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FACT SHEET

HOW PENNSYLVANIA CAN MEET ITS CLEAN POWER PLAN TARGETS

KRISTIN MEEK, REBECCA GASPER, NOAH KAUFMAN

CONTACT

Kristin Meek
Associate
Climate and Energy Program
kmeek@wri.org

Rebecca Gasper
Research Analyst
Climate and Energy Program
rgasper@wri.org

Noah Kaufman
Climate Economist
nkaufman@wri.org

WHAT DOES THE CLEAN POWER PLAN MEAN FOR PENNSYLVANIA?

In August 2015, the U.S. Environmental Protection Agency (EPA) finalized the Clean Power Plan (CPP), the first-ever carbon pollution standards for existing power plants (Box 1). The CPP builds on progress already under way to move the country toward a cleaner electricity system, including rapidly falling prices of renewables and increased deployment of money-saving energy efficiency measures. The plan enables states to use a wide range of options to meet their standards, such as existing clean energy policies and electricity infrastructure (the focus of this analysis), other tools to cut electricity use and increase the use of renewables, and broader initiatives such as participation in a cap-and-trade program or use of a carbon tax (Box 2).

This fact sheet examines how Pennsylvania can meet—and even exceed—its CPP standards through expanding its clean energy policies and making better use of existing power plants while minimizing compliance costs, ensuring reliability, and harnessing economic opportunities in clean energy. Pennsylvania's existing clean energy policies put the state's power plants in good position to make carbon dioxide (CO_2) emission reductions that will help the state meet its CPP targets. Existing policies that promote renewable development and improve energy efficiency through 2020–21 will help Pennsylvania meet its initial targets. If extended and expanded, these policies could provide a basis to meet the targets through 2030.

WHAT DOES THE CLEAN POWER PLAN REQUIRE FOR PENNSYLVANIA'S POWER PLANTS?

Each state has the flexibility to use one of three targets provided in the Clean Power Plan, either (1) an emission rate target for existing power plants, which measures the carbon intensity of the state's existing fossil electricity generation; (2) a mass-based target for existing power plants, which measures the absolute level of CO_2 emissions allowed by the state's affected power plants; or (3) a mass-based target for new and existing power plants (i.e., new source complement).

Pennsylvania can choose one of the following three targets:

- **Emission rate target for existing sources:** 1,095 pounds per megawatt-hour (lbs./MWh) in 2030, a reduction of 33 percent below the state's 2012 power sector emission rate of 1,642 lbs./MWh.
- **Mass-based target for existing sources:** 89.8 million short tons of CO^2 in 2030, which is about 25 percent lower than the state's power sector CO_2 emissions in 2012.
- **Mass-based target for new and existing sources:** 90.9 million short tons of CO_2 in 2030, which is about 24 percent lower than the state's power sector CO_2 emissions in 2012.

The percent reductions are calculated using an adjusted 2012 baseline that includes the CO_2 emissions and generation from fossil plants that were under construction as of January 8, 2014, and are affected by the Clean Power Plan, consistent with EPA's methodology.

HOW PENNSYLVANIA'S POWER PLANTS CAN MEET—OR EXCEED—THE CLEAN POWER PLAN REQUIREMENTS

Pennsylvania's power plants have already reduced their CO_2 emissions by 12 percent between 2005 and 2012,[1] due in large part to using more natural gas and less coal to generate electricity. This has resulted in a 19 percent decrease in the state's fossil emission rate—a measure of the carbon-intensity of its fossil-fuel fired electricity generation—calculated based on the methods in EPA's Clean Power Plan. However, this downward trend in CO_2 emissions is not expected to continue without additional policy action. According to our business-as-usual (BAU) projections, based in part on the U.S. Energy Information Administration's (EIA) *Annual Energy Outlook 2015* (AEO2015), existing power plant emissions in the state are expected to grow by 8 percent from 2012 to 2030 due to increased demand.[2]

Our BAU projections do not include any emissions from possible new natural gas plants. As of October 2015, Pennsylvania had several new natural gas plants under study.[3] Such power plants could be a source of "leakage"—that is, increased emissions from sources not covered under the CPP—if the state adopts the existing source mass-based standard. EPA is requiring any states that adopt that standard to address leakage through allowance allocation rules, allowance set-asides, or other mechanisms.[4] An alternate approach would be to adopt the new source complement standard that also covers new power plants, rather than the existing source standard. The use of this standard would further incentivize zero-carbon generation sources, and ensure that future CO_2 emissions from Pennsylvania's power sector do not increase.

CO_2 REDUCTIONS FROM EXISTING CLEAN ENERGY POLICIES AND INFRASTRUCTURE

Pennsylvania can build on its progress to date and achieve greater reductions by following through on its existing renewable energy and efficiency standards. By meeting the targets of its existing renewable energy and efficiency policies while making better use of existing power plants, the state can reduce its power sector emissions 13 percent below 2012 levels by 2030, achieving over half of the reductions necessary to meet its mass-based emission target.[5] The remaining gap can be closed by expanding the state's current clean energy policies after the current targets are met in the early 2020s.

If the state decides to adopt EPA's rate-based target, complying with its existing clean energy policies while making better use of its existing infrastructure would allow Pennsylvania's plants to reduce their average emission rate by 20 percent below its 2012 emission rate to 1,318 lbs. per MWh in 2030,[6] falling short of the state's rate-based target of 1,095 lbs. per MWh.

- **IMPROVING ENERGY EFFICIENCY**
  In June 2015, Pennsylvania adopted Phase III of its energy efficiency program. This phase sets specific energy efficiency targets for each utility that range from 2.6 percent to 5.0 percent cumulative savings (i.e. the amount of electricity saved in a given year due to measures implemented in that year and prior years)

from 2016 through 2020 compared to the 2009–10 baseline (statewide, this equates to about 3.5 percent cumulative annual savings in 2020).[7] In addition to the reductions captured in Pennsylvania's business-as-usual projections, adopting measures and policies that help achieve its efficiency standard can contribute toward meeting both of Pennsylvania's mass-based emission targets under the Clean Power Plan.[8]

- **INCREASING USE OF RENEWABLE ENERGY**
  Pennsylvania's alternative energy portfolio standard (AEPS) requires 8 percent of electricity sold in the state to be generated by Tier I renewable sources (like wind, solar PV, landfill gas, wood, or black liquor) by 2021.[9] An additional 10 percent of electricity sold in the state must be generated using Tier II sources by 2021, and can include energy sources like municipal solid waste, distributed generation, integrated combined coal gasification technology, waste coal, and other alternative sources.[10] After taking into account the reductions already captured in our business-as-usual projections and achieving the state's energy efficiency goal, ensuring that Pennsylvania generates 8 percent of its electricity from renewable sources located in the state by 2022 and beyond can contribute toward meeting both of the state's mass-based emission targets.[11]

- **INCREASING THE USE OF EXISTING NATURAL GAS PLANTS**
  Pennsylvania's most efficient natural gas plants—combined cycle (NGCC) units—ran at 65 percent of their capacity in 2013, which is lower than they were capable of producing. Running existing (and those already under construction as of January 2014) NGCC plants at 75 percent in addition to the measures listed above can achieve 43–44 percent of the reductions required to meet both of the mass-based targets.[12]

- **INCREASING COAL PLANT EFFICIENCY**
  Operational improvements that increase the average efficiency of the remaining coal fleet by 4.3 percent beginning in 2022, together with the measures above, would allow Pennsylvania to achieve 53–55 percent of the reductions required to meet both of the mass-based targets.[13]

CO_2 REDUCTION OPPORTUNITIES USING EXPANDED CLEAN ENERGY POLICIES

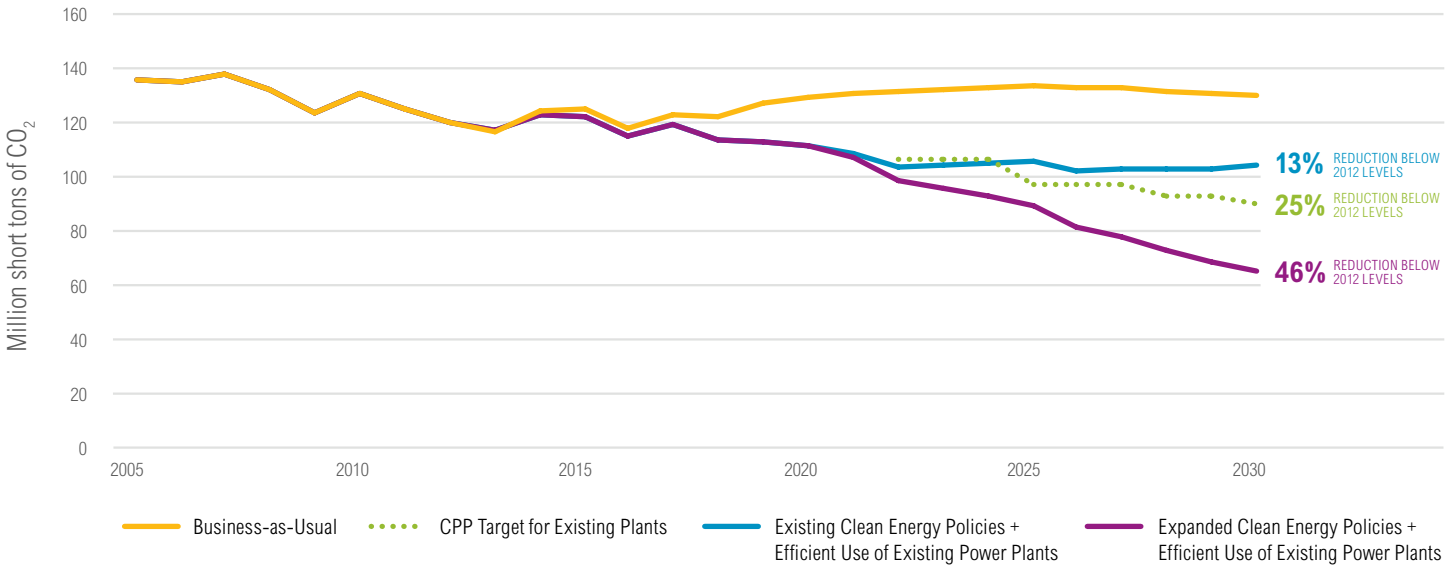
Pennsylvania could meet—or even exceed—its mass-based target for existing plants by expanding its clean energy policies. Doing so could also help reduce the need for new natural gas plants and enable the state to meet its mass-based target for new and existing plants. By taking the following actions in addition to the infrastructure opportunities listed above, the state can reduce existing power plant emissions 46 percent below 2012 levels by 2030, almost doubling the required reductions under a mass-based target:

- After 2020, ramp up the efficiency target so that by 2030, the state achieves the "maximum achievable" cost-effective efficiency potential the state's Public Utility Commission (PUC) identified. Pennsylvania's Public Utility Commission has found that it would be cost-effective for the state to reduce electricity consumption by 19 TWh over the next ten years.[14] However, Pennsylvania cannot currently realize this potential because a spending cap in Act 129 limits utility spending on efficiency programs to 2 percent of 2006 annual revenues. Removing the cap (or adjusting the cap to ensure that it reflects cost-effective potential) could reduce demand growth, while also lowering the household energy bills that are currently among the highest in the nation.[15]
- Increase the Tier I alternative energy standard from the current 8 percent of the state's sales by 2021 to 18 percent by 2030. The state has considerable untapped wind and solar potential,[16] with many of its neighbors requiring at least 20 percent renewable energy by 2020.

Taking these actions would allow Pennsylvania to surpass its rate-based target by reducing the emission rate of its existing fossil fleet to 861 lbs. per MWh if it opted for a rate-based approach. Since the CPP makes it easy for states to trade carbon allowances or emission rate credits, Pennsylvania could generate revenue by going beyond the required reductions and selling excess credits to other states. Pennsylvania could also generate extra credits by taking advantage of EPA's Clean Energy Incentive Program, which rewards early action in renewable energy and energy efficiency in low-income communities.

On the other hand, if Pennsylvania did not expand its clean energy policies but only implemented its existing policies along with the infrastructure opportunities listed above, it would achieve only 53–55 percent of the reductions required to meet either of its 2030 mass-based targets.[17] This would leave the state's existing plants with a shortfall of allowances (equating to 13–14 million short tons of CO_2), which they would have to make up using other measures or by sending money out of state to purchase credits.

Figure 1 | Existing Power Plant Emission Pathways for Pennsylvania



Note: This figure depicts the Clean Power Plan's interim and 2030 mass-based targets for Pennsylvania's affected power plants (CPP Target for Existing Plants). Consistent with EPA's calculation of the 2012 emissions baseline, our Business-as-Usual pathway includes emissions from two NGCC plants starting in 2012, even though the plants were not yet online. Because they were under construction by January 2014, they are counted as existing sources for the purposes of the CPP and their emissions are included starting in 2012. (See endnote 1 for more information.) The Existing Clean Energy Policies + Efficient Use of Existing Power Plants pathway shows emissions from affected plants after implementing the state's clean energy policies (Act 129 and AEPS) and making better use of the state's existing power plants (increasing generation at the existing NGCC fleet, which includes the two NGCC plants that were under construction as of January 2014, and improving efficiency of existing coal plants). The Expanded Clean Energy Policies + Efficient Use of Existing Power Plants pathway shows emissions after expanding the state's clean energy policies and making better use of existing power plants. These pathways do not account for potential credits that Pennsylvania could generate by taking early action under the Clean Energy Incentive Program.

Box 1 | Overview of EPA's Final Clean Power Plan

The power sector is the leading source of carbon dioxide (CO_2) emissions in the United States, but also offers some of the most cost-effective opportunities to reduce those emissions. Power sector emissions at the national level decreased by 16 percent between 2005 and 2012 due to the recession, increased penetration of renewable energy, increased energy efficiency, and the low price of natural gas. Without new policies like the CPP, current projections show that emissions will slowly rise or hold steady through 2030 to reach 10–17 percent below 2005 levels.*

On August 3, 2015, EPA finalized standards for existing power plants that will help drive additional CO_2 emission reductions by 2030. States have the option to comply with either rate-based (lbs. CO_2 per megawatt-hour) targets for existing fossil plants or mass-based (short tons of CO_2) targets for either the existing fossil fleet or for new and existing fossil plants. EPA developed these state-specific standards by taking into account the composition of each state's existing fossil fleet along with an estimate of the potential to increase the existing coal fleet's efficiency, ramping down coal generation by increasing the utilization of the existing natural gas combined cycle fleet, and developing more renewable energy resources.

The Clean Power Plan makes use of the flexibility allowed by the Clean Air Act so that states can take advantage of several different measures to lower the carbon intensity of its power generation mix—such as fuel switching, dispatch of existing low-carbon power plants, increased generation by renewable sources, and energy efficiency. EPA also is providing states with several implementation plan options, including the option to get credit for early action, which we discuss in more detail in Box 2. States have until September 6, 2016 to submit either a final implementation plan or an initial submission with an extension request. All state plans should be completed by 2018 and compliance will begin in 2022. EPA will issue a federal implementation plan for states that do not submit their own plans. EPA is currently taking comments on the federal plan it proposed in August 2015, and is expected to finalize the plan in the summer of 2016.

Notes: * While CO_2 emissions from the power sector have already fallen 16 percent since 2005 (relative to 2012 levels), the U.S. Energy Information Administration's *Annual Energy Outlook 2015* projects that power sector emissions will slowly increase between 2012 and 2030 so that CO_2 emissions reach approximately 10 percent below 2005 levels (note, this only takes into account policies that were on the books as of the end of October 2014). On the other hand, EPA's baseline projections for its modeling of the Clean Power Plan, which includes lower cost estimates for renewable technologies, estimate that power sector emissions will reach 17 percent below 2005 levels by 2030. Specifically, EPA's projections estimate less coal-fired generation and more natural gas and renewable generation in 2030 than EIA's projections.

Box 2 | Clean Power Plan Compliance Options

The Clean Power Plan offers states significant flexibility. As states develop their implementation plans, they will need to make a number of decisions that will affect how they comply. Key considerations include:

- **TYPE OF TARGET**
  States can choose either a rate-based target (in lbs. CO_2/MWh) or a mass-based target (in short tons of CO_2). States using a rate-based target can adopt separate standards for coal and combined cycle natural gas units, a weighted average for all affected units, or equivalent standards that apply to individual units or groups of units. States using a mass-based target can use EPA's standard for existing units only, or for existing and new units collectively (known as a new source complement).

  Since mass-based plans will rely on reported power plant emissions, complementary actions to improve energy efficiency and increase renewable generation do not need to be quantified in the state plans. Rate-based plans require an explicit accounting of actions used to adjust the emission rate from affected units, including evaluation, measurement, and verification of those actions.

- **TYPE OF STATE PLAN**
  The CPP allows two types of state plans. Under an "emission standards" plan, states place mass- or rate-based emissions requirements directly on affected units, which are then required to reduce their emissions or rate directly or by using credits generated by fuel-switching, renewable energy, energy efficiency, or other approved measures. States that adopt a mass-based target can opt for a "state measures" plan. With this type of plan, states can use a portfolio of state-enforced measures, which can apply both to affected units and other entities (for example, demand-side efficiency, renewable portfolio standards, or cap-and-trade programs). Under this approach, states could also implement a carbon tax for compliance. This approach must include emission standards for affected power plants in case the portfolio approach does not achieve the required reductions.[a]

- **INDIVIDUAL OR MULTISTATE COMPLIANCE**
  States can choose to comply individually or as part of a multistate plan with an aggregated target. States also can coordinate with other states while retaining an individual state goal. Joining a regional cap-and-trade program—or just allowing trading with other states that adopt the same compliance approach—may be the most cost-effective option for some states, lowering compliance costs while ensuring reliability.[b] Studies in the Southwest Power Pool, PJM, and MISO regions have found that regional compliance would be the most cost-effective option.[c]
  The Regional Greenhouse Gas Initiative illustrates how a multistate trading approach can help reduce emissions while driving investments in renewable energy and energy efficiency and saving money for electricity customers. Over the first six years of the program, investments from auction proceeds have generated nearly $3 billion in economic value added to the region and created over 28,000 job-years of employment.[d]

- **TRADING:** States don't need to join a cap-and-trade program or formally coordinate with other states to trade. EPA allows states to trade emission rate credits (rate-based target) or emission allowances (mass-based) regardless of their implementation plan type as long as states meet "trading ready" criteria provided in the rule.[e] However, mass-based states may only trade with other mass-based states and rate-based states may only trade with other rate-based states. Once trading-ready state plans are approved, states can begin trading right away without additional requirements or approval from EPA.

- **EARLY ACTION:** EPA is offering a Clean Energy Incentive Program to reward early investments in energy efficiency projects that benefit low-income communities and in renewable energy. States can earn additional credits from EPA by implementing eligible projects in 2020 and 2021.

Notes and Sources:

a. According to the final rule, a state measures plan "must also include a contingent backstop of federally enforceable emission standards for affected EGUs that fully meet the emission guidelines and that would be triggered if the plan failed to achieve the required emission reductions on schedule."

b. Susan Tierney and Paul Hubbard. 2015. "Carbon Control and Competitive Wholesale Electricity Markets: Compliance Paths for Efficient Market Outcomes." Analysis Group. Accessible at: <http://www.analysisgroup.com/uploadedfiles/content/insights/publishing/clean_power_plan_markets_may_2015_final.pdf>.

c. MISO. 2015. "Clean Power Plan Analysis Update." ERSC Meeting. Accessible at: <https://www.misoenergy.org/Library/Repository/Meeting%20Material/Stakeholder/ICT%20Materials/ERSC/2015/20150512/20150512%20ERSC%20Item%2006b%20Clean%20Power%20Plan%20Update.pdf>. PJM. 2015. "PJM Interconnection Economic Analysis of the EPA Clean Power Plan Proposal." Accessible at: <http://www.pjm.com/~/media/4CDA71CBEC864593BC11E7F81241E019.ashx>. Southwest Power Pool. 2015. "SPP Clean Power Plan Compliance Assessment- State by State." SPP Engineering. Accessible at: <http://www.spp.org/publications/SPP_State_by_State_Compliance_Assessment_Report_20150727.pdf>.

d. Analysis Group. 2015. "The Economic Impacts of the Regional Greenhouse Gas Initiative on Nine Northeast and Mid-Atlantic States." Accessible at: <http://www.analysisgroup.com/uploadedfiles/content/insights/publishing/analysis_group_rggi_report_july_2015.pdf>. Acadia Center. 2015. "The Regional Greenhouse Gas Initiative: A Model Program for the Power Sector." Accessible at: <http://acadiacenter.org/wp-content/uploads/2015/07/RGGI-Emissions-Trends-Report_Final.pdf>.

e. These criteria include use of an EPA-approved (or EPA-administered) emission and allowance tracking system (mass-based) and provisions for issuing, tracking, and submitting emission rate credits (rate-based). Section VIII of the final rule provides more guidance (http://www.epa.gov/airquality/cpp/cpp-final-rule.pdf).

HOW PENNSYLVANIA CAN MAXIMIZE THE ECONOMIC BENEFITS OF THE CLEAN POWER PLAN

As we have shown, Pennsylvania can achieve over half of the reductions necessary to meet its mass-based CPP target by following through on its existing clean energy policies and making better use of its existing infrastructure. Looking forward, Pennsylvania can develop an implementation plan that maximizes the economic benefits to the state and achieves the emission reductions necessary to cost-effectively comply with the CPP. Such a plan could include:

- **Adopting a market-based carbon pricing program:** A carbon pricing program—in the form of either a cap-and-trade program or a carbon fee—has major economic advantages over alternative implementation approaches:

    1. A carbon price encourages the most cost-effective emission reductions without favoring any particular technology. A study of air pollution regulations found that market-based approaches have ranged from 1.1 times to 22 times more cost-effective than non-market approaches to regulation.[18]

    2. Revenues from allowance auctions or a carbon fee can be used to accomplish other policy objectives such as reducing the tax burden on Pennsylvanians or making productive public investments. A carbon price of $10 per ton for power plant emissions allowed under Pennsylvania's mass-based target for its existing plants would provide average annual revenues of over $980 million.[19] This revenue could be used to provide assistance to those who may be adversely affected by the carbon price, such as low-income households and coal industry workers. It could also be used to make further investments in energy efficiency to help lower household and business electricity bills and reduce wholesale electricity costs. The Regional Greenhouse Gas Initiative illustrates how investment of auction revenue can benefit the local economy. During the period from 2009 to 2014, investments of nearly $2 billion in auction proceeds—into bill assistance, energy efficiency, renewable energy, and other uses—generated nearly $3 billion in economic value-added across the nine participating states, according to a study by Analysis Group.[20] States that want to maximize their potential revenue stream might find adopting EPA's new source complement standard attractive, as they would not need to devote additional resources to addressing leakage concerns.

    3. The CPP encourages states to take advantage of interstate trading opportunities without needing to formally join a regional program. A recent study by PJM (the regional grid operator for Pennsylvania) examined the proposed Clean Power Plan and found that compliance would be much cheaper if PJM states established a market-based allowance trading program compared to each state complying on its own.[21] Taking advantage of interstate trading would also enable Pennsylvania to sell surplus allowances and generate revenue from out-of-state sources if it surpasses its CPP targets. Assuming an allowance price of $10 per ton, over $160 million in revenues could flow into the state per year on average between 2022–30 if it achieved its clean energy goals and increased its use of the state's existing natural gas fleet and sold the credits on interstate markets. (This does not include consideration of any credits that might be generated through the Clean Energy Incentive Program prior to 2022.)

    4. Carbon pricing provides financial incentives for regulated entities to reduce their emissions beyond the target, which encourages the adoption and diffusion of low-carbon energy technologies. Such technological advancements can lower overall compliance costs and boost economic growth.

- **Investing in energy efficiency:** Pennsylvania's residential electric bills are among the highest in the nation.[22] By reducing electricity demand, improvements in energy efficiency reduce the need for investments in electricity supply, which frees up capital to invest in other productive areas across the economy. If the energy efficiency programs are less expensive than electricity generation—as the empirical evidence indicates many of them are[23]—electricity prices should fall, leaving Pennsylvanians with more income to spend, save, or invest. Utilities exceeded the state's Phase I efficiency targets, with a net $2.5 billion in verified benefits.[24] The Analysis Group found that the reinvestment of auction proceeds made by RGGI states in energy efficiency and renewable energy in the 2012–14 time frame have led to net electricity savings of $341 million for households, businesses, and industry.[25]

The investments needed to move toward a low-carbon future will strengthen Pennsylvania's economy over the long term. While these investments are likely to involve short-run economic costs—including somewhat higher electricity rates and fewer investment dollars available for alternative opportunities in the electricity sector or across the economy—as explained above, there are ways to offset some of these costs. In the long term, these investments are likely to pay off. Pennsylvanians will spend far less of their income on electricity thanks to improvements in efficiency and the low operating costs of renewable energy.[26]

In a transition to a low-carbon power sector, jobs will be gained in the clean energy industry and will decline in high-carbon industries, like coal, accelerating trends already under way. The clean energy industry creates jobs in manufacturing, construction, home maintenance, and other sectors—in 2014, the wind and solar industries employed 4,800 people in Pennsylvania.[27] State and federal governments should help manage the transition to a lower-carbon economy by offering job training or other programs to ensure that opportunities are available for all workers. We have shown how compliance can be structured in a way to generate revenue to cover the costs of these transition policy measures.

Strong implementation of the CPP is a critical component of the U.S. commitment to a global climate agreement that can help reduce global emissions and combat climate change. Failure to avoid the worst effects of climate change could result in high costs for Pennsylvania's residents. According to a Pennsylvania State University study, continued warming could include the following effects on Pennsylvania's economy:[28]

- In the dairy industry, heat stress and declining feed quality are likely to drive milk yields downward and increase production costs.
- Energy consumption, especially electricity, would likely increase during the summer months.
- Higher temperatures in the summer would negatively affecting sport fish populations. In the winter it would reduce snowfall, negatively impacting the state's skiing and snowmobiling sport and tourism industries.
- Droughts and summer flooding events would likely increase.

In addition to helping combat climate change, lowering the carbon intensity of the power sector in Pennsylvania will lead to reductions in harmful local air pollutants. According to EPA, exposure to pollutants—including particulate matter, nitrogen oxides, and sulfur dioxide—can lead to respiratory issues or heart and lung diseases.[29] Reducing these emissions will make for a healthier work force that spends less on medical bills.

THE CLEAN POWER PLAN WILL MAINTAIN ELECTRIC GRID RELIABILITY

The Clean Power Plan provides flexibility aimed at ensuring the continued reliability of the nation's power grid.[30] Under the final CPP, states can choose from a wide variety of compliance options that are best suited to that state's existing resources and policies. While EPA is offering states incentives to invest in renewable energy and energy efficiency early, they also have given states additional time to complete and implement their plans by changing the compliance start date from 2020 to 2022. In addition, the Clean Power Plan is requiring each state to consider reliability issues as it develops its implementation plan, while also providing a mechanism for states to revise their plans if significant unplanned reliability issues arise. EPA also created a reliability safety valve that allows a power plant to temporarily exceed its targets during unexpected events or emergencies that raise reliability concerns. EPA consulted closely with the Department of Energy and the Federal Energy Regulatory Commission in developing the CPP's reliability provisions. These agencies will continue to work together to monitor CPP implementation and help resolve any reliability concerns that arise.

The U.S. power sector also has shown it has the ability to reliably deliver electricity to homes and businesses despite changes in electricity mix and demand. EPA's environmental regulations under the Clean Air Act, such as the Acid Rain Program or Mercury and Air Toxics Standards, have never caused blackouts. This is because EPA granted flexibility to power plants in the past—just like it is doing under the Clean Power Plan—and because state regulators have standard reliability practices that have been used for decades to address reliability issues if and when they arise.[31] Analyses of the proposed Clean Power Plan have shown that compliance is unlikely to affect reliability because of these standard practices and the flexibility inherent in the rule.[32] In addition, several studies have found that the flexibility of the current grid would allow for renewable penetration levels exceeding those required by current state targets. These studies have shown that proven technologies and practices can reduce the cost of operating generation portfolios with high variable renew-

able energy levels and enable reliable grid operation with more than 50 percent renewable penetration.[33] PJM found that it could handle 30 percent variable renewable penetration with no reliability issues as long as adequate additions in transmission and regulation reserves were made.[34]

OPPORTUNITIES IN DETAIL

Below we describe Pennsylvania's opportunities to comply with the Clean Power Plan in more detail, including increasing (1) energy efficiency, (2) renewable energy, (3) use of existing natural gas power plants, and (4) coal plant efficiency.

1. ENERGY EFFICIENCY OPPORTUNITIES

In 2008, Pennsylvania created energy efficiency and conservation requirements for the state's electric distribution companies with at least 100,000 customers. These requirements mandated that electricity sales be reduced by a cumulative 1 percent by May 2011 and a cumulative 3 percent by May 2013 compared to a 2009–10 baseline.[35, 36] Utilities exceeded these Phase I targets, with a net $2.5 billion in verified benefits.[37] Phase II of this program sets specific energy efficiency targets for each utility that range from 1.6 percent to 2.9 percent cumulative savings from 2013 to 2016 compared to the 2009–10 baseline.[38] Phase III of this program, adopted in June 2015, sets specific energy efficiency targets for each utility that range from 2.6 percent to 5.0 percent cumulative savings from 2016 through 2020 compared to the 2009–10 baseline (statewide, this equates to about 3.5 percent cumulative annual savings in 2020).[39]

However, these targets are contingent on a spending cap and the state's Public Utility Commission (PUC) has identified much more cost-effective potential for energy efficiency that can be tapped to reduce demand growth, while also lowering the household energy bills that are currently among the highest in the nation.[40] Specifically, the PUC recently found that the state can achieve nearly 27 TWh of "maximum achievable" cost-effective efficiency potential by 2025; 19 TWh of this potential is considered to be achievable by taking into account real-world barriers to encouraging end users to adopt efficiency measures among other costs and barriers. Our expanded policies pathway assumes that the spending cap is adjusted or removed and the PUC uses its existing authority to ramp up the state's efficiency target after 2020 so that the state achieves this cost-effective efficiency potential by 2030.

The PUC found that this level of savings would result in $2.8 billion in net benefits, with benefits outweighing costs nearly 2 to 1.[41] Pennsylvania has more energy savings opportunities beyond these utility programs—including increasing its use of combined heat and power at power plants,[42] adopting the latest building codes, improving building and energy code compliance, and improving financing for energy efficiency.[43]

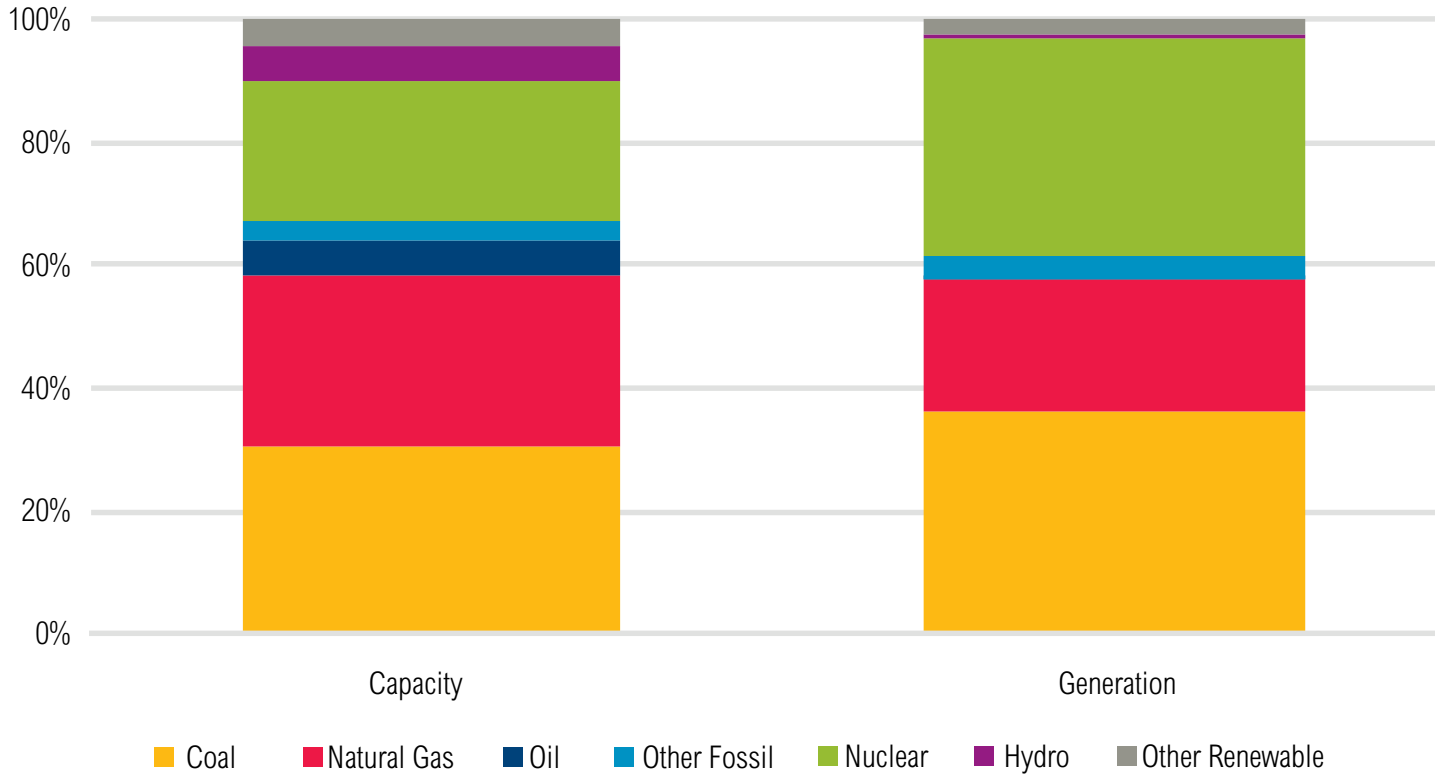
2. RENEWABLE ENERGY OPPORTUNITIES

Pennsylvania's alternative energy portfolio standard (AEPS) requires 8 percent of electricity sold in the state to be generated by Tier I renewable sources by 2021, with 0.5 percent of that total devoted to solar PV resources.[44] Besides solar, Tier I resources include wind, wood and wood waste, low-impact hydro, landfill gas, black liquor (PA only), and other gases. An additional 10 percent of electricity sold in the state must be generated using Tier II sources by 2021, and can include energy sources like municipal solid waste, distributed generation, integrated combined coal gasification, waste coal, and other alternative sources.[45] As of 2013, all utilities were in compliance with the AEPS requirements without having to make an alternative compliance payment.[46]

Pennsylvania has considerable untapped wind and solar potential[47] with many of its neighbors requiring at least 20 percent renewable energy by 2020. The state had over 4,000 MW of installed renewable capacity as of 2013, with about one-third of this capacity coming from wind.[48] Continuing to increase wind capacity could be economically positive for customers in the state and surrounding region. Analysis of PJM found that increased investment in renewable energy in the region would cut system-wide costs, resulting in a net benefit (after taking into account investment costs for new wind and natural gas generation and transmission requirements) of up to $6.9 billion per year in PJM by 2026—or $113 per year per person.[49]

Furthermore, scaling up the state's investment in renewable energy would allow Pennsylvania to keep more economic benefits in-state. Pennsylvania's PUC reports that since its inception, "the AEPS has resulted in sustaining and creating thousands of jobs and business ventures associated with all aspects of renewable and alternative energy generation."[50] In fact, 16 MW of solar capacity built in the state in 2013 resulted in $171 million in investments that support 2,900 jobs from over 400 companies that are involved in solar panel manufacturing, sales, distribution,

Figure 2 | **Pennsylvania Generation and Generating Capacity by Fuel, 2013**



Note: Figure 2 does not include the capacity and generation of the two "under construction" NGCC plants EPA includes in Pennsylvania's baseline.

and installation.[51] Pennsylvania has seen almost $3 billion in capital investment in wind power within the state, with annual school tax, property tax, and landowner lease payments surpassing $3.6 million in 2013. But, as of 2013, only 40 percent of the state's Tier 1 resources came from Pennsylvania. Expanding the Tier I alternative energy standard from the current 8 percent of the state's sales by 2021 to 18 percent by 2030—while ensuring that utilities meet this standard with CPP-qualifying renewable energy with in-state resources—could help the state meet, or even exceed, its CPP targets while also bringing even more economic benefits to the state. This would require an annual percent growth in renewable generation between 2021 and 2030 that is consistent with what is required between 2014 and 2021 (9 percent per year) to meet the current target if Pennsylvania expanded their efficiency target as we discussed above.

3. INCREASING THE USE OF EXISTING NATURAL GAS PLANTS

According to EIA data, the capacity factor of Pennsylvania's existing combined cycle natural gas (NGCC) fleet was 65 percent in 2013—meaning that these plants generated less than the amount of electricity they are capable of producing.[52,53,54] As a result, natural gas comprised 22 percent of the state's generation, while it comprised 27 percent of total generating capacity (Figure 2). Moxie Energy's Liberty and Patriot NGCC plants were under construction as of January 2014 (coming online in 2016) and are counted as part of Pennsylvania's existing fossil fleet under the Clean Power Plan, giving the state even more opportunity to utilize its existing gas fleet over higher carbon generation.

4. INCREASING COAL PLANT EFFICIENCY

Existing coal plants can increase their efficiency through refurbishment and improved operation and maintenance practices.[55,56] In developing the final CPP, EPA found that

coal plants could significantly increase their efficiency by improving operations to return to the best performance they have achieved in the past. By comparing average coal plant heat rates in 2012 to their best demonstrated performance between 2002 and 2012, EPA estimated that the coal fleet could achieve average efficiency improvements ranging from 2.1 to 4.3 percent in the different interconnection regions.[57]

EPA expects that these improvements can largely be achieved through application of low-cost best practices (e.g., operations and maintenance improvements; replacing worn seals and valves; cleaning equipment) and will not require equipment upgrades. However, upgrades can be used to comply with the rule. While there are high upfront costs associated with refurbishing existing coal units, the resulting increase in unit efficiency will lead to annual fuel savings.[58] In addition, some plants could decrease their emissions intensity by co-firing with natural gas using the igniters that are already built into many existing pulverized coal boilers.[59]

Increasing the efficiency of Pennsylvania's existing coal fleet by an average 4.3 percent starting in 2022, the potential improvement rate that EPA identified for the eastern interconnection, could help Pennsylvania achieve over half the reductions required under its mass-based target when implemented with existing clean energy policies and increasing use of natural gas.

OUTLOOK FOR PENNSVLVANIA

Pennsylvania can put itself in a strong position to comply with the Clean Power Plan while taking advantage of economic opportunities and maintaining grid reliability. The state's clean energy policies are already driving investments in renewables and energy-efficient technologies, saving money for the state's residents while reducing power sector CO_2 emissions and other harmful air pollution. However, to meet its CPP targets, Pennsylvania would not only need to take advantage of existing infrastructure, but also expand its existing clean energy policies past their current 2020–21 targets. Doing so would not only put the state in a good position to take advantage of the Clean Energy Incentive Program, but could even surpass the Clean Power Plan targets for its existing power plants. This has potential to create a new revenue stream for the state, given its potential to sell excess CO_2 allowances to other states looking for the most cost-effective ways to meet their own emissions standards. Adopting EPA's new source complement target would further incentivize zero-carbon generation sources and ensure that future CO_2 emissions from the state's power sector do not continue to increase. However, failing to expand the state's clean energy policies would likely put Pennsylvania in a position to have to purchase allowances from other states in order to comply with its CPP targets, subsidizing other states' clean energy economy instead of its own. By expanding its clean energy policies, Pennsylvania can scale up their benefits, reduce the need to invest in new natural gas plants, and achieve deeper reductions more cost-effectively.

Box 3 | **About the Series**

In *Delivering on the U.S. Climate Commitment*, WRI identified ten key actions the Obama administration must take in the absence of congressional action in order to meet the U.S. commitment to reducing greenhouse gas (GHG) emissions by 26–28 percent below 2005 levels by 2025. These actions include setting performance standards for existing power plants, reducing consumption of hydrofluorocarbons, reducing fugitive methane emissions from natural gas systems, and increasing energy efficiency. Of these ten actions, the greatest opportunity for reductions comes from the power sector. In his Climate Action Plan, President Obama directed EPA to work expeditiously to finalize carbon dioxide (CO_2) emission standards for new power plants and adopt standards for existing power plants. As states prepare to comply with these standards, it will be necessary to understand available opportunities for reducing CO_2 emissions from the power sector. This series of fact sheets aims to shed light on these opportunities by illustrating the potential for CO_2 emission reductions in a variety of states. We show how these emissions savings stack up against the reductions required under the Clean Power Plan. This series is based on WRI analysis conducted using publicly available data. See the appendix for additional information on our methodology and modeling assumptions.[a]

Notes:
a. World Resources Institute. 2015. *How States Can Meet Their Clean Power Plan Targets. Appendix A: Detailed Overview of Methods.* Washington, DC: World Resources Institute.

POLICY FRAMEWORK AND INTERACTION

This analysis assumes the existing policies and other reduction opportunities discussed in the text are fully implemented. Depending on the combination of measures actually implemented by Pennsylvania, each will have different impacts on the generation mix and resulting emissions. For example, increasing the use of existing combined cycle natural gas plants results in fewer emission reductions in this analysis than would be the case if it were considered in isolation, because implementation of the renewable standard decreases the amount of coal-fired generation that would otherwise be available to shift to natural gas. The emissions reductions presented in the text are a result of each policy applied in the following sequence: (1) energy efficiency improvements applied to business-as-usual generation; (2) increased renewable generation applied to the resulting adjusted generation; (3) increased use of existing combined cycle natural gas units; and (4) increased efficiency of any remaining coal units. For consistency with EPA's approach, we include only the existing fossil fleet as part of our business-as-usual projections, and only new renewable generation and energy efficiency measures put into place after 2012.

ENDNOTES

1. We adjusted Pennsylvania's 2012 emission levels for existing fossil plants to account for the state's two new NGCC plants, which were under construction as of January 2014 (Moxie Energy's Liberty and Patriot Power Generation Plants). EPA counts these plants as existing sources and includes the generation and emissions from these plants under Pennsylvania's baseline and compliance fossil emission rate and emission levels. Historical emission levels from: U.S. Energy Information Administration. 2014. *Annual Energy Review.* Accessible at: <http://www.eia.gov/electricity/data/state/emission_annual.xls>.

2. Because AEO2015 does not include state-level projections, we relied on regional projections of annual electricity generation growth rates by fuel for Pennsylvania's electricity projections. Because neighboring states have varying policies that will affect future in-state generation differently, these regional projections may not fully capture all the relevant trends that are expected to occur within the state's power sector. We adjusted our projections based on AEO2015 to include the refiring of the Shawville coal plant to natural gas in 2016 (http://www.powermag.com/pa-coal-plant-gets-new-lease-on-life-with-gas-repowering/).

3. http://www.pjm.com/planning/generation-interconnection/generation-queue-active.aspx

4. Specifically, EPA is requiring that states that adopt a mass-based state plan "demonstrate that the plan addresses and mitigates the risk of potential emission leakage to new sources" (http://www3.epa.gov/airquality/cpp/cpp-final-rule.pdf). EPA notes that including new plants in the state plan using the new source complement "could be presumptively approvable." To otherwise address this leakage in its proposed model rule, EPA proposes that states allocate a portion of the state's total allowances to existing NGCC units and/or allow developers of renewable projects to apply to receive set-aside allowances based on the projected generation from eligible renewable energy capacity. EPA is also requesting feedback on other set-aside options that could address leakage, including a set-aside that provides an incentive for demand-side energy efficiency (http://www3.epa.gov/airquality/cpp/cpp-proposed-federal-plan.pdf).

5. While AEO2015 does not explicitly model state efficiency standards, its projections do capture some of the effects of these programs through regional demand trends. We estimate the amount of efficiency embedded in our BAU projections using a methodology developed by EPA and Synapse (http://epa.gov/statelocalclimate/documents/pdf/EPA%20background%20and%20methodology%20EE_RE_02122014.pdf; http://www.synapse-energy.com/project/state-energy-efficiency-embedded-annual-energy-outlook-forecasts). See Appendix A for details. The emission reductions listed here reflect the additional efficiency from Pennsylvania's standard that is not embedded in the BAU projections. Renewable energy standards are explicitly modeled in AEO2015; however, for purposes of our analysis we assume that the standards are met through in-state generation and adjust renewable projections accordingly. This results in 2–7 TWh of additional renewable generation per year beyond business-as-usual projections between 2014 and 2030.

6. This result does not consider increased generation at Pennsylvania's existing nuclear fleet, which could be used as a compliance option.

7. The Pennsylvania PUC estimates that Phase III will result in 5.1 TWh of cumulative annual savings in 2020 (which represents 3.5 percent of 2009–10 load. See: <http://www.puc.pa.gov/filing_resources/issues_laws_regulations/act_129_information/energy_efficiency_and_conservation_ee_c_program.aspx>. The PUC defines cumulative annual savings as savings "that accumulate in any given year due to participation in energy efficiency programs in that given year, as well as participation in prior years, to the extent that participation in prior years continues to yield savings. Cumulative annual energy savings account for the fact that measures installed in prior years may have useful lives longer than one year, and therefore produce savings that persist into the future for some time. However, cumulative annual energy savings also reflect savings decay—that is, savings that can no longer be counted in a given year once a measure is no longer operational or has 'burned out.'" See: <http://www.puc.state.pa.us/Electric/pdf/Act129/SWE_EE_Potential_Study-No_Appendices.pdf>.

8. Our analysis finds that Pennsylvania's compliance emission rate still increases under a scenario where the state achieves its efficiency target without taking other actions to reduce power sector emissions.

9. The General Assembly of Pennsylvania, Senate Bill No. 1030, Session of 2004. Accessible at: <http://www2.legis.state.pa.us/WU01/LI/BI/BT/2003/0/SB1030P1973.pdf>.

10. Because Pennsylvania allows utilities to use some alternative fossil fuels as compliance for Tier II requirements under the AEPS, we conservatively model the Tier I renewable requirements only. Additional CO_2 reductions beyond what is reported in this analysis would be achieved if utilities use non-fossil energy sources for Tier II compliance.

11. Our analysis also finds that generating 8 percent of the state's electricity from renewable sources by 2021 (in addition to meeting its efficiency target) can get Pennsylvania 16 percent of the reductions required between 2012 and 2030 in order to meet its rate-based emissions standard under the Clean Power Plan.

12. Our analysis also finds that running existing NGCC plants at 75 percent—together with meeting its targets under Act 129 and the AEPS—can get Pennsylvania 53 percent of the way toward meeting its rate-based emissions standard.

13. Our analysis also finds that increasing coal plant efficiency together with all other measures can get Pennsylvania 60 percent of the way toward meeting its rate-based emissions standard.

14. Pennsylvania Public Utility Commission. February 2015. "Energy Efficiency Potential Study for Pennsylvania." Prepared by GDS Associates, Inc., Nexant, Research into Action, and Apex Analytics. Accessible at: < http://www.puc.state.pa.us/Electric/pdf/Act129/SWE_EE_Potential_Study-No_Appendices.pdf>.

15. US EIA:<http://www.eia.gov/electricity/sales_revenue_price/pdf/table5_a.pdf>.

16. Anthony Lopez, Billy Roberts, Donna Heimiller, Nate Blair, and Gian Porro. 2012. "U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis." National Renewable Energy Laboratory. Accessible at: <http://www.nrel.gov/docs/fy12osti/51946.pdf>.

17. This figure is calculated assuming all renewable requirements end in 2016 and no additional efficiency is captured beyond what is already embedded in BAU projections from measures implemented to date.

18. Accessible at: <http://yosemite1.epa.gov/EE/epa/eed.nsf/6058a0895486355785257662006 39df3/f9c8c8a37d6aab6f8525774200597f42!OpenDocument>.

19. This estimate of annual revenue from a $10 carbon price uses Pennsylvania's interim and final mass-based targets between 2022 (106 million short tons of CO_2) and 2030 (89.8 million short tons of CO_2). Revenue in any given year will be higher or lower, depending on the response to the carbon price.

20. Analysis Group. 2011. "The Economic Impacts of the Regional Greenhouse Gas Initiative on Ten Northeast and Mid-Atlantic States." Accessible at: http://www.analysisgroup.com/uploadedfiles/content/insights/publishing/economic_impact_rggi_report.pdf. Analysis Group. 2015. "The Economic Impacts of the Regional Greenhouse Gas Initiative on Nine Northeast and Mid-Atlantic States." Accessible at: <http://www.analysisgroup.com/uploadedfiles/content/insights/publishing/analysis_group_rggi_report_july_2015.pdf>.

21. PJM. 2015. "PJM Interconnection Economic Analysis of the EPA Clean Power Plan Proposal." Accessible at: <http://www.pjm.com/~/media/4CDA71CBEC864593BC11E7F81241E019.ashx>.

22. http://www.eia.gov/electricity/sales_revenue_price/pdf/table5_a.pdf

23. http://emp.lbl.gov/sites/all/files/total-cost-of-saved-energy.pdf

24. Pennsylvania Public Utility Commission. 2014. "Act 129 Statewide Evaluator Final Annual Report Phase I: June 1, 2009–May 31, 2013." Prepared by GDS Associates, Inc., Nexant, and Mondre Energy, Inc. Accessible at: <http://www.puc.pa.gov/pcdocs/1274547.pdf>.

25. Analysis Group. 2015. "The Economic Impacts of the Regional Greenhouse Gas Initiative on Nine Northeast and Mid-Atlantic States." Accessible at: <http://www.analysisgroup.com/uploadedfiles/content/insights/publishing/analysis_group_rggi_report_july_2015.pdf>.

26. EPA modeling of the CPP estimated that electricity bills for the average American will be 7–7.7 percent lower in 2030 due to changes in the average electricity price and demand.

27. https://www.whitehouse.gov/sites/default/files/image/climate/Pennsylvania_Factsheet.pdf

28. James Shortle, et al. 2015. "Pennsylvania Climate Impacts Assessment Update." The Pennsylvania State University. Accessible at: <http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-108470/2700-BK-DEP4494.pdf>.

29. U.S. Environmental Protection Agency. "What Are the Six Common Air Pollutants?" Accessible at: <http://www.epa.gov/airquality/urbanair/>.

30. U.S. Environmental Protection Agency. 2015. "Keeping Energy Affordable and Reliable." Accessible at: <http://www.epa.gov/airquality/cpp/fs-cpp-reliability.pdf>.

31. Susan F. Tierney. 2015. "How to Examine the U.S. Energy Information Administration's Report: Analysis of the Impacts of EPA's Clean Power Plan." Testimony Before the U.S. House of Representatives Committee on Science, Space and Technology, Subcommittee on the Environment and Subcommittee on Energy. Accessible at: <http://www.analysisgroup.com/uploadedfiles/content/news_and_events/news/tierney_testimony_house_science_and_technology_committee_6-22-2015.pdf>. Analysis Group. 2015. "Electric System Reliability and EPA's Clean Power Plan: Tools and Practices." Accessible at: http://www.analysisgroup.com/uploadedFiles/Content/Insights/Publishing/Electric_System_Reliability_and_EPAs_Clean_Power_Plan_Tools_and_Practices.pdf>.

32. For example, see: Brattle Group. 2015. "EPA's Clean Power Plan and Reliability Assessing NERC's Initial Reliability Review." Accessible at: <http://info.aee.net/hs-fs/hub/211732/file-2486162659-pdf/PDF/EPAs-Clean-Power-Plan--Reliability-Brattle.pdf?t=1438552731095>. Analysis Group. 2015. "Electric System Reliability and EPA's Clean Power Plan: Tools and Practices." Accessible at: <http://www.analysisgroup.com/uploadedFiles/Content/Insights/Publishing/Electric_System_Reliability_and_EPAs_Clean_Power_Plan_Tools_and_Practices.pdf>. Analysis Group. 2015. "Electric System Reliability and EPA's Clean Power Plan: The Case of MISO." Accessible at: <http://www.analysisgroup.com/uploadedfiles/content/insights/publishing/analysis_group_clean_power_plan_miso_reliability.pdf>.

33. C. Linvill, J. Migden-Ostrander, and M. Hogan. 2014. "Clean Energy Keeps the Lights On." Accessible at: <http://www.raponline.org/press-release/clean-energy-keeps-the-lights-on>.

34. PJM Interconnection, LLC. 2014. "PJM Renewable Integration Study." Prepared by General Electric International, Inc. <Accessible at: http://www.pjm.com/committees-and-groups/subcommittees/irs/pris.aspx>.

35. House Bill No. 2200 Session of 2008, Act 129. Accessible at: <http://www.puc.pa.gov/electric/pdf/Act129/HB2200-Act129_Bill.pdf>.

36. Because Act 129 establishes cumulative reductions as opposed to annual or incremental targets, we assumed that the EIA AEO reference case captured an annual efficiency gain of 0.9 percent, which is consistent with ACEEE estimates. See American Council for an Energy-Efficient Economy. 2012. *The 2012 State Energy Efficiency Scorecard*. Accessible at: <http://www.aceee.org/sites/default/files/publications/researchreports/e12c.pdf>.

37. Pennsylvania Public Utility Commission. 2014. "Act 129 Statewide Evaluator Final Annual Report Phase I: June 1, 2009–May 31, 2013." Prepared by GDS Associates, Inc., Nexant, and Mondre Energy, Inc. Accessible at: <http://www.puc.pa.gov/pcdocs/1274547.pdf>.

38. Joe Sherrick. *Act 129 Phase II Update*. PA PUC, June 20, 2013. Accessible at: <http://www.sydist.com/Portals/0/Presentations/Act129MT2013/2_PUC_Act129PhaseIIUpdate.pdf>.

39. http://www.puc.pa.gov/filing_resources/issues_laws_regulations/act_129_information/energy_efficiency_and_conservation_ee_c_program.aspx

40. US EIA: <http://www.eia.gov/electricity/sales_revenue_price/pdf/table5_a.pdf>.

41. Pennsylvania Public Utility Commission. February 2015. "Energy Efficiency Potential Study for Pennsylvania." Prepared by GDS Associates, Inc., Nexant, Research into Action, and Apex Analytics. Accessible at: <http://www.puc.state.pa.us/Electric/pdf/Act129/SWE_EE_Potential_Study-No_Appendices.pdf>.

42. Power plants that use combined heat and power can convert the useful thermal output to electricity generation for purposes of compliance. EPA estimated that Pennsylvania's useful thermal output was equivalent to 3.8 TWh in 2012.

43. Clean Energy Wins. 2014. "Clean Energy Wins: A Policy Roadmap for Pennsylvania." Accessible at: <http://cleanenergywins.org/wp-content/uploads/2014/03/CleanEnergyWins_PolicyRoadmap.pdf>.

44. The General Assembly of Pennsylvania. "Senate Bill No. 1030, Session of 2004." Accessible at: <http://www.legis.state.pa.us/CFDOCS/Legis/PN/Public/btCheck.cfm?txtType=PDF&sessYr=2003&sessInd=0&billBody=S&billTyp=B&billNbr=1030&pn=1973>.

45. Because Pennsylvania allows utilities to use some alternative fossil fuels as compliance for Tier II requirements under the AEPS, we conservatively model the Tier I renewable requirements only. Additional CO_2 reductions beyond what is reported in this analysis would be achieved if utilities use non-fossil energy sources for Tier II compliance.

46. Pennsylvania Public Utility Commission. *2013 Annual Report Alternative Energy Portfolio Standards Act of 2004.* Accessible at: <http://www.puc.state.pa.us/electric/pdf/AEPS/AEPS_Ann_Rpt_2013.pdf>.

47. Anthony Lopez, Billy Roberts, Donna Heimiller, Nate Blair, and Gian Porro. 2012. "U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis." National Renewable Energy Laboratory. Accessible at: <http://www.nrel.gov/docs/fy12osti/51946.pdf>.

48. U.S. Department of Energy/Energy Information Administration. "EIA-860 2013." Accessible at: <http://www.eia.gov/electricity/data/eia860/>.

49. Bob Fagan, Patrick Luckow, David White, and Rachel Wilson. 2013. "The Net Benefits of Increased Wind Power in PJM." Synapse Energy Economics, Inc. Accessible at: <http://www.synapse-energy.com/sites/default/files/SynapseReport.2013-05.EFC_.Increased-Wind-Power-in-PJM.12-062.pdf>. Josh Ryor and Letha Tawney. 2014. "Shifting to Renewable Energy Can Save U.S. Consumers Money." Washington, DC: World Resources Institute. Accessible at: <http://www.wri.org/blog/2014/06/shifting-renewable-energy-can-save-us-consumers-money>.

50. Pennsylvania Public Utility Commission. *2013 Annual Report Alternative Energy Portfolio Standards Act of 2004.* Accessible at: <http://www.puc.state.pa.us/electric/pdf/AEPS/AEPS_Ann_Rpt_2013.pdf>.

51. Pennsylvania Public Utility Commission. *2013 Annual Report Alternative Energy Portfolio Standards Act of 2004.* Accessible at: <http://www.puc.state.pa.us/electric/pdf/AEPS/AEPS_Ann_Rpt_2013.pdf>.

52. WRI estimates based on data from U.S. Energy Information Administration, EIA-923 Generation and Fuel Data. Accessible at: http://www.eia.gov/electricity/data/eia923/. EIA-860 Annual Electric Generator Data. Accessible at: <http://www.eia.gov/electricity/data/eia860/>.

53. NGCC units are designed to be operated up to 85 percent capacity (see http://mitei.mit.edu/system/files/NaturalGas_Chapter4_Electricity.pdf), but actual maximum capacity factors may differ among units. We assume a conservative maximum capacity factor of 75 percent. Because the majority of NGCC units are located in the northern and eastern part of the state, increasing the output from these existing units may cause transmission bottlenecks; potential transmission constraints should be studied further. Natural gas pipeline constraints also may occur, leading to price spikes. The state will need to consider both the near- and long-term potential cost differences between natural gas and coal as it weighs different compliance options.

54. We did not account for the increases in methane associated with the increased production of natural gas due to higher demand for the fuel. Going forward, industry should work with EPA to reduce methane leakage rates from natural gas systems. For additional information, see these WRI publications: "Reducing Methane Emissions from Natural Gas Development: Strategies for State-level Policymakers" (http://www.wri.org/publication/reducing-methane-emissions-natural-gas-development-strategies-state-level-policymakers), and "Clearing the Air" (http://www.wri.org/publication/clearing-the-air).

55. Phil DiPetro and Katrina Krulla. 2010. *Improving the Efficiency of Coal-Fired Power Plants for Near Term Greenhouse Gas Emissions Reductions*. National Energy Technology Laboratory, Office of Systems, Analyses and Planning. DOE/NETL-2010/1411. Accessible at: <http://www.netl.doe.gov/energy-analyses/pubs/ImpCFPPGHGRdctns_0410.pdf>.

56. "Regulating Greenhouse Gas Emissions Under the Clean Air Act." 73 *Register* §147(2008). Accessible at: <http://www.gpo.gov/fdsys/pkg/FR-2008-07-30/pdf/E8-16432.pdf>.

57. EPA calculated potential heat rate improvement for each region using three different analytical approaches and used the most conservative value for each region when setting the final targets. For more details, see the Clean Power Plan GHG Mitigation Measures Technical Support Document, accessible at: <http://epa.gov/airquality/cpp/tsd-cpp-ghg-mitigation-measures.pdf>.

58. For example, the National Energy Technology Laboratory found a payback period of less than four years for a refurbishment technology that achieves a 2 percent heat rate improvement. For more information, see *Benefits of the Big Bend Power Station Project,* National Energy Technology Laboratory. Accessible at: <http://www.netl.doe.gov/technologies/coalpower/cctc/ccpi/pubs/tampa.pdf>; and "Analyses Show Benefits of Improving Unit Heat Rate as Part of a Carbon Mitigation Strategy." *Lehigh Energy Update* 28 (1), February 2010. Accessible at: <http://www.lehigh.edu/~inenr/leu/leu_65.pdf>.

59. Personal communication with Tomas Carbonell, Environmental Defense Fund, July 12, 2013.

ABOUT THE AUTHORS

Kristin Meek
Associate
Climate and Energy Program

Contact: kmeek@wri.org

Rebecca Gasper
Research Analyst
Climate and Energy Program

Contact: rgasper@wri.org

Noah Kaufman
Climate Economist

Contact: nkaufman@wri.org

ABOUT WRI

World Resources Institute is a global research organization that turns big ideas into action at the nexus of environment, economic opportunity and human well-being.

Our Challenge
Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth's resources at rates that are not sustainable, endangering economies and people's lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

Our Vision
We envision an equitable and prosperous planet driven by the wise management of natural resources. We aspire to create a world where the actions of government, business, and communities combine to eliminate poverty and sustain the natural environment for all people.

Our Approach
COUNT IT
We start with data. We conduct independent research and draw on the latest technology to develop new insights and recommendations. Our rigorous analysis identifies risks, unveils opportunities, and informs smart strategies. We focus our efforts on influential and emerging economies where the future of sustainability will be determined.

CHANGE IT
We use our research to influence government policies, business strategies, and civil society action. We test projects with communities, companies, and government agencies to build a strong evidence base. Then, we work with partners to deliver change on the ground that alleviates poverty and strengthens society. We hold ourselves accountable to ensure our outcomes will be bold and enduring.

SCALE IT
We don't think small. Once tested, we work with partners to adopt and expand our efforts regionally and globally. We engage with decision-makers to carry out our ideas and elevate our impact. We measure success through government and business actions that improve people's lives and sustain a healthy environment.