Preventing Pennsylvania from Powering Down:

ANALYSIS OF GOVERNOR SHAPIRO'S PACER AND PRESS PROPOSALS

AUTHORS

ISAAC ORR
MITCH ROLLING

INTRODUCTION BY

ANDRÉ BÉLIVEAU

MAY 2025

COMMONWEALTH FOUNDATION

AUTHOR

Isaac Orr CO-FOUNDER AND VICE PRESIDENT OF RESEARCH AT ALWAYS ON ENERGY RESEARCH

Isaac Orr is a co-founder and the Vice President of Research at Always On Energy Research, where he conducts energy modeling and writes about energy and environmental issues, electricity policy, and natural resource development.

Mitch Rolling CO-FOUNDER AND DIRECTOR OF RESEARCH AT ALWAYS ON ENERGY RESEARCH

Mitch Rolling is a co-founder and the Director of Research at Always On Energy Research, where he models energy proposals, analyzes the energy industry and electricity policy, and writes about energy and environmental issues.

EDITOR

André Béliveau SENIOR MANAGER OF ENERGY POLICY AT THE COMMONWEALTH FOUNDATION

André Béliveau is the Senior Manager of Energy at the Commonwealth Foundation, where he leads the organization's energy policy initiatives in the state and with our national partners.

GUARANTEE OF QUALITY SCHOLARSHIP

The Board of Directors and Staff of the Commonwealth Foundation are dedicated to providing quality and dependable research on public policy issues in the Keystone State. To this end, the Commonwealth Foundation guarantees that all statements of fact in our publications are verifiable and information attributed to other sources accurately represented.

Committed to providing Pennsylvanians with reliable information, the Commonwealth Foundation welcomes critical review of its work. If the accuracy of our research is questioned and brought to the Foundation's attention with supporting evidence in writing, the Foundation will respond.

If an error exists, the Commonwealth Foundation will issue an errata sheet that will accompany all subsequent distributions of the publication, which constitutes the complete and final remedy under this guarantee.

For additional information or questions, email the Commonwealth Foundation at info@commonwealthfoundation.org or call 717.671.1901.

TABLE OF CONTENTS

KEY FINDINGS

- **The Price Tag**
  Governor Shapiro's Pennsylvania Climate Emissions Reduction Act (PACER) and Pennsylvania Reliable Energy Sustainability Standard (PRESS) proposals would impose $157.2 billion in new electricity costs on Pennsylvanians through 2035—$155 billion from PRESS compliance and $2.2 billion from PACER, even after a 70 percent rebate.
- **The Electricity Rate Hike**
  Under PACER and PRESS, electricity prices would surge from 12.58 cents per kilowatt-hour (kWh) in 2023 to 20.17 cents per kWh by 2035, a 60 percent increase that would hit Pennsylvanian families, small businesses, and manufacturers alike.
- **More than Double Electric Bills**
  Annual electricity costs would rise by $1,754 for households, $5,554 for commercial businesses, and $178,620 for industrial customers—undermining affordability and economic competitiveness.
- **Impact on Household Electric Bills**
  Pennsylvania families would see their annual electricity costs rise from $1,717 in 2023 to $3,471 in 2035—an increase from $143 to $289 per month. That means the average household bill would more than double, rising 102 percent by 2035 under PACER and PRESS.
- **Massive Overbuild of Intermittent Capacity**
  PRESS mandates nearly triple Pennsylvania's power plant capacity—from 45.5 gigawatts (GW) to 124 GW by 2035—driven almost entirely by wind, solar, and battery storage. This immense buildout is not to meet rising consumer demand but to compensate for the intermittency of solar and wind, imposing massive costs for capacity that the grid would not need for dispatchable or baseload energy sources.
- **Emissions Costs Far Exceed Claimed Benefits**
  Carbon dioxide (CO_2) reductions under PACER and PRESS are two times higher than the estimates of climate benefits outlined under the Biden administration's Social Cost of Carbon (SCC), delivering a net economic harm to Pennsylvania.

INTRODUCTION

Energy policy is more than a workforce or environmental issue—it matters for state and national security, the price of consumer goods, economic prosperity, and healthy communities. In short, modern life depends on an affordable, reliable, and secure energy supply. As the third-largest electricity producer, the second-largest natural gas producer, and the largest electricity exporter in the country, Pennsylvania's energy policies impact the entire nation. What happens in Pennsylvania does not stay in Pennsylvania.

Pennsylvania is a pillar of American energy leadership, supplying affordable, reliable electricity from a mix of natural gas, nuclear, and coal while still maintaining a growing renewable sector. The commonwealth is also a case study in reducing emissions responsibly while maintaining a firm electricity supply. Data from the Independent Fiscal Office (IFO) shows that Pennsylvania is one of only three states in the region to lower emissions while increasing power generation, primarily due to a market shift from coal to natural gas. Additionally, analysis of the IFO data proves that the Keystone State is lowering emissions more effectively than states with heavy-handed emissions mandates, such as the Regional Greenhouse Gas Initiative (RGGI).

However, proposed state policies by Gov. Josh Shapiro—the Pennsylvania Climate Emissions Reduction Act (PACER) and the Pennsylvania Reliable Energy Sustainability Standard (PRESS)—represent a dramatic shift away from Pennsylvania's proven energy leadership. If enacted, these policies would increase consumer electricity costs and fundamentally alter Pennsylvania's energy landscape, forcing a transition from reliable generation to intermittent energy sources like wind, solar, and inefficient battery storage.

Pennsylvanians already pay electricity costs above the national average. For an energy-rich state like Pennsylvania, that should not be the case. Excessive red tape, outdated regulations like the Alternative Energy Portfolio Standard (AEPS), and federal policies like the Inflation Reduction Act (IRA) increase costs for Pennsylvanians. A desire to reduce emissions drives many of these regulations, but they counterintuitively get in the way of the industry that successfully reduces emissions while providing reliable power. Shapiro's policies will punish Pennsylvania's success, cripple its competitive advantage in natural gas, and make electricity rates even higher.

Every conceivable energy policy has tradeoffs. Affordability, reliability, security, and environmental conservation must be weighed together, not pursued in isolation.

To fully weigh the costs and benefits of PACER and PRESS, Pennsylvanians need a data-driven analysis answering what these policies mean for electricity prices, economic growth, and grid reliability.

This report provides those answers.

The stakes could not be higher. From Europe and California to other energy-rich states like Texas, one sees the results of pursuing rapid renewable energy transitions. California now has the highest electricity rates in the continental United States, with grid instability leading to rolling blackouts. Europe's aggressive buy-in to net-zero and renewable mandates has delivered soaring energy prices, industrial decline, and grid instability. Germany spent hundreds of billions on its energy transition plan "Energiewende," only to end up with some of the highest electricity prices in the world and a return to coal power when renewables couldn't deliver. Texas also bought into the intermittent energy scheme—increasing its wind and solar capacity and improperly firming the grid—and saw its grid collapse during Winter Storm Uri in 2021, resulting in the deaths of over 240 people.

The Keystone State should not follow these failed policies. The stakes could not be higher. Pennsylvania's energy policy decisions will shape its status as an American energy leader and global energy provider for generations.

Pennsylvania has long been known as an energy powerhouse, but will it remain one?

PREVENTING PENNSYLVANIA FROM POWERING DOWN:
Analysis of Governor Shapiro's PACER and PRESS Proposals

Authors' Note: This report is a continuation of the work performed by the authors at Always On Energy Research, modeling the cost of energy policies in states throughout the country. Portions of this report have been repurposed from previous reports prepared by AOER for other entities and modified to reflect the results of state decarbonization plans in the Commonwealth of Pennsylvania.

EXECUTIVE SUMMARY

Pennsylvania is the third-largest producer of electricity in the country and the nation's largest electricity exporter, exporting 35 percent of the electricity it produces.[1] As a result, Pennsylvania's current fleet of natural gas, nuclear, and coal power plants plays an indispensable role in maintaining the reliability of the electric grids operating within the Eastern United States.[2]

However, policies proposed by Pennsylvania's Gov. Josh Shapiro and other lawmakers to reduce carbon dioxide (CO_2) emissions from the electricity sector and spur the development of alternative energy resources, such as wind turbines, solar panels, and battery storage facilities, would require substantial changes to the Keystone State's generating portfolio.

These policies include the Pennsylvania Climate Emissions Reduction Act (PACER) and the Pennsylvania Reliable Energy Sustainability Standard (PRESS).

PACER would establish a Pennsylvania-specific cap-and-trade system to tax CO_2 emissions from the power sector to reduce greenhouse gas emissions. PRESS would require 50 percent of Pennsylvania's electricity to come from alternative energy sources such as wind, solar, battery storage, advanced nuclear power plants such as small modular reactors (SMRs), "clean" hydrogen, carbon capture and sequestration on coal or natural gas plants, biomass, geothermal, and more, by 2035.[3]

The findings in this report show that**, if enacted, PACER and PRESS would cost Pennsylvania an additional $157.2 billion through 2035 as a result of higher electricity prices,** with $155 billion as the result of PRESS compliance and $2.2 billion as a result of PACER due to the 70 percent rebate of taxes collected in the law. Without this refund, PACER would cost Pennsylvania families and businesses $7.2 billion. These calculations exclude the impact of federal subsidies because subsidies do not reduce the price of a good or service; they simply shift who pays for it.

1 U.S. Energy Information Administration, "Pennsylvania: State Profile and Energy Estimates, Profile Analysis," January 16, 2025 [update], https://www.eia.gov/state/analysis.php?sid=PA.

2 Kathy Hitchens, "What is PJM and What Does It Do?" PCI Energy Solutions, January 3, 2024, https://www.pcienergysolutions.com/2024/01/03/what-is-pjm-and-what-does-it- do/#:~:text=Today%2C%20PJM%20has%20evolved%20into,more%20than%2065%20million%20people.

3 Rep. Danielle Friel Otten, House Bill 2277, Pennsylvania General Assembly, Regular Session of 2023–24, https://www.legis.state.pa.us/CFDOCS/Legis/PN/Public/btCheck.cfm?txtType=PDF&sessYr=2023&sessInd=0&billBody=H&billTyp=B&billNbr=2277&pn=3081.

The high price tag for these policies would hit Pennsylvania electricity customers hard. Across sectors, **PRESS and PACER would cause electricity rates to increase from 12.58 cents per kilowatt-hour (kWh) in 2023 to 20.17 cents per kWh in 2035—a 60 percent increase.**

The result of implementing PACER and PRESS: Pennsylvania **families would see their annual electricity costs increase from $1,717 in 2023 to $3,471 in 2035, an increase of $1,754 per year or $146 per month.**

Always On Energy Research (AOER) used a variety of publicly available data sources to formulate the assumptions in this report, including the U.S. Energy Information Administration (EIA) assumptions on the annual energy outlook, hourly grid monitor, and the State Energy Profile for Pennsylvania. The Appendix provides a more detailed explanation of these assumptions.

Section 1: Pennsylvania's PACER and PRESS

In March of 2024, Shapiro introduced two policy initiatives—PACER and PRESS—in his effort to enact aggressive climate policies to reduce emissions from the electricity generation sector.[4] If enacted, these policies will increase costs for Pennsylvania families and businesses while increasing reliance on unreliable, weather-based electricity resources.

PENNSYLVANIA CLIMATE EMISSIONS REDUCTION ACT (PACER)

Despite campaigning on a healthy skepticism of the Regional Greenhouse Gas Initiative (RGGI), a multistate cap-and-trade carbon tax, Shapiro introduced PACER to establish a Pennsylvania-specific version of RGGI.

PACER's legislation, initially introduced in May 2024 as House Bill (HB) 2275 by Rep. Aerion Abney and Senate Bill (SB) 1191 by Sen. Carolyn Comitta, is now a part of Shapiro's "Lightning Plan."[5] PACER would set strict limits on CO_2 emissions for thermal power plants in the state, charging facilities a fee for every unit of emissions.[6]

Moreover, it would direct the Pennsylvania Department of Environmental Protection (DEP) to set the annual "budgets" (limits) for CO_2 emissions in the state and require coal, natural gas, and other CO_2-emitting resources—referred to as "budget sources"—larger than 25 megawatts (MW) to purchase "allowances" (the right to emit one ton of CO_2) equal to their amount of annual CO_2 emissions to offset their emissions.

The legislation proposes to return 70 percent of the revenue generated by PACER to ratepayers, while the other 30 percent would be invested in efforts to reduce air pollution, help reduce bills for low-income families, and increase the adoption of technologies such as carbon capture and energy storage. This analysis assumes 70 percent of the PACER taxes would be refunded to Pennsylvanians.

---

4 Pennsylvania Office of the Governor, "Governor Josh Shapiro's Energy Plan Builds on Pennsylvania's Legacy of Energy Leadership by Protecting and Creating Energy Jobs and Lowering Electricity Costs for Consumers," press release, March 13, 2024, https://www.pa.gov/governor/newsroom/2024-press-releases/governor-josh-shapiro-s-energy-plan-builds-on-pennsylvania-s-leg.html.

5 Pennsylvania Office of the Governor, "At York Hydropower Plant, Governor Shapiro Launches Legislative Push for 'Lightning Plan' to Build More Energy Projects, Speed Up Permitting, Lower Costs, and Create Jobs for Pennsylvanians," press release, March 11, 2025, https://www.pa.gov/governor/newsroom/2025-press-releases/governor-shapiro-launches-legislative-push-for--lightning-plan--.html.

6 Joseph K. Reinhart et al., "PACER and PRESS Are Introduced in the Pennsylvania General Assembly," Babst Calland, May 30, 2024, https://www.babstcalland.com/news-article/pacer-and-press-are-introduced-in-the-pennsylvania-general-assembly/.

PENNSYLVANIA RELIABLE ENERGY SUSTAINABILITY STANDARD (PRESS)

PRESS, introduced in May 2024 as HB 2277 by Rep. Danielle Friel Otten and as SB 1190 by Sen. Steve Santarsiero—also packaged as part of the governor's "Lightning Plan,"[7] is a modification to the state's current renewable energy mandate, the Alternative Energy Portfolio Standards (AEPS).

PRESS would require 50 percent of Pennsylvania's electricity to come from specified alternative energy sources by 2035. Under the legislation, at least 35 percent of the state's electricity must be sourced from Tier I resources, 10 percent from Tier II resources, and 5 percent from Tier III resources. Tier II and III requirements can also be met using additional Tier I resources.[8]

Figure 1 summarizes the resources HB 2277 listed in each tier.[9]

FIGURE 1: TIER I, TIER II, AND TIER III PRESS RESOURCES

Tier I	Wind, solar, low-impact hydroelectric power, advanced nuclear reactors, fusion energy, geothermal energy, biogas, and fugitive emissions from coal mines.
Tier II	Natural gas or coal plants using 80 percent clean hydrogen co-blending or carbon capture and sequestration technologies, demand side management, hydropower, fuel cells, biomass energy, or battery storage.
Tier III	Natural gas or coal using 20 percent clean hydrogen co-blending or carbon capture, waste coal, municipal solid waste, gasified coal, and electricity generated using wood waste products.

Tier I resources include wind, solar, low-impact hydroelectric power, advanced nuclear reactors, fusion energy, geothermal energy, biogas, and fugitive emissions from coal mines.[10] Tier II resources include natural gas or coal plants using 80 percent clean hydrogen co-blending or carbon capture and sequestration technologies, demand side management, hydropower, fuel cells, biomass energy, or battery storage. Tier III resources include natural gas or coal using 20 percent clean hydrogen co-blending or carbon capture, waste coal, municipal solid waste, gasified coal, and electricity generated using wood waste products.

PRESS would also establish a Zero Emissions Credit (ZEC) mechanism to support the existing nuclear generation fleet in the state and prevent it from prematurely retiring in the 2030s. As such, this report assumes that the existing nuclear power fleet stays in operation throughout the duration of the model, but it does not assume that any new nuclear power facilities are built.

While the text of PRESS contains a broad range of low- or no-CO_2-emitting technologies, physical, political, and economic realities will likely limit the diversity of carbon-free or low-carbon resources used to meet the alternative energy mandates.

For example, no SMRs or fusion nuclear reactors have been built in the United States to date. Similarly, "clean" hydrogen and carbon capture and sequestration are still in their early stages of development, and major recent setbacks at a carbon capture project in North Dakota and multiple setbacks for "green hydrogen" companies indicate these technologies may never

7 Pennsylvania Office of the Governor, "At York Hydropower Plant, Governor Shapiro Launches Legislative Push for 'Lightning Plan.'"
8 Friel Otten, House Bill 2277.
9 Friel Otten, House Bill 2277.
10 Friel Otten, House Bill 2277.

be economically feasible.[11, 12, 13] These realities make it difficult to confidently predict that any new nuclear plants, "clean" hydrogen, or carbon capture projects will be brought online in Pennsylvania before 2035.

As a result, AOER's modeling assumes that state mandates to increase Pennsylvania's AEPS for Tier I, Tier II, and Tier III resources will be met primarily with solar, onshore wind, and battery storage. This resource mix will impose significant costs on Pennsylvania families and businesses.

Section 2: Impacts on Pennsylvania Energy Production

The policies designed to decarbonize the power grid will profoundly impact the way Pennsylvanians produce their electricity. They will artificially increase the costs of coal and natural gas via the PACER program and mandate the use and installation of unreliable energy resources in the PRESS standards.

According to the EIA, in 2023, Pennsylvania derived 59 percent of its electricity from natural gas, 32 percent from nuclear power plants, 6 percent from coal, 1 percent from wind, 1 percent from hydroelectric, and solar generated 0.15 percent of the Keystone State's electricity.[14]

This means the Tier I resources that would need to supply at least 35 percent of Pennsylvania's electricity by 2035 under PRESS produced approximately 2.2 percent of the state's electricity in 2023.

11 David Trilling, "Green Hydrogen Far Pricier than Projected," Harvard Gazette, October 8, 2024, https://news.harvard.edu/gazette/story/newsplus/green-hydrogen-far-pricier-than-projected/.

12 Dan Gearino, "A Carbon Capture Project Faces a New Delay in a Year of Slow Progress for Coal Plants Looking for Retrofits," Inside Climate News, December 10, 2024, https://insideclimatenews.org/news/10122024/north-dakota-coal-plant-carbon-capture-project-faces-new-delay/?utm_source=chatgpt.com.

13 Air Products, "Air Products to Exist Three U.S.-Based Projects," press release, February 24, 2025, https://www.airproducts.com/company/news-center/2025/02/0224-air-products-to-exit-three-us-based-projects.

14 U.S. Energy Information Administration, "State Electricity Profiles: Pennsylvania Electricity Profile 2023," November 6, 2024, https://www.eia.gov/electricity/state/pennsylvania/.

FIGURE 2: PENNSYLVANIA TOTAL ENERGY MIX 2023

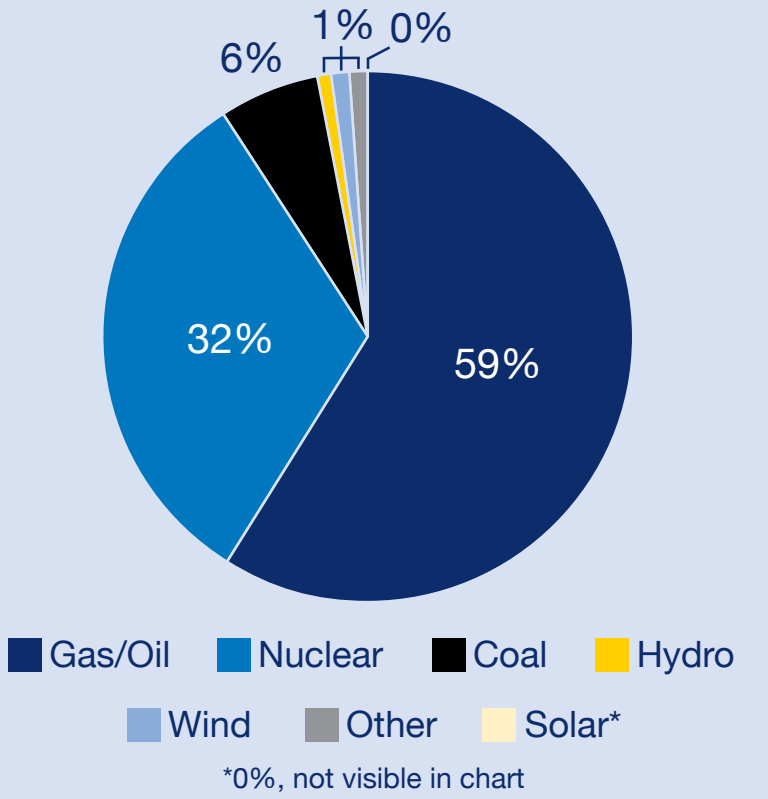


Figure 2 depicts the EIA's breakdown, with natural gas and nuclear power as the top producers, by far, of electricity in Pennsylvania, followed by coal, wind, and hydroelectric power.[15]

Meeting the alternative energy mandates in the proposed PRESS program and the PACER carbon tax will substantially change the resource mix.

Under these plans, Pennsylvania would continue to be a large exporter of electricity. AOER's modeling estimates Pennsylvania would export 72.2 million megawatt-hours (MWh) of electricity in 2035, which accounts for 28 percent of total in-state generation.

In 2035, under PRESS, total electricity generation from Pennsylvania would consist of 30 percent onshore wind, 14 percent solar, 29 percent nuclear, 25 percent natural gas, 1 percent coal, and 1 percent other (see Figure 3). While AOER believes there is promise in recommissioning nuclear power plants, this analysis does not consider the potential restart of the Three Mile Island plant.

15 Some categories from the EIA, such as "other gas" and "other," were excluded from the chart to improve readability.

FIGURE 3: PENNSYLVANIA TOTAL ENERGY MIX IN 2035 UNDER PRESS

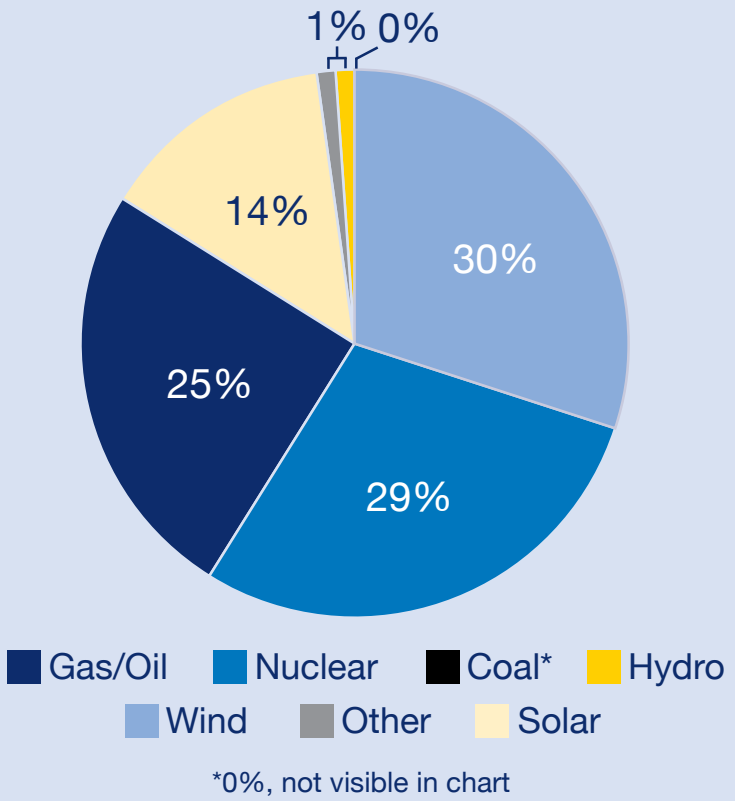
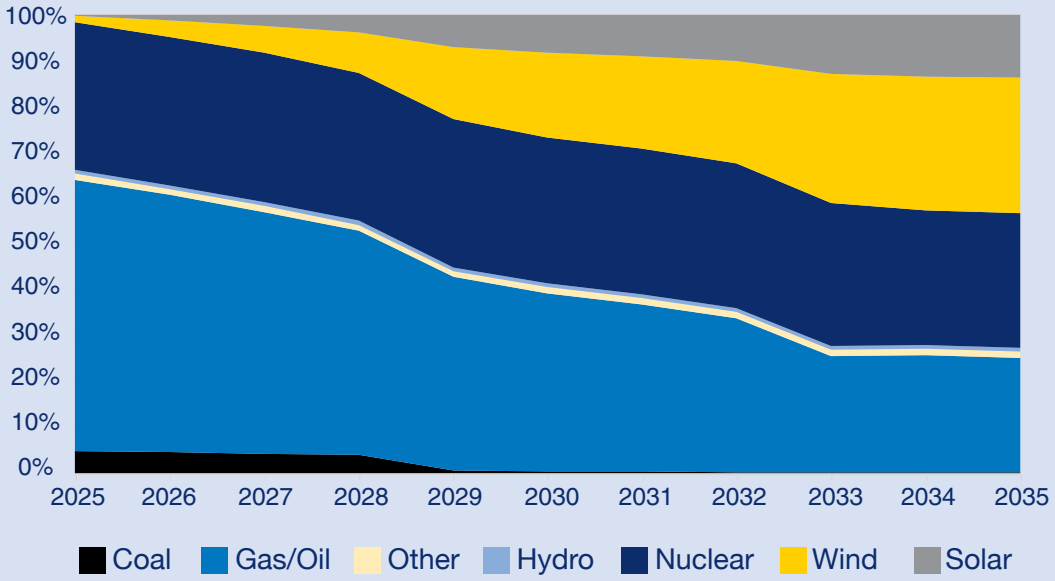


Figure 4 shows the change in electricity generation from 2025 through 2035 under PRESS. AOER modeling suggests wind power becomes the largest source of electricity in Pennsylvania, followed by nuclear and natural gas. When modeling for cost optimization in higher renewable penetrations, AOER finds that wind sometimes has more value over solar in the model, as it can theoretically operate day and night.

Natural gas generation declines as more solar and wind capacity are added to the system, but a significant amount of gas generation remains because the AOER model assumes that the PRESS alternative energy mandates apply only to electricity consumed within Pennsylvania. As a result, many of the natural gas plants currently operating would still be available to export electricity to neighboring states.

FIGURE 4: PENNSYLVANIA ENERGY MIX FROM 2023 THROUGH 2035 UNDER PRESS

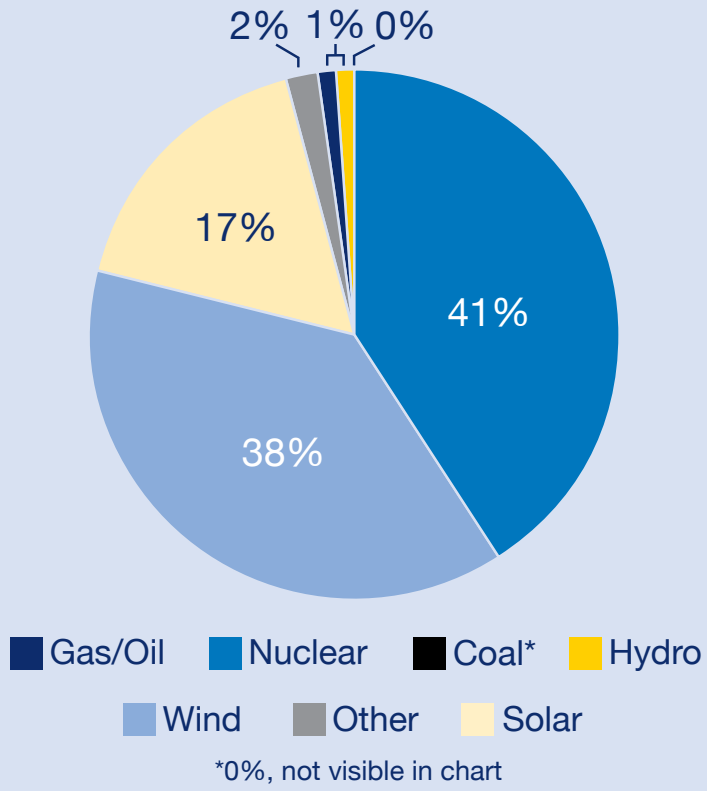


In terms of determining compliance with the PRESS mandates, it is important for the reader to understand that there is no such thing as a "green electron."[16] While it is impossible to know which sources of electricity are being consumed or exported at any given moment, states use Renewable Energy Certificates (RECs), which represent the "renewable" attributes of one MWh of electricity, to demonstrate compliance with Renewable Portfolio Standards (RPSs).

Figure 5 shows Pennsylvania's estimated in-state electricity consumption if the commonwealth retains and retires the RECs generated by PRESS-eligible resources in 2035. Under the PRESS legislation, nuclear would provide 41 percent of in-state electricity consumption, followed by wind at 38 percent, solar at 17 percent, while other would contribute 2 percent, "gas and oil" and hydroelectric would contribute 1 percent, respectively.

16 David Robers, "RECs, Which Put the "Green" in Green Electricity, Explained," *Vox*, November 9, 2015, https://www.vox.com/2015/11/9/9696820/renewable-energy-certificates.

FIGURE 5: PENNSYLVANIA IN-STATE ENERGY CONSUMPTION IN 2035 UNDER PRESS



Section 3: Energy Demand

Pennsylvania expects a substantial increase in the total amount of electricity consumed in the coming decades due to rising demand from data centers, ongoing electrification efforts, and the reshoring of manufacturing. The PJM Interconnection, the regional transmission organization (RTO) supplying Pennsylvania, 11 other states, and the District of Columbia, calculates that electricity demand in the region will increase on average by 1.7 percent annually through 2035.

Using PJM's projected demand growth, AOER estimated that Pennsylvania's peak electricity demand will increase from 27 gigawatts (GW) in 2023 to 35 GW in 2035.[17] Meeting these new peaks, alongside replacing retiring coal, gas, and oil power plants, will require a substantial increase in the amount of power plant capacity on the Pennsylvania power system. However, PJM has warned that the pace of new power plant entries could be insufficient to keep up with expected retirements and demand growth by 2030, leading to capacity issues as soon as 2026.[18]

17 Electricity Peak Demand Calculations use the hourly demand profiles in EIA's Hourly Grid Monitor for the Duquesne Light, Metropolitan Edison Company, PECO Energy, Pennsylvania Electric, and PPL Electric regions that operate within Pennsylvania, which the research then extrapolates upward to match the annual electricity consumption for all of Pennsylvania.

18 Courtney Schlissermann, "PJM Warns of Potential Capacity Shortfall by 2030," Argus, February 27, 2023, https://www.argusmedia.com/en/news-and-insights/latest-market-news/2424089-pjm-warns-of-potential-capacity-shortfall-by-2030?utm_source=chatgpt.com; PJM Inside Lines, "PJM Board Supports Action in Support of Urgent Grid Reliability Needs," February 5, 2025, https://insidelines.pjm.com/pjm-board-supports-action-in-support-of-urgent-grid-reliability-needs/.

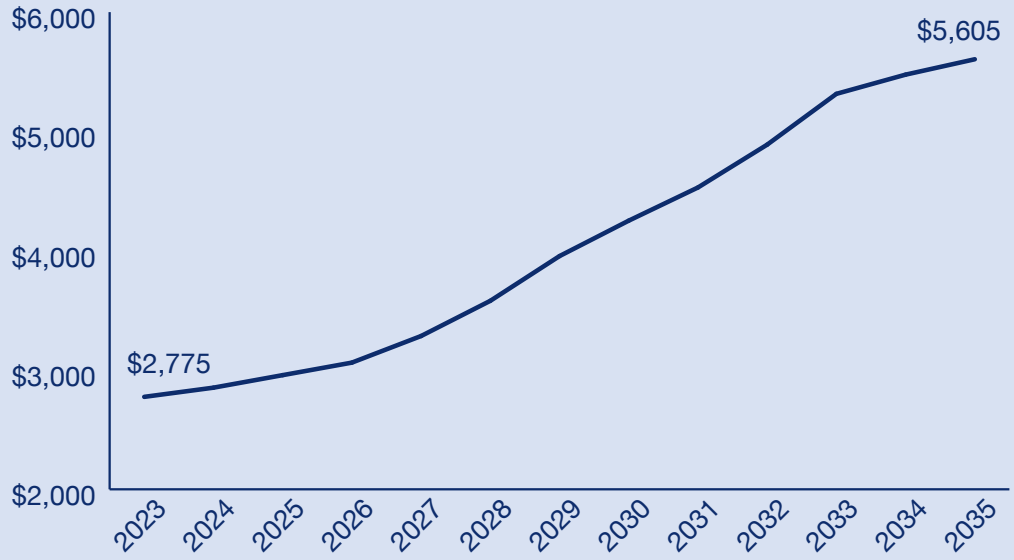
Section 4: Calculating the Costs of PACER and PRESS

Pennsylvania residents currently pay above-average electricity rates, with the average all-sectors cost of electricity from 2018 through 2023 ranking 31st among states.[19]

AOER's modeling indicates that complying with PACER and PRESS will cost an additional $157.2 billion (in constant 2023 dollars) compared to operating the current electric grid without the inclusion of federal subsidies.[20] **This would raise all sectors' electricity rates from 12.58 cents per kWh in 2023 to 20.17 cents per kWh in 2035—a 60 percent increase in the cost of electricity.**

As a result, under the PACER and PRESS programs, Pennsylvania's electricity rates would rank 11th highest if other states experienced no change in their current electricity prices. **The average annual electricity cost for each Pennsylvania utility customer would increase by $2,830 in 2035, the equivalent of paying an additional $235 per month**.

FIGURE 6: ANNUAL AVERAGE ELECTRICITY COST PER CUSTOMER UNDER PACER AND PRESS



19 U.S. Energy Information Administration, "Electricity Data Browser: Average Retail Price of Electricity, Annual," accessed January 9, 2025, https://www.eia.gov/electricity/data/browser/#/topic/7?agg=1,0&geo=80fvvvvvvvvvo&endsec=g&linechart=ELEC.PRICE.NEW-ALL.A~ELEC.PRICE.CT-ALL.A~ELEC.PRICE.ME-ALL.A~ELEC.PRICE.MA-ALL.A~ELEC.PRICE.NH-ALL.A~ELEC.PRICE.RI-ALL.A~ELEC.PRICE.VT-ALL.A~ELEC.PRICE.NJ-ALL.A~ELEC.PRICE.NY-ALL.A~ELEC.PRICE.PA-ALL.A~ELEC.PRICE.IL-ALL.A~ELEC.PRICE.IN-ALL.A~ELEC.PRICE.MI-ALL.A~ELEC.PRICE.OH-ALL.A~ELEC.PRICE.WI-ALL.A~ELEC.PRICE.IA-ALL.A~ELEC.PRICE.KS-ALL.A~ELEC.PRICE.MN-ALL.A~ELEC.PRICE.MO-ALL.A~ELEC.PRICE.NE-ALL.A~ELEC.PRICE.ND-ALL.A~ELEC.PRICE.SD-ALL.A~ELEC.PRICE.DE-ALL.A~ELEC.PRICE.DC-ALL.A~ELEC.PRICE.FL-ALL.A~ELEC.PRICE.GA-ALL.A~ELEC.PRICE.MD-ALL.A~ELEC.PRICE.NC-ALL.A~ELEC.PRICE.SC-ALL.A~ELEC.PRICE.VA-ALL.A~ELEC.PRICE.WV-ALL.A~ELEC.PRICE.AL-ALL.A~ELEC.PRICE.KY-ALL.A~ELEC.PRICE.MS-ALL.A~ELEC.PRICE.TN-ALL.A~ELEC.PRICE.AR-ALL.A~ELEC.PRICE.LA-ALL.A~ELEC.PRICE.OK-ALL.A~ELEC.PRICE.TX-ALL.A~ELEC.PRICE.AZ-ALL.A~ELEC.PRICE.CO-ALL.A~ELEC.PRICE.ID-ALL.A~ELEC.PRICE.MT-ALL.A~ELEC.PRICE.NV-ALL.A~ELEC.PRICE.NM-ALL.A~ELEC.PRICE.UT-ALL.A~ELEC.PRICE.WY-ALL.A~ELEC.PRICE.CA-ALL.A~ELEC.PRICE.OR-ALL.A~ELEC.PRICE.WA-ALL.A~ELEC.PRICE.AK-ALL.A~ELEC.PRICE.HI-ALL.A&columnchart=ELEC.PRICE.NEW-ALL.A&map=ELEC.PRICE.NEW-ALL.A&freq=A&start=2001&end=2023&ctype=linechart&ltype=pin&rtype=s&maptype=0&rse=0&pin=.

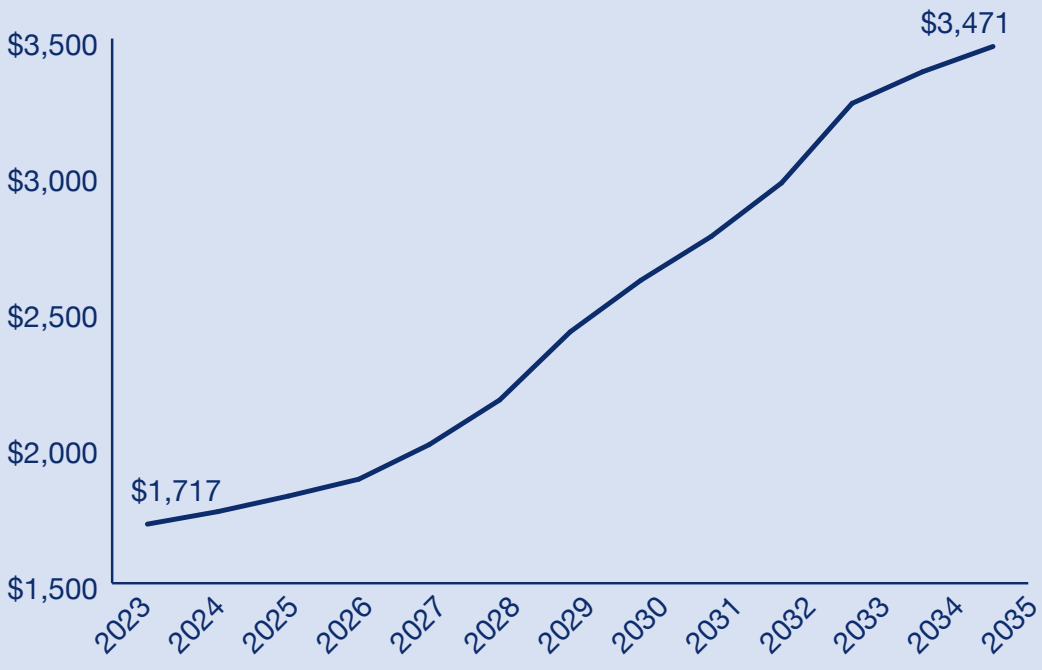
20 These additional costs do not account for the significant costs of upgrading the distribution system to accommodate the additional demand for electricity or necessary upgrades to home electric systems.

Figure 6 shows the average additional cost of complying with PACER and PRESS from 2024 through 2035, compared to the current cost of electricity. This number is obtained by dividing the annual cost of the mandates among all Pennsylvania utility customers, including residential, commercial, and industrial electricity users. PACER and PRESS immediately increase electricity costs as CO_2 emissions are taxed and onshore wind, solar, battery storage, and transmission projects are built.

RESIDENTIAL CUSTOMERS

Under PACER and PRESS, **Pennsylvania families would see their annual electricity costs increase from $1,717 per year in 2023 to $3,471 in 2035, an increase of $1,754 per year** or $146 per month (see Figure 7).

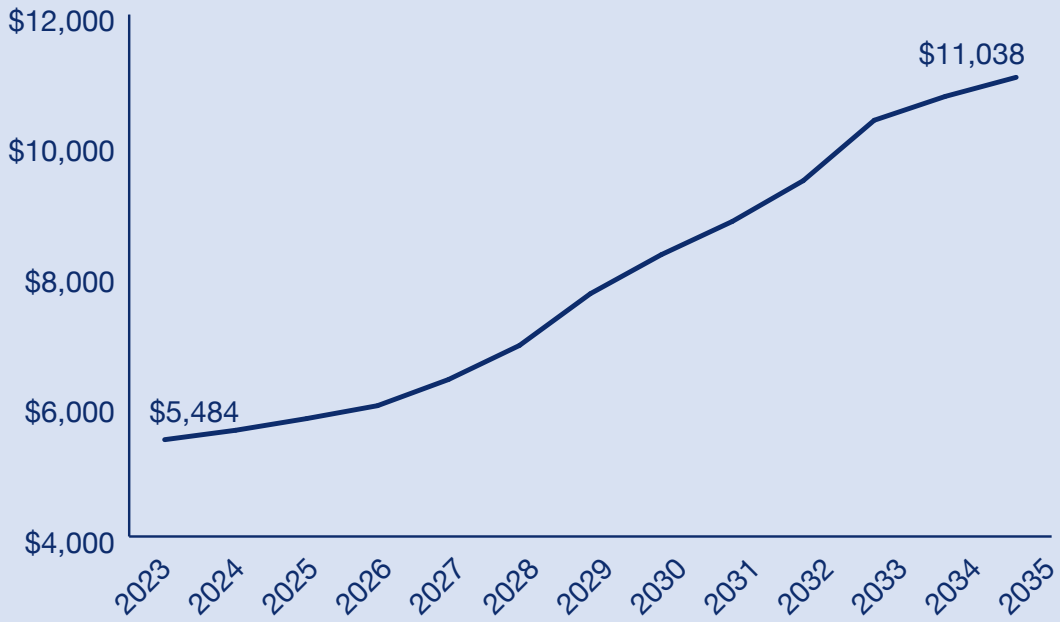
FIGURE 7: ANNUAL ELECTRICITY COST PER RESIDENTIAL CUSTOMER UNDER PACER AND PRESS



COMMERCIAL CUSTOMERS

Under PACER and PRESS, **commercial customers like small businesses, grocery stores, and other retailers would see their electricity costs increase by $5,554 in 2035**, a monthly increase of $462 (see Figure 8).

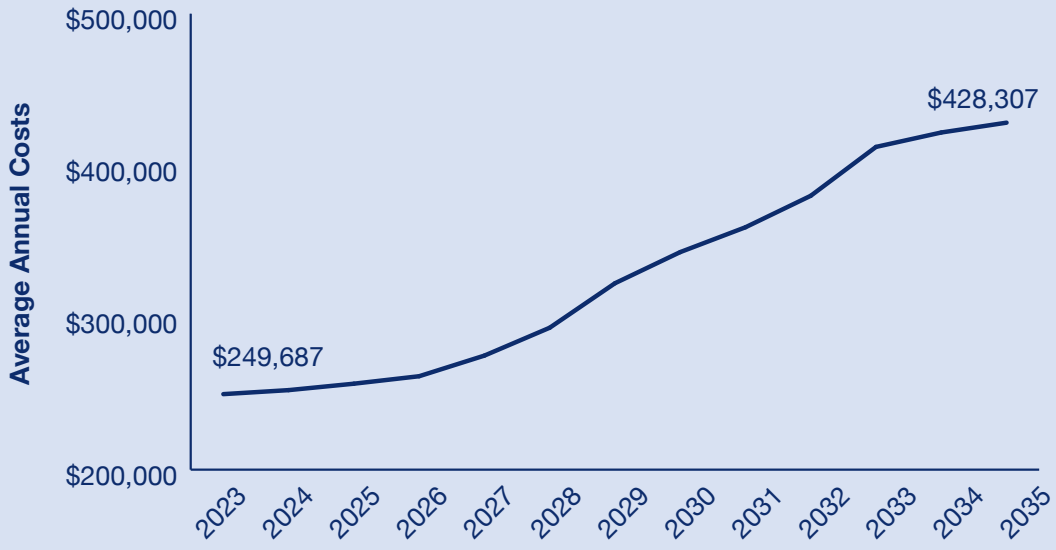
FIGURE 8: ANNUAL ELECTRICITY COST PER COMMERCIAL CUSTOMER UNDER PACER AND PRESS



INDUSTRIAL CUSTOMERS

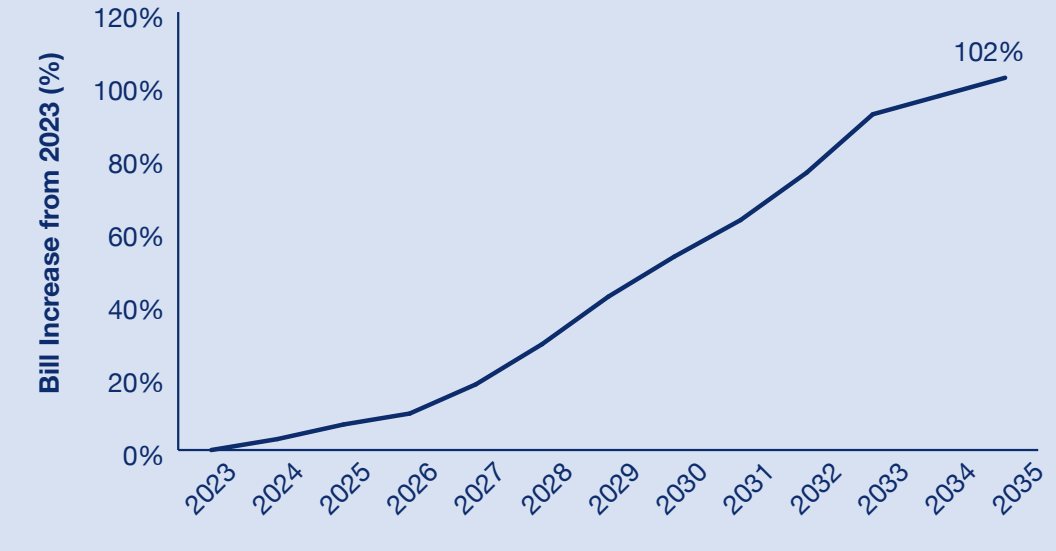
Under PACER and PRESS, electricity costs for industrial firms in Pennsylvania would rise by $178,620 annually, or $14,885 per month (see Figure 9).

FIGURE 9: ANNUAL ELECTRICITY COST PER INDUSTRIAL CUSTOMER UNDER PACER AND PRESS



Bills would more than double across each rate class, as Figure 10 shows below, when summarizing the annual average bill increase for each rate class as a percentage.

FIGURE 10: AVERAGE ANNUAL BILL INCREASE UNDER PACER AND PRESS



Section 5: How PACER and PRESS Drive Up Costs

Thus far, this report has summarized the cost difference between PACER and PRESS using Pennsylvania's existing power plants. In this section, the research discusses the compliance costs of carbon taxes and requiring Pennsylvania to generate rising portions of its electricity using onshore wind, solar, and battery storage.

THE HIGH COST OF THE PACER CARBON TAX

Carbon taxes, like RGGI and the proposed PACER mandates, increase costs for consumers by assigning a financial penalty to power plants that emit CO_2, namely coal, natural gas, and oil-fired power plants. The costs associated with these penalties are passed on to consumers in the form of higher electricity prices.

The proposed PACER program, similar to RGGI, would use a cap-and-trade mechanism that obligates CO_2-emitting power plants to purchase enough credits to offset their annual emissions. Each year, the number of credits, which can be thought of as emissions allowances, declines, reducing the total number of emissions permitted under the cap-and-trade system.

As has been observed with RGGI, as fewer credits are offered in the auction, the price of the credits shows an upward trend over time (see Figure 11).

FIGURE 11: RGGI CREDIT PRICES OVER TIME

The rising costs associated with higher credit prices would likely be passed on to the consumer through higher prices. In the case of PACER, the program would refund 70 percent of these additional costs at the end of the year, while 30 percent would be for state initiatives like funding for low-income households or subsidizing low-carbon energy projects.

This analysis models RGGI as a carbon tax, rather than a true cap-and-trade system, because, in a true cap-and-trade system, the price of credits would be exclusively determined by the power plant operators who must purchase them, but this is not how RGGI works.

Instead, RGGI establishes a price floor, or a minimum price, that allowances can be sold for, and a Cost Containment Reserve (CCR) mechanism that prints additional credits to help reduce the price of credits if the cost of reducing emissions is higher than projected.[21, 22] However, there are a limited number of CCR credits, and if the supply is exhausted early in a year, as happened in 2024, the cost of the credits can exceed the CCR prices.

RGGI's price floor means it is not a market for emissions trading or a cap-and-trade program; it is a de facto carbon tax that will cost Pennsylvania families and businesses an additional $2.2 billion through 2035.

For calculating the cost of the PACER program, the AOER model assumes credit prices would cost an average of the minimum price for RGGI allowances and the "trigger cost" of the CCR mechanism. The model uses these because data on credit costs for PACER do not yet exist. AOER believes this method is conservative because the auction results for 2024 far exceeded the trigger cost for most of the year.

PRESS: HOW BUILDING WIND, SOLAR, AND BATTERY STORAGE INCREASES COSTS

The most important thing to know about the electric grid is that the supply of electricity must be in perfect balance with demand at every second of every day.[23] If demand rises as Pennsylvanians turn on their air conditioners or heaters or charge their electric vehicles, an electric company must increase the supply of power to meet that demand. When companies are unable to increase supply to meet demand, grid operators are forced to cut power to consumers (i.e., initiate brownouts or blackouts) to keep the entire grid from crashing.

Generating more electricity is relatively easy with dispatchable power plants—plants that can be turned up or down on command—like those powered with coal, natural gas, nuclear fuel, or hydroelectric plants. But adjusting to second-by-second fluctuations in electricity demand is much more difficult with wind and solar, whose electricity production is subject to second-by-second fluctuations in the weather. As a result, it is much more difficult to provide reliable power as regions become more reliant upon wind and solar to meet their energy needs.

It is possible to mitigate some of the inherent unreliability of wind and solar by vastly increasing the amount of wind and solar capacity on the grid (known as "overbuilding" wind and solar installations) to allow electricity demand to be met even on cloudy or low-wind days, and curtailing, or turning off, much of this capacity when wind and solar production is higher. Other mitigation strategies

21 RGGI, Inc., "About the Regional Greenhouse Gas Initiative," Fact Sheet," January 2025 [update], https://www.rggi.org/sites/default/files/Uploads/Fact%20Sheets/RGGI_101_Factsheet.pdf.
22 RGGI, Inc., "Elements of RGGI," accessed January 10, 2025, https://www.rggi.org/program-overview-and-design/elements.
23 Isaac Orr and John Noer, "Summertime and the Risk of Blackouts is Higher," *Minneapolis Star Tribune*, June 30, 2022, https://www.startribune.com/summertime-and-the-risk-of-blackouts-is-high/600186757/.

include building more transmission lines and battery storage facilities. Each of these mitigation strategies, however, is a major driver of cost for the entire electric system.

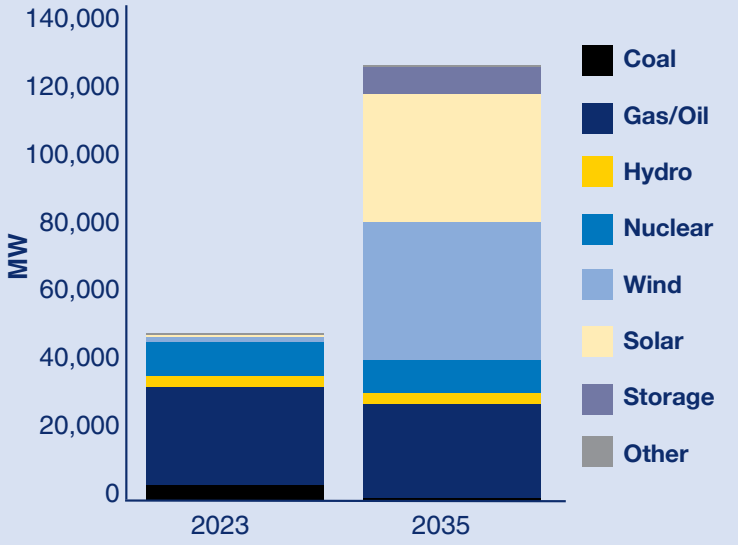
These mitigations come with other additional costs, including higher profits for transmission and distribution companies and higher state and federal taxes. The report discusses each of these additional costs in greater detail below.

INCREASING ELECTRICITY GENERATION CAPACITY

The intermittent and unpredictable nature of the energy sources mandated by PRESS requires a significant increase in power plant capacity on the electric grid. Building or expanding power plants is expensive. PRESS would greatly increase the amount of new power plant capacity on the Pennsylvania electric grid, which would be much more expensive than PACER.

In 2023, Pennsylvania had roughly 45,500 MW of installed power plant capacity on the grid.[24] Under PRESS, the amount of installed power plant capacity in Pennsylvania would increase from 45,500 MW as of 2023 to 124,000 MW by 2035. This means PRESS would require nearly three times more power plant capacity than is currently used to meet Pennsylvania's electricity demand (see Figure 12).

FIGURE 12: PENNSYLVANIA GENERATING CAPACITY IN 2023 VERSUS 2035



	2023	2035
Coal	4,405	920
Gas/Oil	26,780	26,958
Hydro	2,806	2,806
Nuclear	9,429	9,429
Wind	1,338	39,645
Solar	290	36,202
Storage	-	7,857
Other	497	497

While adding power plant capacity to the grid may sound like a good thing, increasing capacity merely to meet green energy mandates rather than meeting electricity demand is an unnecessary cost that will harm Pennsylvania families and the region's economy.

24 U.S. Energy Information Administration, "State Electricity Profiles: Table 4. Electric Power Industry Capacity by Primary Energy Source, 1990 through 2023, Pennsylvania," n.d., https://www.eia.gov/electricity/state/pennsylvania/state_tables.php.

Onshore wind installations under PRESS would increase from 1,400 MW of installed capacity in 2023 to 39.6 GW in 2035. Solar capacity would grow from 290 MW in 2023 to 36.2 GW, and battery storage would increase to 7.8 GW, with four hours of storage per MW (see Figure 12).[25]

A portion of the extra wind and solar power must be used to charge the batteries. Once the batteries are fully charged, any additional solar or wind power that is generated is curtailed, or turned off. Curtailment is expected to become increasingly common in Pennsylvania and the nation as more wind and solar facilities are placed into service on the grid.[26]

It is important to note that AOER has selected these quantities of solar, onshore wind, and battery storage resources because the model cost-optimizes for the lowest-cost portfolio for meeting the alternative energy mandates in PRESS and maintaining grid reliability under 2023 wind and solar generation conditions and future hourly load profiles derived from EIA data.[27] For example, the model could have built more battery storage to reduce the curtailment of wind and solar resources, but this would increase the cost of complying with PRESS.

Building these solar panels, onshore wind turbines, and battery storage facilities would cost $54 billion, $57 billion, and $13.7 billion, respectively. The additional transmission lines would cost $9.7 billion but have a useful service life beyond the scope of this analysis, and they would, therefore, not require repowering.

TRANSMISSION COSTS

Current transmission lines are not sufficient to connect Pennsylvania consumers to wind turbines and solar panels located farther away from population centers than traditional thermal power facilities.

This report assessed the current transmission grid by looking at transmission owner Form 10-K filings with the Securities and Exchange Commission (SEC) in conjunction with the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) Renewables Electricity Futures Study,[28] which shows the amount of transmission required to accommodate more wind and solar increases as they supply ever-greater quantities of electricity, a 50 percent renewable penetration would require a 20 percent increase in the size of the transmission grid. Based on this method, Pennsylvania would need to invest $9.8 billion on transmission lines, including interconnection costs.

GENERATOR PROFITS

As in other markets, Pennsylvania will need to incentivize power companies to build the wind, solar, and battery storage facilities necessary to meet the PRESS mandates and provide enough incentive for dispatchable generators to remain online or enter the market. As such, this report, which uses a cost of compliance methodology, assumes all new generating resources will receive power purchase agreements (PPAs) that ensure their investors recoup their upfront capital costs, with a 7.98 percent return on investment.[29]

25 See "Plant Construction by Type" in the Appendix.
26 National Renewable Energy Laboratory, "The Curtailment Paradox in a High Solar Future," U.S. Department of Energy, April 28, 2021, https://bit.ly/2ZT4JMu.
27 U.S. Energy Information Administration, "Hourly Grid Monitor," accessed January 10, 2025, https://www.eia.gov/electricity/gridmonitor/dashboard/electric_overview/balancing_authority/PJM.
28 National Renewable Energy Laboratory, "Renewable Electricity Futures Study" (Washington, D.C.: U.S. Department of Energy, April 2025), https://www2.nrel.gov/analysis/re-futures.
29 See "Cost of Compliance Modeling" in the Appendix.

Power generators in Pennsylvania are not vertically integrated monopolies; therefore, they are not entitled to recover the cost of providing service to ratepayers with a government-approved return on investment. Instead, generators in Pennsylvania sell their power and reliability attributes into the PJM wholesale energy, capacity, and ancillary service markets.

However, several states in restructured markets like PJM have established public policies that direct electric power companies to enter into ratepayer-funded, long-term contracts for large-scale carbon-free energy that would cover most, if not all, of the resource's costs with out-of-market revenues.[30] These contracts must be lucrative enough to attract investment to the industry and allow companies to recover the upfront capital cost of the generators with a reasonable rate of return for their shareholders or owners.

As these contracted carbon-free resources produce increasing quantities of electricity on the grid, they are expected to reduce the wholesale clearing prices for all generators in the restructured markets, including new wind and solar generators.[31, 32] While there are advantages to lower wholesale energy costs, these advantages may be outweighed by costs if wholesale energy prices do not correspond to the actual value of energy sources in the market.

For example, the trend toward lower, and potentially negative, clearing prices will deprive dispatchable generators of some of the revenue needed to remain on the system, reducing grid reliability during important periods when there is low wind or solar generation.

This lack of revenue for dispatchable plants may result in these generators receiving more of the revenues needed to operate the plant through capacity and ancillary service markets, leading to rising costs for consumers due to higher capacity payments, as observed with PJM in 2024.[33] These generators may also obtain separate contracts to remain on the system to generate electricity when it is needed through Reliability Must Run (RMR) or other similar contracts.[34]

ADDITIONAL PROPERTY, STATE, AND FEDERAL TAXES

Property taxes increase under PRESS and PACER because compared to the current grid, there is much more property to tax. While the property taxes assessed on power plants are often a crucial revenue stream for local communities that host power plants, these taxes also effectively increase the cost of producing and providing electricity for everyone.

Some Pennsylvania counties exempt renewable energy facilities from property taxes entirely, while others assess a "payment in lieu of tax" on these facilities, and in some jurisdictions these

30 ISO New England, "Key Grid and Market Stats: Resource Mix," accessed August 7, 2024, https://www.iso-ne.com/about/key-stats/resource-mix.
31 ISO New England, "Economic Planning for the Clean Energy Transition, Illuminating the Economic Challenges of Tomorrow's Grid," August 16, 2024 https://www.iso-ne.com/static-assets/documents/100016/2024-epcet-report.pdf.
32 Lawrence Berkeley National Laboratory, "The Renewables and Wholesale Electricity Prices (ReWEP) Tool," accessed January 10, 2025, https://emp.lbl.gov/renewables-and-wholesale-electricity-prices-rewep.
33 Ethan Howland, "PJM Capacity Prices Hit Record Highs, Sending Build Signal to Generators," Utility Dive, July 31, 2024, https://www.utilitydive.com/news/pjm-interconnection-capacity-auction-vistra-constellation/722872/.
34 American's Power, "Reliability Must Run Agreements," October 13, 2022, https://americaspower.org/reliability-must-run-agreements/.

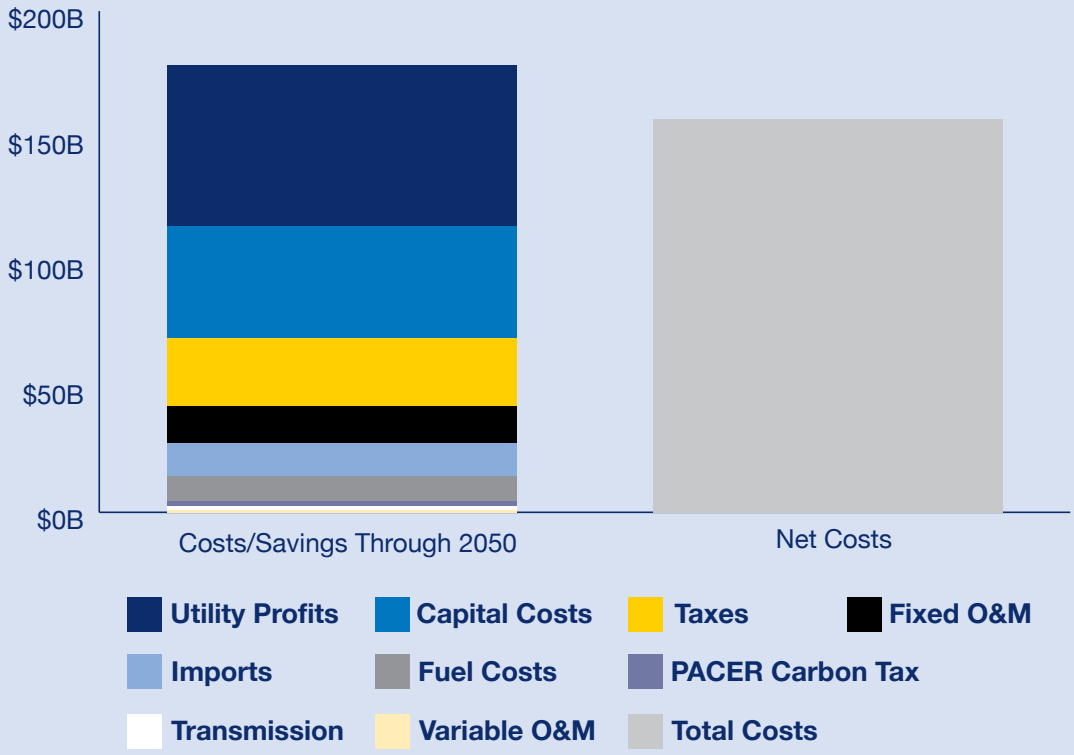
facilities are taxed at normal rates. To simplify these differences, this model assumes a property tax rate of 1 percent of net capital investment (gross plant value minus depreciation).

Additionally, state and federal income taxes increase due to the growth in income for power producers in the region. As a result, additional taxes are $27.8 billion through 2035.

SUMMARY OF COSTS

While Pennsylvania will experience modest declines in fuel expenditures through 2035, $10.8 billion through the model run, the projected costs for PACER and PRESS far outweigh these savings. Through 2035, Pennsylvania businesses will pay an additional $2.2 billion due to the PACER carbon tax and an added $155 billion in capital costs, fixed operations and maintenance costs, taxes, and profits for generation owners due to PRESS (see Figure 13).

FIGURE 13: TOTAL ADDITIONAL COSTS FROM 2025 THROUGH 2035



O&M = operation and maintenance. The net cost bar is the cost after fuel savings.

Section 6: The Levelized Cost of Energy for Different Generating Resources

Most studies assessing renewable energy costs use the Levelized Cost of Energy (LCOE) method to valuate the cost metrics of onshore wind and solar compared to different technologies. "LCOE estimates reflect the cost of generating electricity from different types of power plants, on a per-unit of electricity basis (generally megawatt-hours), over an assumed lifetime and quantity of electricity generated by the plant."[35]

Put simply, LCOE estimates work basically "like calculating the cost of your car on a per-mile-driven basis after accounting for expenses like initial capital investment, loan and insurance payments, fuel costs, and maintenance."[36]

Wind and solar advocates often misquote LCOE estimates from Lazard Inc. or the EIA to claim that wind and solar are now lower cost than other sources of energy. However, Lazard and EIA show the cost of operating a single wind or solar facility at its maximum reasonable output; they do not convey the cost of *reliably operating an entire electricity system* with high penetrations of wind and solar, which costs exponentially more.[37]

For example, Lazard and the EIA do not account for the expenses incurred to build new transmission lines, additional taxes, or the cost of providing backup electricity with battery storage "when the wind is not blowing or the sun is not shining," referred to as a battery storage cost in this report. [38]

Even more importantly, the LCOE estimates generated by Lazard and EIA do not account for the massive overbuilding and curtailment that must occur to ensure that grids with high reliance on wind, solar, and battery storage meet electricity demand.[39]

The costs associated with load balancing, overbuilding, and curtailment increase dramatically because the amount of wind, solar, and battery storage must be "overbuilt" to account for the intermittency of wind and solar, which is why PRESS requires an installed capacity of 124 GW to meet the projected peak demand of 35 GW.

AOER's model accounts for all these additional expenses and attributes them to the cost of wind and solar to get an "All-In" LCOE value for these energy sources. This report's All-In LCOE represents the cost of delivering the same reliability value of other generating technologies, allowing for an apples-to-apples comparison of the cost of reliably meeting electricity demand with existing nuclear, natural gas, and coal plants operating in Pennsylvania, with new plants built under PRESS.

The cost of existing natural gas generators was estimated using historical construction costs based on the average plant life of each energy source and current variable and fixed operation and maintenance (O&M) expenses obtained from the EIA. This method was chosen in the absence of relevant Federal Energy Regulatory Commission (FERC) Form 1 filings in the Pennsylvania region and similar data for independent power producers (IPPs). All other existing

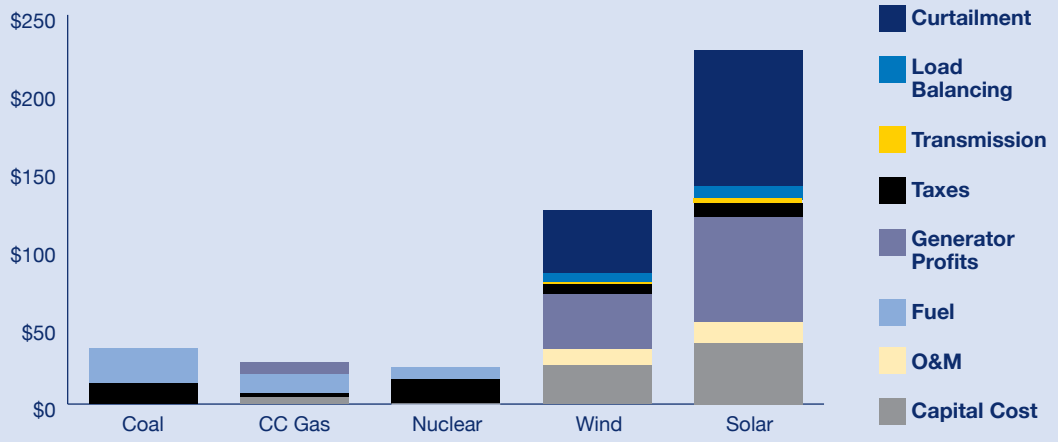
35 Isaac Orr and Mitch Rolling, "Renewables Blueprint: How to Calculate the Cost of Renewable Energy in Your State" (Minnetonka, MN: Center of the American Experiment, March 2021), 15, https://files.americanexperiment.org/wp-content/uploads/2021/06/Renewable-Energy.pdf.
36 Orr and Rolling, "Renewables Blueprint," 15.
37 See "Annual Average Cost of Each Energy Source" in the Appendix.
38 Orr and Rolling, "Renewables Blueprint," 22.
39 See "Overbuilding and Curtailment" in the Appendix.

generators were estimated using the U.S. average cost for power plants in FERC Form 1 filings.[40]

Under PACER and PRESS, power generation from these low-cost, reliable natural gas plants would largely be displaced by generation from onshore wind, solar, and battery storage by 2035. Figure 14 shows the All-In LCOE of new onshore wind and solar reaches approximately $126 and $228 per MWh, respectively, in 2035.

Because curtailment rates reach 40 percent by 2035, overbuilding and curtailment costs are the primary drivers of wind and solar due to the need to build nearly three times more capacity than would be needed to meet peak demand with dispatchable power plants.[41] As a result, the cost of battery storage, overbuilding, and curtailing in Figure 14 can be thought of as a levelized cost of intermittency (LCOI), or unreliability.

FIGURE 14: ALL-IN SYSTEM COST, EXISTING SOURCES VERSUS PRESS NEW SOURCE REQUIREMENTS



Costs are higher for onshore wind and solar facilities because grids powered with large concentrations of intermittent wind and solar resources require battery storage and much more total capacity and transmission to meet electricity demand than systems consisting largely of dispatchable power systems such as traditional fossil fuel and nuclear plants.

Section 7: Implications for Reliability

Reliability is the most crucial function of the electric grid. Lives have never been more dependent upon electronic devices, and this dependence will only grow in the future.

Unfortunately, PJM has warned that the region faces looming capacity shortfalls, i.e. rolling blackouts, as early as the 2026/2027 delivery year due to growing demand for power from electrification and data centers, the retirement of thermal resources due to state and federal

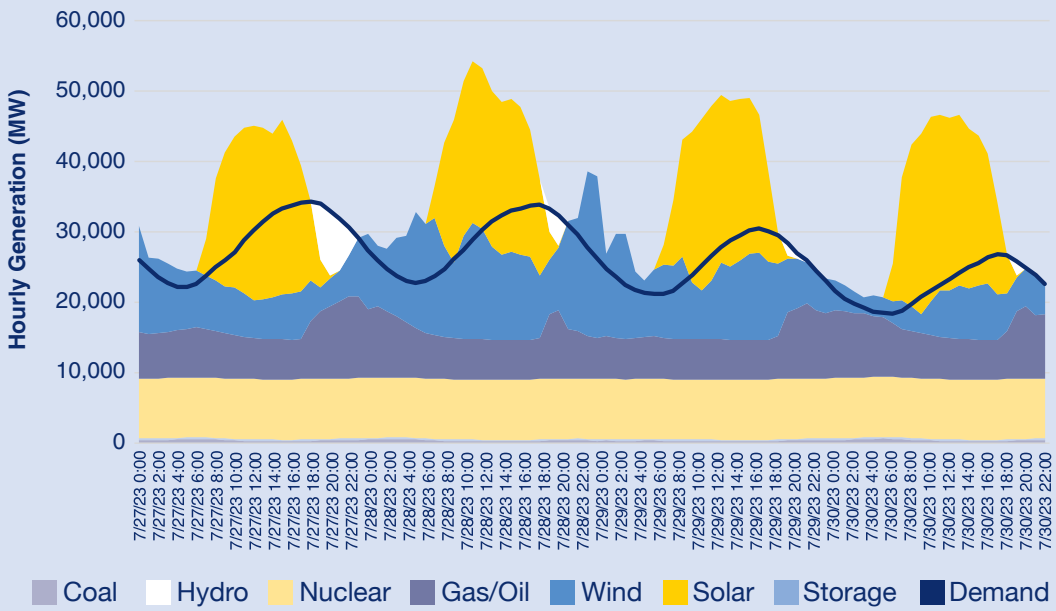
40 See "Assumptions for Levelized Cost of Energy Calculations" in the Appendix.
41 See "Overbuilding and Curtailment" in the Appendix.

policies, and the fact that the intermittent renewable energy sources meant to replace retiring thermal generators are not as reliable.[42]

PACER and PRESS would impact the reliability of the electric grid by making it more dependent on fluctuations in the weather and making otherwise economic natural gas plants uneconomic, thereby reducing the amount of natural gas capacity within Pennsylvania to serve in-state demand or growing demand throughout PJM.

AOER's analysis scales the hourly electricity demand from 2023 to meet the projected peak load for 2035. It then applied hourly wind and solar capacity factors from 2023 to the new capacity built under PRESS to demonstrate that the resource mix on the grid would be able to meet peak electricity demand. Reliability is bolstered by the fact that Pennsylvania would retain enough nuclear and natural gas capacity due to having excess power capacity that allows the state to be the number one electricity exporter in the country (see Figure 15).

FIGURE 15: HOW PENNSYLVANIA UNDER PRESS COULD MEET PEAK DEMAND IN 2035



However, in the real world, Pennsylvania belongs to a larger grid**. The Keystone State cannot isolate itself from the larger reliability trends in the PJM region. If PJM experiences rolling blackouts due to declining reserve margins** resulting from the retirement of dispatchable generators and an overreliance on intermittent ones, then **Pennsylvania would share the burden of the blackouts.**

42 PJM Inside Lines, "PJM Board Supports Action in Support of Urgent Grid Reliability Needs."

Section 8: Cost and Benefit of Emissions Reductions

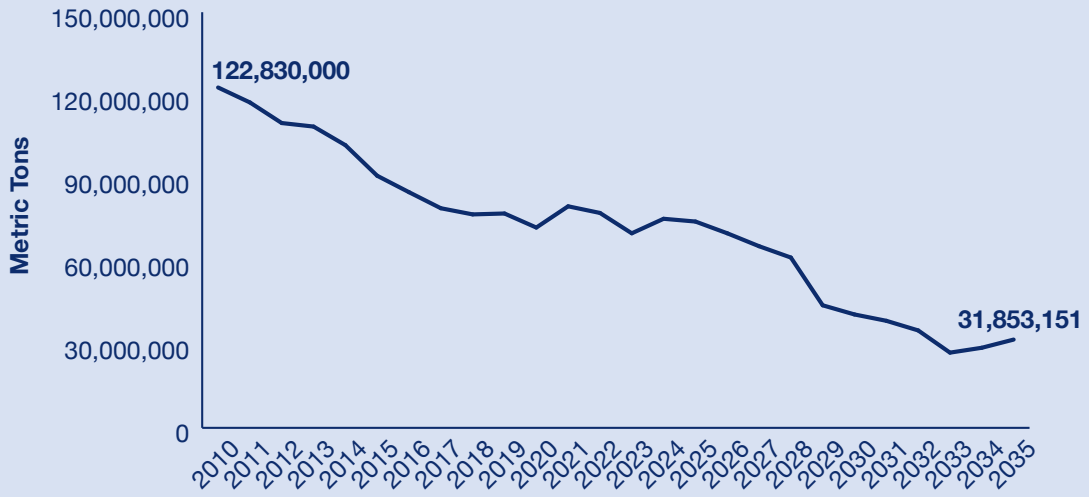
When evaluating energy policies aimed at reducing greenhouse gas emissions, it is important to weigh the cost of reducing emissions against the expected benefits.

To conduct this cost-benefit analysis, policymakers often use a tool called the social cost of carbon (SCC) to estimate the economic costs, or damages, of emitting one additional ton of CO_2 into the atmosphere.[43]

These damages can include health effects, extreme weather events, losses in agricultural productivity, and infrastructure damage. While the SCC has serious shortcomings, it can help illustrate when the costs of a proposed policy obviously outweigh the benefits.[44]

Figure 16 shows the annual decline in CO_2 emissions from the power sector with PACER and PRESS projections to 2035. Under PACER and PRESS, CO_2 emissions would drop 58 percent from the 2024 levels to 31.8 million metric tons by 2035.

FIGURE 16: PENNSYLVANIA ANNUAL CO_2 EMISSIONS

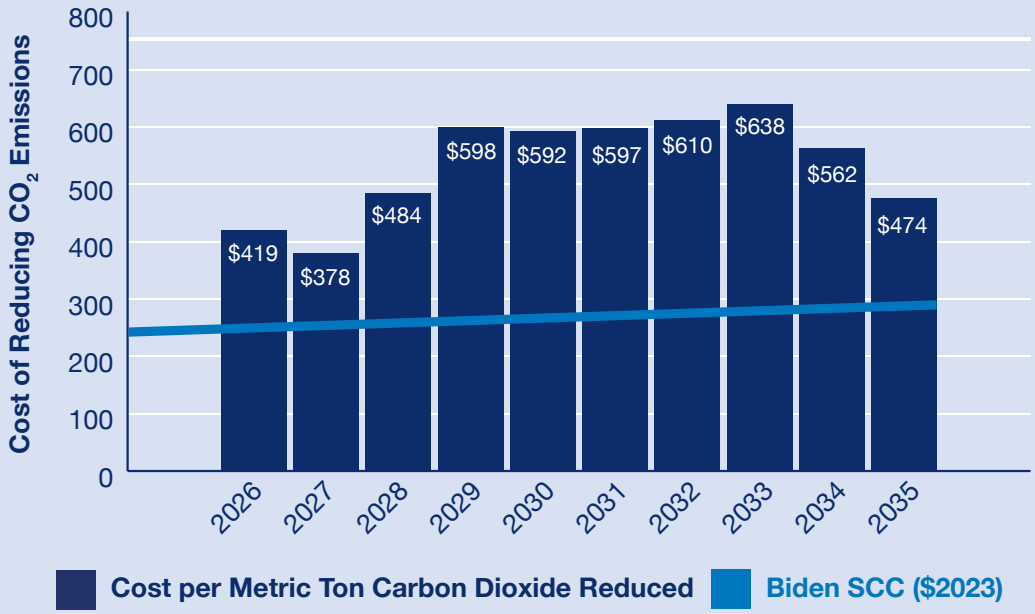


43 Kevin Rennert et al., "The Social Cost of Carbon," Brookings Institute, September 8, 2021, https://www.brookings.edu/bpea-articles/the-social-cost-of-carbon/#:~:text=The%20social%20cost%20of%20carbon%20is%20an%20estimate%20of%20the,the%20United%20States%20and%20abroad.

44 Kevin Dayaratna, "Why Social Cost of Carbon is the Most Useless Number You've Never Heard Of," *Daily Signal*, March 2, 2021, https://www.heritage.org/energy-economics/commentary/why-social-cost-carbon-the-most-useless-number-youve-never-heard.

Figure 17 shows the cost of reducing each ton of CO_2 each year under PACER and PRESS and compares it to the SCC estimates established by the Biden administration.

FIGURE 17: BIDEN SCC VERSUS COST OF REDUCING CO_2 EMISSIONS UNDER PACER AND PRESS



This comparison reveals that the cost of reducing CO_2 emissions in PACER and PRESS would vastly exceed the Biden administration's SCC estimates for every single year. This means the cost of reducing CO_2 emissions under these plans far exceeds their respective expected health or environmental benefits. In short, these programs would impose a net harm on Pennsylvania's economy after accounting for the impacts of climate change.

CONCLUSION

Shapiro's intent to force Pennsylvania to obtain half of its in-state electricity consumption from alternative energy resources and his proposed carbon tax will significantly impact the budgets of Pennsylvania families and businesses.

Compliance with PACER and PRESS would cost $157.2 billion through 2035, which would raise all-sectors electricity rates from 12.58 cents per kWh in 2023 to 20.17 cents per kWh in 2035—a 60 percent increase in the cost of electricity.

As a result, Pennsylvania families would see their electric bills increase by $1,754 by 2035. Commercial businesses would see their costs increase by $5,554 by 2035. Industrial customers, like manufacturers, would see their electric bills increase by an average of $178,620 by 2035.

The 60 percent costs incurred due to PACER and PRESS are driven by a massive buildout of solar panels, wind turbines, and transmission lines. These costs are in addition to the costs associated with higher taxes, generator profits, and building battery storage facilities to provide power when the sun is not shining or the wind is not blowing.

Ultimately, Pennsylvania cannot reduce its electricity costs by raising taxes to finance a significant buildout of wind turbines, solar panels, and batteries.

While Pennsylvania's electric grid would remain reliable under these proposals, this is because the large fleets of nuclear and natural gas plants continue to operate and export excess power out of the state. It is assumed these exports will be curtailed in the event of an electricity shortage. However, if the PJM region experiences more coal and natural gas retirements replaced by intermittent resources, regional reliability will diminish over time.

APPENDIX

ANNUAL AVERAGE ADDITIONAL COST PER CUSTOMER

The annual average additional cost per customer was calculated by dividing the average yearly expense of PACER and PRESS by the number of electricity customers in the region.[45] This methodology is used because rising electricity prices increase the costs of all goods and services. Businesses will attempt to pass these additional costs onto consumers, effectively increasing the cost of everything. Therefore, this method helps convey the total cost of the plans for Pennsylvania households in a way that is more representative than calculating the costs associated with higher residential electric bills.

ANNUAL AVERAGE RATE PER CUSTOMER CLASS

The annual average additional cost per residential, commercial, and industrial rate class customer was calculated by applying the overall cost per kWh of PACER and PRESS compliance during the time horizon of the study to rate classes based on historical rate factors in Pennsylvania. Rate factors are determined by the historical rate ratio (rate factor) of each customer class.

For example, electricity prices for residential, commercial, and industrial rate classes in Pennsylvania were 18.10, 11.26, and 7.75 cents per kWh in 2023, respectively. Based on general electricity prices of 12.58 cents per kWh, residential, commercial, and industrial rates had rate factors of 1.44, .9, and .62, respectively. This means that, for example, residential customers have historically seen electricity prices 44 percent above general rates. This analysis continues these rate factors to assess future rate impacts for each rate class.

ASSUMPTIONS FOR LEVELIZED COST OF ENERGY CALCULATIONS

As stated in prior research, "The main factors influencing LCOE estimates are capital costs for power plants, annual capacity factors, fuel costs, heat rates, variable … O&M costs, fixed O&M costs, the number of years the power plant is in service, and how much electricity the plant generates during that time (which is based on the MW capacity of the facility and the capacity factor)."[46]

LCOE values for existing natural gas generators were estimated using historical construction costs based on the average plant life of each energy source and current variable and fixed O&M expenses. This method was chosen in the absence of relevant FERC Form 1 filings in Pennsylvania and data similar for IPPs. All other existing generators were estimated using the U.S. average cost for power plants in FERC Form 1 filings.

These LCOE values are inserted into the model and adjusted annually based on annual capacity factors for existing resources.

LCOE values for new power plants were calculated using data values presented in the *Capital Cost and Performance Characteristics for Utility-Scale Electric Power Generating Technologies* report commissioned by the EIA for its Annual Energy Outlook 2025.[47] These values are held constant during the model run. The cost of repowering power facilities that need it at the end of their useful lives is accounted for in each value. These values are described in greater detail below.

---

45 U.S. Energy Information Administration, "Electricity Data Browser: Number of Customer Accounts," accessed August 1, 2024, https://www.eia.gov/electricity/data/browser/#/topic/56?agg=0,1&geo=8&endsec=vg&linechart=ELEC.CUSTOMERS.NEW-ALL.A&columnchart=ELEC.CUSTOMERS.NEW-ALL.A&map=ELEC.CUSTOMERS.NEW-ALL.A&freq=A&ctype=linechart&ltype=pin&rtype=s&maptype=0&rse=0&pin=.

46 Orr and Rolling, "Renewables Blueprint," 15.

47 Sargent & Lundy, *Capital Cost and Performance Characteristics for Utility-Scale Electric Power Generating Technologies* (Washington, D.C.: U.S. Energy Information Administration, January 10, 2024), https://www.eia.gov/analysis/studies/powerplants/capitalcost/.

CAPITAL COSTS AND FIXED AND VARIABLE OPERATION AND MAINTENANCE COSTS

Capital costs and expenses for fixed and variable O&M for new onshore wind, solar, and battery storage were obtained from the Capital Cost and Performance Characteristics for Utility-Scale Electric Power Generating Technologies report. The model uses the report's Region 7 capital costs and its national fixed and variable O&M costs.[48]

UNIT LIFESPANS

Different power plant types have different useful lifespans. This analysis takes these lifespans into account when evaluating the LCOE.

ONSHORE WIND TURBINES LAST 20 YEARS

Federal LCOE estimates seek to compare the cost of generating units over a 30-year time horizon.[49] This is problematic for wind energy LCOE estimates because the NREL reports the useful life of a wind turbine is only 20 years before it must be repowered. The AEOR model corrects for this error by using a 20-year lifespan for wind projects before they are repowered and need additional financing.

SOLAR PANELS LAST 25 YEARS

This analysis uses a 25-year lifespan for solar because this is the typical warranty period for solar panels. These facilities are rebuilt after they have reached the end of their useful lifetimes.

BATTERY STORAGE LASTS 15 YEARS

Battery storage facilities are expected to last for 15 years. Battery facilities, like wind and solar, are rebuilt after reaching the end of their useful lifetimes.

FUEL COST ASSUMPTIONS

Delivered fuel costs for existing power facilities were estimated using the most recent estimates from the Pennsylvania EIA state data profile.[50]

NUCLEAR FUEL COSTS

Fuel costs for existing nuclear plants were assumed to be $0.64 per million British Thermal Unit (mmBTU), resulting in an estimated fuel cost of $6.40 per MWh.[51]

NATURAL GAS FUEL COSTS

Existing natural gas prices were assumed to be $2.10 per mmBTu based on data obtained from the Pennsylvania EIA state data profile.[52] This resulted in a fuel cost of approximately $13.86 per MWh for combined cycle natural gas plants and $21 per MWh for combustion natural gas turbines. The AOER model held this fuel cost constant through 2035.

48 Sargent & Lundy, Capital Cost and Performance Characteristics for Utility-Scale Electric Power.
49 National Renewable Energy Laboratory, "Levelized Cost of Energy Calculator: Useful Life," August 3, 2018, https:// www.nrel. gov/analysis/tech-footprint.html.
50 U.S. Energy Information Administration, "State Electricity Profiles: Pennsylvania Electricity Profile 2023."
51 U.S. Energy Information Administration, "Table F18: Nuclear Energy Consumption, Price, and Expenditure Estimates 2023, accessed January 10, 2025, https://www.eia.gov/state/SEDS/data.php?incfile=/state/seds/sep_fuel/html/fuel_nu.html&sid=PA.
52 ISO Pennsylvania Inc. Internal Market Monitor, "2023 Annual Markets Report," ISO New England, May 24, 2024, https://www.Pennsylvania.com/static-assets/documents/100011/2023-annual-markets-report.pdf.

COAL FUEL COSTS

Existing coal fuel cost assumptions of $2.33 per mmBTU result in an estimated fuel cost of $23.30 per MWh.

LEVELIZED COST OF TRANSMISSION, TAXES, AND GENERATOR PROFITS

This report calculates the additional levelized transmission, property and income tax, and generator profit expenses resulting from each new power source during the course of the model and according to the additional capacity in MW installed and generation in MWh of that given source. Capacity installed is used to determine capital costs and additional expenses (transmission, state taxes, and generator profits) of each electricity source over the course of its useful lifespan.[53]

ASSUMPTIONS FOR LEVELIZED COST OF INTERMITTENCY CALCULATIONS

This report also calculates and quantifies the LCOI for onshore wind and solar energy on the entire energy system. These intermittency costs stem from the need to build backup battery storage facilities to provide power during periods of low wind and solar output, referred to as "battery storage costs" in this report, and the need to "overbuild and curtail" wind and solar facilities to limit the need for battery storage. It is important to note that these costs are highly system-specific to the mix of resources being built and operated in any given area.

BATTERY STORAGE COSTS

The model calculates battery storage costs by determining the total cost of building and operating new battery storage facilities to meet electricity demand during the time horizon studied under PACER and PRESS. These costs are then attributed to the LCOE values of wind and solar by dividing the cost of load balancing by the generation of new wind and solar facilities (capacity-weighted).

Attributing battery storage costs to onshore wind and solar allows for a more equal comparison of the expenses incurred to meet electricity demand between non-dispatchable energy sources, which require a backup generation source to maintain reliability, and dispatchable energy sources like coal, natural gas, and nuclear facilities that do not require backup generation.

OVERBUILDING AND CURTAILMENT COSTS

The cost of using battery storage for meeting electricity demand during periods of low wind or solar output is prohibitively high, so many wind and solar advocates argue that it is better to overbuild renewables, often by a factor of five to eight compared to the dispatchable thermal capacity on the grid, to meet peak demand during these low wind and solar periods. These intermittent resources would then be curtailed when wind and solar output improves.

As wind and solar penetration increase, a greater portion of their output will be curtailed for each additional unit of capacity installed.[54]

This "overbuilding" and curtailing vastly increases the amount of installed capacity needed on the grid to meet electricity demand during periods of low wind and solar output. The subsequent curtailment during periods of high wind and solar availability effectively lowers the capacity factor

53 Isaac Orr, Mitch Rolling, and John Phelan, "Doubling Down on Failure: How a 50 Percent By 2030 Renewable Energy Standard Would Cost Minnesota $80.2 Billion," Center of the American Experiment, March 2019, https://bit.ly/3AhwHzR.

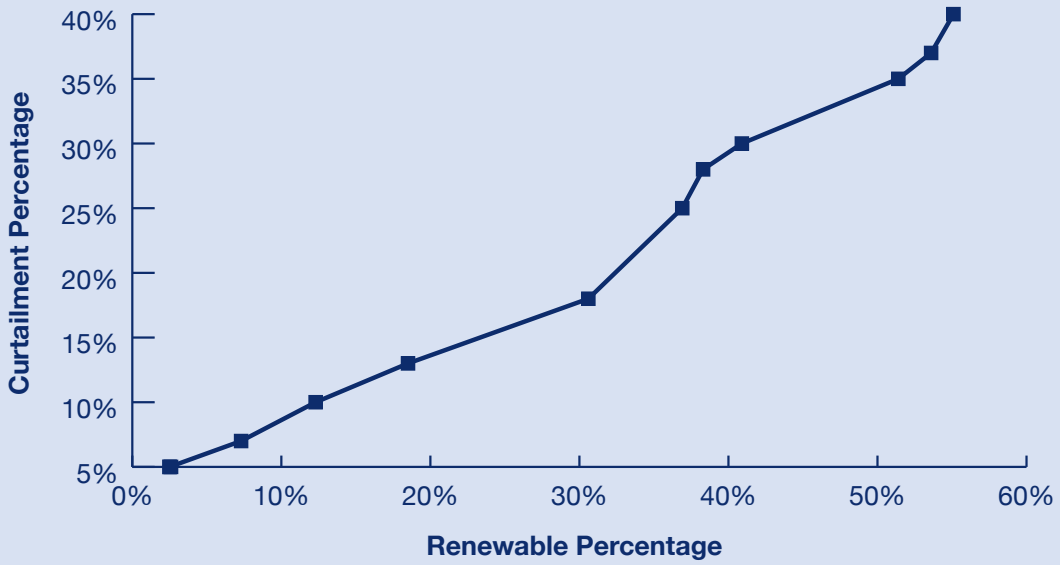
54 Dev Millstein et al., "Solar and Wind Grid System Value in the United States: The Effect of Transmission, Congestion, Generation Profiles, and Curtailment, *Joule* 5, No. 7 (July 2021), 1749–75, https://www.sciencedirect.com/science/article/pii/S2542435121002440.

of all wind and solar facilities, which greatly increases the cost per MWh produced.

The AOER model indicates there would be periods of curtailment in the future grid due to the large capacity additions of onshore wind, and solar resources.

Annual curtailment levels for this model were estimated based on hourly load forecasts and were found to reach up to 40 percent of total wind and solar generation by the end of the model (see Figure 18).

FIGURE 18: CURTAILMENT INCREASES WITH HIGHER AMOUNTS OF INTERMITTENT GENERATION



Curtailment is so high in this analysis because there is limited room for new generation on the Pennsylvania grid. The state has a large percentage of its electricity needs satisfied by carbon-free nuclear power, which this analysis, for multiple reasons, does not curtail to allow for wind and solar generation.

One, the Inflation Reduction Act (IRA) expanded the production tax credit (PTC) for qualifying nuclear power facilities, thus giving the ability to decrease their bids into wholesale power systems to increase the likelihood that they would be economically dispatched.[55] This analysis assumes nuclear operators would lower their bids to the extent necessary to dispatch. Two, nuclear power plants are meant to operate as baseload resources, and continuous ramping causes premature fatigue on the plants.

Rising rates of curtailment stemming from the overbuilding of the grid effectively lower the capacity factor of all generating resources on the grid, thereby increasing the LCOE, which is a calculation of power plant expenses divided by the generation of the plant.

55 William Freebairn, "Layers of IRA Tax Credits Boost Nuclear Energy's Economics, Drive Uprate Interest," S&P Global, May 15, 2024, https://www.spglobal.com/commodity-insights/en/news-research/latest-news/electric-power/051524-layers-of-ira-tax-credits-boost-nuclear-energys-economics-drive-uprate-interest.

COINCIDENT PEAK LOAD

This analysis assumes as coincident each EIA Hourly Grid Monitor subregion in the state of Pennsylvania experienced concurrent peak load.

COST OF COMPLIANCE MODELING

This analysis utilizes cost of compliance modeling to determine the cost of the electric system in Pennsylvania. This approach, which does not consider the impact of the resource portfolio on wholesale prices, is appropriate because most large-scale wind and solar facilities are procured through state-sponsored long-term contracts.

As the system becomes more saturated with these non-dispatchable resources, it is unclear whether the markets will be able to produce the necessary incentives to keep dispatchable units online, resulting in a circumstance where these generators are issued reliability payments to remain available for periods of peak demand. The model assumes generators would secure contracts to recoup their capital costs plus a return of 7.98 percent.

ELECTRICITY CONSUMPTION ASSUMPTIONS

AOER's model estimates electricity consumption in 2035 using the 2023 hourly load shapes from EIA's hourly grid monitor for the Duquesne Light, Metropolitan Edison Company, PECO Energy, Pennsylvania Electric, and PPL Electric regions that operate within Pennsylvania. Electricity sales from these regions includes 86 percent of Pennsylvania's total electricity sales, with the rest of Pennsylvania extrapolated to meet the state's total annual electricity consumption.

ENERGY STORAGE DISPATCH

Energy storage is assumed to be saved for periods of high demand with low wind and solar output and is not used to participate in energy arbitrage on PJM.

This decision was made because using storage systems to capture higher prices via arbitrage would often lead to situations where the energy storage was depleted before a period of wind and solar drought the following week, leaving the system short of energy.

EXPORT INCOME ASSUMPTIONS

Export income was assumed to sell at the real-time clearing price in PJM in 2023, rounded to $31 per MWh.

HOURLY LOAD, CAPACITY FACTORS, AND PEAK DEMAND ASSUMPTIONS

The hourly load shape for the AOER modeling was extrapolated from historical data from the five regions listed in the Electricity Consumption Assumptions section. The hourly load for 2035 was extrapolated from historical years (2019–23) based on annual growth rate projections for Pennsylvania of 1.7 percent.

IMPACT ON ELECTRICITY RATES

The table below (Figure 19) shows annual additional electricity rates by customer class using the cost of PACER and PRESS and adjusting for the rate factor described above in cents per kWh.

FIGURE 19: ANNUAL CONSUMER ELECTRICITY RATE HIKES UNDER PACER AND PRESS

ELECTRICITY RATES				
	Residential	Commercial	Industrial	Average
2023	18.1	11.26	7.75	12.58
2024	18.19	11.31	7.79	12.65
2025	18.38	11.44	7.87	12.84
2026	18.63	11.59	7.98	13.03
2027	19.48	12.12	8.34	13.7
2028	20.67	12.86	8.85	14.64
2029	22.6	14.06	9.68	15.86
2030	23.9	14.87	10.23	16.74
2031	24.9	15.49	10.66	17.5
2032	26.19	16.29	11.21	18.54
2033	28.25	17.57	12.1	19.8
2034	28.74	17.88	12.31	20.05
2035	29.02	18.05	12.43	20.17

IMPORTS

This analysis does not include assumptions about imports because Pennsylvania is a net exporter of electricity.

LOAD MODIFYING RESOURCES

The model does not allow for the use of load modifying resources (LMRs) or demand response (DR) in determining how much reliable capacity will be needed to meet peak electricity demand in PACER and PRESS.

Instead, the model assesses the battery capacity and excess wind and solar capacity built to provide enough power to supply Pennsylvania's electricity needs under the decarbonization plans at all times based on a test year using historical generation in Pennsylvania in 2023 and hourly capacity factors for wind and solar from the EIA Electric Grid Monitor and Pennsylvania.[56] Battery storage capacity was assumed to be 95 percent efficient and fully charged at the start of the test year.

While voluntary LMRs and DRs can play a role in optimizing system cost and reliability, DR resources have been and are inappropriately used by many wind and solar special interest groups to manipulate their models to unrealistically reduce the amount of capacity needed to meet peak demand, and thus artificially suppress the cost of their proposals. In this way, these groups are essentially manipulating

56 See "Hourly Load, Capacity Factors, and Peak Demand Assumptions."

the amount of capacity needed to meet current electricity demand and not providing an apples-to-apples comparison of the cost. Their proposals will effectively place more responsibility on behalf of the customer to keep the grid online.

NUCLEAR RELICENSING

All existing nuclear power plants were assumed to remain operational through the model run. This assumption greatly reduced the need for new onshore wind, solar, and battery storage resources and maintains system reliability.

PLANT CONSTRUCTION BY TYPE

This analysis assumes no new CO_2 emitting power plants will be built in Pennsylvania due to PACER and PRESS.

PLANT RETIREMENT SCHEDULES

AOER's model utilizes announced retirements for coal and natural gas facilities, in addition to retiring older resources as necessary to achieve the thresholds required by PRESS.

TIME HORIZON STUDIED

This analysis studies the impact of PACER and PRESS on electricity prices from 2024 to 2035. This time horizon is examined because, like a mortgage, power plant owners pay off the cost of their plants each year, meaning decisions made today will affect the cost of electricity for decades to come. As such, the total costs highlighted by this study do not represent the total costs incurred due to PACER and PRESS but rather the total cost that electricity customers would pay off through 2035.

TRANSMISSION

Transmission lines are an essential component of expanding the grid to accommodate new wind and solar resources. The National Laboratory of Renewable Energy estimates that to reach a 50 percent renewable energy target, the current transmission grid would need to increase by 20 percent. The current transmission grid—estimated using annual 10-K financial reports from transmission owners in Pennsylvania—resulted in a total capital investment need of $6.3 billion by 2035.

WIND AND SOLAR DEGRADATION

According to the Lawrence Berkeley National Laboratory, output from a typical U.S. wind farm shrinks by about 13 percent over 17 years, with most of this decline taking place after the project turns ten years old. According to the NREL, solar panels lose one percent of their generation capacity each year and last roughly 25 years, which causes the cost per MWh of electricity to increase each year.[57] However, this study does not take wind or solar degradation into account.

57 Liam Stoker, "Built Solar Assets Are 'Chronically Underperforming,' and Modules Degrading Faster than Expected, Research Finds," PV Tech, June 8, 2021, https://www.pv-tech.org/built-solar-assets-are-chronically-underperforming-andmodules-degrading-faster-than-expected-research-finds/.

Acronyms/Abbreviations List

Alternative Energy Portfolio Standard (AEPS)
Always On Energy Research (AOER)
Carbon dioxide (CO_2)
Cost Containment Reserve (CCR)
Federal Energy Regulatory Commission (FERC)
gigawatt (GW)
Independent Fiscal Office (IFO)
Inflation Reduction Act (IRA)
independent power producer (IPP)
kilowatt-hour (kWh)
Levelized Cost of Energy (LCOE)
levelized cost of intermittency (LCOI)
Load Modifying Resource (LMR)
megawatt-hour (MWh)
Metric Million British Thermal Unit (mmBTU)
National Renewable Energy Laboratory (NREL)
operation and maintenance (O&M)
Pennsylvania Department of Environmental Protection (DEP)
Pennsylvania Climate Emissions Reduction Act (PACER)
Pennsylvania Reliable Energy Sustainability Standard (PRESS)
power purchase agreement (PPA)
production tax credit (PTC)
Regional Greenhouse Gas Initiative (RGGI)
regional transmission organization (RTO)
Renewable Energy Certificate (REC)
Renewable Portfolio Standard (RPS)
Securities and Exchange Commission (SEC)
small modular reactors (SMRs)
social cost of carbon (SCC)
U.S. Energy Information Administration (EIA)
Zero Emissions Credit (ZEC)

COMMONWEALTH FOUNDATION

commonwealthfoundation.org

717.671.1901