RGGI and the Carbon Bridge Compact are additive – particularly for states that have strong climate goals that would like to see carbon pricing expanded across much of the Eastern Interconnection.

5.3 NEW RGGI MEMBERSHIP BY NON-RGGI STATES

A central concern regarding any program (the Carbon Bridge Compact or otherwise) that would insulate electric customers from carbon pricing impacts (e.g., via Carbon Reduction Funds) is the potential disincentive for non-RGGI states to join RGGI (or a similar program) in the future. In particular, non-RGGI states would benefit from reduced carbon emissions under the Carbon Bridge Compact but at a reduced (or zero) cost to its electric customers via the introduction of Carbon Reduction Funds. This is an important topic worthy of further consideration by stakeholders.

On the surface, there would be little direct *quantifiable* incentive for a non-RGGI participant in the Carbon Bridge Compact to concurrently enter RGGI as a new market participant. In general, most non-RGGI participants are likely to see a net transfer of Carbon Reduction Funds *into* their respective states, although this is not always the case; in the alternative, entry into the RGGI program during the five-year tenor of the proposed Carbon Bridge Compact would "cap" a respective participant state's funding at the quarterly RGGI allowance auction results (i.e., the supply sold multiplied by the RGGI clearing price).[45] This factor could potentially stunt – at least temporarily – the expansion of the RGGI footprint. However, it is also plausible that the introduction of the Carbon Bridge Compact could facilitate and ease the transition of certain states discussing near-term entry into RGGI (e.g., Pennsylvania, Illinois). Moreover, any near-term movements that non-

[45] We note that for some states, like West Virginia, the impact to its ratepayers of carbon pricing is small relative to the amount of carbon funds collected from in-state generators. There may be more financial benefit to joining RGGI the traditional way, where its funding is based on carbon emissions allowances sold, rather than through the Carbon Bridge Compact, where we are proposing that a state's funding would be calibrated to cover the impact on its ratepayers.

RGGI states make toward decarbonization during the duration of the Carbon Bridge Compact are likely to better position and protect their respective ratepayers for future discussions regarding decarbonization programs.[46]

5.3.1 Pennsylvania: Easing the RGGI transition

Pennsylvania continues to make progress on Governor Tom Wolf's executive order announcing the intent to join RGGI by 2022. The governor acknowledged Pennsylvania's "unique energy mix," which includes significant nuclear resources, and noted the importance of "making sure that the transition to a cleaner energy mix" protected the workers and communities responsible for producing power.[47] With RGGI, higher energy market prices driven by the application of carbon pricing in the commonwealth may be enough to save currently at-risk nuclear facilities and associated jobs. For example, Energy Harbor Corp. indicated it would rescind its prior deactivation notice for the Beaver Valley nuclear power plant if the state were to join RGGI. However, while the commonwealth continues to push forward with implementation of the RGGI program, there is continued resistance from the legislature and potentially negatively affected parties (e.g., coal-fired generators and coal suppliers).

Pennsylvania joining RGGI in the absence of a PJM-wide carbon pricing program would put its fossil generators at a marked disadvantage relative to certain generators in border states as well as create a higher cost burden for its electric customers. However, many of these concerns would be, at least, partially mitigated under the proposed Carbon Bridge Compact. For example, newer combined cycle generators (and the broader Marcellus natural gas production and delivery infrastructure) could see enhanced utilization and energy margins due to the lower carbon intensity of these power generators under the Carbon Bridge Compact (as opposed to a scenario where Pennsylvania only joins RGGI). This is similar to the impact the Carbon Bridge Compact has on natural gas-fired generators within Virginia. Due to Virginia power generators being subject to RGGI under the Base Case (putting its fossil generators at a disadvantage), the introduction of the Carbon Bridge Compact increases overall fossil generation within the state by approximately 49%.

5.4 ALTERNATIVE USES OF CARBON REDUCTION FUNDS

Proposed Carbon Reduction Funds, as investigated in this study, were focused on offsetting cost impacts to electric customers in non-RGGI states. Changes in market rules, however, would impact stakeholders beyond electric customers. The use of Carbon Reduction Funds could therefore potentially be expanded to mitigate any other detrimental effects.

One potential use of Carbon Reduction Funds could be to compensate higher-emitting generators within certain states for any disproportionate impacts felt as a result of regional carbon pricing. For example, as discussed in Section 4, net fossil generator margins in West Virginia, Indiana, Ohio, and Kentucky would be negatively impacted by the introduction of regional carbon pricing.[48] West Virginia's fossil generators would be among the hardest hit in terms of net fossil generator margins. Similarly, Indiana, while not as impacted, would sustain approximately 20% of total net losses. Kentucky and North Carolina are projected to see 9% and 2% of total net losses, respectively, across the same time period, while Ohio, Illinois, Michigan, and Pennsylvania are projected to see total net gains of 60%, 57%, 19%, and 4%, respectively.

While fossil generators in West Virginia, Indiana, Ohio, and Kentucky bear the brunt of economic losses under the Carbon Bridge Compact, these states are also critical to the success of the program. For example, West Virginia is projected to account for 45% of reduced carbon emissions in non-RGGI states over the 2021-2025 period, with Ohio following at 19%, respectively. To persuade key states to participate in the Carbon Bridge Compact, it may be necessary to provide additional Carbon Reduction Funds to compensate for impacts beyond customer electric cost increases. For example, a portion of Carbon Reduction Funds could be allocated directly to West Virginia to redress affected coal-fired generators[49] or help local communities impacted by changing generator dynamics.

Notably, after affected states agree on Carbon Reduction Funds allocation at the state level, each individual state's designated regulatory or legislative entity would be granted the authority to decide how best to utilize funds. While the modeling within this paper uses Carbon Reduction Funds to minimize impacts to electric customers – and demonstrates

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[46] In addition, it is possible that the Carbon Bridge Compact induces certain states to join RGGI within the five-year compact window, if for no other reason than to ensure that the state has a "seat at the table" with regard to future RGGI program discussions.

[47] https://www.governor.pa.gov/newsroom/governor-wolf-takes-executive-action-to-combat-climate-change-carbon-emissions/.

[48] Even if states were to compensate impacted fossil facilities, carbon reductions would likely still occur. More specifically, the Carbon Shadow Price would still be added to the generator's bid, which would impact its marginal dispatch cost. In contrast, a Carbon Reduction Funds payment (depending on how it is allocated by the state) is not likely to impact the marginal bid price (similar to how a capacity payment typically does not directly impact energy market bidding behavior).

[49] Without a carbon market design in place, there is certainly the concern that direct Carbon Reduction Funds transfers to generators may incentivize carbon-intensive fossil-fueled resources to remain in the market longer than economically optimal. Direct Carbon Reduction Funds transfers would need to be designed in a manner that alleviates this concern.

that material stakeholder impacts could be meaningfully mitigated – states themselves are the most qualified to determine how best to mitigate state-level economic impacts.

5.5 CONCLUDING THOUGHTS

Greenhouse gases are inherently global pollutants. Therefore, while well-intentioned and producing a range of co-benefits (e.g., lower NOx and SOx emissions that have important and localized ties to public health), sub-market-wide carbon programs fall short of realizing a given state's intended climate policy goals due to associated emissions leakage. More broadly, to further assist decarbonization goals, various states have created renewable portfolio and clean energy standards; however, these programs have increased tensions between state and federal authority in US electricity markets. All interested parties would benefit from an effort to incorporate state goals into wholesale markets in a manner that respects differences in state decarbonization goals.

This paper explored Vistra's position that a sustainable long-term competitive wholesale electricity market must embrace state-level environmental goals while also maintaining traditional reliability and least-cost requirements. More specifically, this paper evaluated whether Vistra's proposed Carbon Bridge Compact for PJM would (i) alter system dispatch in a manner that promotes clean energy; (ii) enhance market signals for power generation; (iii) address emission leakage concerns, and (iv) fairly compensate any states which may have lesser or more stringent environmental objectives such that state-level rights are preserved.

With careful design, a PJM-wide carbon pricing regime would be a significant step toward a truly sustainable market design by fully integrating carbon costs while also respecting individual state goals through the use of Carbon Reduction Funds. While the primary use of Carbon Reduction Funds could be to mitigate the impact to electric customers, states are in the best position to decide how to use these funds. Successful implementation would allow states to remain in control of their energy future while still benefiting from PJM's multi-state RTO markets.

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